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U.S. Department of Energy Solar Decathlon

PROJECT MANUAL

REVISED 2009.06.02 Final Documents Submission
REVISED 2009.05.15 Interim Review Submission
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1.0 Summary of Changes

Please review changes to complete Construction Drawing Package and complete Project Manual. Changes are significant enough to warrant full review.

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2.0 Rule Compliance Checklist

2.1 Rule Compliance Checklist

SHEET REFERENCE	RULE #	RULE DESCRIPTION	CONTENT REQUIREMENTS
O-102, O-103	4-2	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site
PM 4.0 SPEC	4-2	Construction Equipment	Data sheet(s) and/or specs for heavy machinery
S-111, E-101	4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site
S-101, S-111	4-4	Impact on the Turf	Drawing(s) showing the location, contact area, and soil bearing pressure of every component resting directly on the turf
PM 4.0 SPEC	4-5	Generators	Data sheet(s) and/or specifications for generators
P-101,O-102	4-6	Spill Containment	Drawing(s) showing the locations of all equipment, tanks, and pipes that will contain fluids at any point during the event
PM 4.0 SPEC	4-6	Spill Containment	Data sheet(s) and/or specifications for all equipment, tanks, and pipes that will contain fluids at any point during the event
PM 5.0	4-7	Lot Conditions	Calculations showing that structural design remains compliant even if 18 in. (45.7 cm) of vertical elevation change exists
S-501	4-7	Lot Conditions	Drawing(s) showing shimming methods and materials to be used if 18 in. (45.7 cm) of vertical elevation change exists on the lot
X-104	5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope
N/A	5-2	Solar Envelope Dimensions	List of solar envelope exemption requests accompanied by justifications and drawing references
S-001 through S-601	6-1	Structural Design Approval	List of, or marking on, all sheets in the complete electronic Construction Documents that have been or will be stamped by the structural engineer in the hard-copy, stamped structural submission; the stamped submission shall consist entirely of sheets or pages that also appear in the complete electronic construction document set
A-114	6-2	Maximum Architectural Footprint	Drawing(s) showing all information needed by the Rules Officials to measure the architectural footprint electronically

A-114	6-2	Maximum Architectural Footprint	Drawing(s) showing all movable components that may increase the footprint if operated during contest week
A-105	6-2	Maximum Architectural Footprint	Shading calculations and/or diagrams for components that DO NOT shade the building above its finished floor height between 9 a.m. and 5 p.m. EDT on October 1 (shading calculations and/or diagrams are not necessary for components that are either shorter than finished floor height or obviously do not shade the building)
M-101 thru M-611, A-114	6-3	Minimum Conditioned Space	Drawing(s) showing space conditioning means in primary living spaces
X-101 X-102 X-103	6-4	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route and the ground surface area that will be covered by organizer-provided walkway material
L-101	7-1	Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system
N/A	7-2	Watering Restrictions	Drawings showing the layout and operation of greywater irrigation systems
PM 4.0 SPEC	8-1	PV Technology Limitations	PV Technology Data sheet(s) and/or specifications for photovoltaic components
PM 8.0	8-1	PV Technology Limitations	Retail price quote for photovoltaic components
P-101, P-102	8-3	Thermal Energy Storage	Drawing(s) showing the location of thermal energy storage components
PM 4.0 SPEC	8-3	Thermal Energy Storage	Data sheet(s) and/or specifications for thermal energy storage components
N/A	8-3	Thermal Energy Storage	Shading calculations and/or diagrams for thermal energy storage components (if necessary)
N/A	8-4	Batteries	Drawing(s) showing the location(s) and quantity of stand-alone, PV-powered devices
N/A	8-4	Batteries	Data sheet(s) and/or specifications for all stand-alone, PV-powered devices
N/A	8-5	Desiccant Systems	Drawing(s) describing the operation of the desiccant system
N/A	8-5	Desiccant Systems	Data sheet(s) and/or specifications for desiccant system components

PM 10.0	8-6	Village Grid	Completed Interconnection Application form.
E-101	8-6	Village Grid	Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means
PM 4.0 SPEC	8-6	Village Grid	Data sheet(s) and/or specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means
E-601	8-6	Village Grid	One-line electrical diagram
PM 10.3	8-6	Village Grid	Calculation of service/feeder net computed load per NEC 220
A-101, E-101	8-6	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box
E-201	8-6	Village Grid	Elevation(s) showing the terminal box, meter housing, main utility disconnect, and other service equipment
P-903	9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems
N/A	9-6	Thermal Mass	Drawing(s) showing the locations of water-based thermal mass systems
N/A	9-6	Thermal Mass	Data sheet(s) and/or specifications for components of water-based thermal mass systems
COMM PLAN	10-2	Event Sponsor Recognition	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage
COMM PLAN	10-3	Team Sponsor Recognition	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage
X-101, X-102, X-103	11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route
COMM PLAN	11-4	Public Exhibit	Drawing(s) showing the dimensions, materials, artwork, and content of the handout
COMM PLAN	11-4	Public Exhibit	Drawing(s) showing the artwork and content of the team uniform

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3.0 Code Compliance Checklist

3.1 Code Compliance Checklist

Outline of Regulatory Information Based on Category Group						
1–General	**Project identification**	**Location**				**Remarks**
	Project address					
	Street address, city, and state	R-101	101 Autumn Hill Boulevard, Vaughan, Ontario, Canada			
	Project location map	R-101	Refer to Resource Section for Alternate Market Viability Site			
	Professional design firm(s) identification	G-001				
	Architect	Team North				
	Structural Engineer	Blackwell Bowick Engineering, Cory Zurell				
	Mechanical Engineer	Ecologix, Steve Davies				
	Electrical Engineer					
	Contractor name(s)	G-001				
	Fabricator:	MCM 2001 inc.				
	Electrician:	Red Electric				
	Plumber					
	Design professional name(s)	G-001				
	Design professional address(es)	G-001				
	Design professional phone number(s)	G-001				
	Design professional license number and seal	S-101				Stamped Drawings provide for Structural Set Only
	Listing of applicable codes (titles and edition)					
Category Group	**REGULATORY INFORMATION**	**LOCATION**	**CODE**	**ED.**	**REF. #**	**REMARKS**
	Accessibility		ANSI A117.1	1998		As per Solar Decathlon 2009 Building Code
	Building		IBC	2000		International Building Code
			OBC	2006		Ontario Building Code
	Electrical		IEC	2000		International Electrical Code
			NEC	2008		National Electrical Code
			CEC			Canadian Electrical Code
	Energy Conservation		OBC	2006		Ontario Building Code
	Fire		IFC	2000		International Fire Prevention Code
			NFPA	2008		National Fire Protection Agency
	Fuel / Gas (as applies to temp. const. equipment)		SD2009	2009		Solar Decathlon Building Code
	Mechanical		IMC	2000		International Mechanical Code
	Plumbing		IPC	2000		International Plumbing Code
			ASHRAE			American Society of Heating Refridgerating & Air Conditioning Engineers
	Private sewage disposal	N/A				N/A
	Property maintenance	N/A				
	Residential		IRC	2000		International Residential Code
			OBC	2006		Ontario Building Code
	Zoning		IZC	2000		International Zoning Code
			VZB			Vaughan Zoning By-Law
	Other					
	Flooding		NFIP	1990		National Flood Insurance Program
	Water Conservation		TRCA			Toronto Regional Conservation Authority
NOTE:	**To obtain a copy of the 2006 O.B.C. or Richmond Hill Zoning By-Law, please contact Kathy Velikov of TEAM NORTH at:**	**Team North c/o University of Waterloo School of Architecture, Cambridge, ON, N1S 2H4 1-519-888-4567 ext.27652**				
	Listing of applicable local ordinances and jurisdictions					
	Local amendments					
	Zoning	R-101	VZB			Single Family Residential
	Signage					
	Other					
2–Site	**Site-Related Design Criteria**	**Location**				**Remarks**
	Location on site (distances to lot lines/existing buildings)	R-101				Alternate Site Plan for Market Viability
	Site grading/water run-off	R-101				Proposed Site Drainage not altered
	Erosion control details	N/A				As per Municipal Standards & Requirements
	Environmental impact statements	N/A				
	Zoning drawings	R-101				Alternate Site Plan for Market Viability
	Zoning use (allowable/actual)	R-101	VZB			Single Family Residential
	Site coverage (allowable/actual)	R-101				0.1 R (790 s.f)
	Building height (allowable/actual)	R-xx				(31'-0" / 15'-1")
	Parking/loading requirements (required/actual)					(3 / 3)

Category Group	REGULATORY INFORMATION	LOCATION	CODE	ED.	REF. #	REMARKS
3–Building	**Building Design Criteria**	**Location**				**Remarks**
	NOTE: WHERE CODE AND REFERENCE SECTIONS ARE INDICATED, THE MOST STRINGENT CODE STANDARD HAS BEEN REFERENCED.					
	Use group (occupancy) classification(s)		OBC		Sec. 3.1.2.1	A1 - Assembly / C - Residential As per Table 3.1.2.1
	Type of construction	A-001	OBC		3.1.4.1	Combustible
	Building area (allowable/actual)	A-114	SD2009 BC			(800sf / 791sf)
	Building height (allowable/actual)	A-311	SD2009 BC			(18'-0" / 15'-0")
	Special use and occupancy (e.g., covered mall, high rise)	N/A				
	Seismic design category	N/A	OBC		Table 2.5.1.1	Z_a = 1, Z_v = 0, ratio = 0.05
	Design wind speed	PM	OBC		Table 2.5.1.1	Wind pressure: 1/10kPa = 0.26, 1/30kPa = 0.32, 1/100kPa =0.39
						For Cambridge, ON, CA: q50=0.35 kPa
						For Washington, D.C.: 3 sec gust =90mph
			SD2009 BC		5-2 (a)	60 mph (26.8m/s) (3 sec-gust), exposure C
			IRC		Sec R301.1	Specific point-load connection details for solar panels to resist uplift.
4–Life Safety-Egress	**Means of Egress Design Criteria**	**Location**			**Code Reference**	**Remarks**
	Occupant load(s)	A-114	OBC			Assembly / Standing Space =
					3.1.16.1,	MAX Allowable (544sf/4.3)= 126 people
					9.9.1.3.1(a),	Residential = 2 people
	Building exits per floor (arrangement; required/actua	X-101	OBC		9.9.2.1(2)	2 Exits provided
	Exit capacity per floor	X-101			9.9.3.2	2 x 2'-11"(minimum) provided: 6'-0"
	Travel distance (allowable/actual)	F-101	OBC		9.9.8.2(1) ©	(98'-6"/30'-10")
	Means of egress lighting	I-202, E-103	OBC		9.9.10.7, 9.9.11.2(1)	Illumination must be provided to an average of not less than 4.6 ft-candles at floor or tread
	Interior finish classification (allowable/actual)	I-601	OBC		3.1.13.2(1)	(not more than 150 FSR / _)
	Corridor, stair and door details	X-101, A-311	OBC		9.9.6.4(a)(b), 9.9.6.5(1)	Doors: min 6'-8"h x 2'-8"w, swing out with path of travel / Actual 7'-6"H x 3'-0"W
			SD2009 BC		3-2a	Stairs: 11" min tread, 7" max riser, 4"min riser
			SD2009 BC		3-2b	Handrails as required by the IBC 1009.11
5–Fire Protection-Passive	**Passive Fire Protection Design Criteria**	**Location**			**Code Reference**	**Remarks**
	Fire resistance ratings of building elements, including tested design number (required/actual)		OBC		9.10.8.1 / 9.10.8.3, SG-8	Supporting Structure Require Fire Resistance Rating to Match Requirements of Roof (SG-8), Residential Group C = 0 Hours
	Mixed use (occupancy) separations	N/A				
	Fire resistive assembly location plan		SD2009 BC		3-1(a)	location of extinguishers (UL-2A-10BC) + See Project Manual
	Firestopping, including tested design number		SD2009 BC		3-1(b)	
	Plastics	A-001	OBC		3.1.4.2 / 9.29.6	1/2" Plywood Minimum Separation
			SD2009 BC		Sec. 3-6	23/32" Douglas Fir (Western Species Plywood required as Fireseparation from Interior Spaces
		PM	IRC		Sec. 314.3	Flame Spread to be Max. 75, Smoke Developed Index Max. 450
6–Accessibility	**Accessibility Design Criteria**	**Location**			**Code Reference**	**Remarks**
	Exterior accessible routes, including parking	X-101	SD2009 BC		Sec. 4-3	Slope of a ramp cannot exceed 1:12, "Sloped floor must be less than 1:20, 60" min landing required at the top and bottom of any ramp.
	Location of public facilities on site	N/A				Organizer Provided
	Accessible entrances	X-101	SD2009 BC		4-4, 4-5	32" min. min clearance
			ADAAG		4.13	
	Interior accessible routes		SD2009 BC		Sec. 4-1	
			IBC		Chp 11 / ICC / ANSI A117.1-2003	
	Clear floor space/maneuverability clearances		SD2009 BC		Sec 4-1	3'-0" Clear Path of Travel
	Detectable warnings and signage (exterior)	N/A				
	Detectable warnings and signage (interior)	N/A				
	Toilet and bathing facilities	N/A				Organizer Provided
	Elevator and area of rescue assistance details	N/A				
	Occupancy-specific accessible feature (e.g., assembly, residential dwelling units)	N/A				

Category Group	REGULATORY INFORMATION	LOCATION	CODE	ED.	REF. #	REMARKS
7–Energy	**Energy Design Criteria**	**Location**			**Code Reference**	**Remarks**
	Design conditions (temperatures)		OBC		Section 5	
	Envelope systems analysis		IRC		R703	
			SD2009 BC		Sec. 3-7	
	Envelope insulation levels		OBC		5.3.1.1	
	Air leakage/infiltration, sealing		OBC		5.4	
	Glazing type (fenestration) and areas	Window Schedule	SD2009 BC		Sec. 3-4	All glazing in House required to be safety glazing (tempered)
			IRC		Sec. 308.4	
	Mechanical equipment sizing, loads, and efficiencie	PM	SD2009 BC		Section 7	Refer to Energy Model Analysis
	Electrical equipment sizing, loads, and efficiencies	PM	SD2009 BC		Section 6	Refer to NEC 220 Service & Neutral Ampacity Calculations
	Electrical power budget - overall	PM				3 watts per square foot. Refer to NEC 220 Service & Neutral Ampacity Calculations
	Electrical power budget - only lighting	PM				1.5 watts per square foot. Refer to NEC 220 Service & Neutral Ampacity Calculations
	Service water heating sizing, loads, and efficiencies	PM				Refer to Energy Model Analysis
	Duct and hot water piping insulation	PM	OBC	2006		
	Energy trade-offs	PM				Refer to the Architectural & Engineering Design Narratives.
	Temperature controls	PM / T-601 / M-601				Refer to Central controls System Description in the Engineering Design Narrative.
	Water conservation	PM	TRCA			
8–Structural	**Structural Criteria**	**Location**			**Code Reference**	**Remarks**
	Design dead loads (actual)	PM	SD2009 BC			
	Design live loads (required)	PM	SD2009 BC		Sec. 5-2	
	Design snow loads (required)	PM	OBC	2006		Ss=1.6 kPa, Sr=0.4 kPa, therefore design load= 1.68kPa
	Design wind loads (required)	PM	OBC	2006		For Cambridge, ON, CA: q50=0.35 kPa
						For Washington, D.C.: 3 sec gust =90mph
			SD2009 BC		Sec. 5-2(a)	60mph (26.8 m/s) (3-sec gust)
	Design seismic loads (required)	N/A				Sa(0.2)=0.22, Sa(0.5)=0.11, Sa(1.0)=0.050, Sa(2.0=0.013, PGA=0.14, Site Class C aassumed. The LFRS is regular and the Equivalent Static Procedure applies.
						Wood Based Shear walls - Rd=3.0, R=1.7
	Soil data (frost depth; allowable foundation type/loads)		OBC			42" depth to frost line
	Description of structural system	PM				
	Structural details	S-501, S-502				
	Identification of applicable material design standards (title/edition)		SD2009 BC		Sec. 5-6, 5-7	Structural Steel
			SD2009 BC		Sec. 5-6(c)	Engineered Trusses
			IRC		R502.11, R802.10, R104.11	
			CSA		G40.21-04	Structural Steel
			CAN/CSA		S16-01	Structural Steel
			CSA		O86-01	Structural Timber
	Structural shop drawings		PM			Required where indicated in project specifications (Section 4.0)
9–Fire Protection-Active	**Active Fire Protection Criteria**	**Location**			**Code Reference**	**Remarks**
	Fire department connections	N/A				
	Fire extinguishers	F-101	IRC		Sec. R313	
			SD2009 BC		3-1(b)	minimum: UL rated 2A-10BC Fire Extinguisher
	Fire alarms, automatic and manual	F-101	SD2009 BC		3-1(a)	AC Connected Detector with Integrated Alarm and Battery Back-up
	Single-station smoke detectors	F-101	SD2009 BC		3-1(a)	
	Smoke control	N/A				
	High-hazard abatement	N/A				

Category Group	REGULATORY INFORMATION	LOCATION	CODE	ED.	REF. #	REMARKS
10–Plumbing	**Plumbing Design Criteria**	**Location**			**Code Reference**	**Remarks**
	Required vs. provided fixtures and distribution	I-101	OBC		9.31.4.1(1)	REQUIRED: Kitchen sink, Lavatory, Shower Stall, Water Closet
						Provided Additional: Washing Machine, Dish Washer, Exterior Sink, Hose Bib
	Water distribution sizing criteria	P-101	OBC		9.31.3.2	
	Plumbing riser diagram	P-101, P-901, P-902, P-904, P-905				
	Drain, waste, and vent system details	P-101, P-903, P-904	OBC		9.31.4.4	Floor Drains
	Cleanout locations	P-101, P-903, P-904	OBC		7.2.10.3, 7.4.7.1	
	Indirect waste connections	N/A	SD2009 BC		Sec. 9-2, 9-7	
	Water heater location	P-101				
	Backflow preventors	P-601	OBC		7.2.10.10	Potable Water & Solar Thermal Systems are isolated as required
			SD2009 BC		Sec. 9-5	Required to isolate potable water from the solar systems. IRC P2902.2
	Roof storm water drainage	P-102	OBC		7.3.3.8(1)	
	Piping hanger schedule	N/A	OBC		7.3.4	Pipe Supports
	Interceptors and separators	N/A	N/A	N/A	7.4.4.3	Not Required for Residential
	Special systems (glycol/potable water Heat Exchanger)	P-101	IRC		P2902.5.2	not necessary because propylene glycol has Gosselin rating of 1 (non-toxic)
	Identification of applicable fixture and pipe standards (title/edition)		OBC		7.4.3	
			SD2009 BC		Sec. 9-4	Shower Mixing Valve shall be pressure balanced with high limite set at 120 deg. F. to prevent scalding (IRC, P2802.3, P2708.3)
	Tank Standards	PM	ASHRAE		90.1b	
11– Mechanical	**Mechanical Design Criteria**	**Location**			**Code Reference**	**Remarks**
	Equipment installation and listing	PM				See Division 23 of Specifications
	Specific appliance details (e.g., unit heaters)	PM	OBC		6.2.5	
	Duct construction	PM	OBC		6.2.3	See Division 23 of Specifications
	Piping support	PM				See Division 23 of Specifications
	Ventilation schedule	M-611	SD2009 BC		Sec. 7-4	Bathroom Exhaust: 50cfm intermittent, 20cfm contiuous, or min:1.5sf operable window
			IRC		Sec. R303.3	
	See Appendix G - Ventilation Schedule	PM				
	Exhaust and intake locations	M-101	OBC		6.2.3.13, 9.32.3.12	10' min separation between each
	Kitchen exhaust and suppression	M-101	OBC		9.32.3.4	As per Table 9.32.3.4(a) min. 15 cfm for one bedroom residence
	Fire dampers	N/A	OBC		6.2.3.7 / 3.1.8.7	Not Required as per 3.1.8.7
	Combustion air	N/A				
	Chimneys, flues, and vents	N/A				
	Boilers and water schedule	P-601				
	Fuel/gas piping materials	N/A				
	Refrigerant piping materials	P-101				
	Hydronic piping materials	M-101				
	Controls	PM, M-601				
	Identification of applicable mechanical standards (title/edition)					

Category Group	REGULATORY INFORMATION	LOCATION	CODE	ED.	REF. #	REMARKS
12–Electrical	**Electrical Design Criteria**	**Location**			**Code Reference**	**Remarks**
	Equipment listing	PM	IRC		Sec.R106.1.1	
			CEC		2-024	
			NEC		Article 10	
	Equipment installation & methods	PM	CEC		Sec. 4, 12, 26	
			NEC		690.31, Chapter 3 690.4(D)	
	Wiring methods and materials	E-603,E-604				
	Single-line diagram	E-601	CEC		84-032	
	Over current protection	PM	CEC		Sec. 8, 50-010 (PV)	All inverters to have integral AC & DC overcurrent protection.
			NEC		690.9	
	Grounding details	E-101	SD2009			Grounding Rod Pentration limited to 18"maximum vertical depth.
			CEC		Section 10, 50-018 (PV)	
			NEC		690	
	Service details	E-101	CEC		Sec. 6	
	Transformers	N/A				
	Emergency power/standby systems	N/A				
	Disconnects	E-101, E-102, E-601	CEC		84-022 to 84-028, 50-012	All inverters have integral AC & DC disconnects
			CEC		Sections 8,12 and 28	general disconnects
	Identification of applicable electrical equipment standards (title/edition)		ULC			All electrical equipment ot be ULC listed or equivalent

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4.0 Construction Specifications

North House Product Hyperlink Matrix

DIVISION	SPEC REFERENCE	PRODUCT		MANUFACTURER	HYPERLINK	USE
05 - Metals						
	05 08 00	Fast Clad DTM Urethane		Sherwin Williams	http://www.team-north.com/pdfs/05_Hunter_Douglas_Quadroglass.pdf	Interior Steel Coating
	05 70 00			Thern	http://www.team-north.com/pdfs/05_Thern.pdf	Bed Winch
	05 14 00	Sunframe		Unirac	http://www.team-north.com/pdfs/05_Unirac_SunFrame_System.pdf	Roof Photovoltaic Rack
06 - Wood, Plastic, and Composites						
	06 16 00	G1S Premium Douglas Fir 3/4"		Richply	http://www.team-north.com/pdfs/06_Richply_Armorbond.pdf	Interior fire protection layer
		Armorbond		Richply	http://www.team-north.com/pdfs/06_Richply_G1s.pdf	Exterior Sheating
	06 17 00	Comfort Foam 178 Series		BASF	http://www.team-north.com/pdfs/07_BASF_Comfort_Foam_178.pdf	Foam insulation
07 - Thermal + Moisture						
	07 27 00	Perm-A-Barrier Wall Membrane		Grace	http://www.team-north.com/pdfs/07_Grace_PermABarrier.pdf	Self-adhering air barrier
	07 27 00	Air Bloc 33		Bakor	http://www.team-north.com/pdfs/07_Bakor_AirBloc33.pdf	Air Barrier
	07 92 13	Sikaflec 2c NS EZ Mix	TYPE A	Sika	http://www.team-north.com/pdfs/07_Sika_Sikaflex_2cNS_EZ_Mix.pdf	Joint sealanets + Caulking
		Dymeric 240	TYPE A	Tremco	http://www.team-north.com/pdfs/07_Tremco_Dymeric_240.pdf	Joint sealanets + Caulking
		Sanitary SCS1700	TYPE B	GE Silicones	http://www.team-north.com/pdfs/07_GE_Sanitary_SCS1700.pdf	Joint sealanets + Caulking
		DC786	TYPE B	Dow Corning	http://www.team-north.com/pdfs/07_Dow_Corning_DC786.pdf	Joint sealanets + Caulking
		Tremsil 200	TYPE B	Tremco	http://www.team-north.com/pdfs/07_Tremco_Tremsil_200.pdf	Joint sealanets + Caulking
	07 20 00	Styrofoam SM		Dow Chemical	http://www.team-north.com/pdfs/07_Dow_Chemical_styrofoam_SM.pdf	Exterior Wall Insulation
	07 21 23	UltraTouch		BondedLogic	http://www.team-north.com/pdfs/12_Bonded_Logic_UltraTouch.pdf	Sound attenuation insulation
	07 53 23	RubberGard EcoWhite EPDM		Firestone Building Products	http://www.team-north.com/pdfs/07_Firestone_EcoWhite_EPDM.pdf	Reflective Roof membrane
	07 53 23	ISO 95+		Firestone Building Products	http://www.team-north.com/pdfs/07_Firestone_ISO95_GL.pdf	Roof Polyisocyanurate insulation
	07 92 00	EMSEAL MST		EMSEAL, LLC	http://www.team-north.com/pdfs/07_EMSEAL_MST_Foam_Tape.pdf	Compressive Seal
08 - Openings						
	08 80 00	Thermaproof 1100 Series Quad Glazing		Serious Materials	http://www.team-north.com/pdfs/08_Thermaproof_1100_Series_Quad_Glazing.pdf	Glass
	08 80 00	SGT-900 Series		Tremco	http://www.team-north.com/pdfs/08_Tremco_SGT900.pdf	Glazing tape
	08 41 26	Pivot Doors		Ruch	http://www.cjrush.com/index.asp?MODE=PIV_DOORS	
	08 80 00	QuadroClad Facade		HunterDouglas	http://www.team-north.com/pdfs/05_Sherwin_Williams_fast_clad_DTM.pdf	Glass Cladding Bracket
09 - Finishes						
	09 64 34	Architectural Collection: Maple		Muskoka Prefinished Hardwood Flooring	http://www.team-north.com/pdfs/09_Muskoka_Wood_Flooring_Maple.pdf	Finish Floor
		Delta-Cool 24		Dorken	http://www.team-north.com/pdfs/09_Dorkin_Delta_Cool_24.pdf	Phase change material
	09 77 00	Corian		DuPont	http://www.team-north.com/pdfs/09_DuPont_Corian_Panels.pdf	Interior wall finish panel
	09 90 00	Ecospec 219		Benjamin Moore	http://www.team-north.com/pdfs/09_Benjaimin_Moore_ecospec_219.pdf	Interior paint
11 - Equipment						
	11 31 00	HC 1060		Liebherr	http://www.team-north.com/pdfs/11_Liebherr_HC_1060.PDF	Fully Integrated Refrigerator
		Axxis Compact Washers		Bosch	http://www.team-north.com/pdfs/11_Bosch_Axxis_Compact_Washer.pdf	Compact Washing Machine
		Axxis Condensation Dryers		Bosch	http://www.team-north.com/pdfs/11_Bosch_Axxis_Condensation_Dryer.pdf	Condensation Dryer
		Series 400 Vario induction cooktop		Gagganeau	http://www.team-north.com/pdfs/11_Gagganeau_SERIES_400.PDF	Induction Cooktop
		DF261		Gagganeau	http://www.team-north.com/pdfs/11_Gagganeau_DF261.pdf	Built-in Dishwasher
		BO-250		Gagganeau	http://www.team-north.com/pdfs/11_Gagganeau_BO_250.pdf	Built-in Oven
12 - Funishings						
	12 35 30.13	B1 Base Cabinet		bulthaup	http://www.team-north.com/pdfs/12_Bulthaup_B1.pdf	Kitchen casework
	12 24 13	Motorized FlexShade		Draper	http://www.team-north.com/pdfs/12_Draper_Motorized_FlexShades.pdf	Interior Privacy Shade Roller
	12 24 13	Sheer Weave P61 Cotton		Draper	http://www.team-north.com/pdfs/12_Draper_Phifer_Sheer_Weave_Infinity.pdf	Interior Privacy Shade Roller
	12 58 19	Skip Folding Chair		furnit	http://www.team-north.com/pdfs/12_furnit_skip_folding_chair.pdf	Folding Chair
	12 58 19	Extendable Dining Table		vitra	http://www.team-north.com/pdfs/12_Vitra_Extendable_Dining_Table.pdf	Extendable Dining Table
	12 32 00	Stark 1.2.3 #9778-l/r		Duravit	http://www.team-north.com/pdfs/12_Duravit_Stark_123_9778.pdf	Mirror Medicine Cabinet
	12 32 00	2nd Floor #9266		Duravit	http://www.team-north.com/pdfs/12_Duravit_2ndfloor_9266.pdf	Sideboard wall-mounted wooden tray
	12 58 00	Teak Bench		Daneb	http://www.team-north.com/pdfs/12_deneb_teak_bench.pdf	Exterior Furniture
	12 58 00	Teak Table		Daneb	http://www.team-north.com/pdfs/12_deneb_teak_table.pdf	Exterior Furniture
	12 21 14	Motorized External Louvered Blinds		Nysan Solar Control	http://www.team-north.com/pdfs/10_Nysan_Motorized_External_Louvered_Blinds.pdf	Dynamic Interior Shading Device
21 - Fire Protection						
	21 01 20	Fire Extinguisher		Kidde	http://www.team-north.com/pdfs/21_Kidde_466559.pdf	Fire Extinguisher
22 - Plumbing						
	22 09 00	Monogram Series DPF701		Omega	http://www.team-north.com/pdfs/22_Omega_DPF700.pdf	
	22 09 00	FTB4600 - Long-Life Pulse Output Water Meters		Omega	http://www.team-north.com/pdfs/22_Omega_FTB4600.pdf	
	22 09 00	FPR200		Omega	http://www.team-north.com/pdfs/22_Omega_FPR200.pdf	
	22 11 23	Grundfos Variable Speed Pump		Grundfos	http://www.team-north.com/pdfs/22_Grundfos_Variable_Speed_Pump.pdf	
	22 11 23	MJS Series Shallow Well Jet Pump		Monarch Industries	http://www.team-north.com/pdfs/22_Monarch_MJS.pdf	
	22 12 19	RKLT300		Canwest Tanks	http://www.team-north.com/pdfs/22_Canwest_PolyTanks_RKLT300.pdf	
	22 33 30.23	M-2-HE40S6DS		Bradford White Corporation	http://www.team-north.com/pdfs/23_Bradford_White_M-2-HE40S6DS.pdf	
	22 35 23 16	S-DC-DW2-110R6SW		Bradford White Corporation	http://www.team-north.com/pdfs/22_Bradford_White_S-DC-DW2.pdf	
	22 41 16	Model 111.335.00.1 Option 115.770.21-1		Geberit	http://www.team-north.com/pdfs/22_Geberit_RI111-335-00-1.pdf	WC Wall Carrier + Flush Carrier
	22 41 39	Zero Thermo Valve #4524542		Elte	http://www.team-north.com/pdfs/22_Elte_Zero_Thermo_Valve.pdf	
	22 41 39	Zero One #4524591		Elte	http://www.team-north.com/pdfs/22_Elte_Zero_One.pdf	
	22 41 39	Zero Faucet #4524501		Elte	http://www.team-north.com/pdfs/22_Elte_Zero_Faucet.pdf	
	22 11 33	Electric Drain ED-25		Myers	http://www.team-north.com/pdfs/22_Myers_ED-25.pdf	

23 - HVAC					
	23 09 33	A350PS-1C	Johnson Controls	http://www.team-north.com/pdfs/23_Johnson_Controls_A350PS-1C.pdf	
	23 09 33	System 350 Display Modules	Johnson Controls	http://www.team-north.com/pdfs/23_Johnson_Controls_350_Display.pdf	
	23 09 33	Power Module Y350R	Johnson Controls	http://www.team-north.com/pdfs/23_Johnson_Controls_Y350R.pdf	
	23 09 33	FR-V	AirCycler	http://www.team-north.com/pdfs/23_AirCycler_FRV.pdf	
	23 33 19	LD 6 Silencer	Fantech	http://www.team-north.com/pdfs/23_Fantech_LD6.pdf	
	23 34 16	FG Series Inline Centrifugal Fans	Fantech	http://www.team-north.com/pdfs/23_Fantech_fg6.pdf	
	23 56 13.19	Vitosol 200-T	Viessmann	http://www.team-north.com/pdfs/23_Viessmann_Vitosol-200-T.pdf	Evacuated Tube Solar Thermal
	23 56 13	HD-25 Heat Dissipator	Apricus	http://www.team-north.com/pdfs/23_Apricus_HD_25.pdf	Solar Thermal Heat Dissipator
	23 61 19	ZPD34K5E-PFV	Copeland	http://www.team-north.com/pdfs/23_Copeland_ZPD34K5E-PFV.pdf	
	23 72 00	SH704	Fantech	http://www.team-north.com/pdfs/23_Fantech_sh704.pdf	
	23 73 23	eco-pac EC	Ecologix Heating Technologies Inc.	http://www.team-north.com/pdfs/23_Ecologix_eco_pac_EC.pdf	
	23 09 00	3 way solenoid	Belimo	http://www.team-north.com/pdfs/23_%20Belimo_3_way_solenoid.pdf	
25 - Electrical					
		IntelliFlex SPG4WD	Draper	http://www.team-north.com/pdfs/25_Draper_IntelliFlexSPGC4WD.pdf	
		SG2	B&B Electronics	http://www.team-north.com/pdfs/25_B&B_Electronics_SG2.pdf	
	25 30 01	IntelliFlex SPG4C4	Draper	http://www.team-north.com/pdfs/25_Draper_IntelliFlexSPGC4.pdf	
		LRG2006	Canlyte	http://www.team-north.com/pdfs/25_Canlyte_LRG2006.pdf	
		Facade Controller	Embedia	http://www.team-north.com/pdfs/25_Embedia_Facade_Controller.pdf	
26 - Electrical					
	26 31 00	Xantrex GT Series Grid Tie Solar Inverters	Xantrex	http://www.team-north.com/pdfs/26_xantrex_GTsinglephase.pdf	Inverters
	26 22 16	QO142L225G	Square D - Schneider Electric	http://www.team-north.com/pdfs/26_Groupe_Schneider_QO142l225g.pdf	
	26 27 19	Netselect RF5xxxxx	Hubbell	http://www.team-north.com/pdfs/26_Hubbel_Netselect.pdf	Floor recepticles
	26 28 16	QO and QOB Class 730	Square D - Groupe Schneider	http://www.team-north.com/pdfs/26_Groupe_Schneider_Class_730.pdf	
	26 28 16	QO Loadentres and Circuit Breakers	Square D	http://www.team-north.com/pdfs/26_Groupe_Schneider_QO_Loadcentres_Circuit_Breakers.pdf	
	26 31 00	Day4 48MC	Day4	http://www.team-north.com/pdfs/26_Day4_48MC.pdf	Roof Photovoltaic Panels
	26 31 00	ProSol PV Modules	Schuco	http://www.team-north.com/pdfs/26_Schuco_ProSol.pdf	Facade Building Intergrated Photovoltaic Cladding Panels
	26 51 00	refer to Duravit Stark 1.2.3 #9778-l/r			Mark L1-1
	26 51 00	SV4S1xx-xxxxx	Canlyte	http://www.team-north.com/pdfs/26_Canlyte_CFI_Flourescent.pdf	Mark L1-2
	26 51 00	SV3S1xx-xxxxx	Canlyte	http://www.team-north.com/pdfs/26_Canlyte_CFI_Flourescent.pdf	Mark L1-3
	26 51 00	SV4S1xx-xxxxx	Canlyte	http://www.team-north.com/pdfs/26_Canlyte_CFI_Flourescent.pdf	Mark L1-4
	26 51 00	IColourFlex SLX	Canlyte	http://www.team-north.com/pdfs/26_Canlyte_iColor_Flex_SL.pdf	Mark L2-1
	26 51 00	Icolour Cove MX	Canlyte	http://www.team-north.com/pdfs/26_Canlyte_iColor_Cove_MXP.pdf	Mark L3-1
	26 51 00	LED55/56	MPLighting	http://www.team-north.com/pdfs/26_MPLighting_LED55.pdf	Mark L4-1
	26 51 00	LED55/56	MPLighting	http://www.team-north.com/pdfs/26_MPLighting_LED55.pdf	Mark L4-2
	26 51 00	LED02	MPLighting	http://www.team-north.com/pdfs/26_MPLighting_LED02.pdf	Mark L5-1
	26 51 00	Calculite	Lightolier / Canlyte	http://www.team-north.com/pdfs/26_Lightolier_Calculite.pdf	Mark L6-1
	26 51 00	Calculite	Lightolier /Canlyte	http://www.team-north.com/pdfs/26_Lightolier_Calcultie.pdf	Mark L6-2
	26 56 00	S.6645	Sistemalux	http://www.team-north.com/pdfs/26_Sistemalux_26645.pdf	
	26 56 00	SLLsq SS	Hunza	http://www.team-north.com/pdfs/26_Hunza_sllusq_ss.pdf	Step Lite Louver Square / Mark: L11-1
	26 56 00	DL SS	Hunza	http://www.team-north.com/pdfs/26_Hunza_dl_ss.pdf	Wall Down Light / Mark L12-1
	26 56 00	PL I SS	Hunza	http://www.team-north.com/pdfs/26_Hunza_pl_ss.pdf	Path Lite / Mark 13-1
	26 56 00	BOL300 SS	Hunza	http://www.team-north.com/pdfs/26_Hunza_bol300_ss.pdf	12" Bollard Light / Mark 14-1
28 - Electric Safety and Security					
	28 31 00	900-119	Kidde	http://www.team-north.com/pdfs/28_Kidde_900-0119.pdf	Smoke + Carbon Monoxide Alarm

1 General

1.1 **PRODUCT QUALITY**

.1 Products Incorporated in Work: New or re-newed as specified, not damaged or defective, of best quality compatible with contract requirements for purpose intended. If requested, provide evidence as to type, source and quality of Products provided.

.2 Unless otherwise indicated in specifications, maintain uniformity of manufacture for any particular or like item throughout the Work.

1.2 **PRODUCT DELIVERY, STORAGE, AND HANDLING**

.1 Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft. Comply with manufacturer's written instructions.

.2 Delivery and Handling:

.1 Schedule delivery to minimize long term storage at Project site and to prevent overcrowding of construction spaces.

.2 Coordinate delivery with installation time to ensure minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.

.3 Deliver products to Project site in an undamaged condition in manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.

.4 Package prefinished products individually in protection packages, plastic bags or cardboard cartons.

.5 Ensure complete protection of edges and finishes during shipment to the job site.

.6 Inspect products on delivery to ensure compliance with Drawings and Specifications and to ensure that products are undamaged and properly protected.

.3 Storage

.1 Comply with product manufacturer's written instructions for temperature, humidity, ventilation, and weather-protection requirements for storage.

.2 Protect stored products from damage and liquids from freezing.

.3 Products Subject to Damage by the Elements: Store under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation.

.4 Cementitious Products and Materials: Store on elevated platforms.

.5 Foam Plastic: Store from exposure to sunlight, except to extent necessary for period of installation and concealment.

1.3 **TRANSPORTATION AND HANDLING**

.1 Transport and handle Products in accordance with manufacturer's written instructions.

.2 Promptly inspect shipments to ensure that Products comply with requirements, quantities are correct, and Products are undamaged.

.3 Provide equipment and personnel to handle Products by methods to prevent soiling, disfigurement, or damage.

1.4 **MANUFACTURER'S WRITTEN INSTRUCTIONS**

.1 Unless otherwise indicated in specifications, install or erect Products in accordance with manufacturer's written instructions. Do not rely on labels or enclosures provided with Products. Obtain written instructions directly from manufacturers.

1.5 **COORDINATION**

.1 Ensure cooperation of workers in laying out Work. Maintain efficient and continuous supervision.

.2 Be responsible for coordination and placement of openings, sleeves and accessories.

1.6 **CONCEALMENT**

.1 In finished areas, conceal pipes, ducts and wiring in floors, walls and ceilings, except where indicated otherwise.

2 Products

2.1 **FASTENINGS**

.1 Provide metal fastenings and accessories in same texture, colour and finish as adjacent materials, unless indicated otherwise.

.2 Prevent electrolytic action between dissimilar metals and materials.

.3 Use non-corrosive hot dip galvanized steel fasteners and anchors for securing exterior work, unless stainless steel or other material is specifically requested in affected specification Section.

.4 Space anchors within individual load limit or shear capacity and ensure they provide positive permanent anchorage. Wood, or any other organic material plugs are not acceptable.

.5 Keep exposed fastenings to a minimum, space evenly and install neatly.

.6 Fastenings which cause spalling or cracking of material to which anchorage is made are not acceptable.

3 Execution

3.1 **INSTALLATION**

.1 General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.

.1 Make vertical work plumb and make horizontal work level.

.2 Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.

.3 Conceal pipes, ducts, and wiring in finished areas, unless otherwise indicated.

.2 Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.

.3 Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Performance.

.4 Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

.5 Tools and Equipment: Do not use tools or equipment that produce harmful noise levels.

.6 Templates: Obtain and distribute to the parties involved templates for work specified to be factory prepared and field installed. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing products to comply with indicated requirements.

.7 Anchors and Fasteners: Provide anchors and fasteners as required to anchor each component securely in place, accurately located and aligned with other portions of the Work.

.1 Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by Consultant.

.2 Allow for building movement, including thermal expansion and contraction.

.3 Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

.8 Joints: Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections together to form hairline joints.

.9 Hazardous Materials: Use products, cleaners, and installation materials that are not considered hazardous.

3.2 **PROTECTION OF WORK IN PROGRESS**

.1 Prevent overloading of any part of the Project.

.2 Do not cut, drill or sleeve any load bearing structural member, unless specifically indicated, without written approval of Consultant.

End of Section

1 General

1.1 **ENVIRONMENTAL PRACTICES**

.1 Implement environmentally sound practices by incorporating products that lessen burden on environment in production, use and final disposition. Support implementation of reduction, reuse and recycling strategies and use of environmentally sound products. Promote use of environmentally responsible packaging practices by reducing and/or eliminating products with excessive packaging in this Project where these practices do not negatively affect the proper protection of materials from inclement weather, especially water damage.

.2 Employ environmentally sound products which are made, used and disposed of in a manner that significantly reduces harm to environment. Use Products which improve energy efficiency in its production and use, reduces hazardous by-products, uses recycled material, and/or Product itself can be recycled or reused, and/or in some way is environmentally benign.

1.2 **PROTECTION OF NATURAL ENVIRONMENT**

.1 Develop environmental plan, site waste management implementation plan to be used for construction storage, areas for implementation of site separation of construction waste, and including dimensions of such areas and location and size of trees within and adjacent to these areas.

1.3 **WASTE MANAGEMENT PRACTICES**

.1 For the purposes of this Section, the following definitions shall apply:

.1 3R: Reduce (Reduction), Reuse, Recycle

.2 Reduce (Reduction): Reduction involves actions to minimize quantity of waste at source and consequently, assumes highest priority in hierarchy of 3R activities.

.3 Reuse: Direct reuse of products which otherwise would become waste, provides another means of diverting quantity of waste destined for landfill.

.4 Recycle: Recycling involves collection of materials for use as feedstock in manufacturing of new products. Recycling can be most effectively accomplished if recyclable materials have been source separated at point of generation.

.5 Source Separation: Purposeful segregation of materials from designated solid waste stream into specific material types at point of generation to facilitate recycling.

.6 Source Separated Materials: Specific types of materials that have been purposefully segregated from municipal waste into specific material types at point of generation.

.2 Apply waste management activities of reduction, reuse and recycling of waste materials during construction.

.3 Prepare and implement a source separation program for construction waste.

.1 Identify sorting, storage and disposal requirements anticipated during construction to maximize waste diversion;

.2 Establish reduction, reuse and on-site source separation activities during construction;

.3 Establish effective education and information program for on-site employees, including training sessions, use of signs, and designated waste diversion program;

.4 Recyclable construction materials shall include, but not limited to, paper, corrugated cardboard, non-treated dimensional lumber, manufactured wood. Sort recyclable construction materials separately and cart away to appropriate listed recycling facility or any other approved facility which recycles or reuses construction materials.

.5 Do not mix recyclable construction materials with other construction wastes and debris to be carried to land fill area or other dump or transfer station which would accept these materials.

1.4 **ENERGY EFFICIENCY**

.1 Construct building to minimize annual energy cost for building operation

.2 All mechanical and electrical equipment to meet the energy efficiency requirements of ASHRAE 90.1.

2 Products

2.1 **BUILD GREEN PRODUCTS**

.1 Use building materials, building finishes, furnishings or specialty products which have a recycled content originating from industrial, commercial, institutional or household sources, or which demonstrate efficient use of renewable resources. These Products must comply with applicable codes and standards.

.2 Packaging Requirements: Implement waste reduction on this Project by using Products specified in Contract Documents from manufactures who promotes reduction and elimination of excessive packaging practices.

.3 Use, where appropriate, combination of packaging materials such as re-usable containers, blanket wrap or cushioning material provided that all reasonable requirements of materials handling, transportation and storage are observed.

.4 Where storage conditions provide adequate protection from weather and other sources of wetting, use packaging materials such as kraft paper and corrugated cartons which are made from reclaimed products to facilitate recycling of secondary materials

.5 Use packaging material which clearly displays their recycled content and recyclability.

.6 Ensure packaging materials are removed from site and disposed of or recycled in an environmentally responsible manner.

3 Execution

3.1 **INDOOR AIR QUALITY**

.1 Schedule sequence of installation of finishing materials to reduce harm to indoor air quality. Provide necessary ventilation during and after installation of ‘wet’ products such as paints, sealants, fireproofing materials, adhesives and of ‘packaged dry’ products.

.2 Isolate substances producing hazardous emissions from circulating air. Locate outside air intakes away from potential sources of contaminations.

.3 Take measures to prevent moisture exposure to finished construction or existing construction. Mould growth on either hidden surfaces or visible surfaces is detrimental to indoor air quality, and will be considered deficient and in need of rectification.

3.2 **SURFACE DRAINAGE AND WATERCOURSES**

.1 Maintain ditches and watercourses for surface water drainage of Site and external properties during construction. Be responsible for damage due to negligence.

.2 Incorporate appropriate retention, detention and settling ponds, or similar methods to control surface water run-off to adjacent ditches or other watercourses and to prevent oil, sediment or de-icing materials being carried into such ditches and/or watercourses. Tested quality of water discharged to ditches and/or watercourses shall not be of worse quality than that present in ditches and/or watercourses prior to any discharge of site surface water. Monitor and test discharge water at least weekly.

3.3 **WASTE DISPOSAL**

.1 Do not burn rubbish on Site. Use off-site disposal alternatives, depending upon materials involved; burying, composting, recycling, municipal collection, or local dump or sanitary landfill site.

End of Section

1 General

1.1 **QUALITY ASSURANCE**

.1 Ensure written confirmation is received from steel fabricators of the specific surface preparation procedures and primers used for steel work to ascertain appropriate and compatible finish materials.

.2 All materials used shall be lead and mercury free and shall have low VOC content where possible.

1.2 **PRODUCT DELIVERY, STORAGE AND HANDLING**

.1 Deliver and store materials in sealed, original labelled containers bearing manufacturer's name, brand name, type of paint or coating and color designation, standard compliance, materials content as well as mixing and/or reducing and application requirements.

.2 Take necessary precautionary and safety measures to prevent fire hazards and spontaneous combustion and to protect the environment from hazard spills.

.3 Comply with requirements of authorities having jurisdiction, in regard to the use, handling, storage and disposal of hazardous materials.

2 Products

2.1 **MATERIALS**

.1 Finish Coat: 1 coat, minimum 6 mil DFT with 2 mil DFT above profile, FastClad DTM Urethane (data sheet 5.25) by Sherwin-Williams, gloss finish.

.2 Where required, paints and coatings shall meet flame spread and smoke developed ratings to code requirements and authorities having jurisdiction.

2.2 **EQUIPMENT**

.1 Painting Equipment: To best trade standards for type of product and application.

.2 Spray Painting Equipment: of ample capacity, suited to the type and consistency of paint or coating being applied and kept clean and in good working order at all times.

2.3 **MIXING AND TINTING**

.1 Unless otherwise specified or pre-approved, provide materials ready-mixed and pre-tinted. Re-mix materials in containers prior to and during application to ensure break-up of lumps, complete dispersion of settled pigment, and color and gloss uniformity.

.2 Mix catalyzed materials in strict accordance with manufacturer's written instructions.

.3 Do not exceed amount of thinner beyond manufacturer's recommendations. Do not use kerosene or organic solvents to thin water-based materials.

.4 If required, thin paint for spraying according in strict accordance with paint manufacturer's instructions. If directions are not on container, obtain instructions in writing from manufacturer and provide copy of instructions to Consultant.

3 Execution

3.1 **SURFACE PREPARATION**

.1 Prepare surfaces in accordance with SSPC SP6.

.2 Sand, clean, dry, etch, neutralize and test surfaces under adequate illumination, ventilation and temperature requirements.

.3 Confirm preparation and primer used with fabricator of steel items.

3.2 **APPLICATION**

.1 Spray apply primer and finish coats using equipment acceptable to paint manufacturer.

.2 Do not apply finish coats at faying surfaces.

.3 Work specified is intended to cover surfaces satisfactorily when applied at proper consistency and in accordance with manufacturer's recommendations.

3.3 **PROTECTION**

.1 Protect painted steel items from environmental and mechanical damages during storage, transportation to site and erection.

End of Section

PART 1: GENERAL

1.1 GENERAL REQUIREMENTS

.1 Provide all material and labour required for the completion of the Contract. Breakdown of Work by Section is for guidance only and is not necessarily complete.

.2 Work Furnished and Installed:

i. Structural steel work, including steel joists and bridging.

.3 Work Furnished but not Installed:

1.2 STANDARDS, CODES AND ACTS

.1 Conform with the Building Code under *Ontario Building Code 2006 (O. Reg. 403/97) and any applicable acts of any authority having jurisdiction and the following:

i. CAN/CSA-S16.1-01 - Limits States Design of Steel Structures, ; S16S1-05, Supplement #1; and replacement pages issued June 2003 and December 2003 as Update #1 and Update #2 Canadian Standards Association.

ii. CAN/CSA-G164-M92 (R2003) - Hot Dip Galvanizing of Irregularly Shaped Articles, Canadian Standards Association.

iii. CSA-S136-94 - Cold Formed Steel Structural Members, Canadian Standards Association.

iv. CSA-W47.1-03 - Certification of Companies for Fusion Welding of Steel Structures, Canadian Standards Association.

v. CISC/CPMA 1-73a - Performance Specification for Shop Primer, Canadian Institute of Steel Construction.

vi. CISC/CPMA 2-75 - A Quick-Drying Primer for use on Structural Steel, Canadian Institute of Steel Construction.

vii. SSPC-SP2, Hand Tool Cleaning, The Society for Protective Coatings

viii. SSPC-SP6/NACE No. 3, Commercial Blast Cleaning, The Society for Protective Coatings

ix. SSPC-SP 7/NACE No. 4, Brush-Off Blast Cleaning, The Society for Protective Coatings

x. SSPC-SP 10/NACE No. 2, Near-White Blast Cleaning, The Society for Protective Coatings

xi. ASTM D6386, Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

.2 Where there are differences between the specifications, drawings, standards, codes or acts, the most stringent shall govern.

1.3 TOLERANCES

.1 Conform to erection tolerances specified in CAN/CSA-S16.1 Clause 28.7

.2 Interfacing tolerances may not be compatible with the above. Review and coordinate interfacing tolerances so that the various elements come together properly.

1.4 QUALIFICATIONS

.1 Be certified under the requirements of Division 1, or Division 2.1 of CSA Standard W47.1.

1.5 DESIGN

.1 General

i. Design connections, and the like in accordance with the requirements of CSA S16.1 for the loads shown or implied.

ii. Design calculations shall be carried out by a professional engineer licensed to practice in the Province of Ontario.

.2 Connections

i. Use types of shop or field connection shown, or in absence of such indication, use most appropriate type of connection.

ii. Design of connections shall include not only those between columns, beams, girders, trusses and braces, but also between such members as spandrel angles and beams, hangers, stiffeners, etc., and their supporting members (be they steel or concrete).

iii. Design connections to safely withstand the combined effects of shear, moment and torque at applicable design stresses.

iv. Do not weld galvanized members without the Consultant's approval.

v. Design bracing member connections for positive adjustability.

vi. Design connections that are exposed to weather so that moisture, dirt and the like cannot gain entry to the interior of hollow built-up members.

vii. Design and detail connections so as not to interfere with architectural clearance lines or finishes.

.3 Bearing Assemblies

i. The configuration, loads to be transmitted and movements to be permitted are shown. Design the bearings so that they can safely transmit the loads or permit the movements noted.

1.6 SUBMITTALS

.1 Connection Details, Erection Diagrams, Shop Details, Erection Procedures, Field Work Details and Joist Details

i. Submit connection details, erection diagrams, shop details, erection procedures, field work details and joist details for review by the *Consultant.

ii. Do not reproduce the structural drawings to serve as erection or setting drawings without the Consultant's approval.

.2 Connection Design Details

i. Connection design details shall be prepared before the preparation of shop details and submitted to the Consultant for review that the intent of the design is met.

ii. Connection design details shall bear the signature and stamp of a qualified professional engineer licensed to practice in the *Province of Ontario

iii. Connection design details shall provide details of standard and non-standard connections and other data necessary for the preparation of shop details. Connection design details shall be referenced to the design documents or the erection drawings, or both.

.3 Erection Diagrams

i. Erection diagrams shall be submitted to the Consultant for review.

ii. Amongst other items show the following:
- General arrangement of the structure including all steel load-resisting elements essential to the integrity of the completed structure
- Principal dimensions of the structure
- Piece marks
- Sizes of the members
- Connection details.
- Bearing details.
- Holes.
- Finishes.
- Grades of steel.
- Size and type of bolts and bolt installation requirements
- Shop and field welds
- Elevations of column bases
- All necessary dimensions and details for setting anchor rods
- Sliding expansion joint bearing pad details, including materials, size and thickness of pads, setting out dimensions and load capacity.
- Required clearances and other details to receive correlative items
- Any other information necessary for the assembly of the structure

iii. Show necessary dimensions and details for setting structural steel bearings, anchorages, assemblies and the like where they interface with other building components.

iv. Co-ordinate with shop drawings of cast-in-place concrete, masonry, miscellaneous metal work, metal deck and other interfacing work.

.4 Shop Details

i. Shop details shall be prepared before fabrication and submitted to the Consultant for review.

ii. Shop details shall provide complete information for the fabrication of various members and components of the structure, including the required material and product standards; the location, type, and size of all mechanical fasteners; bolt installation requirements; and welds.

.5 Erection Procedures

i. Erection procedures shall be prepared before erection and submitted to the Consultant for review.

ii. Erection procedures shall outline the construction methods, erection sequence, temporary bracing requirements, and other engineering details necessary for shipping, erecting, and maintaining the stability of the steel frame.

iii. Drawings and sketches that identify the location of permanent and temporary load-resisting elements essential to the integrity of the partially completed structure shall supplement erection procedures.

iv. Submit details of method proposed to apply and verify the magnitude of tension to bracing members within the specified tolerances.

v. Submit procedures proposed when erection is carried out at temperatures greatly differing from 20 degrees C.

.6 Fieldwork Details

i. Fieldwork details shall be submitted for review by the Consultant whenever modifications to the approved structural details are required.

ii. Fieldwork details shall provide complete information for modifying fabricated members in the shop or on the job site. All operations required to modify the member shall be shown on the fieldwork details.

.7 Calculations

i. Submit calculations bearing the signature and stamp of a qualified professional engineer licensed to practice in the Province of Ontario and such further proof as may be necessary to show that non-standard connections and the like and truss connections conform to the requirements set forth herein.

.8 Substitution

i. If the Contractor wishes to make substitutions for steel materials or sizes indicated, submit proposals with the tender with necessary calculations for review of the Consultant.

.9 Drawings for Inspection Company

i. Furnish inspection company with a copy of erection diagrams, shop details, erection procedures and fieldwork details bearing the Consultant's reviewed stamp.

.10 As-Built Drawings

i. Mark on 1 complete sets of final drawings any changes, additions or deletions that occur during the construction as a result of the Contractor's work, change orders or for any other reason.

.11 Mill Test Reports

i. Submit copies of mill test reports properly correlated to the materials available to the Consultant.

PART 2: PRODUCTS

2.1 MATERIALS

.1 Rolled Wide Flange Sections: Conform to CSA-G40.21-M92 350W, unless otherwise noted.

.2 Rolled channels and angles: Conform to CSA-G40.21-M92 300W, unless otherwise noted.

.3 Steel plate, bars and rods: Conform to CSA-G40.21-M92 300W, unless otherwise noted.

.4 Hollow Structural Sections: Conform to CSA-G40.21-M92 Grade 350W, Class C.

.5 Bolts, nuts and washers: ASTM A325 M-00, galvanized when used with galvanized material.

.6 Shop paint primer: Type 1 - Water borne: Low VOCs, and not to be manufactured or formulated with aromatic solvents, formaldehyde, halogenated solvents, mercury, lead, cadmium, hexvalent chromium and their compounds. Devguard 4020 by ICI Devoe Coatings or approved equivalent. Contractor to verify compatibility of primer with finished paint including intumescent paint where applicable.

.7 Primer for steel to receive Cafco Intumescent coating: [Devguard 4160 structural primer by ICI Devoe Coatings][Rustguard 4150-7100 Red Low Voc Shopcoat Primer by ICI Devoe Coatings][Kem Kromik Universal Metal Primer B50NZ6 by Sherwin-Williams] or approved equivalent

.8 Reinforced Inorganic Zinc Primer - Catha-coat 302H by ICI Devoe Coatings or approved Equivalent

.9 Alkyl Silicate Inorganic Zinc Coating - Catha-coat 304 by ICI Devoe Coatings or approved equivalent.

.10 Zinc Rich Coating: Galvafroid as supplied by W.R. Meadows Limited or approved equal.

.11 High Build Epoxy Coating: Devran 224 HS by ICI Devoe Coatings or approved equivalent.

PART 3: EXECUTION

3.1 WORKMANSHIP AND FABRICATION

.1 Conform to CAN/CSA-S16.1-94 and the following:

.2 Camber

i. Provide camber to beams and girders in a manner that will not reduce the safe load carrying capacity of the members.

ii. Unless otherwise noted, provide a nominal camber of 0.002 of the span.

.3 *

.4 Provide holes to 15mm in diameter indicted at any time before shop drawings are reviewed, as required to permit the attachment of other materials.

.5 Provide ceiling extensions for joist bottom chords as required.

.6 Openings

i. Conform to requirements shown for location, size, reinforcing and cutting of openings through structural members.

ii. Obtain written permission of Consultant prior to field cutting or altering of structural members not shown on the drawings.

.7 Galvanized Steel

i. Detailed and fabricated steel such that it will not trap the galvanizing material.

ii. Detailed so that welding of galvanized material is not required.

iii. Provided with vent holes as required.

iv. Cleaned of all weld slag prior to galvanizing.

v. Upon completion of erection, touched up with zinc rich primer at all locations where galvanizing is damaged.

3.2 PROTECTION

.1 Steel ST-1

i. This steel type applies to all structural steel concealed from view in the finished building and not exposed to weather or high humidity environments including:

- *

ii. No cleaning or painting is required for this steel type.

.2 Steel ST-2

i. This steel type applies to all structural steel concealed from view in the finished building and not exposed to weather or high humidity environments including :

- *

ii. Clean structural steel in accordance with SSPC SP2, Hand Tool Cleaning

iii. Within one hour following cleaning, apply one coat of paint conforming to CISC/CPMA 1-73a

.3 Steel ST-3

i. This steel type applies to all structural steel which is to be encased in spray applied fire proofing or concrete including:

- *

ii. Clean structural steel in accordance with SSPC SP2, Hand Tool Cleaning to remove loose mill scale, rust, and other detrimental foreign matter.

iii. No painting is required for this steel type.

.4 Steel ST-4

i. This steel type applies to all interior structural steel which is exposed to view in the finished building, whether or not it is to receive a finish coat of paint, but not designated as “architectural steel” including:

- *

ii. Clean structural steel in accordance with SSPC SP7, Brush off Blast Cleaning.

iii. Within one hour following cleaning, apply one coat of shop primer conforming to CISC/CPMA 2-75.

.5 Steel ST-5

i. This steel type applies to all interior structural steel which is exposed to view in the finished building, whether or not it is to receive a finish coat of paint, and designated as “architectural steel” including:

- *

ii. Clean structural steel in accordance with [SSPC SP6, Commercial Blast Cleaning][SSPC SP10 Near-White Blast Cleaning]

iii. Within one hour following cleaning, apply one coat of shop primer conforming to CISC/CPMA 2-75.

.6 Steel ST-6

i. This steel type applies to all exterior structural steel which is exposed to view in the finished building and structural steel in the pool hall, and designated as “architectural steel” including:

- *

ii. Clean structural steel in accordance with [SSPC SP6, Commercial Blast Cleaning][SSPC SP10 Near-White Blast Cleaning]

iii. Within one hour following cleaning, apply a primer coat of Reinforced Inorganic Zinc to a dry film thickness of 50-100 microns.

iv. Following drying of the primer, apply a mid-coat of High Build Epoxy Coating to a dry film thickness of 100 to 200 microns.

v. A final coat of Aliphatic Urethane is to be done in the field by the paint contractor. Ensure compatibility of primer and mid-coat with top coat.

.7 Steel ST-7

i. This steel type applies to all structural steel which is exposed to weather or moisture in the finished building but is not designated as “architectural” such as steel within the cavity of cavity walls, not protected by a vapour barrier including:

- lintels
- shelf angles
- plates, hangers, braces etc. outside the building envelope

- exterior beams
- exterior columns
- connection materials and inserts associated with the above.
- *

ii. Fully galvanize, in accordance with CSA G164 to a minimum zinc coating of 600 g/m^2.

.8 Steel ST-8

i. This steel type applies to all exterior structural steel which is exposed to view in the finished building, designated as “architectural steel” and intended to receive a galvanized coating including:

- *

ii. Clean structural steel in accordance with [SSPC SP6, Commercial Blast Cleaning][SSPC SP10 Near-White Blast Cleaning]

iii. Fully galvanize, in accordance with CSA G164 to a minimum zinc coating of 600 g/m^2.

.9 Except for steel which is to be left uncoated, upon completion of erection, apply primer to welds, bolts and at locations where original primer is damaged. Primer to match the primer of the base steel. For galvanized steel, touch up with zinc rich coating.

.10 Protect all steel from damage during storage, transportation and erection.

.11 For steel designated as “architectural” sand areas where the coating has been damaged and “feather” into the surrounding field prior to touching up.

.12 Protect weep holes at base of closed column sections that have base plates, but no cap plates.

.13 Provide drain holes in closed sections to prevent water build-up during erection.

3.3 ERECTION

.1 General

i. Conform to requirements of CAN/CSA-S16.1 and the following:

ii. Bracing members and anchor bolts shown are for the finished structure and may not be adequate to resist forces present during construction.

iii. Maintain temporary bracing until completion of entire structure including floor and roof decks, slabs, *masonry walls and other elements which are part of the wind resisting system.

iv. Carry out erection operations, including installation of any temporary guying and shoring required, without loading portions of the existing structure already constructed in excess of its safe load carrying capacity.

v. During erection, forces or reactions in the steel frame members and their connections may exceed those on which the design is based.

vi. Determine the magnitude of such forces and reactions and take such measures as are necessary to ensure that the safety and stability of the structure is maintained until the entire structure, including floor and roof slabs is complete.

vii. Splices, other than those shown, shall not be permitted in members without the Consultant's approval. If approval is given to permit welded splices, they shall be non-destructively tested at no extra cost to the Owner.

viii. Nuts on ordinary bolts ASTM A307 shall be prevented from working loose by use of lock washers, lock nuts, jam nuts, thread burring or other approved methods.

ix. Report to the Consultant where members cannot be erected within the specified tolerances without modification or special procedures. Take corrective measures to the Consultant's approval.

.2 Install bracing members by applying a nominal tension such that they will be initially under tension in the completed building.

i. Install bracing members such that they will be initially under a tension of 35 MPa plus or minus 6 MPa in the completed building.

ii. If permanent bracing is used as part of the temporary bracing system, maintain stress 35 MPa plus or minus 6 MPa during construction period. This will require checking and adjustment of stresses when temperature changes.

iii. When the structural steel is plumb and level, erect the frame bracing so that, at the time of installation, bracing members are under a stress of 35 MPa plus or minus 6 MPa. Tensioning by drifting will not be permitted.

.3 Joists

i. Anchor joists in accordance with CAN3 S16.1 and to safely resist the net uplift forces shown, but not less than 0.50 kPa.

ii. Supply special shoes or steel packing as required to bring joists to required bearing level.

iii. Until such time as the permanent anchorage system can maintain the joists in their correct position under wind and other loadings provide suitable temporary anchorage.

iv. Where drawings call for electrical and/or mechanical services to be recessed between joists, space and arrange joists and bridging to permit installation of services.

.4 Lintels

i. Unless a reinforced block or concrete lintel is noted, provide loose steel lintels, as shown, over openings and recesses in masonry walls or partitions including those for mechanical or electrical services.

.5 Openings

i. Conform to the requirements shown for location, size, reinforcing and cutting of openings through structural members.

ii. No openings through structural steel members will be permitted without the Consultant's approval.

3.4 EXPOSED STEEL

.1 General

i. The following applies to all steel which is left exposed to view in the completed building that is within 3 m of a floor

.2 Fabrication

i. All exposed edges of plates shall be universal mill or guided flame cut. Exposed cut edges of beam flanges shall be guided flame cut. Cut surfaces shall be equal in smoothness to a mill finish.

ii. Where bolted connections are shown, ensure that connections are neatly arranged with tight joints.

iii. Remove mill marks, identification and surface imperfections by grinding smooth and flush with adjacent surfaces.

.3 Welding

i. Continuously weld joints exposed to view.

ii. Grind smooth all welds that are within the reach of the public.

.4 Galvanizing

i. Ensure that the galvanizing process leaves a smooth and uniform surface.

ii. During galvanizing, use procedures to ensure that members do not deform excessively.

.5 Do not use marking paint, crayons or other marking materials on exposed surfaces.

3.5 ARCHITECTURALLY EXPOSED STEEL

.1 General

i. Architecturally exposed steel is all steel which is left exposed to view in the completed building. In addition to the requirements of this Section the requirements of the AISC specification for Architecturally Exposed Steel shall apply, except as varied herein.

.2 Tolerances

i. The "as fabricated and erected" straightness tolerances of architecturally exposed steel members shall not exceed ½ of the standard camber and sweep tolerances specified in CSA-G40.21, excepting that tolerances between structural steel members and window frames shall not exceed plus 3 mm or minus 0.

.3 Fabrication

i. Perform fabrication with special care and necessary straightening to maintain the condition of the material as described herein.

ii. Show clearly the required fabrication tolerances on shop drawings. Show the required tolerances for setting embedded items on erection drawings.

iii. Make copes, mitres and butt cuts in surfaces exposed to view within the closest possible tolerances consistent with structural shop equipment and practice. Plan erection sequence so that these tolerances can be maintained.

iv. Where the fit-up of adjacent members is such that permissible tolerances specified above may result in any unsightly joint, take special care to obtain a visual plane on the exposed surfaces. If both surfaces are exposed, detail joints in such a way as to minimize these unavoidable variations.

v. All exposed edges of plates shall be universal mill or guided flame cut. Exposed cut edges of beam flanges shall be guided flame cut. Cut surfaces shall be equal in smoothness to a mill finish.

vi. Where bolted connections are shown, ensure that connections are neatly arranged with tight joints.

vii. Remove mill marks, identification and surface imperfections by grinding smooth and flush with adjacent surfaces.

.4 Welding

i. Except as otherwise shown on the drawings, all shop and field assembly shall be done by welding. Welders shall be qualified as hereinbefore specified.

ii. Continuously weld joints exposed to view.

iii. Form and weld all joints exposed to weather to exclude water by the use of "seal" welds.

iv. Exposed welds, except f filler welds and concealed welds where clearances or fit Of other items may so necessitate, shall be ground smooth and otherwise finished flush and even with adjacent surfaces. Grinding is not required for well formed fillet welds.

v. Grind bevel welds smooth, forming neat, well-made corners.

vi. Grind smooth any welds on structural steel members in the finished building that are within the reach of the public.

.5 Painting

i. After inspection and before leaving the shop, clean all steel work exposed in the finished work by grit-blasting of all mill scale, rust, weld slag or flux deposit, oil, dirt and other foreign matter, to a "Commercial Bright" finish.

ii. Remove mill marks, identification and surface imperfections by grinding smooth and flush with adjacent surfaces.

iii. Immediately after cleaning, apply a shop coat paint to all steel work, except as follows, to dry surfaces by spray, to a minimum dry film thickness of 2 mils. Allow to dry in dust free areas.

iv. Do not paint metal items that are to be encased in concrete and surfaces that are to have concrete placed against them.

v. Apply 1 additional shop coat of paint as specified to parts of shop coated steel surfaces that will be inaccessible after erection.

vi. Clean surfaces within 50 mm of any field weld location of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

vii. After erection and immediately after grinding welds, etc. touch up and paint with 1 coat of same paint as shop coat, all damaged and abraded spots, including any unpainted areas. Completely remove anti-spatter coating, if used before field touch-up painting.

.6 Galvanizing

i. Ensure that the galvanizing process leaves a smooth and uniform surface.

ii. During galvanizing, use procedures to ensure that members do not deform excessively.

.7 Rusted Steel

i. Where indicated, treat exposed faces of the structural steel to obtain a rusty brown appearance

ii. The appearance shall conform to the colour and texture of samples available for inspection at the office of the Consultant. In addition to these samples, colour photographs may be obtained on request from the Consultant.

iii. Shot blast the exposed faces of the steel to be of rusty appearance to remove the major mill scale, but leaving about 10% of the mill scale on the surfaces.

iv. In order to accelerate the rusting process, the following method is suggested:
- Spray surfaces with saltwater as many times as required after fabrication.
- Thoroughly wash down the salt before application of the final protective coating specified.

v. No erection markings are permitted on the exposed faces. Use tags for markings.

vi. Take care to avoid soiling of the exposed faces with foot prints, tire marks, oil patches, etc. which when wiped off may leave patches of a different colour on the exposed surfaces.

vii. Provide suitable protection to all work adjacent to or below steel framing with rusty surfaces to prevent staining of other exposed construction. Make good any stained surfaces to the Consultant's approval.

.8 Protection

i. Prevent staining of architecturally exposed steel by concrete, mortar, plaster, oils, paints or other foreign substances.

ii. Do not use marking paint, crayons or other marking materials on exposed surfaces.

END OF SECTION

1 General

1.1 **DEFINITIONS**

.1 Exposed Surfaces: Surfaces exposed to view after installation.

.2 Concealed Surfaces: Surfaces not visible after installation.

.3 Dead Loads: Self-weight of construction and permanent materials supported by the construction.

.4 Collateral Loads: Mechanical and electrical equipment, suspended ceilings and all other removable parts of the structure.

.5 Live Loads: Superimposed loads due to the following:

.1 Use and occupancy in the course of normal functioning.

.2 Wind, snow, rain, seismic, thermal, and ice.

.3 Maintenance equipment.

1.2 **PERFORMANCE REQUIREMENTS**

.1 Retain a Professional Engineer, licensed in the Place of the Work, with experience in Work of comparable complexity and scope, to perform the following services as part of the Work of this Section:

.1 Design work as required to resist live, dead and collateral loads.

.2 Structural design.

.3 Review, stamp, and sign shop drawings.

.4 Conduct shop and on-site inspections.

.5 Prepare and submit inspection reports.

.2 Anchors, fasteners and braces shall be structurally stressed not more than 50% of allowable stress when maximum load conditions are applied.

.3 Engineer work to resist wind, snow, rain and ice loads and to accommodate occupancy and operational live and dead loads as required by the building code.

.4 Thermal Movements: Provide exterior metal fabrications that allow for thermal movements resulting from the maximum change in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime sky heat loss.

.5 Seismic Performance: Provide work capable of withstanding the effects of seismic forces in seismic zone applicable to this Project, in accordance with governing building code.

.1 Incorporate in the work seismic supports and bracing as required for stability, extending and fastening members to supporting structure.

.6 Welding:

.1 Qualify procedures and personnel in accordance with the following AWS Structural Welding Codes:

.1 AWS D1.1: Steel.

.2 AWS D1.2: Aluminum.

.3 AWS D1.3: Sheet Steel.

.4 AWS D1.6: Stainless Steel.

.2 Thoroughly clean welded joints and expose metals for a sufficient distance to perform welding operations.

.3 Test welds for conformance and remove work not meeting specified standards and replace to Consultant's acceptance.

.4 Continuous weld all joints for the full length of each joint. Finish exposed welds smooth and flush, file or grind as required.

.5 File or grind exposed welds smooth and flush. Do not leave grinding marks.

1.3 **SUBMITTALS**

.1 Shop Drawings: Show work of this Section including large scale detail of members and materials, of connection and jointing details, and of anchorage devices, dimensions, thicknesses, description of materials, metal finishing, as well as other pertinent data and information.

.1 Shop Drawings Indicating Structural Components in Compliance with Requirements of Authorities Having Jurisdiction: Bearing professional seal and signature of the professional engineer responsible for the engineering design.

2 Products

2.1 **METALS, GENERAL**

.1 Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

2.2 **ALUMINIUM**

.1 Aluminium alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with strength and durability properties for each item of aluminum work required not less than that of alloy and temper designated below.

.1 Extruded Bars and Shapes: ASTM B221/B221M, Alloy 6063-T5/T52.

.2 Extruded Structural Pipe and Round Tubing: ASTM B429, Alloy 6063-T6.

.3 Plate and Sheet: ASTM B209/B209M, Alloy 3003-H14.

.4 Die and Hand Forgings: ASTM B247/B247M, Alloy 6061-T6.

.5 Castings: ASTM B26/B26M, Alloy A356.0-T6.

2.3 **STAINLESS STEEL**

.1 High quality stainless steel manufactured of nonrusting, virgin, and nonrecycled materials.

.1 Tubing: ASTM A554, Grade MT <304> <316> <316L>.

.2 Pipe: ASTM A312/A312M, Grade TP 304.

.3 Sheet, Strip, Plate, and Flat Bar: ASTM A666, Type 304.

.4 Bars and Shapes: ASTM A276, Type 304.

2.4 **FERROUS METALS**

.1 Tubing: ASTM A500 (cold formed) or ASTM A513, Type 5 (mandrel drawn).

.2 Bars: Hot-rolled, carbon steel complying with ASTM A29/A29M, Grade 1010.

.3 Plates, Shapes, and Bars: ASTM A36/A36M.

.4 Steel Sheet, Cold Rolled: ASTM A1008/A1008M, either commercial steel, Type B, or structural steel, Grade 25 (Grade 170), exposed.

.5 Primers: Maximum VOC content of 100 g/L when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).

.1 Universal Shop Primer: Fast-curing, lead and chromate free, universal modified-alkyd primer complying with MPI#79.

.2 Zinc-Rich Primer: Anti-corrosion coating containing zinc content of minimum 90% by weight on dry film.

2.5 **INSTALLATION MATERIALS**

.1 Welding Rods and Bare Electrodes: Select in accordance with AWS specifications for metal alloy welded.

.2 Fasteners: In areas exposed to public use, bolts, nuts, washers, rivets, lock washers, anchor bolts, machine screws and machine bolts hot dipped galvanized.

.1 For joining stainless steel components use stainless steel fasteners.

.3 Drilled Inserts: Mega by ITW Construction Products or HSL by Hilti Inc. heavy duty anchors, sizes to suit.

2.6 **FABRICATION**

.1 Verify dimensions of existing Work before commencing fabrications and report any discrepancies to Consultant.

.2 Fit and assemble Work in shop where possible. Execute work in accordance with details and reviewed shop drawings. Where shop fabrication is not possible, make trial assembly in shop.

.3 Use self tapping shake proof screws on items requiring assembly by screws or as indicated. Use screws for interior metal work. Use welded connections for exterior metal work unless otherwise found acceptable by Consultant.

.4 Comply with AWS for recommended practices in shop welding. Weld behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded joints of flux, and dress exposed and contact surfaces.

.5 Execute shop welding to requirements specified.

.6 Carefully make and fit details. Take special care with exposed finished Work to produce a neat and correct appearance to Consultant’s acceptance.

.7 Assemble members without twists or open joints.

.8 Correctly size holes for connecting Work of other Sections where such can be determined prior to fabrication. Where possible, show holes on shop drawings. Place holes not to cause appreciable reduction in strength of member.

.9 Stainless Steel Work: Use tools that are free of contaminants that will cause corrosion and rusting of stainless steel in the fabrication and finishing of stainless steel work.

2.7 **INSERTS AND HANGERS**

.1 Install inserts, hangers, and supports. Make inserts drilled type.

2.8 **METAL FINISHES**

.1 General: Apply finish after fabrication. Remove tool and die marks and stretch lines or blend into finish, free of cross scratches.

.1 Aluminum Finish Designations Prefixed By AA: Comply with the system established by the Aluminium Association for designating aluminium finishes for

.2 Hot Dip Galvanizing: Hot dip galvanize after fabrication ferrous metals exposed to exterior environmental conditions, forming parts of exterior walls, Imbedded in concrete, or as indicated. Straighten shapes and assemblies true to line and plane after galvanizing. Repair damaged galvanized surfaces with brush or spray apply galvanized prime paint.

.1 Steel Members: ASTM A123/A123M.

.2 Anchors and Fasteners: ASTM A153.

.3 Galvanized Steel Sheet: ASTM A653 coating designation Z275.

.3 Shop Primed Finish: Prepare uncoated, nongalvanized ferrous metal work to SSPC SP6 surface preparation specifications and environmental exposure conditions of installed work. Apply air dried primer immediately after cleaning and pretreatment, to provide a minimum dry film thickness of 3 mils per applied coat, to surfaces that will be exposed after assembly and installation, and to concealed surfaces.

.1 Clean but do not prime surfaces to be field welded.

.2 Do not prime surfaces embedded in concrete, clean as if they were to be primed.

.3 Do not prime machine finished surfaces, but apply an effective anti-rust compound.

.4 Powder Coating Finish: Prepare, treat, and coat metal with pigmented, polyester or acrylic urethane based thermosetting powder coating. Provide coating system that complies with coating manufacturer's written instructions for pre-treatment, application, baking, and minimum dry film thickness.

.1 PT-2: Color RAL 9005 Jet Black.

.2 PT-7: Color RAL 9003 Signal White.

.3 PT-8: Color RAL 9004 Signal Black.

.5 Stainless Steel Finishes: Remove tool and die marks and stretch lines or blend into finish, free of cross scratches. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean. Run grain of directionally textured finishes with long dimension of each piece.

.1 Directional Satin Finish: No. 4 finish.

.2 Mirror-like Reflective, Nondirectional Polish: No. 8 finish.

2.9 **METAL WORKS**

.1 Thoroughly review Drawings and other requirements to complete Work.

.2 In addition to metal works indicated on Drawings, provide following metal works:

.1 Exterior deck substructure by Etobicoke Iron Works.

.2 Exterior canopy, handrails, photovoltaic roof rack by UniRack.

3 Execution

3.1 **EXAMINATION**

.1 Examine previously installed Work, upon which this Section depends, verify dimensions and condition of existing Work, and coordinate repairs, alterations, and rectification if necessary. Commencement of Work of this Section is deemed to signify acceptance of existing, prior conditions.

.2 Obtain Consultant's written approval prior to field cutting or altering of structural members.

3.2 **ERECTION**

.1 General: Provide metal work indicated on Drawings and not included in work of other Sections in addition to items listed below.

.1 Where items are required to be built into other work supply such items to respective Sections with all anchors and accessories for building in.

.2 Fit joints and intersecting members accurately. Make Work in true planes with adequate fastenings. Build and erect Work plumb, true, square, straight, level and accurate to sizes detailed, free from distortion or defects detrimental to appearance or performance.

.3 Perform drilling of steel and wood members as required to fasten work of this Section.

.4 Before openings are cut through structure, obtain Architect's written acceptance for procedures, locations and reinforcements required.

.5 Continuously weld connections, and anchor directly to building structure.

.6 Isolate dissimilar metals, between metals and concrete or masonry with two coats of isolation coating.

3.3 **FIELD PAINTING**

.1 Paint bolt heads, washers, nuts, field welds and previously unpainted items. Touch up shop primer damaged during transit and installation, with primer to match shop primer.

End of Section

PART 1: GENERAL

1.1 GENERAL REQUIREMENTS

.1 Provide all material and labour required for the completion of the Contract. Breakdown of Work by Section is for guidance only and is not necessarily complete.

.2 Work Furnished and Installed:

i. All timber framing, including walls, floors, roofs and parapet, complete with air/vapour barrier and in-frame and sheathing insulation as called for.

.3 Related Work specified Elsewhere:

i. Insulation/stucco system provided by Section 07240, Exterior Insulation and Finish System, plywood sheathing under same provided by this Section.

ii. Metal through-wall flashing provided by this Section, built into masonry face by Section 04200

1.2 STANDARDS, CODES AND ACTS

.1 Conform with the *Ontario Building Code 2006 (O. Reg. 403/97) and any applicable acts of any authority having jurisdiction *and the following:

i. CSA-O86-01 (Including supplement CAN/CSA-086S1-05), Engineering Design in Wood (Limits States Design), Canadian Standards Association.

ii. CSA-O80 Series-97, Wood Preservation, Canadian Standards Association.

iii. CSA A123.3-98, Asphalt Saturated Organic Roofing Felt, Canadian Standards Association.

iv. CSA-B111-1974, Wire Nails, Spikes and Staples, Canadian Standards Association.

v. CSA O112-M1977 (R1999), Standard for Wood Adhesives, Canadian Standards Association.

vi. CAN3-O188.3-M82, Exterior-Bond Mat-Formed Wood Particleboard, Canadian Standards Association .

vii. CSA O121-M1978, Douglas Fir Plywood, Canadian Standards Association.

viii. CAN/CSA-O122-M89(R1999), Structural Glued-Laminated Timber, Canadian Standards Association.

ix. CAN/CSA-O141-91(R1999), Softwood Lumber, Canadian Standards Association.

x. CSA O153-M1980 (R1998), Poplar Plywood, Canadian Standards Association.

xi. CAN/CSA-O177-M89, Qualification Code for Manufacturers of Structural Glued-Laminated Timber, Canadian Standards Association.

xii. CAN/CSA-S16-01 (Including supplement CSN/CSA A-S16S1-05) Limit States Design of Steel Structures, Canadian Standards Association.

xiii. CSA W47.1-92(R1998), Certification of Companies for Fusion Welding of Steel Structures, Canadian Standards Association

xiv. CISC/CPMA 2-75 Quick-Drying, Primer for use on Structural Steel, Canadian Institute of Steel Construction.

xv. CAN/CGSB 51-34-M86, Vapour Barrier, Polyethylene Sheet for Use in Building Construction, Canadian General Standards Board.

xvi. A307-02 Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

xvii. ASTM A325M-00, Standard Specification for High-Strength Bolts for Structural Steel Joints, American Society for Testing and Materials.

1.3 TOLERANCES

.1 Members shall be aligned level and plumb, within a tolerance of 1 in 500 and the following:

i. Level and plumb: 5 mm in 3 m

ii. True to lines: 10 mm in 3 m.

1.4 QUALIFICATIONS

.1 Timber trusses shall be fabricated by and connections designed by a recognized timber truss manufacturing firm with at least 3 years experience in timber truss work.

.2 Glued-Laminated Timber shall be manufactured by manufacturers certified to the requirements of CAN/CSA-O177.

.3 Welders shall be certified by the Canadian Welding Bureau and shall conform to CSA W47.1.

1.5 DESIGN

.1 Connections

i. Design and detail connections and anchorages in accordance with the Ontario Building Code to safely transmit the loads shown or implied. The configuration of connections shall follow the details shown on the drawings.

ii. Note that no allowance for holes has been made in design of truss members.

iii. Conform to profile of members as shown on the drawings.

iv. Design members of structural grade timber to safely support the loading shown or implied on the drawings. Deflection shall be not more than 1/240 of the span when subjected to the live load.

v. Camber members as required to suit the design dead load.

.2 Erection Procedure

i. Make adequate provisions for stresses arising from the selected erection procedure.

ii. Design all necessary temporary support and bracing required to erect the structure.

1.6 SUBMITTALS

.1 Shop Drawings

i. Submit erection and fabrication drawings for review by the Consultant.

ii. Do not reproduce the structural drawings to serve as shop drawings.

iii. Amongst other items, show complete details, layout, member sizes, grades of materials, connection details, holes, finishes, erection sequence and the like. Show orientation, relation to appropriate grid lines and setting elevations for bases and bearing assemblies.

iv. Coordinate timber shop drawings with shop drawings of reinforced concrete, structural steel and other related work.

v. Furnish inspection company with a copy of each reviewed drawing.

.2 Calculations

i. Submit calculations bearing the signature and seal of a registered Professional Engineer in the Province of Ontario and such further proof as may be necessary to show that connections, including truss connections, wood roof trusses conform to the requirements set forth herein.

.3 Supply factory inspection certificates in the form recommended by the Canadian Institute of Timber Construction certifying that all glued laminated flanges of H B members supplied have been fabricated in full accordance with this Specification.

PART 2: PRODUCTS

2.1 MATERIALS

.1 Conform to:

i. The National Lumber Grades Authority Standard Grading Rules for Canadian Lumber, 1977.

ii. CSA O141, Softwood Lumber.

.2 Moisture Content: All wood products shall by dry at time of delivery and installation.

.3 Framing Lumber: NLGA Spruce-Pine-Fir.

i. Studs: Structural Light Framing, Grade No. 1/ No. 2;

ii. Joists and Beams: Structural Joists and Planks, Grade No. 1 / No. 2

iii. Built-up Beams and Lintels: Structural Joists and Planks, Grade No.1 / No. 2.

iv. Structural Composite Lumber

- PSL: Parallam Grade 2.0E as supplied by Trus-Joist Weyerhaeuser or approved equal.

- LVL: Microllam Grade 1.9E as supplied by Trus-Joist Weyerhaeuser or approved equal.

.4 Sheathing Plywood: CSA O12, Douglas Fir,G1S:

i. Floor Sheathing: 20 mm, T & G.

ii. Roof Sheathing: 16 mm, T & G.

.5 Floor and Roof Underlayment: CSA O153 - M 1980, Poplar Plywood, G1S, 6mm thick.

.6 Adhesive: CSA O112 - M1977, Resorcinal and Pheno - Resorcinal Resin Adhesives, Type 1 (room temperature curing).

.7 Nails: CSA B 111 - 1974:

i. For Structural Framing: Comman Spiral Nails.

ii. For Floor and Wall Sheathing and Floor Underlayment: Plywood Subfloor Attachment nails, ring thread.

iii. For Sheathing Insulation: Sheathing insulation nails 19 mm longer than thickness of insulation with 19 mm large heads.

iv. Galvanize Nails: for wall sheathing and insulation sheathing.

.8 Wood Screws: CSA B35.4-1972, galvanized or cadmium plated.

i. For Roof Underlayment: Flat-head wood screws.

.9 Bolts Nuts and Washers: CSA S16.1-M89 and ASTM A 307, standard structural grade, hex heads and nuts. Galvanized where exposed to view in the finished building.

.10 Preservative Treatment: Copper Azole. Vacuum pressure impregnate to an average net retention of 6.4kg/m3. Do not use preservative treatments containing arsenic.

.11 Sill Joint Seal, between top of masonry or concrete foundation wall and wood sill plate: Ethafoam, 125 mm wide x 12mm thick in continuous strip, manufactured by Dow Chemical Canada Inc.

.12 Moisture Barrier Between Masonry, Concrete and Wood: CSA A 123-3-M1979, Asphalt or Tar Saturated Roofing Felt or same as air/vapour barrier.

.13 Air/Vapour Barrier: Vapour Barrier Polyethylene Sheet for Use in Building Construction, 0.152 mm (6 mil) thick, in roll full height of storey.

i. General: CGSB 51-34-M86

ii. Flashing, Where called for: FR40 reinforced PVC flexible flashing sheet in roll of width as required, manufactured by Lexsluco Canada Limited.

.14 Sheet Metal Flashing: ASTM AS26, (Commercial Quality) 0.46mm core thickness, Z275 galvanized.

.15 Insulation:

i. Between Framing: As per Section 07200, Type F.

- For Wood Stud Walls: 152 mm thick, R20.
- For Roof: 265 mm thick, R40.

ii. Exterior Wall Sheathing: Rigid, faced exterior sheathing insulation board, 25 mm thick, R4.4, Glas Clad manufactured by Fiberglass Canada Inc.

iii. Rigid Insulation: As per Section 07200, Type C.

.16 Sheathing Insulation Tape: No. Y - 8086, Contractor's Sheathing Tape, manufactured by 3M Canada Inc.

.17 Paint:

i. Interior steel not exposed to view - *Conform to CISC/CPMA Standard 1-73a. *No paint required.

ii. *Interior steel exposed to view - Conform to CISC/CPMA Standard 2-75. *Ensure that the primer is compatible with any finish paint coat.

iii. Steel exposed to weather - Inorganic zinc primer, $2^1/_2$ to 3 mills dry thickness.

.18 Hot dip galvanizing: Galvanize steel exposed to weather to CAN/CSA G164-M92 (R1998), minimum zinc coating of 600 g/m2.

.19 Zinc Rich Primer: Galvafroid as supplied by W.R. Meadows Limited or approved equal.

PART 3: EXECUTION

3.1 WORK AND FABRICATION

.1 Conform to CSA-O86.1 and CAN/CSA-S16.1.

.2 Unless noted otherwise, timber construction shall conform to Part 9 of the Ontario Building Code.

.3 Do work by mechanics skilled in their respective trades, according to best practice and as specified herein or indicated on the Drawings.

.4 Joints and intersecting members shall be accurately fitted and made in true planes with adequate fastenings.

.5 Clusters of knots, splits and other strength reducing features shall be avoided at connections.

.6 Supply and rigidly connect approved joist hangers, strap anchors and lag bolts.

.7 Provide all connection material required for timber members including bases, shear connectors, bolts, nuts, washers, packing, baseplates and the like.

3.2 PROTECTION

.1 Protect all wood products from damage and staining due to wetting and moisture

.2 Clean structural steel as follows:

.3 Interior steel not exposed to view - in accordance with CISC/CPMA Standard 1-73a. No cleaning required.

.4 Interior steel exposed to view - in accordance with CISC/CPMA Standard 2-75. Grind smooth welds that are in normal view of the public.

.5 Steel exposed to weather that is to be painted - in accordance with SSPC-SP6/NACE No. 3 - Commercial Blast Cleaning.

.6 Except for steel to be galvanized, within one hour following cleaning, apply one coat of primer in the shop to a minimum dry film thickness of 2 mils, *except that steel in the pool hall shall be painted with a single coat of Devron Series corrosion resistant primer to a dry film thickness of 4 to 6 mils. Apply Devthane 369 alphatic two component urethane top coat to steel in the pool hall to a dry film thickness of 2 to 3 mils in accordance with manufacturer's specifications.

.7 Upon completion of erection, apply primer to welds, bolts and at locations where original primer is damaged.

.8 Protect all steel painted with the urethane system from damage during storage, transportation and erection. Upon completion of erection. Re-coat all areas where urethane paint is damaged in order to maintain specified thickness and a consistent finish.

.9 Fully galvanize, in accordance with CSA G164, all structural steel exposed to weather, including lintels, shelf angles, beams, columns and the like including connection material and inserts.

.10 Detail and fabricate steel such that it will not trap the galvanizing material. Provide vent holes as required.

.11 Remove all weld slag prior to galvanizing.

.12 Upon completion of erection, apply zinc rich primer to all locations where galvanizing is damaged.

3.3 INSTALLATION

.1 Provide moisture barrier specified under all wood products resting on concrete.

.2 Install sill seal between top of foundation wall and sill plate.

.3 Treat end and first 300mm of wood members meeting masonry or concrete at or below grade with 2 brush coats of preservative treatment.

.4 Bridging: Install solid bridging over supports and cross bridging at maximum 1.8m spacing elsewhere.

.5 Provide 38 x 140 wood stud framing in walls at maximum spacing of 400mm O.C. Provide double studs at each side of openings and triple studs at corners. Provide built-up stud columns under beams of same number of members as beam and not less than as shown.

.6 Provide additional framing as shown and required and stud and bridging backing in locations where items are to be attached to walls.

.7 Install Floor and Roof Joists to bear 50mm on top plate of 139mm wood stud walls so that there remains 50mm between outside face of header and outside face of stud wall to recve 50mm (R10) of rigid insulation (over continuation of air/vapor barrier - see below).

.8 Receive and install prefabricated plywood web joists in accordance with manufacturer's shop drawings, printed instructions and directions.

.9 Glue and nail floor sheathing to joists.

.10 Roof Deck: Provide plywood underlayment over roof decks, curbs and parapets secured with flat head screws driven flush with deck.

.11 Wall Sheathing: Provide waferboard wall sheathing for wind-bracing adjacent to corners and where called for on the Drawings. Provide same over wood framing where the wall or soffit is to be covered with insulation/ stucco finish system.

.12 Nailing of framing and sheathing shall conform to or exceed requirements of Tables 9.23.3A and l9.23.3.B of the Code.

.13 Provide bolts of sizes, and where shown and required.

.14 Air/Vapour Barrier:

i. Ensure that air/vapour barrier is continuous over inside of exterior wall studs, under sill plates, over top plates and over face of joist headers for full height of exterior walls and across underside of roof tie joists.

ii. To facilitate the above, lay continuous strip of air/vapour barrier material over sills and plates before installing joists and joist headers. While so doing, provide sufficient width of air/vapour barrier material to lap, secure to, and seal against main wall air/vapour barrier above and below floors and below roofs and against roof membrane.

iii. Lap joints in air/vapour barrier over two studs. Lay lap over a bed of sealant in conformance with Section 07900 at one stud and staple air/vapour barrier in place.

iv. Where wood framed wall or soffit is to be finished outside with exterior insulation and finish system, provide continuous air/vapour barrier on 6mm plywood sheathing to outside of framing.

v. Secure and seal air/vapour barrier to existing air/vapour barrier, or element that functions as such, at junctures with existing walls and roofs.

.15 Insulation:

i. Provide a complete coverage of insulation between studs, over headers and across roof.

ii. Provide no insulation in joist spaces inside of air/vapour barrier.

iii. Provide complete coverage of sheathing insulation over exterior of wood framed walls shown to be faced with masonry and cavity.

iv. Tape all joints in sheathing insulation with specified contractor's tape.

3.4 ERECTION

.1 Timber

i. Make adequate provision for erection stresses and for sufficient temporary bracing to keep the structural frame plumb and in true alignment until the completion of the entire frame including installation of the deck.

ii. Report to the *Consultant every failure of the materials to come together properly before any measures are taken for correction.

.2 Joists

i. Fire cut ends bearing on masonry. Frame around all openings with double headers and trimmers well spiked together. Provide 50 mm x 50 mm diagonal cross bridging at maximum of 2500 mm centres. Secure bottom end after surface sheathing is installed. Anchor joists to plates or sills and adjacent parts of the structure in an approved manner.

.3 Sheathing

i. Apply sheathing diagonally over joists or rafters. Locate joints over bearing and distribute all over the roof area. Adequately secure each board to each joist with a minimum of three 2 1/2" ringed or spiral nails.

.4 Retightening Connections.

i. Approximately twelve months after completion of installation of structural timber, at a time arranged by agreement with the owners, all exposed structural connections shall be retightened.

ii. Any paint or other finishes damaged by these operations shall be made good.

iii. The cost of this work shall be included in the general contract tender price, but also identified as a separate price.

END OF SECTION

1 General

1.1 **PERFORMANCE REQUIREMENTS**

.1 Have work of this Section designed by a professional structural engineer.

.2 Provide work capable of withstanding the effects of gravity, dead loads, snow, ice, wind, seismic and stresses in accordance with minimum requirements of the governing building code and maintain weathertight.

.3 Thermal Movements: Allow for thermal movements resulting from maximum change in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime sky heat loss.

.4 Water Infiltration: Watertight to the interior under design conditions in combination with movements occurring due to imposed loads.

.5 Air Leaking: Air leakage through assembly of not more than 0.06 cfm/sq. ft. of wall area at 1.57 psf pressure difference when tested in accordance with ASTM E283.

.6 Maximum Deflection Under Full Design Loads:

.1 Roof: 1/360 of clear span.

.2 Wall: 1/180 of clear span.

.3 Floor: 1/360 of clear span.

.7 Ensure total absence of condensation on interior surfaces under following indoor environmental conditions in accordance with governing building code.

.8 Design building enclosure elements to accommodate, by means of expansion and contraction provision, any movement in element itself and between element and building structure caused by structural movements without permanent distortion, damage to infills, racking of joints, breakage of seals, water penetration or glass breakage.

1.2 **SUBMITTALS**

.1 Shop Drawings: Bearing seal and signature of professional engineer responsible for the engineering design of work of this Section.

.1 Indicate plans and grid lines, structural members and connection details, bearing and anchorage details, framed openings, accessories, schedule of materials and finishes, camber, loads and reaction forces, fasteners and welds, sealant locations and details.

.2 Submit description of methods and sequence of erection and type of equipment proposed for use in erecting work.

.3 Indicate on shop drawings related provisions required for mechanical, electrical and other work.

.2 Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

.1 Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used, net amount of preservative

retained, and chemical treatment manufacturer's written instructions for handling, storing, installing, and finishing treated material.

.2 Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials, both before and after exposure to elevated temperatures when tested in accordance with ASTM D5516 and ASTM D5664.

.3 For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

.4 Include copies of warranties from chemical treatment manufacturers for each type of treatment.

.3 Material Certificates: For dimension lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by the American Lumber Standards Committee Board of Review.

2 Products

2.1 **MATERIALS - GENERAL**

.1 Use wood products carrying a certification authorized under authority of the Forest Stewardship Council (FSC) and certified to meet FSC requirements as pertaining to certified sourcing, content and chain-of-custody.

.2 Use composite panels fabricated without added urea-formaldehyde.

2.2 **WOOD PRODUCTS**

.1 Lumber: DOC PS 20 and applicable rules of lumber grading agencies certified by the American Lumber Standards Committee Board of Review.

.1 Factory mark each piece of lumber with grade stamp of grading agency.

.2 For exposed lumber indicated to receive a stained or natural finish, if acceptable to authority having jurisdiction, mark grade stamp on end or back of each piece, or omit grade stamp and provide certificates of grade compliance issued by grading agency.

.3 Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.

.4 Provide dressed lumber, S4S, unless otherwise indicated.

.5 Provide dry lumber with 19 percent maximum moisture content at time of dressing for 2” nominal thickness or less, unless otherwise indicated.

.6 Spruce-Pine-Fir: NELMA, NLGA, WCLIB, or WWPA.

.2 Engineered Wood Products: Provide engineered wood products acceptable to authorities having jurisdiction and for which current model code research or evaluation reports exist that show compliance with the governing building code in effect for Project.

.1 Allowable Design Stresses: Provide engineered wood products with allowable design stresses as published by manufacturer that meet or exceed those

indicated. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis and demonstrated by comprehensive testing performed by a qualified independent testing agency.

.3 Panels:

.1 Plywood: DOC PS 2, unless otherwise indicated.

.2 Thickness: As needed to comply with requirements specified but not less than thickness indicated.

.3 Comply with "Code Plus" provisions in APA Form No. E30K, APA Design/Construction Guide: Residential & Commercial.

.4 Factory mark panels in accordance with indicated standard.

2.3 **WOOD-PRESERVATIVE-TREATED MATERIALS**

.1 Preservative Treatment by Pressure Process: AWPA C2 (lumber) and AWPA C9 (plywood), using preservative chemicals acceptable to authorities having jurisdiction, ammoniacal or amine copper quat (ACQ), or copper azole (AC), except that lumber that is not in contact with the ground and is continuously protected from liquid water may be treated in accordance with AWPA C31 with inorganic boron (SBX).

.1 For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not require incising, contain colorants, bleed through, or otherwise adversely affect finishes.

.2 Kiln dry material after treatment to a maximum moisture content of 19 percent for lumber and 15 percent for plywood. Do not use material that is warped or does not comply with requirements for untreated material.

.3 Mark each treated item with the treatment quality mark of an inspection agency approved by the American Lumber Standards Committee Board of Review.

.1 For exposed lumber indicated to receive a stained or natural finish, if acceptable to authority having jurisdiction, mark end or back of each piece, or omit marking and provide certificates of treatment compliance issued by inspection agency.

2.4 **FIRE RETARDANT TREATED MATERIALS**

.1 Where fire retardant treated materials are indicated, provide materials that comply with performance requirements in AWPA C20 (lumber) and AWPA C27 (plywood). Identify fire-retardant-treated wood with appropriate classification marking of UL, U.S. Testing, Timber Products Inspection, or another testing and inspecting agency acceptable to authorities having jurisdiction.

.1 Use treatment that does not promote corrosion of metal fasteners.

.2 Use Exterior type for exterior locations and where indicated.

.3 Use Interior Type A High Temperature (HT), unless otherwise indicated.

.2 For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not bleed through, contain colorants, or otherwise adversely affect finishes.

2.5 **FASTENERS**

.1 Where work is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M.

.2 Nails, Brads, and Staples: ASTM F1667.

.3 Lag Bolts: ASME B18.2.1.

.4 Bolts: Steel bolts complying with ASTM A307, Grade A with ASTM A563 hex nuts and, where indicated, flat washers.

.5 Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing per ASTM E488 conducted by a qualified independent testing and inspecting agency.

.1 For Indoor Exposure: Carbon steel components, zinc plated to comply with ASTM B633, Class Fe/Zn 5.

.2 For Outdoor Exposure: Stainless steel with bolts and nuts complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2.

2.6 FOAM INSULATION

.1 Foam Insulation: Sprayed applied polyurethane foam insulation and zero ozone depletion substance blowing agents, 2.1 pcf minimum density, flame spread 75 to ASTM E84

2.7 MISCELLANEOUS MATERIALS

.1 Sheathing Tape: Pressure sensitive plastic tape for sealing joints and penetrations in sheathing and recommended by sheathing manufacturer for use with type of sheathing required.

.2 Sill-Sealer Gaskets: Closed-cell neoprene foam, 1/4” thick, selected from manufacturer's standard widths to suit width of sill members indicated.

.3 Panel Sealants:

.1 Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2” wide and 1/8” thick.

.2 Joint Sealant: ASTM C920; elastomeric polyurethane, polysulfide, or silicone sealant; of type, grade, class, and use classifications required to seal joints in panels and remain weathertight; and as recommended in writing by panel manufacturer.

.4 Adhesives for Field Gluing Panels to Framing: Low VOC formulation complying with APA AFG-01 or ASTM D3498 that is approved for use with type of construction panel indicated by both adhesive and panel manufacturers.

.5 Sheet Metal Flashing and Trim: Formed from 0.018” minimum thickness, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers.

2.8 FABRICATION

.1 Fabricate and finish panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements. Comply with indicated profiles and with dimensional and structural requirements, and minimise thermal bridging.

.2 Foam Insulation: Apply insulation in full coverage without air pockets.

.3 Fabricate panels in a manner that eliminates condensation on interior side of panel and with joints between panels designed to form weathertight seals.

.4 Fabricate panel joints with factory installed captive gaskets or separator strips that provide a tight seal and in a manner that will minimize noise from movements within panel assembly.

.5 Sheet Metal Accessories: Fabricate flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of item indicated.

.1 Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.

.2 Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

.3 Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

.4 Sealed Joints: Form nonexpansion but movable metal joints to accommodate elastomeric sealant to comply with SMACNA standards.

.5 Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.

.6 Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended by panel manufacturer.

.7 Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or panel manufacturer for application.

3 Execution

3.1 **INSTALLATION**

.1 Install work in accordance with manufacturer's written instructions in orientation, sizes, and locations indicated on Drawings. Anchor panels and other components of the Work securely in place, with provisions for thermal and structural movement.

.1 Do not use materials with defects that impair quality of work.

.2 Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Fit to other construction; scribe and cope as needed for accurate fit. Locate furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.

.1 Shim or otherwise plumb substrates receiving panels.

.3 Apply field treatment complying with AWPA M4 to cut surfaces of preservative-treated lumber and plywood.

.4 Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood; predrill as required.

.5 Use finishing nails for exposed work, unless otherwise indicated. Countersink nail heads and fill holes with wood filler.

.6 Apply sheathing tape to joints between sheathing panels and at items penetrating sheathing. Apply at upstanding flashing to overlap both flashing and sheathing.

.7 Flash and seal panels with weather closures at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until weather barrier and flashings that will be concealed by panels are installed.

.8 Locate and space fastenings in uniform vertical and horizontal alignment.

.9 Install flashing and trim as panel work proceeds.

.10 Apply sill seal gaskets or sealant continuously between panel sill and concrete, and elsewhere as indicated or, if not indicated, as necessary for waterproofing.

.11 Provide weathertight escutcheons for pipe and conduit penetrating exterior walls.

.12 Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action as recommended by panel manufacturer.

.13 Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weathertight performance of panel assemblies. Provide types of gaskets, fillers, and sealants indicated or, if not indicated, types recommended by panel manufacturer.

End of Section

1 General

1.1 **QUALITY ASSURANCE**

.1 Quality of Work and Materials: Unless otherwise specified, comply with the requirements for Premium Grade in accordance with 2005 AWI/AWMAC Architectural Woodwork Quality Standards Illustrated Eighth Edition Version 2 (QSI8V2).

.2 Finish Matching: Finish for solid wood members shall match wood veneer finish.

.3 Regulatory Requirements: Provide finished wall assemblies flame spread rating of not more than 150 and finished ceiling assemblies flame spread of not more than 25.

1.2 **DELIVERY, STORAGE AND HANDLING**

.1 Store work in a temperature and humidity controlled area.

.2 Protect fire-retardant materials against high humidity and moisture.

.3 Provide protective coverings of suitable material for plastic laminate items; take special precautions at corners.

.4 Provide dry storage areas. Stack materials with 6" clearance off the floor.

2 Products

2.1 **MATERIALS - GENERAL**

.1 Use wood products carrying a certification authorized under authority of the Forest Stewardship Council (FSC) and certified to meet FSC requirements as pertaining to certified sourcing, content and chain-of-custody.

.2 Use composite panels fabricated free of added urea-formaldehyde.

2.2 **WOOD PRODUCTS**

.1 Wood Types:

.1 WD-1: Clear Maple, flat cut.

.2 WD-2: Douglas Fir, quarter sawn.

.3 WD-3: Cedar.

.2 Lumber: DOC PS 20 and applicable rules of lumber grading agencies certified by the American Lumber Standards Committee Board of Review.

.1 Factory mark each piece of lumber with grade stamp of grading agency.

.2 For exposed to view lumber indicated to receive a stained or natural finish, if acceptable to authority having jurisdiction, mark grade stamp on end or back of each piece, or omit grade stamp and provide certificates of grade compliance issued by grading agency.

.3 Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.

.4 Provide dressed lumber, S4S, unless otherwise indicated.

.5 Provide dry lumber with 19 percent maximum moisture content at time of dressing for 2” nominal thickness or less, unless otherwise indicated.

.6 Spruce-Pine-Fir: NELMA, NLGA, WCLIB, or WWPA.

.7 Exposed Framing, Solid Members and Trim: Species indicated on Drawings, quarter sawn, architectural grade, matched or compatibility of grain and colour.

.3 Wood Veneer: QSI8 Grade AA, species as indicated, plain sliced, book match, equal width, uniform, clean, without open defects, patches, plastic repair, minimum 1/32" thick after sanding.

.4 Panels

.1 Plywood: DOC PS 2, unless otherwise indicated.

.2 Particleboard: ANSI A208.1, 45 lb/cu.ft. density, mat formed wood particleboard.

.3 Medium Density Fibreboard (MDF, WD-4): ANSI A208.2, density 48 lb/cu.ft.

.4 Melamine Board: Melamine resin impregnated paper, thermally fused to particleboard or MDF core, furniture finish in solid colour to be selected by Consultant.

.5 Hardboard: CGSB 11-GP-3, impregnated, pressed wood with a tempering compound and polymerized by baking.

.5 Wood Door Staved Lumber Core: Combination of kiln dried soft wood blocks or strips of one wood species at 6-9% moisture content; not exceeding 2” and of random lengths placed vertically or horizontally in tight staggered joints, and laminated by heat and pressure.

.6 Wood Door Stile and Rail: Structural composite lumber of wood strands and binder, engineered for strength and stability for intended use.

2.3 FIRE RETARDANT TREATED MATERIALS

.1 Where fire retardant treated materials are indicated, provide materials that comply with performance requirements in AWPA C20 (lumber) and AWPA C27 (plywood). Identify fire-retardant-treated wood with appropriate classification marking of UL, U.S. Testing, Timber Products Inspection, or another testing and inspecting agency acceptable to authorities having jurisdiction.

.1 Use treatment that does not promote corrosion of metal fasteners.

.2 Use Exterior type for exterior locations and where indicated.

.3 Use Interior Type A High Temperature (HT), unless otherwise indicated.

.2 For exposed items indicated to receive a stained or natural finish, use chemical formulations that do not bleed through, contain colorants, or otherwise adversely affect finishes.

2.4 MATERIALS - ACCESSORIES

.1 Adhesives and Sealants: Recommended by manufacturer to suit work and substrate conditions, and maximum VOC of 50 g/L as tested to EPA method 24.

.2 Cabinet Hardware: As indicated.

2.5 MATERIALS - SOLID SURFACING

.1 Solid Surfacing: Homogeneous filled acrylic sheets; not coated, laminated or of composite construction, superficial damage to a depth of 0.25 mm shall be repairable by sanding and polishing, semi-gloss finish with a gloss rating of 25-50, Corian by Dupont.

.1 SS1: Glacier Ice.

.2 SS2: Glacier White.

.2 Joint Adhesive, Solid Surfacing: Manufacturer's standard two-part adhesive kit to create inconspicuous, non-porous joints, with a chemical bond.

.3 Panel Adhesive, Solid Surfacing: Manufacturer's standard neoprene-based panel adhesive.

.4 Sealant, Solid Surfacing: Manufacturer's standard mildew-resistant silicone sealant color formulated to match sheets, maximum VOC content of 250 g/L as tested to EPA Method 24.

2.6 OPERABLE STOREFRONT HARDWARE

.1 General: Provide manufacturer's standard hardware fabricated from aluminum, stainless steel, carbon steel complying with AAMA 907, or other corrosion-resistant material compatible with wood; designed to smoothly operate, tightly close, and securely lock wood windows and sized to accommodate sash or ventilator weight and dimensions. Do not use aluminum in frictional contact with other metals. Where exposed, provide nonmagnetic stainless steel.

.2 Locks and Latches: Designed to allow unobstructed movement of the sash across adjacent sash in direction indicated and operated from the inside only.

.3 Gear Type Rotary Operators: Comply with AAMA 901 when tested in accordance with ASTM E405, Method A.

.1 Operation Function: All ventilators move simultaneously and securely close at both jambs without using additional manually controlled locking devices.

.4 Hinges: AAMA 904, four or six-bar friction hinges.

.1 Locking mechanism and handles for manual operation.

.2 Friction Shoes: Provide friction shoes of nylon or other nonabrasive, nonstaining, noncorrosive, durable material.

.5 Limit Devices: Provide concealed support arms with adjustable, limited, hold-open limit devices designed to restrict sash or ventilator opening to 4” for ventilation.

.6 Insect Screens: Design windows and hardware to accommodate screens in a tight-fitting, removable arrangement, with a minimum of exposed fasteners and latches. Locate screens on inside of window and provide for each operable exterior sash or ventilator.

.1 Aluminum Tubular Framing Sections and Cross Braces: Roll-formed from aluminum sheet with minimum wall thickness as required, in baked-on organic coating in color selected by Architect from manufacturer's full range.

2.7 FABRICATION - GENERAL

.1 As far as practical, shop assemble work for delivery to site ready for installation and in size easily handled and to ensure passage through building openings. Leave ample allowance for fitting and scribing on the job.

.2 Fabricate work square and to the required lines. Recess and conceal fasteners and anchor heads. Fill with matching wood plugs.

.3 Make each unit rigid and self supporting, suitable for individual removal.

.4 Provide wood members free from bruises, blemishes, mineral marks, knots, shake and other defects and select for colour, grain and texture. Machine and hand sand surfaces exposed in the finished work to an even, smooth surface free from defects detrimental to appearance.

.5 Finish exposed edges and curves smooth. Keep contrast in colour and grain in adjoining materials to a minimum.

.6 Provide running members in the maximum lengths obtainable. Provide thickness of members in maximum dressed size of standard lumber. Where thickness or width indicated is not available in hardwoods, use glue laminations to obtain sizes required.

.7 Spline or key solid boards 6" and wider and glue under pressure. Unless otherwise specified or indicated, book-match veneered faces, using selected and approved veneers. Provide unexposed backs of veneers having the same physical characteristics as the face veneer.

.8 Design and fabricate work to allow for expansion and contraction of the materials. Unless otherwise specified, work shall be glued, and blind screwed or nailed. Properly frame material with tight, hairline joints and hold rigidly in place. Use glue blocks where necessary.

.9 Conceal joints and connections wherever possible. Locate prominent joints where directed. Glue and pin mortise and tenon joints. Intermediate joints between supports will not be permitted. Set and fill surface nails. Prevent opening-up of glue lines in the finished work.

.10 Comply with glue manufacturer's recommendations for lumber moisture content, glue shelf life, pot life, working life, mixing, spreading, assembly time, time under pressure and ambient temperature.

.11 Provide exposed and grain of solid members and edges of exposed plywood with matching solid edging at least 1/4" thick.

.12 Seal finish carpentry wood items before they leave the fabricating shop. For surfaces to receive a natural or stain finish ensure that the sealer is compatible with the final finish. Co-operate with Division 9 Painting Section and obtain written approval of proposed sealer.

.13 Fit shelf, door, drawer, gable and cabinet edges and other edges with 1/2" hardwood edging prior to application of laminated plastic edging or subsequent finishing.

.14 Set nails and screws, apply wood filler to indentations, sand smooth and prepare to receive finish. Clean, ensure surfaces are free of dust.

2.8 **FABRICATION – WOOD VENEER WORK**

.1 Check job dimensions and conditions. Do not proceed until unsatisfactory conditions are corrected.

.2 As far as practical, assemble work at the shop and deliver to the job ready for installation. Leave ample allowance for fitting and scribing on the job.

.3 Fabricate work square and to required lines. Recess and conceal fasteners and anchor heads.

.4 Parallel clip veneer pieces in equal widths and join by tapeless splicer and glue.

.5 Provide unexposed backs of panels with backing veneer having the same physical characteristics as the face veneer.

.6 Properly join panels with tight, hairline joints and hold rigidly in place with assembly bolts. Use glue blocks where necessary. Conceal joints and connections. Locate prominent joints where directed. Intermediate joints between supports will not be permitted. Prevent opening-up of glue lines in the finished work.

.7 Comply with glue manufacturer's recommendations for moisture content, glue shelf life, pot life, working life, mixing, spreading, assembly time, time under pressure and ambient temperature.

2.9 **FABRICATION - FRAMES AND JAMBS FOR TRANSPARENT FINISH**

.1 Wood Species and Cut, transparent Finish: Match species and cut indicated for other types of transparent-finished woodwork located in same area of building, unless otherwise indicated.

.1 For frames or jambs wider than available lumber, use veneered construction. Do not glue for width.

2.10 **FABRICATION - DOORS**

.1 Fabricate doors in solid core construction, finish as indicated.

.2 Provide exposed edges with matching solid wood at least 6 mm thick. Extend veneer to conceal edges.

.3 Wood Veneer Flush Doors, Transparent Finish, Solid Core, Bonded: Staved lumber core, 5 ply construction, full length stiles and rails bonded to core. QSI8 No. 2 and matching edge. Laminate crossbandings to core, stiles and rails. Hot press veneer in accordance with manufacture's instructions.

2.11 **FABRICATION - BENCHES**

.1 Form continuous slats for benches of solid wood to configurations indicated, trim with solid wood frame with mitred and rounded corners. Provide wood plugs finished to match surfaces to conceal mounting as required. Support benches on solid wood framing.

2.12 **FABRICATION – SOLID SURFACING**

.1 Shop fabricate work to greatest extent practical and to sizes and shapes indicated, in accordance with reviewed shop drawings and solid surfacing manufacturer requirements.

.2 Form joints between work using manufacturer's joint adhesive. Make joints inconspicuous in appearance and without voids. Attach 2” wide reinforcing strip of solid surfacing material under each joint or as recommended by the manufacturer.

.3 Cut holes and cutouts for items penetrating the work to templates. Reinforce holes and cutouts to manufacturer’s requirements.

.4 Provide edge details indicated. Rout and finish component edges to a smooth, uniform finish. Rout all cutouts, then sand all edges smooth. Repair or reject defective or inaccurate work.

2.13 **FABRICATION - TRIM**

.1 Trim members shall be of sizes and profiles indicated. Trim members shall be slow-fed work, free from chatter and other machine marks.

.2 Provide trim over 2-1/2" wide with backs ploughed or kerfed. Mitre all joints. Carefully machine drum-sand exposed flat surfaces. Minimize sanding on the job.

2.14 **FABRICATION - FIRE RETARDANT TREATMENT**

.1 Provide ULC label for treated wood products as received from the pressure treating plant.

.2 Do not expose pressure treated material to dampness between the time the material is treated and the time the finish is applied. Carefully sand surfaces which show surface salt deposits to remove such deposits before finish is applied.

.3 Provide quality of finished work of equal standard to that of untreated material. Provide identification on materials delivered to Project site showing that these Specifications have been complied with, on each large item, and on bundles of small items. Arrange wood members in pressure treating cylinder to avoid sticker marks on best face of members.

.4 Fire retardant varnish: Apply varnish to substrates in strict accordance to manufacturer's instructions. Maintain room temperature and humidity recommended by the varnish manufacturer.

2.15 **FACTORY FINISH**

.1 Factory finish work scheduled to receive stained and clear finish to match approved control sample. Apply finish to QSI8V2 Factory Finishing Catalyzed Polyurethane Premium Grade requirements and in accordance with manufacturer's approved methods using approved equipment. Apply finish to cut outs, and exposed surfaces. Unfinished work will be listed as deficiencies.

.2 Sand smooth work and clean surfaces free of dust before applying successive coat. Carefully sand with even strokes to provide perfect, scratch free surface.

3 Execution

3.1 **INSTALLATION**

.1 Set and secure materials and components in place, rigid, straight, level, plumb and square with hairline joints. Scribe neatly to adjoining surfaces; install blocking and fillers required. Secure units using concealed fasteners.

.2 Provide matching scribing closer strips between units and partitions or similar surfaces.

.3 Apply sealant between units and adjacent wall and floor surface, around sills, pipes and escutcheon plates and similar areas to seal and finish installation, in accordance with Division 7 Joint Sealants Section.

.4 Make allowances around perimeter where fixed objects pass through or project into carpentry work to permit normal movement without restriction.

.5 Touch up cut edges and surfaces with sealer.

.6 Apply water resistant building paper or bituminous coating over wood framing members in contact with cementitious construction.

.7 Install handrails and bumpers level and plumb; bracket spacing shall not exceed 36" o.c., adjust to suit. Bracket supply specified in Division 5 Metal Fabrications Section.

.8 Mechanically fasten wall panelling to framing by concealed means.

.9 After installation, adjust operating hardware for proper fit and function.

.10 Protect finished surfaces by approved means. Do not remove until immediately before final inspection.

3.2 **INSTALLATION – SOLID SURFACING**

.1 Install work plumb and level, in accordance with reviewed shop drawings and product installation details.

.2 Adhere solid surfacing tops to support framing with panel adhesives or concealed fasteners.

.3 Form field joints using manufacturer's recommended adhesive, with joints inconspicuous in finished work. Keep components and hands clean when making joints.

.4 Apply sealant at joints to adjacent construction, to requirements of Division 7 Joint Sealants Section.

.5 Keep components and hands clean during installation. Remove adhesives, sealants and other stains.

End of Section

1 General

1.1 **QUALITY ASSURANCE**

.1 Perform the work of this Section by an insulation subcontractor of recognized standing having not fewer than 5 years proven experience in this type of work.

.2 Employ only skilled installers having experience and understanding of the design principles of the thermal and air/vapour barriers specified and indicated.

1.2 **DELIVERY, STORAGE AND HANDLING**

.1 Store packaged materials and products in their original wrappings or containers with manufacturer's labels and seals intact.

.2 Store flammable materials outside the building and protect from all weather hazards and open flame. Conform to all fire protection regulations imposed by authorities having jurisdiction, and take precautionary measures to avoid fire.

.3 Do not store insulation in direct contact with the earth, road surface, or floors. Place suitable forms or skids under the insulation upon delivery to protect the insulation from absorbing dampness from the surrounding terrain or floor. Cover material with approved tarpaulins and secure.

.4 In cold weather, provide warm storage for adhesives such that their consistency is suitable for ease of application.

1.3 **SITE CONDITIONS**

.1 Protect surfaces, and in particular the building cladding finish, from being marred or contaminated by the materials, by means of protective covers, boards, tapes and other acceptable means.

.2 Co-ordinate the work of other Sections where such work is closely associated with the work of this Section and report any damage done to the work of this Section.

.3 Protect the work of this Section from damage due to high winds until the building cladding or other permanent protection is in place.

2 Products

2.1 **MATERIALS**

.1 Exterior Wall Insulation: Extruded polystyrene board insulation, R=5 per 1" thickness and a minimum compressive strength of 30 psi at 10% deformation or yield; Styrofoam SM by Dow Chemical.

.2 Self-Adhering Stick Clips: Galvanized steel clips with 2" x 2" base, steel pin and locking washers. Pin length to suit insulation thickness and application.

.3 Z-Section Strapping: Roll-formed from 25 gauge electro-galvanized sheet steel and having a 1-1/4" minimum wide flanges and web depth to suit insulation thickness. Provide flanges knurled to facilitate acceptance of screws, and with rolled lips at outer edges for added stiffness.

.4 Lightweight Cement Board: Panels of Portland cement slurry with a fully embedded alkali resistant glass fibre mesh facing.

3 Execution

3.1 **INSTALLATION - INSULATION**

.1 Install insulation to thicknesses shown on the Drawings.

.2 Install all materials in accordance with the manufacturers' printed directions unless otherwise specified herein.

.3 Ensure a uniform, continuous thermal barrier effect.

.4 Arrange clips at 12" centres both ways with 2 clips minimum for each full board width and 4 clips minimum for each full board length. Where insulation occurs on the underside of horizontal construction, provide each clip with a 2" diameter 28 gauge galvanized steel washer before applying retainer.

.5 Press insulation boards firmly to substrate impaling them on clips without bending clips. Cut insulation as required and fit snugly to strapping, pipes, ducts, obstructions, openings and corners. Bevel board edges abutting sloping surfaces.

.6 Butt insulation boards tightly and stagger joints. Cut out back of board insulation as required to accommodate substrate irregularities and build up over cut out areas on the other side as required to ensure thermal barrier uniformity.

3.2 **INSTALLATION - LIGHTWEIGHT CEMENT BOARD**

.1 Arrange Z Section strapping at 16’ centers.

.2 Fasten cement boards to strapping with appropriate screws at every 8’’, and at a minimum edge distance of 3/8". Drive screws so that screw heads are flush with board surface without damaging the fibreglass mesh facing. Ensure that the boards are well attached and that they are in continuous contact with the support.

.3 Install 2” x 2” x 20 gauge galvanised steel corner casing bead at interior and exterior corners, using concealed fasteners.

.4 Do not attach other work directly to cement boards.

End of Section

1 General

1.1 **QUALITY ASSURANCE**

.1 Installation: Maintain continuity of air barrier at interface with adjacent construction and at where work of other Sections project through the air barriers. Allow for expansion and contraction and linear movement of these items.

.2 Source Limitations: Obtain each type of product from a single manufacturer.

1.2 **DELIVERY, STORAGE AND HANDLING**

.1 Deliver materials in factory wrapped rolls with labels indicating manufacturer and trade name, material type, thickness, roll width and area.

.2 Protect materials from direct exposure to sunlight and physical damage.

1.3 **COORDINATION**

.1 Coordinate installation of air barrier with work of other Sections to achieve an air and vapour tight building envelope.

2 Products

2.1 **MATERIALS**

.1 Sheet Air Barrier: Minimum 40 mils thick modified bituminous composite sheet, Perm-A-Barrier by W.R. Grace Co. of Canada Ltd., Air-Shield by WR Meadows, or Sopraseal Stick 1100T by Soprema, complete with primer, mastic and liquid membrane as required.

.2 Liquid Air Barrier: Liquid applied, fire retardant, compatible with specified insulations, Air-Bloc 33 and primer by Monsey Inc. or other approved equivalents, complete with self-adhering membrane reinforcing sheet and primer recommended by the membrane manufacturer.

3 Execution

3.1 **INSTALLATION – SHEET AIR BARRIER**

.1 Install the membrane in strict accordance with the manufacturer's written instructions and the representative's on site instructions.

.2 Ensure complete coverage of and adhesion to all substrate to receive the air/vapour barrier membrane, including all wall protrusions. Extend membrane 6" beyond termination of membrane at juncture of dissimilar wall construction. Co-operate with other Sections to ensure continuity of the barrier.

.3 Apply the membrane to primed substrate in 8' lengths or as recommended by the membrane manufacturer.

.4 Apply membrane so that horizontal joints overlap with the upper sheet over the lower sheet, shingle style. Lap all horizontal joints minimum 2" all side joints minimum 2-1/2" and all end joints minimum 6". Stagger vertical joints to avoid four way joints.

.5 Apply a trowelled head of mastic to all terminations of the membrane at the end of a day's work and at membrane terminations.

.6 Reinforce all inside and outside corners with a continuous 12" wide sheet membrane prior to installing the air/vapour barrier.

.7 Fill gaps and joints with liquid membrane and reinforce with a continuous 12" wide sheet membrane prior to installing the air/vapour barrier.

.8 Use liquid membrane at all protrusions and difficult detail areas and provide a minimum 2-1/2" overlap with the sheet membrane.

.9 Apply air/vapour barrier so that the exterior wall is air tight, with air tight junctures at openings, penetrations and edges.

.10 Inspect air/vapour barrier for continuity immediately prior to installation of insulation. Do not cover the air/vapour barrier until it has been inspected.

.11 Repair punctures, rips and tears with pieces of membrane completely adhered to the damaged membrane.

.12 Where punctures and tears are extensive, replace entire damaged section.

.13 Install membrane over doors, windows and other openings to exterior walls.

.14 At openings, extend membrane 8" beyond jambs, heads and sills.

.15 Use mastic or fixing bars to adhere membrane to windows, doors etc. to maintain continuity of the barrier.

3.2 **INSTALLATION – LIQUID AIR BARRIER**

.1 Install the membrane in strict accordance with the manufacturer's written instructions and the representative's on site instructions.

.2 Apply primer in accordance with manufacturer's instructions.

.3 Apply membrane reinforcing to joints in substrates in excess of 1/4" and at interfacing of masonry and gypsum board to steel or concrete, control or expansion joints, joints between dissimilar substrates and sill plates at foundation walls.

.4 Centre membrane reinforcing over joints and extend minimum 4" on each side of joints. Overlap reinforcing 2".

.5 Trowel apply a continuous coating of minimum 1/8" thick air barrier to the substrate and to all insulation board edges. Overlap membrane on to membrane reinforcing at connections a minimum of 1/2". Butter projections from substrates liberally with air/vapour barrier membrane and ensure continuity of air/vapour barrier provisions.

.6 Apply membrane reinforcing over doors, windows and other openings in exterior walls, extending membrane reinforcing 8" beyond jambs, heads and sills. Mechanically fastening membrane reinforcing on substrates through a metal bar or by adhesive.

3.3 **INSPECTION**

.1 Do not cover any portion of the air barrier until it has been inspected by the Architect or by an inspection agency appointed by the Architect.

End of Section

1 General

1.1 **PERFORMANCE REQUIREMENTS**

.1 General: Provide installed roofing membrane and base flashings that remain watertight; do not permit the passage of water; and resist uplift pressures required by the governing building code, thermally induced movement, and exposure to weather without failure.

.2 Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by roofing membrane manufacturer based on testing and field experience.

1.2 **QUALITY ASSURANCE**

.1 Source Limitations: Obtain components for membrane roofing system from same manufacturer as roofing membrane or as approved by roofing membrane manufacturer.

.2 Fire Performance Characteristics: Provide membrane roofing materials with the fire performance characteristics indicated as determined by testing identical products in accordance with test method below by UL, FMG, or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.

.1 Exterior Fire-Test Exposure: Class A tested to ASTM E108, for application and roof slopes indicated.

1.3 **PROJECT CONDITIONS**

.1 Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed in accordance with manufacturer's written instructions and warranty requirements.

2 Products

2.1 **EPDM ROOFING MEMBRANE**

.1 EPDM Roofing Membrane: ASTM D4637, Type I, nonreinforced, uniform, flexible sheet made from EPDM, 60 mil nominal thickness, white exposed face color.

2.2 **AUXILIARY MATERIALS**

.1 General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with membrane roofing.

.1 Liquid-type auxiliary materials shall meet VOC limits of authorities having jurisdiction.

.2 Sheet Flashing: 60 mil thick EPDM, partially cured or cured, for intended end use.

.3 Bonding Adhesive: Manufacturer's standard bonding adhesive.

.4 Seaming Material: Single-component butyl splicing adhesive and splice cleaner, or manufacturer's standard synthetic-rubber polymer primer and 3” wide minimum, butyl splice tape with release film.

.5 Lap Sealant: Manufacturer's standard single-component sealant, color to match roofing membrane.

.6 Water Cutoff Mastic: Manufacturer's standard butyl mastic sealant.

.7 Metal Termination Bars: Manufacturer's standard predrilled stainless-steel or aluminum bars, approximately 1” x 1/8” thick; with anchors.

.8 Metal Battens: Manufacturer's standard aluminum-zinc-alloy-coated or zinc-coated steel sheet, approximately 1” x 0.05” thick, prepunched.

.9 Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FMG 4470, designed for fastening membrane to substrate, and acceptable to membrane roofing system manufacturer.

.10 Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, in-seam sealants, termination reglets, cover strips, and other accessories.

2.3 **VAPOR RETARDER**

.1 Polyethylene Vapor Retarder: ASTM D4397, 6 mils thick, minimum, with maximum permeance rating of 0.13 perm.

.1 Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.

2.4 **ROOF INSULATION**

.1 Polyisocyanurate Board Insulation: ASTM C1289, Type II, felt or glass-fiber mat facer on both major surfaces.

.1 Taper Insulation: Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

2.5 **INSULATION ACCESSORIES**

.1 General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatible with membrane roofing.

.2 Fasteners: Factory-coated steel fasteners and metal or plastic plates meeting corrosion-resistance provisions in FMG 4470, designed for fastening roof insulation to substrate, and acceptable to roofing system manufacturer.

.3 Cold Fluid-Applied Adhesive: Manufacturer's standard cold fluid-applied adhesive formulated to adhere roof insulation to substrate.

3 Execution

3.1 **EXAMINATION**

.1 Examine substrates, areas, and conditions, for compliance with the following requirements and other conditions affecting performance of roofing system:

.1 Verify that roof openings and penetrations are in place and set and braced and that roof drains are securely clamped in place.

.2 Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.

.3 Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 **PREPARATION - WOOD DECK**

.1 Verify flatness and tight joints of wood decking.

.2 Seal joints of plywood with tape.

.3 Fill knot holes with latex filler.

.4 Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.

.5 Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.

3.3 **VAPOR-RETARDER INSTALLATION**

.1 Loosely lay polyethylene-film vapor retarder in a single layer over area to receive vapor retarder, side and end lapping each sheet a minimum of 2” and 6”, respectively.

.1 Seal side and end laps.

.2 Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into membrane roofing system.

3.4 **INSULATION INSTALLATION**

.1 Coordinate installing membrane roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.

.2 Comply with membrane roofing system manufacturer's written instructions for installing roof insulation.

.3 Install tapered insulation under area of roofing to conform to slopes indicated.

.4 Install one or more layers of insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2” or greater, install 2 or more layers of equal thickness with joints of each succeeding layer staggered from joints of previous layer a minimum of 6” in each direction.

.5 Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.

.6 Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4” with insulation.

.1 Cut and fit insulation within 1/4” of nailers, projections, and penetrations.

.7 Mechanically Fastened and Adhered Insulation: Secure first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening insulation to resist uplift pressure at corners, perimeter, and field of roof. Install subsequent layers of insulation in a cold fluid-applied adhesive.

3.5 **ADHERED ROOFING MEMBRANE INSTALLATION**

.1 Install roofing membrane over area to receive roofing in accordance with membrane roofing system manufacturer's written instructions. Unroll roofing membrane and allow to relax before installing.

.2 Accurately align roofing membrane and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

.3 Bonding Adhesive: Apply bonding adhesive to substrate and underside of roofing membrane at rate required by manufacturer and allow to partially dry before installing roofing membrane. Do not apply bonding adhesive to splice area of roofing membrane.

.4 Mechanically or adhesively fasten roofing membrane securely at terminations, penetrations, and perimeter of roofing.

.5 Apply roofing membrane with side laps shingled with slope of roof deck where possible.

.6 Adhesive Seam Installation: Clean both faces of splice areas, apply splicing cement, and firmly roll side and end laps of overlapping roofing membranes according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of roofing membrane terminations.

.1 Apply a continuous bead of in-seam sealant before closing splice if required by membrane roofing system manufacturer.

.7 Tape Seam Installation: Clean and prime both faces of splice areas, apply splice tape, and firmly roll side and end laps of overlapping roofing membranes according to manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of roofing membrane terminations.

.8 Repair tears, voids, and lapped seams in roofing that does not meet requirements.

.9 Spread sealant or mastic bed over deck drain flange at deck drains and securely seal roofing membrane in place with clamping ring.

3.6 **BASE FLASHING INSTALLATION**

.1 Install sheet flashings and preformed flashing accessories and adhere to substrates in accordance with membrane roofing system manufacturer's written instructions.

.2 Apply bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply bonding adhesive to seam area of flashing.

.3 Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.

.4 Clean splice areas, apply splicing cement, and firmly roll side and end laps of overlapping sheets to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of sheet flashing terminations.

.5 Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

3.7 **PROTECTING AND CLEANING**

.1 Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report.

.2 Correct deficiencies in or remove membrane roofing system that does not comply with requirements, repair substrates and repair or reinstall membrane roofing system to a condition free of damage and deterioration.

End of Section

1 General

1.1 **QUALITY ASSURANCE**

.1 Pre-Installation Field Adhesion Testing

.1 Conduct site field-tests for adhesion of sealants to actual joint substrates using proposed preparation methods and materials recommended by manufacturer.

.2 Conduct tests for each type of sealant and substrate.

.3 Locate field-test joints where inconspicuous or as directed by Architect.

.4 Test Method: Use manufacturer's standard field adhesion test methods and methods proposed for joint preparation to verify proper priming and joint preparation techniques required to obtain optimum adhesion of joint sealants to joint substrate.

.5 Do not use joint preparation methods or sealants that produce less than satisfactory adhesion to joint substrates during testing.

1.2 **PROJECT CONDITIONS**

.1 Environmental Requirements: Do not apply any sealant under adverse weather conditions, when joints to be sealed are damp, wet or frozen or when at ambient temperatures below 40 degree C. Maintain minimum temperature of application during application and for 8 hours after application. Consult manufacturer for specific instructions before proceeding.

2 Products

2.1 **MATERIALS**

.1 Sealants, Cleaning Materials and Primers: Compatible with each other, recommended by manufacturer to suit products and substrate conditions.

.1 VOC Content of Interior Sealants: Provide sealants and sealant primers for use inside the weatherproofing system that comply with the following limits for VOC content when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24):

.1 Architectural Sealants: 250 g/L.

.2 Sealant Primers for Nonporous Substrates: 250 g/L.

.3 Sealant Primers for Porous Substrates: 775 g/L.

.2 Sealants, General: Non-bleeding, non-migrating, and capable of supporting their own weight.

.1 Horizontal Joints: Self levelling.

.2 Vertical and Overhead Joints: Non-sag.

.3 Sealant Type A: ASTM C920, Type M, Grade NS, Class 50, Use NT-M-A, multi-component, chemical curing, modified polyurethane, Sikaflex 2cNS EZ Mix by Sika, or Dymeric 240 by Tremco.

.4 Sealant Type B: ASTM C920, Type S, Grade NS, Class 25, Use NT, one component, chemical curing, mildew resistant silicone, DC786 by Dow Corning, Sanitary SCS1700 by GE Silicones, or Tremsil 200 by Tremco.

.5 Compressible Tape Sealant: Preformed, pre-compressed, self-expanding resilient cellular foam tape infused with a hydrophobic, modified-acrylic, liquid adhesive sealant, MST by Emseal.

.6 Joint Backing: Preformed, compressible, resilient, non-waxing, non-extruding, non-staining closed cell polyethylene or urethane foam, shape to suit intended use, oversize 25% and compatible with sealant, primer and substrate.

.7 Bond Breaker Tape: As recommended by sealant manufacturer.

.8 Joint Primer: Non-staining, suitable for substrate surfaces, compatible with joint sealants and as recommended by sealant manufacturer.

.9 Cleaning Material: Non-corrosive, non-staining, as recommended by sealant manufacturer and acceptable to material or finish manufacturers for surfaces adjacent to sealed areas.

3 Execution

3.1 **PREPARATION**

.1 Before any sealing work is commenced, test materials for indications of staining or poor adhesion.

.2 Clean joints and spaces which are to be sealed and ensure they are dry and free of dust, loose mortar, oil, grease, oxidation, coatings, form release agents, sealers and other foreign material.

.3 Install joint backing material to achieve correct and uniform joint profile.

.4 Where joint design or depth of joint prevents use of joint backing material, apply bond breaker tape to prevent three-sided adhesion.

.5 Do not stretch, twist, puncture or tear joint backing. Butt joint backing at intersections. Install bond breaker tape at back of joint where joint backing is not required or cannot be installed.

.6 Where surfaces adjacent to joints are likely to become coated with sealant during application, mask them prior to priming and sealing.

.7 Do not exceed shelf life and pot life of materials, and installation times, as stated by manufacturers.

.8 Be familiar with work life of sealant to be used. Do not mix multiple component materials until required for use.

.9 Use materials as received from manufacturer, without additions, deletions and adulterations of materials.

.10 Mix multiple component sealants and bulk sealants using mechanical mixer capable of mixing without mixing air into material, strictly in accordance with manufacturer's directions and recommendations. Continue mixing until material is homogeneously blended, uniform in colour and free from streaks of unmixed material. Install compound prior to start of hardening or curing cycle.

.11 Seal joints in surfaces to be painted before surfaces are painted. Where surfaces to be sealed are prime painted in shop before sealing check to make sure prime paint is compatible with primer and sealant. If they are incompatible, inform Consultant and change primer and sealant to compatible types approved by Consultant.

.12 Where irregular surface or sensitive joint border exists, apply masking tape at edge of joint to ensure joint neatness and protection.

.13 Prime joints as required by sealant manufacturer. Prime sides of joints for type of surface being sealed prior to application of joint backing, bond breaker or sealant.

3.2 **APPLICATION**

.1 Apply sealant using hand operated guns or pressure equipment fitted with suitable nozzle size and equipment approved by sealant manufacturer. Apply in accordance with manufacturer's directions and recommendations.

.2 Force sealant into joint and against sides of joints to obtain uniform adhesion. Use sufficient pressure to completely fill all voids in joint regardless of variation in joint widths and to proper joint depth as prepared. Ensure full firm contact with interfaces of joint. Superficial pointing with skin bead shall not be acceptable.

.3 Finish face of compound to form smooth, uniform beads. At recesses in angular surfaces, finish compound with flat face, flush with face of materials at each side. At recesses in flush surfaces, finish compound with concave face flush with face of materials at each side.

.4 Tool surfaces as soon as possible after sealant application or before any skin formation has occurred. Avoid pulling of sealant from sides.

.5 Joint surfaces shall be straight, neatly finished, free from ridges, wrinkles, sags, dirt, stains, air pockets and embedded foreign matter or other defacement and be uniform in colour, free from marbling and/or colour streaking due to improper mixing or use of out of shelf life products.

3.3 **SEALANT SCHEDULE**

.1 Use one of sealants specified for each type in following locations. Ensure sealant chosen for each location is recommended by manufacturer for use for conditions encountered.

.2 Seal following joints with Sealant Type A:

.1 Exterior door and window frames, both sides.

.2 Joints between thresholds and slabs.

.3 Seal following joints with Sealant Type B:

.1 Underside of rims of sinks between sink rims and counters/vanities.

.2 Around pipes and conduits passing through walls and ceilings in washrooms. Conceal sealant with escutcheons.

.3 Joints between counters/vanities and walls in washrooms.

.4 Joints between water closets and walls in washrooms.

.5 Joints between wall mounted lavatories and walls in washrooms.

.6 Joints between splash backs and walls.

.4 Seal Joints with compressible tape sealant where shown.

End of Section

1 General

1.1 **ENGINEERING DESIGN**

.1 Design work of this Section engineered by a professional engineer registered in the Place of Work. Design work in accordance with the requirements of the building code and authorities having jurisdiction.

.2 Design support framing and anchoring to support their own weight, the weight of the glass and loads imposed by the motion of operable elements.

1.2 **SUBMITTALS**

.1 Shop drawings: Bearing the seal and signature of the professional engineer responsible for the engineering design. Show construction, methods of joining, welding, bonding, fastening, sealing, gasketing and anchorage, as well as type of metal, material thickness, finishes, finish hardware and other pertinent data and bearing stamp or seal and signature of the professional engineer responsible for the engineering design of the work of this Section.

2 Products

2.1 **MATERIALS**

.1 All aluminum work: Comply with CSA HA Series.

.2 Aluminum: Extruded shapes of 6063-T5 alloy, sheet and plate of 1100-H14 alloy, anodizing quality.

.3 Heat Treated Glass: Minimum 1/4” thick, heat treated using the horizontal tong free method, with roll-wave distortion parallel to bottom edge of glass as installed.

.4 Tempered Glass: ASTM C1048 Type FT, heat treated using the horizontal tong free method, with roll-wave distortion parallel to bottom edge of glass as installed.

.5 Fasteners: Steel or stainless steel, finished to match adjacent material.

.6 Shims, Spacers and Setting Blocks: 45, 70 and 90 Durometer A hardness plus/minus 5 respectively, neoprene rubber or EPDM, resistant to sunlight, weathering, oxidation and permanent deformation under load.

.7 Glazing Gaskets: Extruded neoprene or EPDM of approved profile, Durometer A hardness of 50 plus/minus 5, resistant to ozone and uv degradation.

.8 Glazing Tape: Preformed polyisobutylene tape with spacer, paper release, Polyshim tape by Tremco Ltd. or other approved equivalents.

.9 All glazing materials, products, primers and cleaning solvents: Mutually compatible.

.10 Back paint: Approved, quick-drying, acid and alkaline resistant.

2.2 **FABRICATION**

.1 Execute fitting and assemblies in the shop with the various parts or assemblies ready for erection at the building site.

.2 Take field measurements and levels required to verify or supplement those shown on the Drawings for the proper layout and installation of the work. Co-ordinate dimensional tolerances in adjacent building elements and confirm prior to commencement of work.

.3 Extrude members in wall thickness to meet engineering design requirements.

.4 Accurately machine file and fit and rigidly frame together all joints, corners and mitres. Match components carefully to produce perfect continuity of line and design. Metal in contact shall have hairline joints unless otherwise shown on the approved shop drawings. Location of exposed joints shall be subject to the approval of the Consultant. No exposed fixings are permitted.

.5 Reinforce work by concealed means as necessary.

.6 Provide devices for anchoring assemblies to the building structure with sufficient adjustment to permit correct and accurate alignment.

.7 Glazed Doors: Minimum 1/2" thick tempered glass in extruded clear anodized aluminum top and bottom patch fittings.

.1 Hardware: Each leaf, overhead concealed closer, centre pivots, off set 7/8" diameter 9" pull and push handles.

3 Execution

3.1 **PREPARATION**

.1 Apply a heavy brush-coat of back paint to aluminum or galvanized steel placed in or in contact with concrete, masonry, mortar or dissimilar metals.

.2 Erection tolerances for operable elements: Consistent with smooth operation.

3.2 **INSTALLATION**

.1 Install work of this Section in accordance with manufacturer's instructions.

.2 Apply specific torques to bolts to ensure satisfactory performance.

.3 Fabricate and install glass in accordance with manufacturer's instructions.

.4 Use spacers, setting blocks and shims of proper size to support and hold glass in position.

.5 Install performed tape to ensure complete contact on surface of glass and stops. Make joints only at corners of sash or frame. Cut tape to fit close around spacers. Fit tape accurately with tight joints, free from tension, gaps and cracks.

.6 Set glass properly centred with uniform bite and face and edge clearance, free from twist, warp or other distortion likely to develop stress.

3.3 **ADJUSTMENTS**

.1 Test all operable elements and ensure easy and smooth operation.

.2 After alignment, positively lock anchorage devices to prevent movement other than that designed to accommodate deflection and thermal expansion and contraction.

End of Section

1 General

1.1 **PERFORMANCE REQUIREMENTS**

.1 General: Provide glazing systems capable of withstanding normal thermal movement and wind loads without failure, including loss or glass breakage attributable to defective manufacture, fabrication, and installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.

.2 Glass Design: Glass thickness designations indicated are minimums. Confirm glass thicknesses by analyzing Project loads and in-service conditions. Provide glass lites in the thickness designations indicated for various size openings, but not less than thicknesses and in strengths (annealed or heat treated) required to meet or exceed the following criteria:

.1 Glass Thicknesses: Select minimum glass thicknesses to comply with ASTM E1300, in accordance with the following requirements:

.1 Design Wind Load: To requirements of governing building code.

.2 Worse-Case Probability of Breakage for Vertical Glazing: 8 lites per 1000 for lites set vertically or not more than 15 degrees off vertical and under wind action for 60 second load duration.

.3 Maximum Lateral Deflection: For the following types of glass supported on all 4 edges, provide thickness required that limits center deflection at design wind pressure to 1/50 times the short side length or 1”, whichever is less.

.1 For monolithic glass lites heat treated to resist wind loads.

.2 For insulating glass.

.3 For laminated glass lites.

.3 Thermal Movements: Provide glazing that allows for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures acting on glass framing members and glazing components. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

.1 Temperature Change (Range): To requirements of governing building code.

1.2 **QUALITY ASSURANCE**

.1 Source Limitations - Glass: Obtain each type of glass from a single manufacturer.

.2 Source Limitations - Glazing Accessories: Obtain glazing accessories through one source from a single manufacturer for each product and installation method indicated.

.3 Preconstruction Adhesion and Compatibility Testing: Submit to elastomeric glazing sealant manufacturers, for testing indicated below, samples of each glazing material type, tape sealant, gasket, glazing accessories, and glass framing member that will contact or affect elastomeric glazing sealants:

.1 Use ASTM C1087 methods to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of glazing sealants to glass, tape sealants, gaskets, and glazing channel substrates.

.2 Schedule sufficient time for testing and analyzing results to prevent delaying the Work.

.3 For materials failing tests, obtain sealant manufacturer's written instructions for corrective measures, including the use of specially formulated primers.

.4 Testing will not be required if glazing sealant manufacturers submit data based on previous testing of current sealant products for adhesion to, and compatibility with, glazing materials matching those submitted.

.4 Insulating Glass Certification Program: Permanently marked either on spacer core or on at least one component lite of units with appropriate certification label of an acceptable independent testing and inspecting agency.

.5 Safety Glass: Permanently mark safety glass with certification label of certification agency acceptable to authorities having jurisdiction.

1.3 **DELIVERY, STORAGE, AND HANDLING**

.1 Protect glazing materials in accordance with manufacturer's written instructions and as necessary to prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, mechanical damage or other causes.

.2 Deliver materials in manufacturer’s original, unopened, undamaged containers with identification labels intact.

.3 Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer.

.4 Exercise exceptional care to prevent edge damage to glass, and damage/deterioration to coating on glass.

1.4 **PROJECT CONDITIONS**

.1 Environmental Limitations: Do not proceed with work when ambient and substrate temperature conditions are outside the limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.

2 Products

2.1 **GLASS PRODUCTS**

.1 Annealed Float Glass: ASTM C1036, Type I (transparent flat glass), Quality-Q3.

.2 Ultra-Clear (Low-Iron) Float Glass: Class I (clear); with a minimum 91 percent visible light transmission and a minimum solar heat gain coefficient of 0.87.

.1 AGC Inc: Krystal Klear.

.2 Pilkington Building Products North America: Optiwhite.

.3 PPG Industries, Inc: Starphire.

.3 Laminated Glass: ASTM C1172, fabricated with interlayer between 2 lites of glass, free of foreign substances and air or glass pockets. Treat exposed edges of laminated glass susceptible to degradation by organic solvents and glazing compounds.

.1 Interlayer: Polyvinyl butyral of thickness indicated with a proven record of no tendency to bubble, discolour, or lose physical and mechanical properties after laminating glass lites and installation.

.1 Laminate lites in autoclave with heat plus pressure.

.4 Heat Treated Glass: Minimum 1/4" thick, heat treated using the horizontal tong free method, with roll-wave distortion parallel to bottom edge of glass as installed.

.1 Tempered Glass: ASTM C1048 Type FT.

.1 Provide tempered float glass in place of annealed or heat strengthened float glass where safety glass is indicated.

.2 Heat Strengthened Glass: ASTM C1048 Type HS.

.1 Provide heat strengthened float glass in place of annealed float glass where required to resist thermal stresses induced by differential shading of individual glass lites and to comply with glass design requirements.

.5 Low Emissivity Coating: Coating deposited by vacuum deposition process after glass manufacture and heat treatment, Comfort Ti-PS by AGC.

.6 Uncoated Monolithic Cell-Cast Acrylic Sheet: ASTM D4802, Category A-1, Type UVF (UV filtering), Finish 1 (smooth or polished), Plexiglas G P-95 by Altuglas International, Inc.

.7 Coated Solar Films: Thin film solar shading film, Heat Mirror HM88 by Southwall Technologies.

.8 Glass Opaque Glass Coating: Manufacturer's standard, applied by silk-screening, colour to match RAL 9005 Jet Black.

2.2 **GLAZING MATERIALS**

.1 General: Provide products of material, size, and shape complying with referenced glazing standard, requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.

.2 Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

.3 Shims: pressure sensitive resilient extruded synthetic rubber and as recommended by the glass manufacturer.

.4 Setting Blocks: Silicone rubber, compatible with silicone sealant, 90 plus or minus 5 Durometer A hardness.

.5 Spacers: Continuous, bond breaker type and compatible with silicone sealant.

.6 Glazing Unit Spacer Core: Manufacturer's standard spacer material and construction complying with the following requirements:

.1 Desiccant: Molecular sieve or silica gel, or blend of both.

.2 Corner Construction: Manufacturer's standard corner construction.

.7 Anti-Reflection and Protecive Coating: ClearShield by Ritec International Ltd.

.8 Insulating Glass Unit Pressure Plates and Mullion Caps:

.1 Pressure Plates: Pultruded fibreglass, in profile to accept mullion caps.

.2 Mullion Caps: Extruded aluminium, prefinished.

.9 Glass Cladding Brackets: Quadroclad by Hunter Douglas, clear anodized.

2.3 **FABRICATION - GENERAL**

.1 Glass Lites: Annealed, tempered, laminated or heat strengthened and in thicknesses in accordance with requirements of glass manufacturer as substantiated by the glass manufacturer's stress analysis for each location required, unless otherwise indicated.

.1 Provide heat strengthened float glass in place of annealed glass where required to resist thermal stresses induced by differential shading of individual glass lites and to comply with glass design requirements.

.2 Provide fully tempered or laminated glass lites where safety glass is indicated or required.

.2 Accurately size glass to fit openings allowing edge and bite clearances complying with written instructions of product manufacturer and requirements of Glass Association of North America and to comply with system performance requirements.

.1 Cut glass clean and free of nicks and damaged edges. Do not cut or abrade tempered, heat treated, or coated glass.

.3 Butt Glazing: Clean cut edges of butt glazed monolithic lites in a manner that produces square edges with slight kerfs.

.1 Sealed Edges: Flat grind.

.2 Exposed Edges: Flat polished.

.4 Exposed Glass Edges and Corners: Grind smooth and polish.

.5 Glass Shelf: Grind arris to edges which will be unexposed in the finished work. Flat polish glass shelf edges which will be exposed in the finished work.

.6 Sandblast glass at depth recommended by the glass manufacturer and to patterns indicated. Do not weaken glass by sandblasting. Apply protective coating.

.7 Anti-Reflective Coating: Apply full coverage in accordance with manufacturer’s recommendations, free of pin holes and runs.

2.4 **FABRICATION – INSULATING GLASS UNITS**

.1 Insulating Glass Units: Factory assembled units consisting of sealed lites of minimum 1/4” thick glass separated by dehydrated interpane space filled with Krypton and atmospheric pressure equalized to prevent bowing of the glass lites in the vertical position. Edges of glass shall be straight cut, free of nicks and other imperfections conducive to breakage.

.2 Spacer Core: Set spacer core straight and even into glass units with a maximum variation in line of spacer core of plus or minus 0.080” and the primary seal not extend past the inside edge of spacer core by more than 0.060”. Weld or vulcanize spacer core corners and joints.

2.5 **GLASS AND GLAZING TYPES**

.1 GL-1: Single glazed 3/8” thick clear tempered glass.

.2 GL-2: Single glazed 1/2” thick clear tempered glass with sandblasting on one side.

.3 GL-3: 1/4” thick clear tempered glass with anti-reflective coating on one side.

.4 GL-4: Single glazed 1/2” thick clear laminated glass with 0.030” thick black interlayer laminate.

.5 GL-5: Uncoated Monolithic Cell-Cast Acrylic Sheet.

.6 GL-6: Double glazed insulating glass units, 1/4” thick outer lite of ultra-clear glass, 11/32” interpane space, coated solar film, 0.60” interpane space, coated solar film, 11/32” interpane space, 1/4” thick inner lite of clear glass with on No. 3 surface, Thermaproof 1100 Series by Series Materials.

3 Execution

3.1 **EXAMINATION**

.1 Examine framing glazing, with Installer present, for compliance with the following:

.1 Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.

.2 Presence and functioning of weep system.

.3 Minimum required face or edge clearances.

.4 Effective sealing between joints of glass-framing members.

.2 Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 **PREPARATION**

.1 Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.

3.3 **GLAZING - GENERAL**

.1 Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

.2 Glazing channel dimensions, as indicated on Drawings, provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances. Adjust as required by Project conditions during installation.

.3 Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass is glass with edge damage or other imperfections that, when installed, could weaken glass and impair performance and appearance.

.4 Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction sealant-substrate testing.

.5 Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.

.6 Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

.7 Provide spacers for glass lites where length plus width is larger than 50” as follows:

.1 Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.

.2 Provide 1/8” minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.

.8 Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.

.9 Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.

3.4 **TAPE GLAZING**

.1 Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.

.2 Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.

.3 Cover vertical framing joints by applying tapes to heads and sills first and then to jambs. Cover horizontal framing joints by applying tapes to jambs and then to heads and sills.

.4 Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.

.5 Do not remove release paper from tape until just before each glazing unit is installed.

.6 Apply heel bead of elastomeric sealant.

.7 Center glass lites in openings on setting blocks and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.

.8 Apply cap bead of elastomeric sealant over exposed edge of tape.

3.5 **GASKET GLAZING (DRY)**

.1 Fabricate compression gaskets in lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.

.2 Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.

.3 Center glass lites in openings on setting blocks and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

.4 Install gaskets so they protrude past face of glazing stops.

3.6 **LOCK-STRIP GASKET GLAZING**

.1 Comply with ASTM C716 and gasket manufacturer's written instructions. Provide supplementary wet seal and weep system, unless otherwise indicated.

3.7 **CLEANING AND PROTECTION**

.1 Protect exterior glass from damage immediately after installation by attaching crossed streamers to framing held away from glass. Do not apply markers to glass surface. Remove temporary labels, and clean surfaces.

.2 Protect glass from contact with contaminating substances resulting from construction operations, including weld splatter. If, despite such protection, contaminating substances do come into contact with glass, remove substances immediately as recommended by glass manufacturer.

.3 Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains; remove as recommended in writing by glass manufacturer.

.4 Remove and replace glass that is broken, chipped, cracked, or abraded or that is damaged from natural causes, accidents, and vandalism, during construction period.

.5 Wash glass on both exposed surfaces in each area of Project not more than four days before date scheduled for inspections that establish date of Substantial Performance. Wash glass as recommended in writing by glass manufacturer.

End of Section

1 General

1.1 **QUALITY ASSURANCE**

.1 Source Limitations: Obtain each type of product from a single manufacturer.

.2 Engineered Wood Flooring: Comply with ANSI/HPVA LF.

1.2 **SUBMITTALS**

.1 Product Data: For each type of product indicated.

.2 Shop Drawings: Show installation details including location and layout of each type of wood flooring and accessory.

.3 Maintenance Data: Include recommended methods and frequency of maintenance for maintaining optimum condition of work under anticipated usage and use conditions. Include precautions against using cleaning materials and methods that may be detrimental to finishes and performance. Include product data for maintenance products recommended by installer and names, addresses, and telephone numbers of local sources for products.

1.3 **PROJECT CONDITIONS**

.1 Conditioning: Maintain relative humidity planned for building occupants and an ambient temperature between 65 and 75 deg F in spaces to receive wood flooring for at least seven days before installation, during installation, and for at least seven days after installation. After post-installation period, maintain relative humidity and ambient temperature planned for building occupants.

.1 Do not install flooring until it adjusts to the relative humidity of and is at the same temperature as the space where it is to be installed.

.2 Close spaces to traffic during flooring installation and for time period after installation recommended in writing by flooring and finish manufacturers.

.2 Install factory finished wood flooring after other finishing operations, including painting, have been completed.

2 Products

2.1 **MATERIALS - GENERAL**

.1 Use wood products carrying a certification authorized under authority of the Forest Stewardship Council (FSC) and certified to meet FSC requirements as pertaining to certified sourcing, content and chain-of-custody.

.2 Use composite panels fabricated free of added urea-formaldehyde.

2.2 **MATERIALS – WOOD FLOORING**

.1 Engineered Wood Flooring: Three ply laminated construction, top layer of prefinished natural Maple, mid-layer of natural spruce softwood, bottom layer of spruce or pine softwood, Architectural Collection by Muskoka Flooring.

.2 Battens: 15 mm thick wood battens.

.3 Expansion Strips: Composite cork, complying with FS HH-C-576, Type I-B, Class 2.

.4 Phase Change Panels: 140 mm wide x 14 mm thick x longest permissible length, Delta Cool 24 by Dorken.

.5 Fasteners: As recommended by manufacturer, but not less than that recommended in NOFMA's Installing Hardwood Flooring.

.6 Wood Trim: In same species and grade as wood flooring, unless otherwise indicated.

.1 Wood Base: 5/8” thick by height as indicated.

.2 Base Shoe Moulding: 1/2” x 3/4”.

.3 Threshold: Tapered on each side and routed at bottom of one side to accommodate wood flooring.

.4 Reducer Strip: 2” wide, tapered on one side, and in thickness matching flooring.

.7 Wood Filler: Formulated to fill and repair seams, defects, and open-grain hardwood floors; compatible with finish system components and recommended by filler and finish manufacturers for use indicated. If required to match approved samples, provide pigmented filler.

3 Execution

3.1 **EXAMINATION**

.1 Examine substrates, areas, and conditions, for compliance with requirements, installation tolerances, and other conditions affecting performance of wood flooring. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 **INSTALLATION**

.1 General: Comply with flooring manufacturer's written instructions, but not less than recommendations in NOFMA's Installing Hardwood Flooring, as applicable to flooring type.

.2 Securely fasten battens at 16” centers on floor.

.3 Loose lay phase change panels between battens, full coverage.

.4 Blind nail engineered wood flooring perpendicular to battens, in pattern indicated on Drawings or, if not indicated, as directed by Architect.

.5 Provide expansion space at walls and other obstructions and terminations of flooring of not less than 1/2”, unless otherwise indicated on Drawings.

.1 Unless fully concealed by trim, fill expansion space with flush cork expansion strip.

.6 Accessories: Nail baseboard to wall and nail shoe molding or other trim to baseboard; do not nail to flooring.

3.3 **PROTECTION**

.1 Protect installed work from damage or deterioration during remainder of construction period.

End of Section

1 General

1.1 **SUMMARY**

.1 This Section includes surface preparation and field painting of exposed items and surfaces.

.1 Surface preparation, priming, and finish coats specified in this Section are in addition to shop priming and surface treatment specified in other Sections.

.2 Paint exposed surfaces, except where Contract Documents indicate that the surface or material is not to be painted or is to remain natural. If an item or a surface is not specifically mentioned, paint the item or surface the same as similar adjacent materials or surfaces. If a color of finish is not indicated, Architect will select from standard colors and finishes available.

.1 Painting includes field painting of exposed bare and covered pipes and ducts (including color coding), hangers, exposed steel and iron supports, and surfaces of mechanical and electrical equipment that do not have a factory-applied final finish.

.3 Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels.

.1 Labels: Do not paint over UL, FMG, or other code required labels or equipment name, identification, performance rating, or nomenclature plates.

1.2 **SUBMITTALS**

.1 Product Data: For each paint system indicated. Include block fillers and primers.

.1 Material List: An inclusive list of required coating materials. Indicate each material and cross-reference specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.

.2 Manufacturer's Information: Manufacturer's technical information, including label analysis and instructions for handling, storing, and applying each coating material.

.2 Samples for Confirmation: For each color and material to be applied, with texture to simulate actual conditions, on representative samples of the actual substrate.

.1 Provide stepped samples, defining each separate coat, including primers. Use representative colours when preparing Samples for review. Resubmit until required sheen, colour, and texture are achieved.

.2 Provide a list of materials and applications for each coat of each sample. Label each sample for location and application.

.3 Submit triplicate samples on the following substrates for Architect’s review of color and texture only:

.1 Painted Wood: 8” square samples for each color and material on hardboard.

.2 Stained or Natural Wood: 4” x 8” samples of natural or stained wood finish on representative surfaces.

.3 Ferrous Metal: 4” square samples of flat metal and 8” long samples of metal for each color and finish.

1.3 **QUALITY ASSURANCE**

.1 Applicator Qualifications: A firm or individual experienced in applying paints and coatings similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

.2 Source Limitations: Obtain primers for each coating system from the same manufacturer as the finish coats.

1.4 **DELIVERY, STORAGE, AND HANDLING**

.1 Deliver materials to Project site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label and the following information:

.1 Product name or title of material.

.2 Product description (generic classification or binder type).

.3 Manufacturer's stock number and date of manufacture.

.4 Contents by volume, for pigment and vehicle constituents.

.5 Thinning instructions.

.6 Application instructions.

.7 Color name and number.

.8 VOC content.

.2 Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45 deg F. Maintain storage containers in a clean condition, free of foreign materials and residue.

.1 Protect from freezing. Keep storage area neat and orderly. Remove oily rags and waste daily.

1.5 **PROJECT CONDITIONS**

.1 Apply waterborne paints only when temperatures of surfaces to be painted and surrounding air are between 50 and 90 deg F.

.2 Do not apply paint in snow, rain, fog, or mist; or when relative humidity exceeds 85 percent; or at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

.1 Painting may continue during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature limits specified by manufacturer during application and drying periods.

2 Products

2.1 **MATERIALS**

.1 Proprietary Names: Use of manufacturer's proprietary product names to designate colors or materials is not intended to imply that products named are required to be used to the

exclusion of equivalent products of other manufacturers. Furnish manufacturer's material data and certificates of performance for proposed substitutions.

.2 Material Compatibility: Provide primers, and finish coat materials that are compatible with one another and with the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.

.3 Maximum VOC less water, tested to EPA Method 24:

.1 Primer and Undercoat: 100 g/L.

.2 Interior Paints, Top Coat:

.1 Flat: 50 g/L.

.2 Non-Flat: g/L.

.3 Exterior Paints, Top Coat:

.1 Flat: 100 g/L.

.2 Non-Flat: 200 g/L.

.4 Anti-Corrosion Paints: 250 g/L.

.5 Floor Coating: 100 g/L.

.4 Material Quality: Provide manufacturer's best quality paint material of the various coating types specified that are factory formulated and recommended by manufacturer for application indicated. Paint-material containers not displaying manufacturer's product identification will not be acceptable.

.1 Provide materials having good flowing and brushing properties and capable to dry or cure free of blemishes, sags, air entrapment.

.2 Where required, paints and coatings shall meet flame spread and smoke developed ratings to code requirements and authorities having jurisdiction.

2.2 FINISH AND COLOURS

.1 Paint Gloss: Defined as the gloss and sheen ratings of applied paint, in accordance with the following values:

Description	Gloss Units@ 60 Degrees	Sheen Units@ 85 Degrees
Matte or Flat Finish		Max. 15
Eggshell Finish	20 to 35	Min. 35
Semi-Gloss Finish	35 to 70	

.2 Colours:

.1 PT-1: Automotive opaque white lacquer, white, semi-gloss.

.2 PT-3: Moisture resistant lacquer, matt finish.

.3 PT-4: Marine coating.

.4 PT-5: Penofin Verde.

.5 PT-6: White, matt.

.3 Access doors, prime coated butts and other prime painted hardware, registers, radiators and covers, exposed piping and electrical panels: To match adjacent surfaces, unless otherwise noted or where pre-finished.

3 Execution

3.1 **EXAMINATION**

.1 Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for paint application.

.1 Proceed with paint application only after unsatisfactory conditions have been corrected and surfaces receiving paint are thoroughly dry.

.2 Start of painting will be construed as applicator's acceptance of surfaces and conditions within a particular area.

.2 Coordination of Work: Review other Sections in which primers are provided to ensure compatibility of the total system for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.

.1 Notify Architect about anticipated problems when using the materials specified over substrates primed by others.

3.2 **PREPARATION**

.1 General: Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of size or weight of the item, provide surface-applied protection before surface preparation and painting.

.1 After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.

.2 Cleaning: Before applying paint or other surface treatments, clean substrates of substances that could impair bond of the various coatings. Remove oil and grease before cleaning.

.1 Schedule cleaning and painting so dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.

.3 Surface Preparation: Clean and prepare surfaces to be painted in accordance with manufacturer's written instructions for each particular substrate condition and as specified.

.1 Cementitious Materials: Remove efflorescence, chalk, dust, dirt, grease, oils, and release agents. Roughen as required to remove glaze. If hardeners or sealers have been used to improve curing, use mechanical methods of surface preparation.

.1 Use abrasive blast-cleaning methods if recommended by paint manufacturer.

.2 Determine alkalinity and moisture content of surfaces by performing appropriate tests. If surfaces are sufficiently alkaline to cause the finish paint to blister and burn, correct this condition before application. Do not paint surfaces if moisture content exceeds that permitted in manufacturer's written instructions.

.2 Wood: Clean surfaces of dirt, oil, and other foreign substances with scrapers, mineral spirits, and sandpaper, as required. Sand surfaces exposed to view smooth and dust off.

.1 Scrape and clean small, dry, seasoned knots, and apply a thin coat of white shellac or other recommended knot sealer before applying primer. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood filler. Sand smooth when dried.

.2 Prime, stain, or seal wood to be painted immediately on delivery. Prime edges, ends, faces, undersides, and back sides of wood, including cabinets, counters, cases, and paneling.

.3 If transparent finish is required, backprime with spar varnish.

.4 Backprime paneling on interior partitions where masonry, plaster, or other wet wall construction occurs on back side.

.5 Seal tops, bottoms, and cutouts of unprimed wood doors with a heavy coat of varnish or sealer immediately on delivery.

.3 Ferrous Metals: Clean ungalvanized ferrous metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with SSPC's recommendations.

.1 Blast steel surfaces clean as recommended by paint system manufacturer and in accordance with SSPC-SP 6/NACE No. 3.

.2 Treat bare and sandblasted or pickled clean metal with a metal treatment wash coat before priming.

.3 Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by paint manufacturer, and touch up with same primer as the shop coat.

.4 Galvanized Surfaces: Clean galvanized surfaces with nonpetroleum-based solvents so surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.

.4 Material Preparation: Mix and prepare paint materials according to manufacturer's written instructions.

.1 Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.

.2 Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.

.3 Use only thinners approved by paint manufacturer and only within recommended limits.

.5 Tinting: Tint each undercoat a lighter shade to simplify identification of each coat when multiple coats of same material are applied. Tint undercoats to match the color of the finish coat, but provide sufficient differences in shade of undercoats to distinguish each separate coat.

3.3 **APPLICATION**

.1 General: Apply paint according to manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.

.1 Paint colors, surface treatments, and finishes are indicated in the paint schedules.

.2 Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.

.3 Provide finish coats that are compatible with primers used.

.4 The term "exposed surfaces" includes areas visible when permanent or built-in fixtures, grilles, convector covers, covers for finned-tube radiation, and similar components are in place. Extend coatings in these areas, as required, to maintain system integrity and provide desired protection.

.5 Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only.

.6 Paint interior surfaces of ducts with a flat, nonspecular black paint where visible through registers or grilles.

.7 Paint back sides of access panels and removable or hinged covers to match exposed surfaces.

.8 Finish exterior doors on tops, bottoms, and side edges the same as exterior faces.

.9 Finish interior of wall and base cabinets and similar field-finished casework to match exterior.

.10 Sand lightly between each succeeding enamel or varnish coat.

.2 Scheduling Painting: Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.

.1 The number of coats and film thickness required are the same regardless of application method. Do not apply succeeding coats until previous coat has cured as recommended by manufacturer. If sanding is required to produce a smooth, even surface according to manufacturer's written instructions, sand between applications.

.2 Omit primer over metal surfaces that have been shop primed and touchup painted.

.3 If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance. Give special attention to ensure that edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.

.4 Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until paint has dried to where it feels firm, and does not deform or feel sticky under moderate thumb pressure, and until application of another coat of paint does not cause undercoat to lift or lose adhesion.

.3 Application Procedures: Apply paints and coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.

.1 Brushes: Use brushes best suited for type of material applied. Use brush of appropriate size for surface or item being painted.

.2 Rollers: Use rollers of carpet, velvet-back, or high-pile sheep's wool as recommended by manufacturer for material and texture required.

.3 Spray Equipment: Use airless spray equipment with orifice size as recommended by manufacturer for material and texture required.

.4 Minimum Coating Thickness: Apply paint materials no thinner than manufacturer's recommended spreading rate to achieve dry film thickness indicated. Provide total dry film thickness of the entire system as recommended by manufacturer.

.5 Prime Coats: Before applying finish coats, apply a prime coat, as recommended by manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn-through or other defects due to insufficient sealing.

.6 Pigmented (Opaque) Finishes: Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.

.7 Transparent (Clear) Finishes: Use multiple coats to produce a glass-smooth surface film of even luster. Provide a finish free of laps, runs, cloudiness, color irregularity, brush marks, orange peel, nail holes, or other surface imperfections.

.1 Provide satin finish for final coats.

.8 Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not complying with requirements.

3.4 CLEANING

.1 Cleanup: At the end of each workday, remove empty cans, rags, rubbish, and other discarded paint materials from Project site.

.1 After completing painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping without scratching or damaging adjacent finished surfaces.

3.5 PROTECTION

.1 Protect work of other trades, whether being painted or not, against damage from painting. Correct damage by cleaning, repairing or replacing, and repainting, as approved by Architect.

.2 Provide "Wet Paint" signs to protect newly painted finishes. After completing painting operations, remove temporary protective wrappings provided by others to protect their work.

.1 After work of other Section is complete, touch up and restore damaged or defaced painted surfaces.

3.6 EXTERIOR PAINT SCHEDULE

.1 Smooth Wood: Provide the following finish systems over smooth wood siding, wood trim, and other smooth exterior wood surfaces:

.1 Flat Acrylic Finish: Two finish coats over a primer.

.1 Primer: Exterior wood primer for acrylic enamels.

.2 Finish Coats: Exterior flat acrylic paint.

.2 Wood Trim: Provide the following finish systems over exterior wood trim:

.1 Semi-gloss Acrylic-Enamel Finish: Two finish coats over a primer.

.1 Primer: Exterior wood primer for acrylic enamels.

.2 Finish Coats: Exterior semigloss acrylic enamel.

.3 Plywood: Provide the following finish systems over exterior plywood:

.1 Flat Acrylic Finish: Two finish coats over a primer.

.1 Primer: Exterior wood primer for acrylic enamels.

.2 Finish Coats: Exterior flat acrylic paint.

.4 Ferrous Metal: Provide the following finish systems over exterior ferrous metal. Primer is not required on shop-primed items.

.1 Semi Gloss Acrylic Enamel Finish: Two Finish coats over a rust-inhibitive primer.

.1 Primer: Exterior ferrous-metal primer.

.2 Finish Coats: Exterior high gloss acrylic enamel for ferrous and other metals.

.5 Zinc-Coated Metal: Provide the following finish systems over exterior zinc-coated metal surfaces:

.1 Semi Gloss Acrylic Enamel Finish: Two finish coats over a galvanized metal primer.

.1 Primer: Exterior galvanized metal primer.

.2 Finish Coats: Exterior high gloss acrylic enamel for ferrous and other metals.

3.7 **INTERIOR PAINT SCHEDULE**

.1 Wood and Hardboard: Provide the following paint finish systems over new interior wood surfaces:

.1 Semigloss Acrylic-Enamel Finish: **Two finish coats** over a wood undercoater.

.1 Primer: Interior wood primer for acrylic-enamel and semigloss alkyd-enamel finishes.

.2 Finish Coats: Interior semigloss acrylic enamel.

.2 Ferrous Metal: Provide the following finish systems over ferrous metal:

.1 Semi Gloss Acrylic Enamel Finish: Two finish coats over a primer.

.1 Primer: Interior ferrous-metal primer.

.2 Finish Coats: Interior semi gloss acrylic enamel.

.3 Zinc-Coated Metal: Provide the following finish systems over interior zinc-coated metal surfaces:

.1 Semi Gloss Acrylic Enamel Finish: Two finish coats over a primer.

.1 Primer: Interior zinc-coated metal primer.

.2 Finish Coats: Interior semi gloss acrylic enamel.

3.8 **INTERIOR STAIN AND NATURAL-FINISH WOODWORK SCHEDULE**

.1 Stained Woodwork: Provide the following stained finishes over new interior woodwork:

.1 Waterborne Stain Satin Varnish Finish: Two finish coats of waterborne clear satin varnish over a sealer coat and waterborne interior wood stain. Wipe wood filler before applying stain.

.2 Natural-Finish Woodwork: Provide the following natural finishes over new interior woodwork:

.1 Waterborne Satin Varnish Finish: Two finish coats of waterborne clear satin varnish over a sanding sealer. Wipe wood filler before applying stain.

.1 Filler Coat: Open-grain wood filler.

.2 Sealer Coat: Clear sanding sealer.

.3 Finish Coats: Interior waterborne clear satin varnish.

End of Section

1 General

1.1 **QUALITY ASSURANCE**

.1 Fire Performance Characteristics: Fire performance characteristics as determined by testing identical products in accordance with test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:

.1 Flame-Resistance Ratings: Passes NFPA 701.

.2 Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

.3 Maximum Light Blocking Blinds: Designed for eliminating all visible light gaps if slats are tilted closed; with tight tape properly spaced and slats with minimal sized rout holes for ladders hidden and placed near back edge for maximum slat overlap; with headrail and bottom rail extended and formed for light-tight joints between rail and adjacent slats or construction.

1.2 **SUBMITTAL**

.1 Submit duplicate samples of the key components of the specified specialty venetian blind system with the specified finish. Minimum size 12” for review

.2 Submit duplicate samples of the specified sections of headrail, bottom rail, brackets / attachment methods and side guide wires / channels for review

.3 Electric venetian blind motors and all electronic control equipment supplied by this section shall comply with CSA/UR and ULC/UL standards. Copies of compliance available for submission upon request.

.4 Shop Drawings: Show location and extent of horizontal louver blinds. Include elevations, sections, details, and dimensions not shown in Product Data. Show installation details, mountings, attachments to other Work, operational clearances, and relationship to adjoining work.

.1 Motorized Blind Operators: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.

.2 Wiring Diagrams: Power, system, and control wiring.

.5 Maintenance Data: For horizontal louver blinds to include in maintenance manuals. Include the following:

.1 Methods for maintaining horizontal louver blinds and finishes.

.2 Precautions about cleaning materials and methods that could be detrimental to finishes and performance.

.3 Operating hardware.

.4 Motorized blind operator.

2 Products

2.1 **MATERIALS**

.1 Headrail: Extruded aluminum, alloy 6063-T6, 2-1/2" x 2", open on the underside to give access to the gearbox and to the tilt shaft and tape spools for maintenance as required, complete with 2 slat infill pieces to close off the bottom off the headrail when the blind is installed.

.2 Slats: 4" wide, 0.4 to 0.5 mm thick aluminum, double stove enamel finish.

.3 Slat Support: Colour to match or blend with blind colour.

.1 Lifting Tape: Flame resistant polyester, tear resistant, 3/8" wide.

.2 Ladder Tape: Flame resistant polyester with cross webs positively attached to slats, maximum 24" spacing between ladders.

.4 Bottom Rail: Prefinished, extruded aluminum with aluminum end pieces.

.5 Side Guides: PVC coated stainless steel wires 3 x 4mm diameter stainless steel cables, held by an extruded aluminum housing or a special clamping bolt.

.6 Operators: Totally enclosed in a suitable NEMA enclosure, 110V - 60 Hz, asynchronous, reversible, thermally protected, automatic shut off, totally enclosed and concealed in the headrail, plenum rated motro lead. Provide maintenance free locking disconnect plug assembly with each operator.

.1 Motor speed: 20 to 35 RPM.

.2 Limit Switch: Externally located limit switches for exact control of blind travel, complete with safety cut off switch in case upper limit fails.

.7 Control Stations: Combination maintained-momentary-contact, five-position, rocker-style, wall-switch-operated control station with open, close, tilt forward, tilt backward, and center off functions.

.1 Sun Sensor Controls: Adjustable system consisting of LEDs detecting sun intensity and responding by automatically adjusting blinds.

.8 Head Box: Manufactured from aluminum sheet to protect blinds in the raised position.

.9 Fabric Veil: Aluminium wire woven into 14 x 18 or 16 x 18 mesh screen cloth complete with custom fabricated fastening clips.

2.2 FABRICATION

.1 Fabricate blind system components for custom installation to suit project requirements

.2 Finished Assemblies: Square, true to size and free from twist or other defects that could affect their strength or appearance.

2.3 FINISHES

.1 Factory applied finish for an uniform, smooth and blemish-free work.

.2 Exposed Metal Finish: Chromatized or equivalent to provide maximum bond between metal and finish and capable of withstanding a 5% salt spray solution at 32 degree C for 100 hours without blistering, corroding, chalking, changing colour and without loss of gloss or adhesion after a recovery period of 30 minutes. Finish longitudinal edges the same as faces. Polyester powder coating, standard colour.

.3 Unexposed Aluminum Finish: Mill finish.

.4 Steel Components: Hot dip galvanized or zinc plated.

3 Execution

3.1 **INSTALLATION**

.1 Securely install work in accordance with manufacturer's instructions, accurately aligned, free of sag, in uniform clearances, in true and flat planes.

.2 Coordinate installation and fastenings with building wall panel and window Sections, and Sections providing adjacent finishes.

3.2 **ADJUSTMENT AND CLEANING**

.1 Adjust work for smooth operation and correct alignment.

End of Section

1 General

1.1 **QUALITY ASSURANCE**

.1 Source Limitations: Obtain each type of product from a single manufacturer.

.2 Fire Performance Characteristics: Provide work with fire performance characteristics required by authority having jurisdiction, and determined by testing performed by testing agency acceptable to authorities having jurisdiction.

.1 Fire Resistance: Comply with NFPA 701.

.3 Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 **SUBMITTALS**

.1 Product Data: For each type of product indicated. Include styles, material descriptions, construction details, dimensions of individual components and profiles, features, finishes, and operating instructions.

.1 Motors: Show nameplate data, ratings, characteristics, and mounting arrangements.

.2 Shop Drawings: Show location and extent of roller shades. Include elevations, sections, details, and dimensions not shown in Product Data. Show installation details, mountings, attachments to work of other Sections, operational clearances, and relationship to adjoining work.

.1 Motorized Shade Operators: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.

.2 Wiring Diagrams: Power, system, and control wiring.

.3 Maintenance Data: For roller shades to include in maintenance manuals. Include the following:

.1 Methods for maintaining roller shades and finishes.

.2 Precautions about cleaning materials and methods that could be detrimental to fabrics, finishes, and performance.

.3 Operating hardware.

.4 Motorized shade operator.

1.3 **DELIVERY, STORAGE, AND HANDLING**

.1 Deliver shades in factory packages, marked with manufacturer and product name, fire test response characteristics, and location of installation using same room designations indicated on Drawings and in a window treatment schedule.

1.4 **PROJECT CONDITIONS**

.1 Environmental Limitations: Do not install work until construction and wet and dirty finish work in spaces, including painting, is complete and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

2 Products

2.1 **MATERIALS**

.1 Rollers: Extruded aluminium tube of diameter and wall thickness required to support and fit internal components of operating system and the weight and width of shade band material without sagging; designed to be easily removable from support brackets.

.1 Flexshade by Draper Inc.

.2 Mounting Brackets: Fascia end caps, fabricated from steel finished to match fascia or headbox.

.3 Fascia: L-shaped, extruded aluminium; long edges returned or rolled; continuous panel concealing front and bottom of shade roller, brackets, and operating hardware and operators, removable design for access.

.4 Top and Back Cover: L shaped; material and finish to match fascia; combining with fascia and end caps to form a six-sided headbox enclosure sized to fit shade roller and operating hardware inside.

.5 Shade Band, Sun Control Fabric: Duplex twill, light outer panel color, dark interior color, heat seal, non-ravelling, flame resistant to NFPA 701, washable, woven from 0.026” thick 14.1 oz/sq.yd. yarn, 10% open, GreenGuard certified, SW2710 P28 by Phifer.

.6 Bottom Bar: Steel or extruded aluminium, with plastic or metal capped ends, with concealed weight bar as required for smooth, properly balanced shade operation.

.7 Removable and replaceable shade and spline assembly without disassembling the hardware.

.8 Mounting shall permit free flow of air over top of shade with a minimum of 12 sq.in./lin.ft.

2.2 **MOTORIZED ROLLER SHADE OPERATORS**

.1 General: Factory assembled motorized shade operation systems designed for lifting shades of type, size, weight, construction, use, and with features, characteristics, and accessories suitable for Project conditions and recommended by shade manufacturer, complete with electric motors and factory prewired motor controls, remote control stations, power disconnect switches, enclosures protecting controls and all operating parts, and accessories required for reliable operation without malfunction. Include wiring from motor controls to motors. Coordinate operator wiring requirements and electrical characteristics with the building electrical system.

.1 Include back-up gear and crank operator for manual operation during power failures with detachable handle, length required to make operation convenient from floor level.

.2 Electric Motors: Asynchronous, totally enclosed, insulated, capacitor start motors, complying with NEMA MG 1, with thermal overload protection, brake, permanently lubricated bearings, and limit switches; sized by shade manufacturer to start and operate size and weight of shade considering service factor or considering Project's service conditions without exceeding nameplate ratings.

.1 Motor Mounting: Within manufacturer's standard roller enclosure.

.3 Radio Controls: Digital system consisting of code compatible universal coaxial receiver, portable multiple channel transmitters for operating groups of shades on each building elevation individually, each with a single button to open, close, stop and hold shades at any position.

.4 Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop shade at fully raised and fully lowered positions.

2.3 **FABRICATION**

.1 Concealed Components: Noncorrodible or corrosion resistant coated materials.

.1 Lifting Mechanism: With permanently lubricated moving parts.

.2 Installation Brackets: Designed for easy removal and reinstallation of shade, for supporting fascia, headbox, roller, and operating hardware and for hardware position and shade mounting method indicated.

.3 Installation Fasteners: Not fewer than two fasteners per bracket, fabricated from metal noncorrosive to shade hardware and adjoining construction; type designed for securing to supporting substrate; and supporting shades and accessories under conditions of normal use.

.4 Steel Components: Manufacturer's standard baked finish, complying with manufacturer's written instructions for surface preparation including pretreatment, application, baking, and minimum dry film thickness.

.5 Aluminium Components: Clear Anodized.

3 **Execution**

3.1 **EXAMINATION**

.1 Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, operational clearances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 **INSTALLATION**

.1 Install roller shades level, plumb, square, and true according to manufacturer's written instructions, and located so shade band is not closer than 2” to interior face of glass. Allow clearances for window operation hardware.

.2 Connections: Connect motorized operators to building electrical system.

.3 Set shade control system such that each group of shade travels at exact timing and distance.

3.3 **ADJUSTING**

.1 Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.

End of Section

PART 1 GENERAL

1.1 SUBMITTALS

.1 Shop drawings; submit drawings stamped and signed for approval by Owner's Representative.

.2 Shop drawings to show:

.1 Mounting arrangements.
.2 Operating and maintenance clearances.

.3 Shop drawings and product data accompanied by:

.1 Detailed drawings of bases, supports, and anchor bolts.
.2 Acoustical sound power data, where applicable.
.3 Points of operation on performance curves.
.4 Manufacturer to certify current model production.
.5 Certification of compliance to applicable codes.

1.2 MAINTENANCE

.1 Furnish spare parts as follows:

.1 One set of packing for each pump.
.2 One casing joint gasket for each size pump.
.3 One glass for each gauge glass.

.2 Provide one set of special tools required to service equipment as recommended by manufacturers.

.3 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

1.3 DELIVERY, STORAGE, AND HANDLING

.1 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

PART 2 PRODUCTS

2.1 MATERIALS

.1 All materials used on this project shall be new and CSA approved unless noted otherwise.

PART 3 EXECUTION

3.1 PAINTING, REPAIRS AND RESTORATION

.1 Prime and touch up marred finished paintwork to match original.

.2 Restore to new condition, finishes which have been damaged.

3.2 CLEANING

.1 Clean interior and exterior of all systems including strainers. Vacuum interior of ductwork and air handling units.

3.3 FIELD QUALITY CONTROL

.1 Site Tests: conduct following tests and submit report.

.1 Perform tests as specified in other sections of this specification.

3.4 DEMONSTRATION

.1 Consultant will use equipment and systems for test purposes prior to acceptance. Contractor to supply labour, material, and instruments required for testing.

.2 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.

.3 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.

.4 Instruction duration time requirements as specified in appropriate sections.

.5 Consultant may record these demonstrations on video tape for future reference.

3.5 PROTECTION

.1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 Materials and installation for plumbing pumps.

1.2 REFERENCES

.1 Solar Decathlon Building Code (SDC)

.1 SDC Section 9, Plumbing

.2 International Residential Code (IRC)

.1 IRC Section 603, Plumbing Wall
.2 IRC Section P2802, Shower Valves
.3 IRC Section P2902, Backflow Prevention

.3 Team North Solar Decathlon Health and Safety Plan

.1 As approved by the US Department of Energy

.4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS)

1.3 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and data sheet for fixtures and equipment.
.2 Submit WHMIS MSDS. Indicate VOC's for adhesive and solvents during application and curing.

.2 Shop Drawings:

.1 Submit shop drawings to indicate:
.1 Equipment, including connections, fittings, control assemblies and ancillaries. Identify whether factory or field assembled.
.2 Wiring and schematic diagrams.
.3 Dimensions and recommended installation.
.4 Pump performance and efficiency curves.

.3 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.4 Instructions: submit manufacturer's installation instructions.

.5 Manufacturers' Field Reports: manufacturers' field reports specified.

1.4 QUALITY ASSURANCE

.1 Pre-Installation Meeting:

.1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installation.

.1 Verify project requirements.

.2 Review installation and substrate conditions.

.3 Co-ordination with other building subtrades.

.4 Review manufacturer's installation instructions and warranty requirements.

1.5 DELIVERY, STORAGE AND HANDLING

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling.

.4 Divert unused metal materials from landfill to metal recycling facility as approved by Consultant.

.5 Unused sealant materials must not be disposed of into sewer system, into streams, lakes, onto ground or in other location where it will pose health or environmental hazard.

.6 Fold up metal and plastic banding, flatten and place in designated area for recycling.

PART 2 PRODUCTS

2.1 DOMESTIC AND SOLAR PUMPS

.1 See Plumbing Equipment Schedule P-611 for details

.2 Construction: closed-coupled, in-line centrifugal, all bronze or stainless steel, construction, stainless steel shaft, stainless steel or bronze shaft sleeve, two oil lubricated bronze sleeves or ball bearings. Design for 860 kPa wp and 105□C continuous service.

.3 Motor: drip proof, with thermal overload protection.

.4 Supports: provide as recommended by manufacturer.

.5 Acceptable Product: Grundfoss for Domestic Pump, Monarch for High Pressure Tank, Myers for Effluent Tank Pump, Viessmann and Wilo for Solar Thermal Pump or approved equal by Consultant.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and data sheet.

3.2 INSTALLATION

.1 Make piping and electrical connections to pump and motor assembly and controls as indicated.

.2 Ensure pump and motor assembly do not support piping.

.3 Align vertical pit mounted pump assembly after mounting and securing cover plate.

3.3 FIELD QUALITY CONTROL

.1 Check power supply.

.2 Check starter protective devices.

.3 Start-up, check for proper and safe operation.

.4 Check settings and operation of hand-off-auto selector switch, operating, safety and limit controls, audible and visual alarms, over-temperature and other protective devices.

.5 Adjust flow from water-cooled bearings.

.6 Adjust impeller shaft stuffing boxes, packing glands.

3.4 START-UP

.1 General:

.1 Procedures:

.1 Check power supply.

.2 Check starter O/L heater sizes.

.3 Start pumps, check impeller rotation.

.4 Check for safe and proper operation.

.5 Check settings, operation of operating, limit, safety controls, over-temperature, audible/visual alarms, other protective devices.

.6 Test operation of HOA switch.

.7 Test operation of alternator.

.8 Adjust leakage through water-cooled bearings.

.9 Adjust shaft stuffing boxes.

.10 Adjust leakage flow rate from pump shaft stuffing boxes to manufacturer's recommendations.

.11 Check base for free-floating, no obstructions under base.

.12 Run-in pumps for 12 continuous hours.

.13 Check installation, operation of mechanical seals, packing gland type seals. Adjust as necessary.

.14 Adjust alignment of piping and conduit to ensure full flexibility at all times.

.15 Eliminate causes of cavitations, flashing, air entrainment.

.16 Measure pressure drop across strainer when clean and with flow rates as finally set.

.17 Replace seals if pump used to degrease system or if pump used for temporary heat.

.18 Verify lubricating oil levels.

3.5 DOMESTIC HW CIRCULATING PUMPS

.1 Balance flows using circuit setter balancing valve.

3.6 PERFORMANCE VERIFICATION (PV)

.1 Obtain manufacturer's approval, before performing PV, to ensure warranties remain intact.

.2 Application tolerances:

.1 Flow: +/- 10%.

.2 Pressure: Plus 20%, minus 5%.

.3 PV procedures:

.1 Open pump balancing valve fully.

.2 Measure differential pressure (DP) across pump.

.3 Measure amperage and voltage and compare with manufacturer's data sheets and motor nameplate data.

.4 If suction is different size than discharge connection, add velocity head correction factor to DP.

.5 Mark this DP on manufacturer's pump curve.

.6 If flow rate is higher than specified, slow close balancing valve until specified DP is reached.

.7 Repeat measurements of amps and volts. Compare with manufacturer's data sheets.

.8 Calculate BHP and compare with nameplate data.

END OF SECTION

Part 1 GENERAL

1.1 REFERENCES

.1 Solar Decathlon Building Code (SDBC)

.1 SDBC Section 9, Plumbing

.2 American National Standards Institute (ANSI)/American Society of Mechanical Engineers International (ASME).

.1 ANSI/ASME B16.15, Cast Bronze Threaded Fittings, Classes 125 and 250.

.2 ANSI/ASME B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.

.3 ANSI/ASME B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

.4 ANSI/ASME B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500.

.3 American Society for Testing and Materials International (ASTM).

.1 ASTM A 307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

.2 ASTM B 88M, Standard Specification for Seamless Copper Water Tube (Metric).

.3 ASTM F 492, Standard Specification for Propylene and Polypropylene (PP) Plastic-Lined Ferrous Metal Pipe Fittings.

.4 American Water Works Association (AWWA).

.1 AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

.5 Canadian Standards Association (CSA International).

.1 CSA B242, Groove and Shoulder Type Mechanical Pipe Couplings.

.6 Department of Justice Canada (Jus).

.1 Canadian Environmental Protection Act (CEPA).

.7 Health Canada/Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

.8 Solar Decathlon Health and Safety Plan

.1 Team North Health and Safety Plan as approved by the U.S. Department of Energy.

.9 Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS).

.1 MSS-SP-67, Butterfly Valves.

.2 MSS-SP-70, Cast Iron Gate Valves, Flanged and Threaded Ends.

.3 MSS-SP-71, Cast Iron Swing Check Valves, Flanged and Threaded Ends.

.4 MSS-SP-80, Bronze Gate, Globe, Angle and Check Valves.

.10 National Research Council (NRC)/Institute for Research in Construction.

.1 NRCC 38728, National Plumbing Code of Canada (NPC).

.11 Transport Canada (TC).

.1 Transportation of Dangerous Goods Act (TDGA).

1.2 SUBMITTALS

.1 Submit product data for following: valves.

.2 Submit WHMIS MSDS - Material Safety Data Sheets.

1.3 WASTE MANAGEMENT AND DISPOSAL

.1 Separate waste materials for reuse and recycling.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Separate for reuse and recycling and place in designated containers Steel, Metal, Plastic waste.

.4 Place materials defined as hazardous or toxic in designated containers.

.5 Handle and dispose of hazardous materials in accordance with CEPA, TDGA , Regional and Municipal regulations.

.6 Fold up metal banding, flatten and place in designated area for recycling.

PART 2 <u>PRODUCTS</u>

2.1 PIPING

.1 Domestic hot, cold and recirculation systems, within building.

.1 Above ground: copper tube, hard drawn, type L: to ASTM B88M.

.2 Buried or embedded: copper tube, soft annealed, type K: to ASTM B88M, in long lengths and with no buried joints.

2.2 FITTINGS

.1 Bronze pipe flanges and flanged fittings, Class 150 and 300: to ANSI/ASME B16.24.

.2 Cast bronze threaded fittings, Class 125 and 250: to ANSI/ASME B16.15.

.3 Cast copper, solder type: to ANSI/ASME B16.18.

.4 Wrought copper and copper alloy, solder type: to ANSI/ASME B16.22.

.5 NPS2 and larger: roll grooved to CSA B242.

2.3 JOINTS

.1 Rubber gaskets, latex-free, 1.6 mm thick: to ANSI/AWWA C111.

.2 Bolts, nuts, hex head and washers: to ASTM A307, heavy series.

.3 Solder: 95/5 tin copper alloy lead free.

.4 Teflon tape: for threaded joints.

.5 Grooved couplings: designed with angle bolt pads to provide rigid joint, complete with EPDM flush seal gasket.

.6 Dielectric connections between dissimilar metals: dielectric fitting to ASTM F492, complete with thermoplastic liner.

2.4 VALVES

.1 See Plumbing Equipment Schedule – Part B for Plumbing Valve Schedule.

.1 Approved Manufacturers; Belimo – Three Way Solenoid Valve; Alco Controls – Electrical Control Expansion Valve, Sparco – Anti-Scald Mixing Valve.

PART 3 EXECUTION

3.1 INSTALLATION

.1 Install in accordance with Canadian Plumbing Code and local authority having jurisdiction.

.2 Install pipe work by certified journeyperson supplemented as specified herein.

.3 Assemble piping using fittings manufactured to ANSI standards.

.4 Install CWS piping below and away from HWS and HWR and other hot piping so as to maintain temperature of cold water as low as possible.

.5 Connect to fixtures and equipment in accordance with manufacturer's written instructions unless otherwise indicated.

3.2 VALVES

.1 Isolate equipment, fixtures and branches with butterfly or ball valves.

.2 Balance recirculation system using lockshield globe valves. Mark settings and record on as-built drawings on completion.

3.3 PRESSURE TESTS

.1 Conform to requirements of Section 21 05 00 - Common Work Results-Mechanical.

.2 Test pressure: greater of 1 ½ times maximum system operating pressure or 860 kPa.

3.4 FLUSHING AND CLEANING

.1 Flush entire system for 8 h. Ensure outlets flushed for 2 h. Let stand for 24 h, then draw one sample off longest run. Submit to testing laboratory for bacteriological testing to verify that system is clean to Provincial potable water guidelines. Let system flush for additional 2 h, then draw off another sample for testing.

3.5 PRE-START-UP INSPECTIONS

.1 Systems to be complete, prior to flushing, testing and start-up.

.2 Verify that system can be completely drained.

.3 Ensure that pressure booster systems are operating properly.

.4 Ensure that air chambers, expansion compensators are installed properly.

3.6 DISINFECTION

.1 Flush out, disinfect and rinse system to requirements of authority having jurisdiction and approval of Consultant.

3.7 START-UP

.1 Timing: Start up after:

- .1 Pressure tests have been completed.
- .2 Disinfection procedures have been completed.
- .3 Water treatment systems operational.

.2 Provide continuous supervision during start-up.

.3 Start-up procedures:

- .1 Establish circulation and ensure that air is eliminated.
- .2 Check pressurization to ensure proper operation and to prevent water hammer, flashing and/or cavitation.
- .3 Bring HWS storage tank up to design temperature slowly.
- .4 Monitor HWS and HWR piping systems for freedom of movement, pipe expansion as designed.
- .5 Check control, limit, safety devices for normal and safe operation.

.4 Rectify start-up deficiencies.

3.8 PERFORMANCE VERIFICATION

.1 Timing:

- .1 After pressure and leakage tests and disinfection completed, and certificate of completion has been issued by authority having jurisdiction.

.2 Procedures:

- .1 Verify that flow rate and pressure meet Design Criteria.

.2 TAB HWR in accordance with Section 23 05 93 - Testing Adjusting and Balancing for HVAC.

.3 Adjust pressure regulating valves while withdrawal is maximum and inlet pressure is minimum.

.4 Sterilize HWS and HWR systems for Legionella control.

.5 Verify performance of temperature controls.

.6 Verify compliance with safety and health requirements.

.7 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut off water immediately. If water hammer occurs, replace water hammer arrestor or re-charge air chambers. Repeat for outlets and flush valves.

.8 Confirm water quality consistent with supply standards, verifying that no residuals remain as a result of flushing and/or cleaning.

.3 Reports:

.1 Include certificate of water flow and pressure tests conducted on incoming water service, demonstrating adequacy of flow and pressure.

END OF SECTION

Part 1 GENERAL

1.1 REFERENCES

.1 Solar Decathlon Building Code (SDBC)

.1 SDBC Section 9, Plumbing

.2 American National Standards Institute (ANSI)

.1 ANSI B16.1, Cast Iron Pipe Flanges and Flange Fittings, Class 25, 125, 250 and 800.

.2 CAN/ULC S115 Standard Method of Fire Tests of Firestop Systems.

.3 Canadian Standard Association (CSA)

.1 CSA B137.6 CPVC Pipe, Tubing and Fittings for Both Hot and Cold Water Distribution Systems.

.4 National Sanitation Foundation (NSF)

.1 NSF61 Potable Water Listing.

.5 Underwriters Listing of Canada (ULC)

.1 CAN/ULC S102.2 Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings and Miscellaneous Materials and Assemblies.

.2 CAN/ULC S115 Standard Method of Fire Tests of Firestop Systems.

.3 American Society for Testing and Materials International, (ASTM).

.1 ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

.2 ASTM D1784 Standard Specification for Rigid Poly (Vinyl Chloride) PVC Compounds and Chlorinated Poly (Vinyl Chloride) CPVC compounds.

.3 ASTM D2467, Standard Specification for Poly (Vinyl Chloride) PVC Plastic Pipe Fittings, Schedule 80.

.4 ASTM F437 Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) CPVC Plastic Pipe Fittings Schedule 80.

.5 ASTM F439 Standard Specification for Chlorinated Poly (Vinyl Chloride) CPVC Plastic Pipe Fittings Schedule 80.

.6 ASTM F441/441M Standard Specification for Chlorinated Poly (Vinyl Chloride) CPVC Plastic Pipe Schedules 40 and 80.

.7 ASTM F876 Standard Specification for Crosslinked Polyethyline (PEX) Tubing.

.8 ASTM F877 Standard Specification for Crosslinked Polyethyline (PEX) Hot and Cold Water Distribution System.

.4 Department of Justice Canada (Jus).

.1 Canadian Environmental Protection Act (CEPA).

.5 Solar Decathlon Health and Safety Plan

.1 Team North Health and Safety Plan as approved by the U.S. Department of Energy.

.6 Health Canada/Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

.7 Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS).

.1 MSS-SP-67, Butterfly Valves.

.2 MSS-SP-70, Cast Iron Gate Valves, Flanged and Threaded Ends.

.3 MSS-SP-71, Cast Iron Swing Check Valves, Flanged and Threaded Ends.

.4 MSS-SP-80, Bronze Gate, Globe, Angle and Check Valves.

.5 MSS-SP-110 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

.8 National Research Council (NRC)/Institute for Research in Construction.

.1 NRCC, National Plumbing Code of Canada (NPC).

.9 Transport Canada (TC).

.1 Transportation of Dangerous Goods Act (TDGA).

1.2 WASTE MANAGEMENT AND DISPOSAL

.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management And Disposal.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Separate for reuse and recycling and place in designated containers Steel, Metal, Plastic waste in accordance with Waste Management Plan.

.4 Place materials defined as hazardous or toxic in designated containers.

.5 Handle and dispose of hazardous materials in accordance with CEPA , TDGA , Regional and Municipal regulations.

.6 Fold up metal banding, flatten and place in designated area for recycling.

PART 2 PRODUCTS

2.1 PIPING

.1 Domestic hot, cold and recirculation systems, within building.

.1 Above ground: NPS ½ to 3 CPVC to SDR11 with IPS outside dimensions: CSA B 137.6 and ASTM D1784 cell class of 24447.

.2 Buried or embedded:

.1 Copper tube, soft annealed, type K: to ASTM B88M, in long lengths and with no buried joints.

.2 UO to NPS 1½: PEX Tubing to ASTM F876 and F877 and certified to NSF61 rated at 93° at 551kPa, 82°C at 690 kPa, 23°C at 1100 kPa, color coded for hot or cold water service.

2.2 FITTINGS

.1 CPVC Fittings: to CSA B137.6 and ASTM D1784 Cell Class of 24447

.2 CPVC Flanges: to ASTM F1970.

.1 Flanged CPVC: 1034 kPa at 23^0C, 517 kPa at 60^0C not to be used above 60^0C.

.2 Bolt hole patterns to ANSI B16.1 class 125

.3 Transition points: as recommended by manufacturer.

.4 PEX compression fittings with PEX tubing.

2.3 JOINTS

.1 Rubber gaskets, elastomeric, full face, hardness of 50 to 70 durometer.

.2 Bolts, nuts, hex head and washers: to ASTM A307, heavy series.

.3 Solder: 95/5 tin copper alloy lead free for copper pipe.

.4 Teflon tape: for threaded joints.

.5 Solvent weld with primer to ASTM F493.

.1 Pressure rating 690 kPa at 82^0C, 2760 kPa at 23^0C

2.4 VALVES

.1 See Plumbing Equipment Schedule – Part B for Plumbing Valve Schedule.

.1 Approved Manufacturers; Belimo – Three Way Solenoid Valve; Alco Controls – Electrical Control Expansion Valve, Sparco – Anti-Scald Mixing Valve.

PART 3 EXECUTION

3.1 INSTALLATION

.1 Install in accordance with Canadian Plumbing Code and local authority having jurisdiction.

.2 Install pipe work by certified journeyperson supplemented as specified herein.

.3 Assemble piping using fittings manufactured to ANSI standards.

.4 Install CWS piping below and away from HWS and HWR and other hot piping so as to maintain temperature of cold water as low as possible.

.5 Connect to fixtures and equipment in accordance with manufacturer's written instructions unless otherwise indicated.

3.2 VALVES

.1 Isolate equipment, fixtures and branches with butterfly or ball valves.

.2 Balance recirculation system using lockshield globe valves. Mark settings and record on as-built drawings on completion.

3.3 PRESSURE TESTS

.1 Conform to requirements of Section 21 05 00 - Common Work Results-Mechanical.

.2 Test pressure: greater of 1 ½ times maximum system operating pressure or 860 kPa.

3.4 FLUSHING AND CLEANING

.1 Flush entire system for 8 h. Ensure outlets flushed for 2 h. Let stand for 24 h, then draw one sample off longest run. Submit to testing laboratory for bacteriological testing to verify that system is clean to Provincial potable water guidelines. Let system flush for additional 2 h, then draw off another sample for testing.

3.5 PRE-START-UP INSPECTIONS

.1 Systems to be complete, prior to flushing, testing and start-up.

.2 Verify that system can be completely drained.

.3 Ensure that pressure booster systems are operating properly.

.4 Ensure that air chambers, expansion compensators are installed properly.

3.6 DISINFECTION

.1 Flush out, disinfect and rinse system to requirements of authority having jurisdiction and approval of Consultant.

3.7 START-UP

.1 Timing: Start up after:

- .1 Pressure tests have been completed.
- .2 Disinfection procedures have been completed.
- .3 Water treatment systems operational.

.2 Provide continuous supervision during start-up.

.3 Start-up procedures:

- .1 Establish circulation and ensure that air is eliminated.
- .2 Check pressurization to ensure proper operation and to prevent water hammer, flashing and/or cavitation.
- .3 Bring HWS storage tank up to design temperature slowly.

.4 Monitor HWS and HWR piping systems for freedom of movement, pipe expansion as designed.

.5 Check control, limit, safety devices for normal and safe operation.

.4 Rectify start-up deficiencies.

3.8 PERFORMANCE VERIFICATION

.1 Timing:

.1 After pressure and leakage tests and disinfection completed, and certificate of completion has been issued by authority having jurisdiction.

.2 Procedures:

.1 Verify that flow rate and pressure meet Design Criteria.

.2 TAB HWR in accordance with Section 23 05 93 - Testing Adjusting and Balancing for HVAC.

.3 Adjust pressure regulating valves while withdrawal is maximum and inlet pressure is minimum.

.4 Sterilize HWS and HWR systems for Legionella control.

.5 Verify performance of temperature controls.

.6 Verify compliance with safety and health requirements.

.7 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut off water immediately. If water hammer occurs, replace water hammer arrestor or re-charge air chambers. Repeat for outlets and flush valves.

.8 Confirm water quality consistent with supply standards, verifying that no residuals remain as a result of flushing and/or cleaning.

.3 Reports:

.1 Include certificate of water flow and pressure tests conducted on incoming water service, demonstrating adequacy of flow and pressure.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 The installation of drainage waste and vent piping – plastic.

1.2 REFERENCES

.1 American Society for Testing and Materials (ASTM)

.1 ASTM D2235, Specification for Solvent Cement for Acrylonitrille-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.

.2 ASTM D2564, Specification for Solvent Cements for Poly(Vinyl-Chloride) (PVC) Plastic Piping Systems.

.2 Canadian Standards Association (CSA)

.1 CSA-B1800 Series, ABS Drain, Waste and Vent Pipe and Pipe Fittings.

.2 CSA-B181.2, PVC Drain, Waste and Vent Pipe and Pipe Fittings.

.3 CSA-B182.1, Plastic Drain and Sewer Pipe and Pipe Fittings.

.3 Underwriters Laboratory of Canada (ULC)

.1 CAN/ULC-S102.2 Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings, and Miscellaneous Materials and Assemblies.

1.3 DELIVERY STORAGE AND DISPOSAL

.1 Waste Management and Disposal:

.1 Separate and recycle waste materials in accordance with Section 01 74 21 – Construction/Demolition Waste Management and Disposal.

.2 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.

PART 2 PRODUCTS

2.1 PIPING AND FITTINGS

.1 For aboveground DWV piping for combustible construction to:

.1 CSA – B181.2

.2 For aboveground DWV piping for non-combustible construction:

.1 Flame spread rating less than 25 and smoke developed classification less than 50.

.2 CSA B181.2

2.2 JOINTS

.1 Solvent weld for PVC: to ASTM D2564.

.1 NPS 1 ½ to 6: one step or two step cement

.2 NPS 8 and above: two step cement.

.2 Solvent weld for ABS: to ASTM D2235.

PART 3 EXECUTION

3.1 INSTALLATION

.1 Install in accordance with Canadian Plumbing Code and local authority having jurisdiction.

3.2 TESTING

.1 Pressure test buried systems before backfilling in accordance with Canadian Plumbing Code.

.2 Hydraulically test to verify grades and freedom from obstructions.

3.3 PERFORMANCE VERIFICATION

.1 Cleanouts:

.1 Ensure accessible and that access doors are correctly located.

.2 Open, cover with linseed oil and re-seal.

.3 Verify cleanout rods can probe as far as the next cleanout, at least.

.2 Test to ensure traps are fully and permanently primed.

.3 Storm water drainage:

.1 Verify domes are secure.

.2 Ensure weirs are correctly sized and installed correctly.

.3 Verify provisions for movement of roof system.

.4 Ensure fixtures are properly anchored, connected to system and effectively vented.

.5 Affix applicable label (storm, sanitary, vent, pump discharge etc.) c/w directional arrows.

END OF SECTION

PART 1 GENERAL

1.1 REFERENCES

.1 Solar Decathlon Building Code (SDC)

.1 SDC Section 9, Plumbing

.2 International Residential Code (IRC)

.1 IRC Section 603, Plumbing Wall
.2 IRC Section P2802, Shower Valves
.3 IRC Section P2902, Backflow Prevention

.3 Team North Solar Decathlon Health and Safety Plan

.1 As approved by the US Department of Energy

.4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS)

.5 American Society for Testing and Materials International (ASTM)

.1 ASTM A126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
.2 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.

.6 American Water Works Association (AWWA)

.1 AWWA C700, Cold Water Meters-Displacement Type, Bronze Main Case.
.2 AWWA C701, Cold Water Meters-Turbine Type for Customer Service.
.3 AWWA C702, Cold Water Meters-Compound Type.

.7 American National Standards Institute (ANSI)

.1 ANSI Z358.1 Emergency eyewash and shower equipment.

.8 Canadian Standards Association (CSA)

.1 CSA-B64 Series, Backflow Preventers and Vacuum Breakers.
.2 CSA-B356, Water Pressure Reducing Valves for Domestic Water Supply Systems.

.9 Plumbing and Drainage Institute (PDI)

.1 PDI-G101, Testing and Rating Procedure for Grease Interceptors with Appendix of Sizing and Installation Data.
.2 PDI-WH201, Water Hammer Arresters Standard.

1.2 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet for fixtures and equipment.
.2 Indicate dimensions, construction details and materials for specified items.

.3 Submit WHMIS MSDS. Indicate VOC's for adhesive and solvents during application and curing.

.2 Shop Drawings:

.1 Submit shop drawings to indicate materials, finishes, method of anchorage, number of anchors, dimensions, construction and assembly details and accessories.

.3 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.4 Instructions: submit manufacturer's installation instructions.

1.3 QUALITY ASSURANCE

.1 Pre-Installation Meetings:

.1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations.

.1 Verify project requirements.

.2 Review installation and substrate conditions.

.3 Co-ordination with other building subtrades.

.4 Review manufacturer's installation instructions and warranty requirements.

1.4 DELIVERY, STORAGE AND HANDLING

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling in accordance.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging materials in appropriate on-site bins for recycling.

.4 Divert unused metal materials from landfill to metal recycling facility as approved by Owner's Representative.

.5 Fold up metal and plastic banding flatten and place in designated area for recycling.

PART 2 PRODUCTS

2.1 FLOOR DRAINS

.1 See Plumbing Drawing P-601 for locations

2.2 ROOF DRAINS

.1 See Plumbing Drawing P-601 for locations

2.3 CLEANOUTS

.1 PVC DWD Cleanouts, see Plumbing Drawing P-601 for locations

2.4 BACK FLOW PREVENTERS

.1 During competition toilet to be capped. When house to be installed at permanent location, product to be specified.

2.5 PRESSURE REGULATORS

.1 Capacity: as indicated.

.1 Inlet pressure: 1034 kPa.
.2 Outlet pressure: 413 kPa.
.3 Capacity: as indicated.

.2 Up to NPS1-1/2 bronze bodies, screwed: to ASTM B62, strainer and stainless steel strainer screen.

.3 NPS2 and over, semi-steel bodies, Class 125, flanged: to ASTM A126, Class B, strainer.

.4 Semi-steel spring chambers with bronze trim.

2.6 BACKWATER VALVES

.1 Coated extra heavy cast iron body with bronze seat, bronze flapper and threaded cover.

.2 Access:

.1 Surface access.
.2 Concrete access pit with steel cover, as indicated.

2.7 HOSE BIBBS AND SEDIMENT FAUCETS

.1 Bronze construction complete with integral back flow preventer, hose thread spout, replaceable composition disc, and chrome plated in finished areas.

2.8 WATER MAKE-UP ASSEMBLY

.1 Complete with backflow preventer, pressure gauge on inlet and outlet, pressure reducing valve to CSA B356, pressure relief valve on low pressure side and gate valves on inlet and outlet, strainer.

2.9 WATER METERS

.1 Displacement type to AWWA C700, Turbine type to AWWA C701, Compound type to AWWA C702.

.2 Capacity: flow rate, pressure drop, pipe connections as indicated.

.3 Accessories: remote readout device.

2.10 DOMESTIC CLOTHES WASHER SUPPLY FITTING

.1 To control both hot and cold water simultaneously.

.2 "Finger-tip" lever operation.

.3 Bronze body construction with NPT ½ copper connections and satin chrome finish.

.4 Provide complete with mini water hammer arrestor on hot and cold.

.5 Mount in 300 mm x 300 mm x 100 mm deep stainless steel valve box, 16 gauge, #4 finish. Provide less access door and complete with back in box.

.6 Acceptable Product: Watts Duo-Cloz Model No. 2-M2-SC complete with Watts Model No. 05-H mini water hammer arrestor on hot and cold and entire assembly mounted in a MIFAB Model MI-VB stainless steel valve box, Precision Plumbing Products, MIFAB.

2.11 POTABLE WATER THERMAL EXPANSION TANK

.1 Quantity: as indicated.

.2 Application: absorb expanded water from domestic hot water tanks because of the inability to expand back into the Town potable water system due to the presence of a backflow preventer on the incoming water supply to the building.

.3 ASME Section VIII construction and label.

.4 FDA approved butyl bladder.

.5 1NPT stainless steel system connection.

.6 Standard tire air charging valve connection.

.7 1033 kPa maximum working pressure.

.8 Vertical tank, floor mounted.

.9 Dimensions: as indicated.

.10 Tank volume: as indicated.

.11 Acceptance volume: as indicated.

.12 Red primer exterior finish.

.13 Air pre-charge to be adjusted in field by the Mechanical Contractor to equal the residual cold water pressure on the discharge side of the pressure reducing valve on the domestic water service entrance by the Mechanical Contractor.

.14 Acceptable Product: ExpanFlex, Amtrol, Taco, S. A. Armstrong, Bell and Gossett.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: Comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and data sheet.

3.2 INSTALLATION

.1 Install in accordance with Canadian Plumbing Code , and local authority having jurisdiction.

.2 Install in accordance with manufacturer's instructions and as specified.

3.3 CLEANOUTS

.1 In addition to those required by code, and as indicated, install at base of soil and waste stacks, and rainwater leaders.

.2 Bring cleanouts to wall or finished floor unless serviceable from below floor.

.3 Building drain cleanout and stack base cleanouts: line size to maximum NPS4.

3.4 BACK FLOW PREVENTORS

.1 Install in accordance with CSA-B64 Series, where indicated and elsewhere as required by code.

.1 Reduced pressure type where backflow would constitute a health hazard.

.2 Double check type where backflow would constitute a nuisance or be aesthetically objectionable or material which would not constitute a health hazard.

.2 Pipe discharge to terminate over nearest drain and or service sink.

3.5 BACKWATER VALVES

.1 Install in main sewer lines where indicated.

.2 Install in access pit as indicated.

3.6 HOSE BIBBS AND SEDIMENT FAUCETS

.1 Install at bottom of risers, at low points to drain systems, and as indicated.

3.7 TRAP SEAL PRIMERS

.1 Install for floor drains and elsewhere, as indicated.

.2 Install on cold water supply to nearest frequently used plumbing fixture, in concealed space, to approval of Owner’s Representative.

.3 Install Type K soft copper tubing to floor drain.

3.8 WATER METERS

.1 Install water meter provided by local water authority.

.2 Install water meter as indicated.

3.9 WATER MAKE-UP ASSEMBLY

.1 Install on valved bypass.

.2 Pipe discharge from relief valve to nearest floor drain.

3.10 START-UP AND COMMISSIONING

.1 Timing: Start-up only after:

- .1 Pressure tests have been completed.
- .2 Disinfection procedures have been completed.
- .3 Water treatment systems operational.

.2 Provide continuous supervision during start-up.

3.11 TESTING AND ADJUSTING

.1 Timing:

- .1 After start-up deficiencies rectified.
- .2 After certificate of completion has been issued by authority having jurisdiction.

.2 Application tolerances:

- .1 Pressure at fixtures: +/- 70 kPa.
- .2 Flow rate at fixtures: +/- 20%.

.3 Adjustments:

- .1 Verify that flow rate and pressure meet design criteria.
- .2 Make adjustments while flow rate or withdrawal is (1) maximum and (2) 25% of maximum and while pressure is (1) maximum and (2) minimum.

.4 Floor drains:

- .1 Verify operation of trap seal primer.
- .2 Prime, using trap primer. Adjust flow rate to suit site conditions.
- .3 Check operations of flushing features.
- .4 Check security, accessibility, removeability of strainer.
- .5 Clean out baskets.

.5 Backflow preventers, backwater valves:

- .1 Test tightness, accessibility for O&M of cover and of valve.
- .2 Simulate reverse flow and back-pressure conditions to test operation of vacuum breakers, backflow preventers.
- .3 Verify visibility of discharge from open ports.

.6 Roof drains:

- .1 Check location at low points in roof.
- .2 Check security, removeability of dome.
- .3 Adjust weirs to suit actual roof slopes, meet requirements of design.
- .4 Clean out sumps.

.5 Verify provisions for movement of roof systems.

.7 Access doors:

.1 Verify size and location relative to items to be accessed.

.8 Cleanouts:

.1 Verify covers are gas-tight, secure, yet readily removable.

.9 Pressure regulators, PRV assemblies:

.1 Adjust settings to suit locations, flow rates, pressure conditions.

.10 Hose bibbs, sediment faucets:

.1 Verify operation and at all low points.

.11 Hydronic system water Make-up Assembly:

.1 Verify operation.

.12 Water meters:

.1 Verify calibration certificate.

.13 .Dilution Tank:

.1 Install as per manufacturer's instructions.
.2 Fill with limestone chips.

.14 Training:

.1 Demonstrate full compliance with Design Criteria.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 The supply and installation of washroom fixtures and trim.

.2 Products installed but not supplied under this section as indicated elsewhere in the contract:

.1 Install rough-in for equipment supplied by others, complete with valves on hot and cold water supplies, waste and vent.

.2 Equipment not installed

.1 Capped for future connection by others.

1.2 REFERENCES

.1 Solar Decathlon Building Code (SDBC)

.1 SDBC, Section 9, Plumbing

.2 Canadian Standards Association (CSA)

.1 CAN/CSA-B45 Series, Plumbing Fixtures.

.2 CAN/CSA-B125, Plumbing Fittings.

1.3 SUBMITTALS

.1 Submit shop drawings and product data.

.2 Indicate fixtures and trim:

.1 Dimensions construction details, roughing-in dimensions.

.2 Factory-set water consumption per flush at recommended pressure.

.3 For water closets, urinals: minimum pressure required for flushing.

1.4 DELIVERY STORAGE AND DISPOSAL

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling.

.2 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling.

.3 Fold up metal and plastic banding, flatten and place in designated area for recycling.

1.5 ACCEPTABLE PRODUCT

.1 Fixtures:

Duravit Starck 10X Wall Mount Toilet, or approved equal
Second Floor Wall Basin, or approved equal

.2 Trim:

Elte, Zero Line, or approved equal

PART 2 PRODUCTS

2.1 MANUFACTURED UNITS

.1 Fixtures: manufacture in accordance with CAN/CSA-B45 series.

.2 Trim, fittings: manufacture in accordance with CAN/CSA-B125.

.3 Exposed plumbing brass to be chrome plated.

.4 Number, locations: Architectural drawings to govern.

.5 Fixtures to be product of one manufacturer and of same type, see Acceptable Products listed above.

.6 Trim to be product of one manufacturer and of same type, see Acceptable Products listed above.

PART 3 EXECUTION

3.1 INSTALLATION

.1 Mounting heights:

- .1 Standard: to comply with manufacturer's recommendations unless otherwise indicated or specified.
- .2 Wall-hung fixtures: as indicated, measured from finished floor.
- .3 For barrier-free washrooms: to comply with most stringent of either NBCC or CAN/CSA B651, or Provincial Building Accessibility Act and Regulations.

3.2 ADJUSTING

.1 Conform to water conservation requirements specified this section.

- .1 Adjustments.
  - .1 Adjust water flow rate to design flow rates.
  - .2 Adjust pressure to fixtures to ensure no splashing at maximum pressures.
  - .3 Adjust flush valves to suit actual site conditions.
  - .4 Adjust urinal flush timing mechanisms.
  - .5 Automatic flush valves for urinals and waterclosets: set controls to prevent unnecessary flush cycles during silent hours.
- .2 Checks.
  - .1 Water closets, urinals: flushing action.
  - .2 Aerators: operation, cleanliness.
  - .3 Vacuum breakers, backflow preventers: operation under all conditions.

.3 Thermostatic controls.

.1 Verify temperature settings, operation of control, limit and safety controls.

END OF SECTION

PART 1 GENERAL

1.1 REFERENCES

.1 Canadian Standards Association (CSA)

- .1 CAN/CSA-B45 Series, Plumbing Fixtures.
- .2 CAN/CSA-B125, Plumbing Fittings.
- .3 CAN/CSA-B651, Barrier-Free Design.

.2 American Society of Sanitary Engineering (ASSE)

1.2 SUBMITTALS

.1 Product Data: Submit WHMIS MSDS – Material Safety Data Sheets.

- .1 Submit shop drawings and product data.
- .2 Indicate for all fixtures:
  - .1 Dimensions, construction details, roughing-in dimensions.

1.3 DELIVERY STORAGE AND DISPOSAL

.1 Waste Management and Disposal:

- .1 Separate waste materials for reuse and recycling.
- .2 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling.
- .3 Fold up metal and plastic banding, flatten and place in designated area for recycling.

1.4 ACCEPTABLE PRODUCT

.1 Fixtures:

Custom Fabricated Stainless steel pan or approved equal.

.2 Fittings:

Elte fitting, Zero line or approved equal.

PART 2 PRODUCTS

2.1 MANUFACTURED UNITS

.1 Fixtures: manufacture in accordance with CAN/CSA-B45 series.

.2 Trim, fittings: manufacture in accordance with CAN/CSA-B125.

.3 Number, locations: Architectural drawings to govern.

.4 Fixtures in any one location to be product of one manufacturer and of same type.

.5 Trim in any one location to be product of one manufacturer and of same type.

2.2 INDIVIDUAL SHOWER STALL SHOWERHEAD

.1 Individual, vandal-proof showerhead, non-handicapped.

.1 Trim:

.1 Concealed in-wall single lever pressure balancing shower control valve.

.2 Pressure balanced mixer.

.3 Complete with toe tester

.4 Acceptable product: Elte Zero or approved equal

2.3 SHOWER CABINET

.1 Custom fabricated stainless steel pan with glass panels.

.1 Sizes: as indicated on Architectural Drawings

.2 Master Thermostatic Mixing valve.

.1 Bronze body, non-corrosive parts, liquid-filled thermostatic element, safety limit feature set at 45^0C, built-in union-strainer-stop-check on each inlet, balanced independently seated hot and cold water poppets, tamper-resistant outlet, temperature to hold as set even with:

.1 50% drop in inlet pressure.

.2 13^0C fluctuation in hot water temperatures.

.3 85% restriction in outlet flow.

.2 Capacity: 9.5 L/min shower head at 310 kPa.

.3 Accessories:

.1 Approximately 3 in. dia. Dial thermometer on mixing valve outlet.

.2 Ball valve and union for shut-off and volume control on mixing valve outlet.

.3 Additional valved cold water branch for cold water run-out to showerheads.

.4 Escutcheons on all pipes entering enclosure.

.5 Piping, valves,, fittings in enclosure to be chrome plated.

.4 Enclosure for thermostatic mixing valve.

.1 As indicated on Architectural Drawings

.5 Fixture Piping

.1 Waste:

.1 Brass P trap with cleanout on each fixture not having integral trap.

PART 3 EXECUTION

3.1 INSTALLATION

.1 Mounting heights:

.1 Standard: to comply with manufacturer's recommendations unless otherwise indicated or specified.

.2 Physically handicapped: to comply with most stringent of either NBCC or CAN/CSA B651.

3.2 ADJUSTING

.1 Conform to water conservation requirements specified this section.

.2 Adjustments.

.1 Adjust water flow rate to design flow rates.

.2 Adjust pressure to fixtures to ensure no splashing at maximum pressures.

.3 Checks.

.1 Aerators: operation, cleanliness.

.2 Vacuum breakers, backflow preventers: operation under all conditions.

.3 Thermostatic controls. Verify temperature settings, operation of control, limit and safety controls.

END OF SECTION

PART 1 GENERAL

1.1 SUBMITTALS

.1 Shop drawings; submit drawings stamped and signed for approval by Consultant.

.2 Shop drawings to show:

- .1 Mounting arrangements.
- .2 Operating and maintenance clearances.

.3 Shop drawings and product data accompanied by:

- .1 Detailed drawings of bases, supports, and anchor bolts.
- .2 Acoustical sound power data, where applicable.
- .3 Points of operation on performance curves.
- .4 Manufacturer to certify current model production.
- .5 Certification of compliance to applicable codes.

.4 In addition to transmittal letter referred to in Section 01 33 00 - Submittal Procedures: use MCAC "Shop Drawing Submittal Title Sheet". Identify section and paragraph number.

.5 Closeout Submittals:

- .1 Operation and maintenance manual approved by, and final copies deposited with, Consultant before final inspection.
- .2 Operation data to include:
  - .1 Control schematics for systems including environmental controls.
  - .2 Description of systems and their controls.
  - .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.
  - .4 Operation instruction for systems and component.
  - .5 Description of actions to be taken in event of equipment failure.
  - .6 Valves schedule and flow diagram.
  - .7 Colour coding chart.
- .3 Maintenance data to include:
  - .1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
  - .2 Data to include schedules of tasks, frequency, tools required and task time.
- .4 Performance data to include:
  - .1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
  - .2 Equipment performance verification test results.
  - .3 Special performance data as specified.
  - .4 Testing, adjusting and balancing reports as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
- .5 Approvals:

.1 Submit 2 copies of draft Operation and Maintenance Manual to Consultant for approval. Submission of individual data will not be accepted unless directed by Consultant.

.2 Make changes as required and re-submit as directed by Consultant.

.6 Additional data:

.1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.

.7 Site records:

.1 Consultant will provide 1 set of reproducible mechanical drawings or AutoCAD files. Provide sets of white prints as required for each phase of work. Mark changes as work progresses and as changes occur. Include changes to existing mechanical systems, control systems and low voltage control wiring.

.2 Transfer information weekly to reproducibles, revising reproducibles to show work as actually installed.

.3 Use different colour for each service.

.4 Make available for reference purposes and inspection.

.8 As-built drawings:

.1 Prior to start of Testing, Adjusting and Balancing for HVAC, finalize production of as-built drawings.

.2 Identify each drawing in lower right hand corner in letters at least 12 mm high as follows: - "AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (Date).

.3 Submit to Consultant for approval and make corrections as directed.

.4 Perform testing, adjusting and balancing for HVAC using as-built drawings.

.5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.

.9 Submit copies of as-built drawings for inclusion in final TAB report.

1.2 QUALITY ASSURANCE

.1 Health and Safety Requirements: do construction occupational health and safety in accordance with Team North Health and Safety Plan.

1.3 MAINTENANCE

.1 Furnish spare parts as follows:

.1 One set of packing for each pump.

.2 One casing joint gasket for each size pump.

.3 One head gasket set for each heat exchanger.

.4 One glass for each gauge glass.

.5 One filter cartridge or set of filter media for each filter or filter bank in addition to final operating set.

.2 Provide one set of special tools required to service equipment as recommended by manufacturers.

.3 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

1.4 DELIVERY, STORAGE, AND HANDLING

.1 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

PART 2 PRODUCTS

2.1 MATERIALS

.1 All materials used on this project shall be new and CSA approved unless noted otherwise.

PART 3 EXECUTION

3.1 PAINTING, REPAIRS AND RESTORATION

.1 Do painting in accordance with Section 09 00 00 - Interior Painting.

.2 Restore to new condition, finishes which have been damaged.

3.2 CLEANING

.1 Clean interior and exterior of all systems including strainers. Protect open ends of ducts, diffusers, grilles and registers during construction to prevent ingress of dust and dirt into interior of ducts. If dust or dirt is detected prior to startup, vacuum interior of all ducts and air handling units. Prior to vacuuming use video camera to record condition of ductwork. Also use video camera to record condition of ducts after cleaning.

3.3 FIELD QUALITY CONTROL

.1 Manufacturer's Field Services:

.1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports.

.2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

.3 Schedule site visits, to review Work.

3.4 DEMONSTRATION

.1 Consultant will use equipment and systems for test purposes prior to acceptance. Contractor to supply labour, material, and instruments required for testing.

.2 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.

.3 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.

.4 Instruction duration time requirements as specified in appropriate sections.

.5 Consultant may record these demonstrations on video tape for future reference.

3.5 PROTECTION

.1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system

END OF SECTION

PART 1 GENERAL

1.1 RELATED SECTIONS

.1 Section 23 08 02 – Cleaning and Start-up of Mechanical Piping Systems.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-1.181, Ready-Mixed Organic Zinc-Rich Coating.

1.3 QUALITY ASSURANCE

.1 Installers to be certified to journeyperson.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 CONNECTIONS TO EQUIPMENT

.1 In accordance with manufacturer's instructions unless otherwise indicated.

.2 Use valves and either unions or flanges for isolation and ease of maintenance and assembly.

.3 Use double swing joints when equipment mounted on vibration isolation and when piping subject to movement.

3.2 CLEARANCES

.1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer.

.2 Provide space for disassembly, removal of equipment and components as recommended by manufacturer or as indicated (whichever is greater) without interrupting operation of other system, equipment, components.

3.3 DRAINS

.1 Install piping with grade in direction of flow except as indicated.

.2 Install drain valve at low points in piping systems, at equipment and at section isolating valves.

.3 Pipe each drain valve discharge separately to above floor drain. Discharge to be visible.

.4 Drain valves: NPS 3/4 gate or globe valves unless indicated otherwise, with hose end male thread, cap and chain.

3.4 AIR VENTS

.1 Install automatic air vents at high points in piping systems.

.2 Install isolating valve at each automatic air valve.

.3 Install drain piping to approved location and terminate where discharge is visible.

3.5 DIELECTRIC COUPLINGS

.1 General: Compatible with system, to suit pressure rating of system.

.2 Locations: Where dissimilar metals are joined.

.3 NPS 2 and under: Isolating unions or bronze valves.

.4 Over NPS 2: Isolating flanges.

3.6 PIPEWORK INSTALLATION

.1 Installation by certified journeyperson.

.2 Screwed fittings jointed with Teflon tape or pipe dope as recommended by manufacturer.

.3 Protect openings against entry of foreign material.

.4 Install to isolate equipment and allow removal without interrupting operation of other equipment or systems.

.5 Assemble piping using fittings manufactured to ANSI standards.

.6 Saddle type branch fittings may be used on mains if branch line is no larger than half the size of main.

.1 Hole saw (or drill) and ream main to maintain full inside diameter of branch line prior to welding saddle.

.7 Install exposed piping, equipment, rectangular cleanouts and similar items parallel or perpendicular to building lines.

.8 Install concealed pipework to minimize furring space, maximize headroom, conserve space.

.9 Slope piping, except where indicated, in direction of flow for positive drainage and venting.

.10 Install, except where indicated, to permit separate thermal insulation of each pipe.

.11 Group piping wherever possible and as indicated.

.12 Ream pipes, remove scale and other foreign material before assembly.

.13 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.

.14 Provide for thermal expansion as indicated.

.15 Valves:

.1 Install in accessible locations.

.2 Remove interior parts before soldering.

.3 Install with stems above horizontal position unless otherwise indicated.

.4 Valves accessible for maintenance without removing adjacent piping.

.5 Install globe valves in bypass around control valves.

.6 Use ball or butterfly valves at branch take-offs for isolating purposes except where otherwise specified.

.7 Install butterfly valves on chilled water and related condenser water systems only.

.8 Install butterfly valves between weld neck flanges to ensure full compression of liner.

.9 Install ball valves for glycol service.

.10 Use chain operators on valves NPS 2-1/2 and larger where installed more than 2400 mm above floor in Mechanical Rooms.

.16 Check Valves:

.1 Install silent check valves on discharge of pumps and in vertical pipes with downward flow and elsewhere as indicated.

.2 Install swing check valves in horizontal lines on discharge of pumps and elsewhere as indicated.

3.7 SLEEVES

.1 General: Install where pipes pass through masonry, concrete structures, fire rated assemblies, and elsewhere as indicated.

.2 Material: Schedule 40 black steel pipe.

.3 Construction: Foundation walls and where sleeves extend above finished floors to have annular fins continuously welded on at mid-point.

.4 Sizes: 6 mm minimum clearance between sleeve and uninsulated pipe or between sleeve and insulation.

.5 Installation:

.1 Concrete, masonry walls, concrete floors on grade: Terminate flush with finished surface.

.2 Other floors: Terminate 25 mm above finished floor.

.3 Before installation, paint exposed exterior surfaces with heavy application of zinc-rich paint to CAN/CGSB-1.181.

.6 Sealing:

.1 Foundation walls and below grade floors: Fire retardant, waterproof non-hardening mastic.

.2 Elsewhere: Provide space for firestopping. Maintain fire rating integrity.

.3 Sleeves installed for future use: Fill with lime plaster or other easily removable filler.

.4 Ensure no contact between copper pipe or tube and sleeve.

3.8 ESCUTCHEONS

.1 Install on pipes passing through walls, partitions, floors, and ceilings in finished areas.

.2 Construction: One piece type with set screws. Chrome or nickel plated brass or type 302 stainless steel.

.3 Sizes: Outside diameter to cover opening or sleeve. Inside diameter to fit around pipe or outside of insulation if so provided.

3.9 FLUSHING OUT OF PIPING SYSTEMS

.1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.

.2 Before start-up, clean interior of piping systems - Cleaning supplemented as specified in relevant sections of other Divisions.

.3 Preparatory to acceptance, clean and refurbish equipment and leave in operating condition, including replacement of filters in piping systems.

3.10 PRESSURE TESTING OF EQUIPMENT AND PIPEWORK

.1 Advise Consultant, 48 hours minimum prior to performance of pressure tests.

.2 Pipework: Test as specified in relevant sections of other sections or Divisions.

.3 Maintain specified test pressure without loss for 4 hours minimum unless specified for longer period of time in relevant sections of other Divisions.

.4 Prior to tests, isolate equipment and other parts which are not designed to withstand test pressure or media.

.5 Conduct tests in presence of Consultant. Work to be carried out in off hours after 5 p.m., weekends or holidays.

.6 Pay costs for repairs or replacement, retesting, and making good. Consultant to determine whether repair or replacement is appropriate.

.7 Insulate or conceal work only after approval and certification of tests by Consultant.

3.11 EXISTING SYSTEMS

.1 Connect into existing piping systems at times approved by Consultant. Work to be carried out off hours after 5 p.m., weekends or holidays.

.2 Request written approval 10 days minimum, prior to commencement of work.

.3 Be responsible for damage to existing plant by this work.

.4 Ensure daily clean-up of existing areas.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Electrical motors, drives and guards for mechanical equipment and systems.

.2 Supplier and installer responsibility indicated in Motor, Control and Equipment Schedule on electrical drawings and related mechanical responsibility is indicated on Mechanical Equipment Schedule on mechanical drawings.

.3 Control wiring and conduit is by Division 26 except final connections to control systems specified in Division 21, 22, 23 and 25 is by Division 25.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society of Heating, Refrigeration and Air-Conditioning Consultants (ASHRAE)

.1 ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA cosponsored; ANSI approved; Continuous Maintenance Standard).

.3 Model National Energy Code for Buildings (MNECB).

.4 Health Canada/Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

.5 National Electrical Manufacturers Association (NEMA).

1.3 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet. Include product characteristics, performance criteria, and limitations.

.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS).

.2 Shop Drawings: Submit drawings stamped and signed for approval by Consultant.

.3 Quality Control:

.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.2 Instructions: submit manufacturer's installation instructions.

.1 Consultant will make available 1 (one) copy of systems supplier's installation instructions.

.4 Closeout Submittals

.1 Provide maintenance data for motors, drives and guards for incorporation into manual.

1.4 QUALITY ASSURANCE

.1 Regulatory Requirements: work to be performed in compliance with Canadian Environmental Protection Act (CEPA), Canadian Environmental Assessment Agency (CEAA), Transportation of Dangerous Goods Act (TDGA) and applicable Provincial regulations.

.2 Health and Safety Requirements: do construction occupational health and safety in accordance with Team Ontario/BC Health and Safety Plan.

1.5 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

PART 2 PRODUCTS

2.1 GENERAL

.1 Motors to be premium efficiency, in accordance with local hydro company standards and the requirements of ASHRAE 90.1.

2.2 MOTORS

.1 Provide motors for mechanical equipment as specified.

.2 Motors under 1/2 HP : speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, 120 V, unless otherwise specified or indicated.

.3 Motors 1/2 HP and larger: NEMA, Class B, squirrel cage induction, premium efficiency, speed as indicated, continuous duty, enclosure as indicated, ball bearing, maximum temperature rise 40 ^{o}C, 3 phase, 575 V, unless otherwise indicated.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 Fasten securely in place.

.2 Make removable for servicing, easily returned into, and positively in position.

3.3 FIELD QUALITY CONTROL

.1 Manufacturer's Field Services:

.1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - SUBMITTALS.

.2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

.3 Schedule site visits, to review Work, as directed in PART 1 - QUALITY ASSURANCE.

3.4 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 GENERAL

1.1 SECTION INCLUDES

.1 Materials and installation for thermometers and pressure gauges in piping systems.

1.2 RELATED SECTIONS

.1 Section 23 05 23.01 – Valves - Bronze

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society of Mechanical Consultants (ASME)

.1 ASME B40.100, Pressure Gauges and Gauge Attachments.

.2 ASME B40.200, Thermometers, Direct Reading and Remote Reading.

.3 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-14.4, Thermometers, Liquid-in-Glass, Self Indicating, Commercial/Industrial Type.

.2 CAN/CGSB-14.5, Thermometers, Bimetallic, Self-Indicating, Commercial/Industrial Type.

1.4 HEALTH AND SAFETY

.1 Do construction occupational health and safety in accordance with Team North Health and Safety Plan

1.5 WASTE MANAGEMENT AND DISPOSAL

.1 Separate waste materials for reuse and recycling

.2 Collect, separate and place in designated containers for reuse and recycling, paper, plastic, polystyrene, corrugated cardboard packaging, steel, metal, in accordance with Waste Management Plan.

.3 Fold up metal banding, flatten and place in designated area for recycling.

.4 Place materials defined as hazardous or toxic waste in designated containers.

.5 Ensure emptied containers are sealed, labelled and stored safely for disposal away form children.

PART 2 PRODUCTS

2.1 GENERAL

.1 Design point to be at mid point of scale or range.

.2 Ranges: dual imperial and metric.

2.2 DIRECT READING THERMOMETERS

.1 Industrial, variable angle type, liquid filled, accuracy ± l scale division, 175 mm scale length: to CAN/CGSB14.4.

.1 Acceptable Product: Trerice, Ashcroft, Wika, Winters, Marsh.

2.3 REMOTE READING THERMOMETERS

.1 100 mm diameter liquid filled or vapor activated dial type: to CAN/CGSB-14.5, accuracy within one scale division, brass movement, stainless steel capillary, stainless steel spiral armour, stainless steel bulb and polished brass or stainless steel case for wall mounting.

.1 Acceptable Product: Trerice, Ashcroft, Wika, Winters, Marsh.

2.4 THERMOMETER WELLS

.1 Copper pipe: copper or bronze.

.2 Steel pipe: brass or stainless steel.

2.5 PRESSURE GAUGES

.1 112 mm, dial type: to ASME B40.1, Grade 2A, stainless steel or phosphor bronze bourdon tube having 0.5% accuracy full scale, 1% accuracy for liquid filled.

.1 Acceptable Product: Trerice, Ashcroft, Wika, Winters, Marsh.

.2 Provide:

.1 Siphon for steam service.
.2 Snubber for pulsating operation.
.3 Diaphragm assembly for corrosive service.
.4 Gasketted pressure relief back with solid front.
.5 Bronze ball valve to Section 23 05 23.01 – Valves – Bronze.
.6 Oil filled for high vibration applications.

PART 3 EXECUTION

3.1 GENERAL

.1 Install so they can be easily read from floor or platform. If this cannot be accomplished, install remote reading units.

.2 Install between equipment and first fitting or valve.

3.2 THERMOMETERS

.1 Install in wells on piping. Provide heat conductive material inside well.

.2 Install in locations as indicated and on inlet and outlet of:

.1 Heat exchangers.

.2 Heating and cooling coils.
.3 Boilers.
.4 Chillers.
.5 Cooling towers.
.6 DHW tanks.

.3 Install wells.

.4 Use extensions where thermometers are installed through insulation.

3.3 PRESSURE GAUGES

.1 Install in following locations:

.1 Suction and discharge of pumps. (Liquid filled.)
.2 Upstream and downstream of PRV's.
.3 Upstream and downstream of control valves.
.4 Inlet and outlet of coils.
.5 Inlet and outlet of heat exchangers.
.6 Outlet of boilers.
.7 In other locations as indicated.

.2 Install ball valves.

.3 Use extensions where pressure gauges are installed through insulation.

3.4 NAMEPLATES

.1 Install engraved lamicoid nameplates as specified in Section 23 05 53.01 - Mechanical Identification, identifying medium.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Bronze – valves.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American National Standards Institute (ANSI)/American Society of Mechanical Consultants (ASME)

.1 ANSI/ASME B1.20.1, Pipe Threads, General Purpose (Inch.)

.2 ANSI/ASME B16.18, Cast Copper Alloy Solder Joint Pressure Fittings

.3 ASTM A 276, Specification for Stainless Steel Bars and Shapes.

.4 ASTM B 62, Specification for Composition Bronze or Ounce Metal Castings.

.5 ASTM B 283, Specification for Copper and Copper Alloy Die Forgings (Hot Pressed)

.6 ASTM B 505/B505M, Specification for Copper-Base Alloy Continuous Castings.

.3 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS).

.1 MSS SP-25, Standard Marking System for Valves, Fittings, Flanges and Unions.

.2 MSS SP-80, Bronze Gate, Globe, Angle and Check Valves.

.3 MSS SP-110, Ball Valves, Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

1.3 QUALITY ASSURANCE

.1 Health and Safety

.1 Do construction occupational health and safety in accordance with Team North Health and Safety Plan

1.4 DELIVERY, STORAGE AND DISPOSAL

.1 Waste Management and Disposal

.1 Separate and recycle waste materials.

.2 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling.

1.5 MAINTENANCE

.1 Extra Materials

.1 Furnish following spare parts:

.1 Valve seats: one for every 10 valves each size. Minimum 1.
.2 Discs: one for every 10 valves, each size. Minimum 1.
.3 Stem packing: one for every 10 valves, each size. Minimum 1.
.4 Valve handles: 2 of each size.
.5 Gaskets for flanges: one for every 10 flanged joints.

PART 2 PRODUCTS

2.1 MATERIALS

.1 Except for specialty valves, to be single manufacturer.

.2 All products to have Canadian registration numbers (CRN).

.3 End Connections

.1 Connection into adjacent piping/tubing:
.1 Steel pipe systems: Screwed ends to ANSI/ASME B1.20.1.
.2 Copper tube systems: Solder ends ANSI/ASME B16.18.

.4 Lockshield Keys

.1 Where lockshield valves are specified, provide 10 keys of each size: malleable iron cadmium plated.

2.2 GATE VALVES

.1 Requirements common to all gate valves, unless specified otherwise:

.1 Standard specification: MSS SP-80.
.2 Bonnet: with hex. shoulders.
.3 Connections: with hex. shoulders.
.4 Inspection and pressure testing: to MSS SP-80. Tests to be hydrostatic.
.5 Packing: high grade non-asbestos packing.
.6 Handwheel: non-ferrous.
.7 Handwheel Nut: bronze to ASTM B62.
.8 Glass 125, WP=860 kPa steam, 1.4 mPa WOG
.9 Class 150 WP=1.03 mPa steam, 2.07 mPa WOG.

.2 NPS 2 and under, non-rising stem, solid wedge disc, Class 125:

.1 Body: with long disc guides, screwed bonnet with stem retaining nut.
.2 Operator: Handwheel

.3 NPS 2 and under, non-rising stem, solid wedge disc, Class 150:

.1 Body: with long disc guides, screwed bonnet with stem retaining nut.
.2 Operator: Handwheel

.4 NPS 2 and under, rising stem, split wedge disc, Class 125:

.1 Body: with long disc guides, screwed bonnet.
.2 Disc: split wedge, bronze to ASTM B283, loosely secured to stem.

.3 Operator: Handwheel

.5 NPS 2 and under, rising stem, solid wedge disc, Class 125:

.1 Body: with long disc guides, screwed bonnet.

.2 Operator: Handwheel

.6 NPS 2 and under, rising stem, solid wedge disc, Class 150:

.1 Body: with long disc guides, screwed bonnet.

.2 Operator: Handwheel

2.3 GLOBE VALVES

.1 Requirements common to all globe valves, unless specified otherwise:

.1 Standard specification: MSS SP-80.

.2 Bonnet: union with hex. shoulders.

.3 Connections: screwed with hex. shoulders.

.4 Inspection and pressure testing: to MSS SP-80. Tests to be hydrostatic.

.5 Packing: non-asbestos.

.6 Handwheel: non-ferrous.

.7 Handwheel Nut: bronze to ASTM B62.

.8 Glass 125, WP=860 kPa steam, 1.4 mPa WOG

.9 Class 150 WP=1.03 mPa steam, 2.07 mPa WOG.

.2 NPS 2 and under, composition disc, Class125:

.1 Body and bonnet: screwed bonnet.

.2 Disc and seat: renewable rotating PTFE disc regrindable bronze seat, loosely secured to bronze stem to ASTM B505.

.3 Operator: Handwheel.

.3 NPS 2 and under, composition disc, Class 150:

.1 Body and bonnet: union bonnet.

.2 Disc and seat: renewable rotating PTFE disc in easily removable disc holder, regrindable bronze seat, loosely secured to bronze stem to ASTM B505.

.3 Operator: Handwheel

.4 NPS 2 and under, plug disc, Class 150, screwed ends:

.1 Body and bonnet: union bonnet.

.2 Disc and seat ring: tapered plug type with disc stem ring of AISI S420 stainless steel to ASTM A276, loosely secured to stem.

.3 Operator: Handwheel

.5 Angle valve, NPS 2 and under, composition disc, Class 150:

.1 Body and bonnet: union bonnet.

.2 Disc and seat: renewable rotating PTFE disc in slip-on easily removable disc holder having integral guides, regrindable bronze seat, loosely secured to stem.

.3 Operator: Handwheel.

2.4 CHECK VALVES

.1 Requirements common to all check valves, unless specified otherwise:

- .1 Standard specification: MSS SP-80.
- .2 Connections: with hex agonal shoulders.
- .3 Glass 125, WP=860 kPa steam, 1.4 mPa WOG
- .4 Class 150 WP=1.03 mPa steam, 2.07 mPa WOG
- .5 Class 200 1.4 mPa CWP

.2 NPS 2 and under, swing type, bronze disc, Class 125:

- .1 Body: Y-pattern with integral seat at 45°, screw-in cap with hex head.
- .2 Disc and seat: renewable rotating disc, two-piece hinge disc construction; seat: regrindable.

.3 NPS 2 and under, swing type, bronze disc:

- .1 Body: Y-pattern with integral seat at 45°, screw-in cap with hex head.
- .2 Disc and seat: renewable rotating disc, two-piece hinge disc construction; seat: regrindable.

.4 NPS 2 and under, swing type, composition disc, Class 200:

- .1 Body: Y-pattern with integral seat at 45°, screw-in cap with hex. head.
- .2 Disc: renewable rotating disc, of number 6 composition to suit service conditions, bronze two-piece hinge disc construction.

.5 NPS 2 and under, horizontal lift type, composition disc, Class150:

- .1 Body: with integral seat, union bonnet ring with hex. shoulders, cap.
- .2 Disc: renewable PTFE for steam, #6 composition rotating disc for water, oil or gas service in disc holder having guides top and bottom, of bronze to ASTM B62.

.6 NPS 2 and under, vertical lift type, bronze disc, Class 125:

- .1 Disc: rotating disc having guides top and bottom, disc guides, retaining rings.

2.5 SILENT CHECK VALVES

.1 NPS 2 and under:

- .1 Body: cast high tensile bronze to ASTM B62 with integral seat.
- .2 Pressure rating: Class 125.
- .3 Connections: screwed ends to ANSI B1.20.1 and with hex. shoulders.
- .4 Disc and seat: renewable rotating disc.
- .5 Stainless steel spring, heavy duty.
- .6 Seat: regrindable.

2.6 BALL VALVES

.1 NPS 2 and under:

- .1 Body and cap: cast high tensile bronze to ASTM B62.
- .2 Pressure rating: Class 125, 860 MPa steam.
- .3 Connections: Screwed ends to ANSI B1.20.1 and with hex. shoulders.

.4 Stem: tamperproof ball drive.

.5 Stem packing nut: external to body.

.6 Ball and seat: replaceable stainless steel or hard chrome solid ball and teflon seats.

.7 Stem seal: TFE with external packing nut.

.8 Operator: removable lever handle with extension for insulated pipe.

2.7 ACCEPTABLE PRODUCT

.1 Acceptable Product: Jenkins, Crane, Watts, Newman Hattersley, Milwaukee, Conbraco, Kitz, Red White, M.A. Stewart, Nibco.

PART 3 EXECUTION

3.1 INSTALLATION

.1 Install rising stem valves in upright position with stem above horizontal.

.2 Remove internal parts before soldering.

.3 Install valves with unions at each piece of equipment arranged to allow servicing, maintenance, and equipment removal.

3.2 COMMISSIONING

.1 As part of commissioning activities, develop schedule of valves and record thereon identifier, location, service, purchase order number and date, manufacturer, identification data specified above.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 Concrete housekeeping pads, hangers and supports for mechanical piping, ducting and equipment.

1.2 RELATED SECTIONS

.1 Section 05 12 00 - Structural Steel for Buildings.

.2 Section 05 50 00 - Metal Fabrications.

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American National Standards Institute/ American Society of Mechanical Consultants (ANSI/ASME)

.1 ANSI/ASME B31.1, Power Piping, (SI Edition).

.3 American Society for Testing and Materials (ASTM)

.1 ASTM A125, Specification for Steel Springs, Helical, Heat-Treated.

.2 ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

.3 ASTM A563, Specification for Carbon and Alloy Steel Nuts.

.4 Factory Mutual (FM)

.5 Health Canada / Workplace Hazardous Materials Information System (WHMIS).

.1 Materials Safety Data Sheets (MSDS).

.6 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)

.1 MSS SP-58, Pipe Hangers and Supports - Materials, Design and Manufacture.

.2 ANSI/MSS SP-69, Pipe Hangers and Supports - Selection and Application.

.3 MSS SP-89, Pipe Hangers and Supports - Fabrication and Installation Practices.

.7 Underwriter's Laboratories of Canada (ULC)

1.4 SYSTEM DESCRIPTION

.1 Design Requirements

.1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.

.2 Base maximum load ratings on allowable stresses prescribed by MSS SP58 or ASME B31.1.

.3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.

.4 Design hangers and supports to support systems under all conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.

.5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment to be in accordance with MSS SP58.

.2 Performance Requirements

.1 Design supports, platforms, catwalks, hangers, to withstand seismic events for location as per the National Building Code

1.5 QUALITY ASSURANCE

.1 Health and Safety:

.1 Do construction occupational health and safety in accordance with Team North Health and Safety Plan.

1.6 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

PART 2 PRODUCTS

2.1 GENERAL

.1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS SP-58 and SP-89.

.2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

2.2 PIPE HANGERS

.1 Finishes:

.1 Pipe hangers and supports: galvanized painted with zinc-rich paint after manufacture.

.2 Use electro-plating galvanizing process or hot dipped galvanizing process.

.3 Ensure steel hangers in contact with copper piping are copper plated or epoxy coated.

.2 Upper attachment structural: Suspension from lower flange of I-Beam.

.1 Cold piping NPS 2 maximum: malleable iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.

.1 Rod: 9 mm UL listed, 13 mm FM approved.

.2 Cold piping NPS 2 1/2 or greater, hot piping: Malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed, FM approved where required to MSS-SP58 and MSS-SP69.

.3 Upper attachment structural: Suspension from upper flange of I-Beam.

.1 Cold piping NPS 2 maximum: Ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed FM approved where required to MSS SP69.

.2 Cold piping NPS 2 1/2 or greater, all hot piping: Malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut UL listed, FM approved where required.

.4 Upper attachment to concrete.

.1 Ceiling: Carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm minimum greater than rod diameter.

.2 Concrete inserts: wedge shaped body with knockout protector plate UL listed FM approved where required to MSS SP-69.

.5 Shop and field-fabricated assemblies.

.1 Trapeze hanger assemblies: MSS SP-89.

.2 Steel brackets: MSS SP-89.

.3 Sway braces for seismic restraint systems: to MSS SP-89.

.6 Hanger rods: threaded rod material to MSS SP-58.

.1 Ensure that hanger rods are subject to tensile loading only.

.2 Provide linkages where lateral or axial movement of pipework is anticipated.

.3 Do not use 22 mm or 28 mm rod.

.7 Pipe attachments: material to MSS SP-58.

.1 Attachments for steel piping: carbon steel galvanized.

.2 Attachments for copper piping: copper plated black steel.

.3 Use insulation saddles for hot pipework.

.4 Oversize pipe hangers and supports for insulated pipes.

.8 Adjustable clevis: material to MSS SP-69, UL listed FM approved, where required clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.

.1 Ensure "U" has hole in bottom for rivetting to insulation shields.

.9 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll, to MSS SP-69.

.10 U-bolts: carbon steel to MSS SP-69 with 2 nuts at each end to ASTM A563.

.1 Finishes for steel pipework: galvanized.

.2 Finishes for copper, glass, brass or aluminum pipework: black with formed portion plastic coated or epoxy coated.

.11 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP-69.

2.3 RISER CLAMPS

.1 Steel or cast iron pipe: galvanized black carbon steel to MSS SP-58, type 42, UL listed FM approved where required.

.2 Copper pipe: carbon steel copper plated to MSS SP-58, type 42.

.3 Bolts: to ASTM A307.

.4 Nuts: to ASTM A563.

2.4 INSULATION PROTECTION SHIELDS

.1 Insulated cold piping:

.1 64 kg/m^3 density insulation plus insulation protection shield to: MSS SP-69, galvanized sheet carbon steel. Length designed for maximum 3 m span.

.2 Insulated hot piping:

.1 Curved plate 300 mm long, with edges turned up, welded-in centre plate for pipe sizes NPS 12 and over, carbon steel to comply with MSS SP-69.

2.5 CONSTANT SUPPORT SPRING HANGERS

.1 Springs: alloy steel to ASTM A125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, loaded height and provided with Certified Mill Test Report(CMTR).

.2 Load adjustability: 10 % minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities.

.3 Provide upper and lower factory set travel stops.

.4 Provide load adjustment scale for field adjustments.

.5 Total travel to be actual travel + 20%. Difference between total travel and actual travel 25 mm minimum.

.6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

2.6 VARIABLE SUPPORT SPRING HANGERS

.1 Vertical movement: 13 mm minimum, 50 mm maximum, use single spring pre-compressed variable spring hangers.

.2 Vertical movement greater than 50 mm: use double spring pre-compressed variable spring hanger with 2 springs in series in single casing.

.3 Variable spring hanger to be complete with factory calibrated travel stops. Provide certificate of calibration for each hanger.

.4 Steel alloy springs: to ASTM A125, shot peened, magnetic particle inspected, with +/-5 % spring rate tolerance, tested for free height, spring rate, loaded height and provided with CMTR.

2.7 EQUIPMENT SUPPORTS

.1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel meeting requirements of Section 05 12 23 - Structural Steel for Buildings. Submit calculations with shop drawings.

2.8 EQUIPMENT ANCHOR BOLTS AND TEMPLATES

.1 Provide templates to ensure accurate location of anchor bolts.

2.9 PLATFORMS AND CATWALKS

.1 To Section 05 50 00 - Metal Fabrication.

2.10 OTHER EQUIPMENT SUPPORTS

.1 From structural grade steel meeting requirements of Section 05 00 00 - Structural Steel for Buildings.

.2 Submit structural calculations with shop drawings.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 Install in accordance with:

.1 Manufacturer's instructions and recommendations.

.2 Vibration Control Devices:

.1 Install on piping systems at pumps, boilers, chillers, cooling towers, elsewhere as indicated.

.3 Clamps on riser piping:

.1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.

.2 Bolt-tightening torques to be to industry standards.

.3 Steel pipes: Install below coupling or shear lugs welded to pipe.

.4 Cast iron pipes: Install below joint.

.4 Clevis plates:

.1 Attach to concrete with 4 minimum concrete inserts, one at each corner.

.5 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.

.6 Use approved constant support type hangers where:

.1 vertical movement of pipework is 13 mm or more,

.2 transfer of load to adjacent hangers or connected equipment is not permitted.

.7 Use variable support spring hangers where:

.1 transfer of load to adjacent piping or to connected equipment is not critical.

.2 variation in supporting effect does not exceed 25 % of total load.

3.3 HANGER SPACING

.1 Plumbing piping: most stringent requirements of Canadian Plumbing Code

.2 Fire protection: to applicable fire code.

.3 Gas and fuel oil piping: up to NPS 1/2: every 1.8 m.

.4 Copper piping: up to NPS 1/2: every 1.5 m.

.5 Hydronic, steam, condensate, rigid, and flexible joint roll groove pipe: in accordance with table below, but not less than one hanger at joints.

Maximum Pipe Size: NPS	Maximum Spacing: Steel	Maximum Spacing: Copper
up to 1-1/4	2.1 m	1.8 m
1-1/2	2.7 m	2.4 m
2	3.0 m	2.7 m
2-1/2	3.6 m	3.0 m
3	3.6 m	3.0 m
3-1/2	3.9 m	3.3 m
4	4.2 m	3.6 m
5	4.8 m	
6	5.1 m	
8	5.7 m	
10	6.6 m	
12	6.9 m	

.6 Within 300 mm of each elbow.

.7 Pipework greater than NPS 12: to MSS SP69.

3.4 HANGER INSTALLATION

.1 Install hanger so that rod is vertical under operating conditions.

.2 Adjust hangers to equalize load.

.3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members, comprised of angel iron or c-channel.

3.5 HORIZONTAL MOVEMENT

.1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4 degrees from vertical.

.2 Where horizontal pipe movement is less than 13 mm, offset pipe hanger and support so that rod hanger is vertical in the hot position.

3.6 FINAL ADJUSTMENT

.1 Adjust hangers and supports:

.1 Ensure that rod is vertical under operating conditions.

.2 Equalize loads.

.2 Adjustable clevis:

.1 Tighten hanger load nut securely to ensure proper hanger performance.

.2 Tighten upper nut after adjustment.

.3 C-clamps:

.1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.

.4 Beam clamps:

.1 Hammer jaw firmly against underside of beam.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Materials and requirements for the identification of piping systems, duct work, valves and controllers, including the installation and location of identification systems.

.2 Sustainable requirements for construction and verification.

1.2 RELATED SECTIONS

.1 Section 09 91 23 - Interior Painting.

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 Canadian Gas Association (CGA)

.1 CSA/CGA B149.1, Natural Gas and Propane Installation Code.

.2 CSAZ7396.1 Medical Gas pipeline Systems – Part 1: Pipelines for medical gases and vacuum.

.3 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-1.60, Interior Alkyd Gloss Enamel.

.2 CAN/CGSB-24.3, Identification of Piping Systems.

.4 National Fire Protection Association (NFPA)

.1 NFPA 13, Standard for the Installation of Sprinkler Systems.

.2 NFPA 14, Standard for the Standpipe and Hose Systems.

1.4 SUBMITTALS

.1 Product Data:

.1 Product data to include paint colour chips, other products specified in this section.

.2 Samples:

.1 Submit samples

.2 Samples to include nameplates, labels, tags, lists of proposed legends.

1.5 QUALITY ASSURANCE

.1 Quality assurance submittals: submit following.

.2 Health and Safety:

.1 Do construction occupational health and safety in accordance with Team North Health and Safety Plan

1.6 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling

.2 Dispose of unused paint coating material at official hazardous material collections site approved by Consultant / Consultant.

.3 Do not dispose of unused paint coating material into sewer system, into streams, lakes, onto ground or in locations where it will pose health or environmental hazard.

PART 2PRODUCTS

2.1 MANUFACTURER'S EQUIPMENT NAMEPLATES

.1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.

.2 Lettering and numbers to be raised or recessed.

.3 Information to include, as appropriate:

.1 Equipment: Manufacturer's name, model, size, serial number, capacity.

.2 Motor: voltage, Hz, phase, power factor, duty, frame size.

2.2 SYSTEM NAMEPLATES

.1 Colours:

.1 Hazardous: red letters, white background.

.2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).

.2 Construction:

.1 3 mm thick laminated plastic or white anodized aluminum, matte finish, with square corners, letters accurately aligned and machine engraved into core.

.3 Sizes:

.1 Conform to following table:

Size # mm	Sizes (mm)	No. of Lines	Height of Letters (mm)
1	10 x 50	1	3
2	13 x 75	1	5
3	13 x 75	2	3
4	20 x 100	1	8
5	20 x 100	2	5
6	20 x 200	1	8
7	25 x 125	1	12
8	25 x 125	2	8
9	35 x 200	1	20

.2 Use maximum of 25 letters/numbers per line.

.4 Locations:

.1 Terminal cabinets, control panels: Use size # 5.

.2 Equipment in Mechanical Rooms: Use size # 9.

2.3 EXISTING IDENTIFICATION SYSTEMS

.1 Apply existing identification system to new work.

.2 Where existing identification system does not cover for new work, use identification system specified this section.

.3 Before starting work, obtain written approval of identification system from Consultant.

2.4 PIPING SYSTEMS GOVERNED BY CODES

.1 Identification:

.1 Natural gas: to CSA/CGA B149.1, authority having jurisdiction.

.2 Propane gas: to CSA/CGA B149.1 authority having jurisdiction.

.3 Sprinklers: to NFPA 13.

.4 Standpipe and hose systems: to NFPA 14.

.5 Medical Gas: to CAN/CSA Z7396.1.

2.5 IDENTIFICATION OF PIPING SYSTEMS

.1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.

.2 Pictograms:

.1 Where required, to Workplace Hazardous Materials Information System (WHMIS) regulations.

.3 Legend:

.1 Block capitals to sizes and colours listed in CAN/CGSB 24.3.

.4 Arrows showing direction of flow:

.1 Outside diameter of pipe or insulation less than 75 mm: 100 mm long x 50 mm high.

.2 Outside diameter of pipe or insulation 75 mm and greater: 150 mm long x 50 mm high.

.3 Use double-headed arrows where flow is reversible.

.5 Extent of background colour marking:

.1 To full circumference of pipe or insulation.

.2 Length to accommodate pictogram, full length of legend and arrows.

.6 Materials for background colour marking, legend, arrows:

.1 Pipes and tubing 20 mm and smaller: Waterproof and heat-resistant pressure sensitive plastic marker tags.

.2 All other pipes: Pressure sensitive plastic-coated cloth or vinyl with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of

100%RH and continuous operating temperature of 150°C and intermittent temperature of 200°C.

.7 Colours and Legends:

.1 Where not listed, obtain direction from Consultant.

.2 Colours for legends, arrows, to following table:

Background colour	Legend, arrows
Yellow	BLACK
Green	WHITE
Red	WHITE

.3 Background colour marking and legends for piping systems:

Contents	Background colour marking	Legend
** Add design temperature		
++ Add design temperature and pressure		
Raw water	Green	RAW WATER
River water	Green	RIVER WATER
Sea water	Green	SEA WATER
City water	Green	CITY WATER
Treated water	Green	TREATED WATER
Brine	Green	BRINE
Condenser water supply	Green	COND. WTR. SUPPLY
Condenser water return	Green	COND. WTR. RETURN
Chilled water supply	Green	CH. WTR. SUPPLY
Chilled water return	Green	CH. WTR. RETURN
Hot water heating supply	Yellow	HEATING SUPPLY
Hot water heating return	Yellow	HEATING RETURN
High temp HW Htg. supply	Yellow	HTHW HTG. SUPPLY++
High temp HW Htg. return	Yellow	HTHW HTG. RETURN++
Make-up water	Yellow	MAKE-UP WTR
Boiler feed water	Yellow	BLR. FEED WTR
Steam ___kPa	Yellow	___kPa STEAM
Steam condensate (gravity)	Yellow	ST.COND.RET (GRAVITY)
Steam condensate (pumped)	Yellow	ST.COND.RET (PUMPED)
Safety valve vent	Yellow	STEAM VENT
Intermittent blow-off	Yellow	INT. BLOW-OFF
Continuous blow-off	Yellow	CONT. BLOW-OFF
Chilled drinking water	Green	CH. DRINK WTR
Drinking water return	Green	CH. DRINK WTR. CIRC
Domestic hot water supply	Green	DOM. HW SUPPLY
Dom. HWS recirculation	Green	DOM. HW CIRC
Domestic cold water supply	Green	DOM. CWS
Waste water	Green	WASTE WATER
Contaminated lab waste	Yellow	CONT. LAB WASTE

Contents	Background colour marking	Legend
** Add design temperature		
++ Add design temperature and pressure		
Acid waste	Yellow	ACID WASTE (add source)
Storm water	Green	STORM
Sanitary	Green	SAN
Plumbing vent	Green	SAN. VENT
Refrigeration suction	Yellow	REF. SUCTION
Refrigeration liquid	Yellow	REF. LIQUID
Refrigeration hot gas	Yellow	REF. HOT GAS
No. ___ fuel oil suction	Yellow	# ___ FUEL OIL
No. ___ fuel oil return	Yellow	# ___ FUEL OIL
Engine exhaust	Yellow	ENGINE EXHAUST
Lubricating oil	Yellow	LUB. OIL
Hydraulic oil	Yellow	HYDRAULIC OIL
Gasoline	Yellow	GASOLINE
Natural gas	to Codes	
Propane	to Codes	
Gas regulator vents	to Codes	
Distilled water	Green	DISTILL. WTR
Demineralized water	Green	DEMIN. WATER
Chlorine	Yellow	CHLORINE
Nitrogen	Yellow	NITROGEN
Oxygen	Yellow	OXYGEN
Compressed air (<700kPa)	Green	COMP. AIR ___ kPa
Compressed air (>700kPa)	Yellow	COMP. AIR ___ kPa
Vacuum	Green	VACUUM
Fire protection water	Red	FIRE PROT. WTR
Sprinklers	Red	SPRINKLERS
Carbon dioxide	Red	CO2
Instrument air	Green	INSTRUMENT AIR
Control air tubing	To Section 25 05 54 – EMCS: Identification	
Conduit for low voltage control wiring	To Section 25 05 54 – EMCS: Identification	
Medical Gases	To Code	

2.6 IDENTIFICATION DUCTWORK SYSTEMS

.1 50 mm high stencilled letters and directional arrows 150 mm long x 50 mm high.

.2 Colours: Black, or co-ordinated with base colour to ensure strong contrast.

.3 Identify system : e.g. Supply AHU-1,Exhaust F-7.

2.7 VALVES, CONTROLLERS

.1 Brass tags 12 mm diameter with stamped identification data filled with black paint.

.2 Include flow diagrams for each system, of approved size, showing charts and schedules with identification of each tagged item, valve type, service, function, normal position, location of tagged item.

2.8 CONTROLS COMPONENTS IDENTIFICATION

.1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in section 25 05 54 – EMCS: Identification. If no EMCS included in project, identification as per this section.

.2 Inscriptions to include function and (where appropriate) fail-safe position, component ID name.

2.9 LANGUAGE

.1 Identification to be in English.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 TIMING

.1 Provide identification only after all painting specified in Section 09 91 23 - Interior Painting has been completed.

3.3 INSTALLATION

.1 Perform work in accordance with CAN/CGSB-24.3 except as specified otherwise.

.2 Provide ULC and/or CSA registration plates as required by respective agency.

3.4 NAMEPLATES

.1 Locations:

.1 In conspicuous location to facilitate easy reading and identification from operating floor.

.2 Standoffs:

.1 Provide for nameplates on hot and/or insulated surfaces.

.3 Protection

.1 Do not paint, insulate or cover in any way.

3.5 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS

.1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: At not more than 17 m intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.

.2 Adjacent to each change in direction.

.3 At least once in each small room through which piping or ductwork passes.

.4 On both sides of visual obstruction or where run is difficult to follow.

.5 On both sides of separations such as walls, floors, partitions.

.6 Where system is installed in pipe chases, ceiling spaces, galleries, confined spaces, at entry and exit points, and at access openings.

.7 At beginning and end points of each run and at each piece of equipment in run.

.8 At point immediately upstream of major manually operated or automatically controlled valves, dampers, etc. Where this is not possible, place identification as close as possible, preferably on upstream side.

.9 Identification to be easily and accurately readable from usual operating areas and from access points.

.1 Position of identification to be approximately at right angles to most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.6 VALVES, CONTROLLERS

.1 Valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve: Secure tags with non-ferrous chains or closed "S"hooks.

.2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass where directed by Consultant. Provide one copy (reduced in size if required) in each operating and maintenance manual.

.3 Number valves in each system consecutively.

3.7 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, rubbish, tools and equipment.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 TAB is used throughout this Section to describe the process, methods and requirements of testing, adjusting and balancing for HVAC.

.2 TAB means to test, adjust and balance to perform in accordance with requirements of Contract Documents and to do other work as specified in this Section.

1.2 QUALIFICATIONS OF TAB PERSONNEL

.1 TAB: performed in accordance with the requirements of standard under which TAB Firm's qualifications are approved:

.1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1.

.2 National Environmental Balancing Bureau (NEBB) TABES, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

.3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), HVAC TAB HVAC Systems – Testing, Adjusting and Balancing.

.2 Recommendations and suggested practices contained in the TAB Standard: mandatory.

.3 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.

.4 Use TAB standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.

.5 Where instrument manufacturer calibration recommendations are more stringent than those listed in the TAB standard, use manufacturer's recommendations.

.6 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.

.1 For systems or system components not covered in TAB standard, use TAB procedures developed by TAB Specialist.

.2 Where new procedures and requirements are applicable to Contract requirements have been published or adopted by body responsible for TAB Standard used (AABC, NEBB, or SMACNA), requirements and recommendations contained in these procedures and requirements are mandatory.

1.3 PURPOSE OF TAB

.1 Test to verify proper and safe operation, determine actual point of performance, evaluate qualitative and quantitative performance of equipment, systems and controls at design, average and low loads using actual or simulated loads.

.2 Adjust and regulate equipment and systems so as to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.

.3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges.

1.4 EXCEPTIONS

.1 TAB of systems and equipment regulated by codes, standards to be to satisfaction of authority having jurisdiction.

1.5 CO-ORDINATION

.1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule so as to ensure completion before acceptance of project.

.2 Do TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems.

1.6 PRE-TAB REVIEW

.1 Review contract documents before project construction is started and confirm in writing to Consultant adequacy of provisions for TAB and other aspects of design and installation pertinent to success of TAB.

.2 Review specified standards and report to Consultant in writing all proposed procedures which vary from standard.

.3 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

1.7 START-UP

.1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.

.2 Follow special start-up procedures specified elsewhere in other Divisions.

1.8 OPERATION OF SYSTEMS DURING TAB

.1 Operate systems for length of time required for TAB and as required by Consultant for verification of TAB reports.

1.9 START OF TAB

.1 Notify Consultant 7 days prior to start of TAB.

.2 Start TAB when building is essentially completed, including:

.1 Installation of ceilings, doors, windows, other construction affecting TAB.
.2 Application of weatherstripping, sealing, caulking.
.3 All pressure, leakage, other tests specified elsewhere in other Divisions.
.4 All provisions for TAB installed and operational.

.3 Start-up, verification for proper, normal and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:

.1 Proper thermal overload protection in place for electrical equipment.

.2 Air systems:

.1 Filters in place, clean.

.2 Duct systems clean.

.3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.

.4 Correct fan rotation.

.5 Coil fins combed, clean.

.6 Access doors, installed, closed.

.3 Liquid systems:

.1 Flushed, filled, vented.

.2 Correct pump rotation.

.3 Strainers in place, baskets clean.

.4 Isolating and balancing valves installed, open.

.5 Calibrated balancing valves installed, at factory settings.

1.10 APPLICATION TOLERANCES

.1 Do TAB to following tolerances of design values:

.1 Laboratory HVAC systems: plus 10 %, minus 0 %.

.2 Other HVAC systems: plus 5 %, minus 5 %.

.3 Hydronic systems: plus or minus 10 %.

.4 Refrigeration systems: plus or minus 10%.

1.11 ACCURACY TOLERANCES

.1 Measured values to be accurate to within plus or minus 2 % of actual values.

1.12 INSTRUMENTS

.1 Prior to TAB, submit to Consultant list of instruments to be used together with serial numbers.

.2 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.

.3 Calibrate within 3 months of TAB. Provide certificate of calibration to Consultant.

1.13 SUBMITTALS

.1 Submit, prior to commencement of TAB:

.2 Proposed methodology and procedures for performing TAB if different from referenced standard.

1.14 PRELIMINARY TAB REPORT

.1 Submit for checking and approval of Consultant, prior to submission of formal TAB report, sample of rough TAB sheets. Include:

.1 Details of instruments used.
.2 Details of TAB procedures employed.
.3 Calculations procedures.
.4 Summaries.

1.15 TAB REPORT

.1 Format to be in accordance with referenced standard.

.2 TAB report to show results in SI units and to include:

.1 Project record drawings.
.2 System schematics.

.3 Submit 3 copies of TAB Report to Consultant for verification and approval, in English in D-ring binders, complete with index tabs.

1.16 VERIFICATION

.1 Reported results subject to verification by Consultant.

.2 Provide manpower and instrumentation to verify up to 30 % of reported results.

.3 Number and location of verified results to be at discretion of Consultant.

.4 Bear costs to repeat TAB as required to satisfaction of Consultant.

1.17 SETTINGS

.1 After TAB is completed to satisfaction of Consultant, replace drive guards, close access doors, lock devices in set positions, ensure sensors are at required settings.

1.18 COMPLETION OF TAB

.1 TAB to be considered complete when final TAB Report received and approved by Consultant.

1.19 AIR SYSTEMS

.1 Standard: TAB to be to most stringent of this section or TAB standards of AABC or NEBB.

.2 Do TAB of systems, equipment, components, controls specified in other Divisions.

.3 Qualifications: personnel performing TAB to be qualified to standards of AABC or NEBB.

.4 Quality assurance: Perform TAB under direction of supervisor qualified to standards of AABC or NEBB.

.5 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop (or loss), temperatures (dry bulb, wet bulb, dewpoint), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration, amperage and volts for each stage of electrical heating coils.

.6 Locations of equipment measurements: To include, but not be limited to, following as appropriate:

.1 Inlet and outlet of dampers, filter, coil, humidifier, fan, other equipment causing changes in conditions.

.2 At controllers, controlled device.

.7 Locations of systems measurements to include, but not be limited to, following as appropriate: Main ducts, main branch, sub-branch, run-out (or grille, register or diffuser).

1.20 HYDRONIC SYSTEMS

.1 Definitions: for purposes of this section, to include low pressure hot water heating, chilled water, condenser water, glycol systems.

.2 Standard: TAB to be to most stringent of TAB standards of AABC or NEBB.

.3 Do TAB of systems, equipment, components, controls specified in other Divisions.

.4 Qualifications: personnel performing TAB to be qualified to standards of AABC or NEBB.

.5 Quality assurance: perform TAB under direction of supervisor qualified to standards of AABC or NEBB.

.6 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: flow rate, static pressure, pressure drop (or loss), temperature, specific gravity, density, RPM, electrical power, voltage, noise, vibration.

.7 Locations of equipment measurement: to include, but not be limited to, following as appropriate:

.1 Inlet and outlet of heat exchangers (primary and secondary sides), boiler, chiller, coil, humidifier, cooling tower, condenser, pump, PRV, control valve, other equipment causing changes in conditions.

.2 At controllers, controlled device.

.8 Locations of systems measurements to include, but not be limited to, following as appropriate: supply and return of primary and secondary loops (main, main branch, branch, sub-branch) of all hydronic systems, inlet connection of make-up water.

1.21 DOMESTIC WATER SYSTEMS

.1 Meet requirements as specified for hydronic systems.

.2 Locations of equipment measurements: To include, but not be limited to, following as appropriate: inlet and outlet of heaters, tank, pump, circulator, at controllers, controlled device.

.3 Locations of systems measurements to include, but not be limited to, following as appropriate: main, main branch, branch, sub-branch.

1.22 OTHER SYSTEMS

.1 Plumbing systems:

.1 Standard: National Plumbing Code.

.2 TAB procedures:

.1 Flush valves: adjust to suit project pressure conditions.

.2 Pressure booster systems: test for capacity and pressures under all conditions and at all times.

.3 Controlled flow roof drain systems: adjust weirs to suit actual roof conditions, slopes, areas drained.

.2 Wet pipe sprinkler sprinkler systems:

.1 Standard: NFPA.

.3 Refrigeration systems forming part of HVAC systems:

.1 Standard: CSA B52 – Mechanical Refrigeration Code.

.2 TAB procedures: Refer to Standard as follows:

.1 Suction Pressure and Temperature.

.2 Discharge Pressure and Temperature.

.3 Suction Superheat

.4 Evaporation Pressure and Temperature.

.4 Chemical treatment systems:

.1 Standard: Section 23 25 00 – HVAC Water Treatment Systems.

.2 TAB procedures: refer to Section 23 25 00 – HVAC Water Treatment Systems.

1.23 OTHER TAB REQUIREMENTS

.1 General requirements applicable to work specified this paragraph:

.1 Qualifications of TAB personnel: as for air systems specified this section.

.2 Quality assurance: as for air systems specified this section.

.2 Laboratory fume hoods:

.1 Standard: ASHRAE 110 – Method of Testing Performance of Laboratory Fume Hoods, applicable provincial standard.

.2 TAB procedures: as described in standard.

.3 Building pressure conditions:

.1 Adjust HVAC systems, equipment, controls to ensure specified pressure conditions during winter and summer design conditions.

.4 Zone pressure differences:

.1 Adjust HVAC systems, equipment, controls to establish specified air pressure differentials, with all systems in all possible combinations of normal operating modes.

.5 Measurement of spatial noise:

.1 Standard: Section 23 32 48 – Acoustical Air Plenums.

1.24 POST- OCCUPANCY TAB

.1 Measure DBT, WBT (or %RH), air velocity, air flow patterns, NC levels, in occupied zone of areas designated by Consultant.

.2 Participate in systems checks twice during Warranty Period - #1 approximately 3 months after acceptance and #2 within 3 months of termination of Warranty Period.

PART 2 PRODUCTS (NOT APPLICABLE)

PART 3 EXECUTION (NOT APPLICABLE)

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Materials and methods for pressure testing ducts over 5 m in length, forming part of a supply, return or exhaust ductwork system directly or indirectly connected to air handling equipment.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

.3 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)

.1 SMACNA HVAC Air Duct Leakage Test Manual.

1.3 QUALITY ASSURANCE

.1 Pre-Installation Meetings:

.1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations.

.1 Verify project requirements.

.2 Review installation and substrate conditions.

.3 Co-ordination with other building subtrades.

.4 Review manufacturer's installation instructions and warranty requirements.

.2 Health and Safety:

.1 Do construction occupational health and safety in accordance with Team North Health and Safety Plan.

PART 2 PRODUCTS

2.1 TEST INSTRUMENTS

.1 Test apparatus to include:

.1 Fan capable of producing required static pressure.

.2 Duct section with calibrated orifice plate mounted and accurately located pressure taps.

.3 Flow measuring instrument compatible with the orifice plate.

.4 Calibration curves for orifice plates used.

.5 Flexible duct for connecting to ductwork under test.

.6 Smoke bombs for visual inspections.

.2 Test apparatus: accurate to within +/- 3 % of flow rate and pressure.

.3 Submit details of test instruments to be used to Consultant at least three months before anticipated start date.

.4 Test instruments: calibrated and certificate of calibration deposited with Consultant no more than 28 days before start of tests.

.5 Re-calibrated every six months thereafter.

2.2 EQUIPMENT LEAKAGE TOLERANCES

.1 Equipment and system components such as VAV boxes, duct heating leakage: 2%.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 TEST PROCEDURES

.1 Maximum lengths of ducts to be tested consistent with capacity of test equipment.

.2 Section of duct to be tested to include:

.1 Fittings, branch ducts, tap-ins.

.3 Repeat tests until specified pressures are attained. Bear costs for repairs and repetition to tests.

.4 Base partial system leakage calculations on SMACNA HVAC Air Duct Leakage Test Manual.

.5 Seal leaks that can be heard or felt, regardless of their contribution to total leakage.

3.3 SITE TOLERANCES

.1 System leakage tolerances specified are stated as percentage of total flow rate handled by system. Pro-rate specified system leakage tolerances. Leakage for sections of duct systems: not to exceed total allowable leakage.

.2 Leakage tests on following systems not to exceed specified leakage rates.

.1 Small duct systems up to 250 Pa: leakage 2 %.

.2 VAV box and duct on downstream side of VAV box: leakage 2 %.

.3 Large low pressure duct systems up to 500 Pa: leakage 2 %.

.4 HP duct systems up to 1000 Pa pressure classification, including upstream side of VAV boxes: leakage 1%.

.3 Evaluation of test results to use surface area of duct and pressure in duct as basic parameters.

3.4 TESTING

.1 Test ducts before installation of insulation or other forms of concealment.

.2 Test after seals have cured.

.3 Test when ambient temperature will not affect effectiveness of seals, and gaskets.

.4 Flexible connections to VAV boxes.

3.5 FIELD QUALITY CONTROL

.1 Manufacturer's Field Services.

.1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of Work with Contract.

.2 Manufacturer's Field Services: provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

.3 Schedule site visits, to review Work, at stages listed:

.1 After delivery and storage of products, and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.

.2 Twice during progress of Work at 25% and 60% complete.

.3 Upon completion of the Work, after cleaning is carried out.

.4 Obtain reports, within 3 days of review, and submit, immediately, to Consultant.

.2 Performance Verification:

.1 Consultant to witness tests and to verify reported results.

.2 To be certified by same TAB agency approved by Consultant to undertake TAB on this project.

3.6 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 GENERAL

1.1 RELATED SECTIONS

.1 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment

.2 Section 23 05 53.01 – Mechanical Identification.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society of Heating, Refrigeration and Air Conditioning Consultants (ASHRAE)

.1 ANSI/ASHRAE/IESNA 90.1, SI; Energy Standard for Buildings Except Low-Rise Residential Buildings.

.3 American Society for Testing and Materials International, (ASTM)

.1 ASTM B209M, Specification for Aluminum and Aluminum Alloy Sheet and Plate (Metric).

.2 ASTM C335, Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.

.3 ASTM C411, Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.

.4 ASTM C449/C449M, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.

.5 ASTM C547, Specification for Mineral Fiber Pipe Insulation.

.6 ASTM C553, Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

.7 ASTM C612, Specification for Mineral Fiber Block and Board Thermal Insulation.

.8 ASTM C795, Specification for Thermal Insulation for Use with Austenitic Stainless Steel.

.9 ASTM C921, Standard Practice for Determining Properties of Jacketing Materials for Thermal Insulation.

.4 Canadian General Standards Board (CGSB)

.1 CGSB 51-GP-52Ma, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.

.5 Thermal Insulation Association of Canada (TIAC): National Insulation Standards.

.6 Underwriters Laboratories of Canada (ULC)

.1 CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.

.2 CAN/ULC-S701, Thermal Insulation Polystyrene, Boards and Pipe Covering.

.7 Model National Energy Code of Canada for Buildings (MNECB)

1.3 DEFINITIONS

.1 For purposes of this section:

.1 "CONCEALED" - insulated mechanical services and equipment in suspended ceilings and non-accessible chases and furred-in spaces.

.2 "EXPOSED" - will mean "not concealed" as defined herein.

.3 Insulation systems - insulation material, fasteners, jackets, and other accessories.

.2 TIAC Codes:

.1 CRD: Commercial Round Ductwork,

.2 CRF: Commercial Rectangular Finish.

1.4 SHOP DRAWINGS

.1 Submit shop drawings.

.2 Submit for approval manufacturer's catalogue literature related to installation, fabrication for duct jointing recommendations.

1.5 SAMPLES

.1 Submit samples.

.2 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed. Mount sample on 12 mm plywood board. Affix typewritten label beneath sample indicating service.

1.6 MANUFACTURERS' INSTRUCTIONS

.1 Submit manufacturer's installation instructions.

.2 Installation instructions to include procedures used and installation standards achieved.

1.7 QUALIFICATIONS

.1 Installer: certified in performing work of this section, and have at least 5 years successful experience in this size and type of project, qualified to standards of TIAC.

1.8 DELIVERY, STORAGE AND HANDLING

.1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.

.2 Protect from weather and construction traffic.

.3 Protect against damage from any source.

.4 Store at temperatures and conditions recommended by manufacturer.

1.9 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.

.4 Divert unused metal materials from landfill to metal recycling facility approved by Consultant.

.5 Divert unused adhesive material from landfill to official hazardous material collections site approved by Consultant.

.6 Do no dispose of unused adhesive materials into sewer systems, into lakes, streams, onto ground or in other locations where it will pose health or environmental hazard.

PART 2 PRODUCTS

2.1 FIRE AND SMOKE RATING

.1 In accordance with CAN/ULC-S102:

.1 Maximum flame spread rating: 25.

.2 Maximum smoke developed rating: 50.

2.2 INSULATION

.1 Mineral fibre: as specified includes glass fibre, rock wool, slag wool.

.2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335.

.3 TIAC Code C-1: Rigid mineral fibre board to ASTM C612, with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).

.4 TIAC Code C-2: Mineral fibre blanket to ASTM C553 faced with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this section).

.1 Mineral fibre: to ASTM C553.

.2 Jacket: to CGSB 51-GP-52Ma.

.3 Maximum "k" factor: to ASTM C553.

2.3 JACKETS

.1 Canvas:

.1 220 gm/m^2 cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.

.2 Lagging adhesive: Compatible with insulation.

.3 Aluminum:

.1 To ASTM B209 with moisture barrier as scheduled in PART 3 of this section.

.2 Thickness: 0.40 mm sheet.

.3 Finish: Stucco embossed or corrugated.

.4 Jacket banding and mechanical seals: 12 mm wide, 0.5 mm thick stainless steel.

.4 Stainless steel:

.1 Type: 304 or 316 where additional corrosion protection is required.
.2 Thickness: 0.25 mm sheet.
.3 Finish: Corrugated or stucco embossed.
.4 Jacket banding and mechanical seals: 12mm wide, 0.5 mm thick stainless steel.

2.4 ACCESSORIES

.1 Vapour retarder lap adhesive:

.1 Water based, fire retardant type, compatible with insulation.

.2 Indoor Vapour Retarder Finish:

.1 Vinyl emulsion type acrylic, compatible with insulation.

.3 Insulating Cement: hydraulic setting on mineral wool, to ASTM C449.

.4 ULC Listed Canvas Jacket:

.1 220 gm/m^2 cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.

.5 Outdoor Vapour Retarder Mastic:

.1 Vinyl emulsion type acrylic, compatible with insulation.
.2 Reinforcing fabric: Fibrous glass, untreated 305 g/m^2.

.6 Tape: self-adhesive, aluminum, reinforced, 75 mm wide minimum.

.7 Contact adhesive: quick-setting

.8 Canvas adhesive: washable.

.9 Tie wire: 1.5 mm stainless steel.

.10 Banding: 12 mm wide, 0.5 mm thick stainless steel.

.11 Facing: 25 mm galvanized steel hexagonal wire mesh stitched on one face of insulation.

.12 Fasteners: 4 mm diameter pins with 35 mm diameter or square clips, length to suit thickness of insulation.

PART 3 EXECUTION

3.1 PRE-INSTALLATION REQUIREMENTS

.1 Pressure testing of ductwork systems complete, witnessed and certified.

.2 Surfaces clean, dry, free from foreign material.

3.2 INSTALLATION

.1 Install in accordance with TIAC National Standards.

.2 Apply materials in accordance with manufacturer's instructions and as indicated.

.3 Use two layers with staggered joints when required nominal thickness exceeds 75 mm.

.4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.

.1 Hangers, supports to be outside vapour retarder jacket.

.5 Supports, Hangers in accordance with Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment

.1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.

.6 Fasteners: At 300 mm oc in horizontal and vertical directions, minimum two rows each side.

3.3 DUCTWORK INSULATION SCHEDULE

.1 Insulation types and thicknesses: Conform to following Table:

.2

	TIAC Code	Vapour Retarder	Thickness (mm)
Rectangular cold and dual temperature supply air ducts (exposed)	C-1	yes	50
Round cold and dual temperature supply air ducts (concealed)	C-2	yes	50
Rectangular warm air ducts (exposed)	C-1	no	25
Round warm air ducts (exposed)	C-1	no	25
Rectangular cold and dual temperature supply air ducts (concealed)	C-2	Yes	25
Round cold and dual temperature supply air ducts (exposed)	C-1	yes	50
Rectangular warm air ducts (concealed)	C-2	No	25
Round warm air ducts (concealed)	C-2	No	25
Supply, return and exhaust ducts exposed in space being served			none
Outside air ducts to mixing plenum	C-1	yes	50
Mixing plenums	C-1	yes	25
Exhaust duct between dampers and louvers	C-1	no	50
Rectangular ducts outside	C-1	special	50
Round ducts outside	C-1	special	50

.3 Exposed round ducts 600 mm and larger, smaller sizes where subject to abuse:

.1 Use TIAC code C-1 insulation, scored to suit diameter of duct.

.2 Finishes: Conform to following table:

	TIAC Code Rectangular	Round
Indoor, concealed	None	none
Indoor, exposed within mechanical room	CRF/1	CRD/2
Indoor, exposed elsewhere	CRF/2	CRD/3
Outdoor, exposed to precipitation	CRF/3	CRD/4
Outdoor, elsewhere	CRF/4	CRD/5

END OF SECTION

PART 1 GENERAL

1.1 RELATED SECTIONS

.1 Section 22 42 01 – Plumbing Specialities and Accessories.

.2 Section 23 05 93 – Testing, Adjusting and Balancing for HVAC.

.3 Section 23 08 02 – Cleaning and Start-up of Mechanical Piping Systems.

.4 Section 23 11 13 – Facility Fuel-Oil Piping.

.5 Section 22 11 18 – Domestic Water Piping Copper.

.6 Section 23 21 13.02 – Hydronic Systems: Steel.

.7 Section 23 23 00 – Copper Tubing and Fittings Refrigerant.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 ASTM E202, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

1.3 CLEANING AND START-UP OF MECHANICAL PIPING SYSTEMS

.1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.

1.4 HYDRONIC SYSTEMS - PERFORMANCE VERIFICATION (PV)

.1 Perform hydronic systems performance verification after cleaning is completed and system is in full operation.

.2 When systems are operational, perform following tests:

.1 Conduct full scale tests at maximum design flow rates, temperatures and pressures for continuous consecutive period of 48 hours to demonstrate compliance with design criteria.

.2 Verify performance of hydronic system circulating pumps as specified in relevant technical sections, recording system pressures, temperatures, fluctuations by simulating maximum design conditions and varying.

.1 Pump operation.

.2 Boiler and/or chiller operation.

.3 Pressure bypass open/closed.

.4 Control pressure failure.

.5 Maximum heating demand.

.6 Maximum cooling demand.

.7 Boiler and/or chiller failure.

.8 Cooling tower (and/or industrial fluid cooler) fan failure.

.9 Outdoor reset. Re-check heat exchanger output supply temperature at 100% and 50% reset, maximum water temperature.

1.5 HYDRONIC SYSTEM CAPACITY TEST

.1 Timing: After:

.1 TAB has been completed

.2 Verification of operating, limit, safety controls.

.3 Verification of primary and secondary pump flow rates.

.4 Verification of accuracy of temperature and pressure sensors and gauges.

.2 Calculate system capacity at test conditions.

.3 Using manufacturer's published data and calculated capacity at test conditions, extrapolate system capacity at design conditions.

.4 When capacity test is completed, return controls and equipment status to normal operating conditions.

.5 Submit sample of system water to approved testing agency to determine if chemical treatment is correct. Include cost.

.6 Heating system capacity test:

.1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:

.1 Increasing OA flow rates through heating coils (in this case, monitor heating coil discharge temperatures at all times to ensure that coils are not subjected to freezing conditions) or

.2 Reducing space temperature by turning off heating system for sufficient period of time before starting testing.

.2 Test procedures:

.1 Open fully heat exchanger, heating coil and radiation control valves.

.2 With solar thermal collectors in full operation and hot water heating supply temperature stabilized, record flow rates and supply and return temperatures simultaneously.

1.6 POTABLE WATER SYSTEMS

.1 When cleaning is completed and system filled:

.1 Verify performance of equipment and systems as specified elsewhere in mechanical Division.

.2 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut of water immediately. If water hammer occurs, replace water hammer arrestor. Repeat for each outlet and flush valve.

.3 Confirm water quality consistent with supply standards, verifying that no residuals remain as a result of flushing and/or cleaning.

PART 2 PRODUCTS (NOT APPLICABLE)

PART 3 EXECUTION (NOT APPLICABLE)

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Procedures and cleaning solutions for cleaning mechanical piping systems.

1.2 RELATED SECTIONS

.1 Section 23 05 93 - Testing, Adjusting and Balancing of HVAC

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society for Testing and Materials International (ASTM)

.1 ASTM E202 – Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

.3 Health Canada / Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

1.4 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet. Include product characteristics, performance criteria, and limitations.

.2 Quality assurance submittals: submit following.

.1 Instructions: submit manufacturer's installation instructions.

.1 Consultant will make available one (1) copy of systems supplier installation instructions.

1.5 QUALITY ASSURANCE

.1 Health and Safety:

.1 Do construction occupational health and safety in accordance with Team North Health and Safety Plan

1.6 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading.

.1 Deliver, store and handle in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction / Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

PART 2 PRODUCTS

2.1 CLEANING SOLUTIONS

.1 Low foaming detergent at all temperatures

.2 No pH neutralization required

.3 Designed for use on most metals including aluminium

.4 Bio-degradable

.5 Phosphate Free

.6 Nitrite Free

PART 3 EXECUTION

3.1 CLEANING HYDRONIC

.1 Timing

.1 Systems to be operational, hydrostatically tested and with safety devices functional, before cleaning is carried out.

.2 Cleaning Agency:

.1 Retain qualified water treatment specialist to perform system cleaning.

.3 Install instrumentation such as flow meters, orifice plates, pitot tubes, flow metering valves only after cleaning is certified as complete by water treatment specialist.

.4 Cleaning procedures:

.1 Provide detailed report outlining proposed cleaning procedures at least 4 weeks prior to proposed starting date. Report to include:

.1 Cleaning procedures, flow rates, elapsed time.

.2 Chemicals and concentrations to be used.

.3 Inhibitors and concentrations.

.4 Specific requirements for completion of work.

.5 Special precautions for protecting piping system materials and components.

.6 Complete analysis of water to be used to ensure water will not damage systems or equipment.

.5 Conditions at time of cleaning of systems

.1 Systems to be free from construction debris, dirt and other foreign material.

.2 Control valves to be operational, fully open to ensure that terminal units can be cleaned properly.

.3 Strainers to be clean prior to initial fill.

.4 Install temporary filters on pumps not equipped with permanent filters.

.5 Install pressure gauges on strainers to detect plugging.

.6 Report on Completion of Cleaning

.1 When cleaning is completed, submit report, complete with certificate of compliance with specifications of cleaning component supplier.

.7 Hydronic Systems:

.1 Flush system thoroughly with water, back flush pump, strainers, blow down drain valves and risers to remove all loose debris. Remove accumulated sludge in boilers if necessary.

.2 Then add 2% solution of low foaming detergent to the system through a by-pass feeder or another feeding device.

.3 Circulate for 36 hours at 82° C. For chilled systems, circulate at least 48 hours at ambient temperature.

.4 During recirculation, back flush strainers, drain valves and risers at their lowest point once every 8 hours.

.5 Drain cleaning water completely.

.6 Then fill and drain system several times. Circulate 30 minutes every time the system is refilled.

.7 Bleed system at several points until water is clear and non-foaming. Clean pump strainers.

.8 Draw a water sample from the system and send it to out laboratory for analysis.

.9 If the laboratory report is satisfactory, the system must then be treated with the appropriate formula.

.8 Glycol Systems:

.1 In addition to procedures specified above perform procedures specified herein.

.2 Test to prove concentration will prevent freezing to minus 40°C. Test inhibitor strength and include in procedural report. Refer to ASTM E202.

3.2 START-UP OF HYDRONIC SYSTEMS

.1 After cleaning is completed and system is filled:

.1 Establish circulation and expansion tank level, set pressure controls.

.2 Ensure air is removed.

.3 Check pumps to be free from air, debris, possibility of cavitation when system is at design temperature.

.4 Dismantle system pumps used for cleaning, inspect, replace worn parts, install new gaskets and new set of seals.

.5 Clean out strainers repeatedly until system is clean.

.6 Commission water treatment systems as specified in Section 23 25 00 - HVAC Water Treatment Systems.

.7 Check water level in expansion tank with cold water with circulating pumps OFF and again with pumps ON.

.8 Repeat with water at design temperature.

.9 Check pressurization to ensure proper operation and to prevent water hammer, flashing, cavitation. Eliminate water hammer and other noises.

.10 Bring system up to design temperature and pressure slowly over a 48 hour period.

.11 Perform TAB as specified in Section 23 05 93 - Testing, Adjusting and Balancing (TAB).

.12 Adjust pipe supports, hangers, springs as necessary.

.13 Monitor pipe movement, performance of expansion joints, loops, guides, anchors.

.14 If sliding type expansion joints bind or if bellows type expansion joints flex incorrectly, shut down system, re-align, repeat start-up procedures.

.15 Re-tighten bolts, etc. using torque wrench, to compensate for heat-caused relaxation. Repeat several times during commissioning.

.16 Check operation of drain valves.

.17 Adjust valve stem packings as systems settle down.

.18 Fully open all balancing valves (except those that are factory-set).

.19 Check operation of over-temperature protection devices on circulating pumps.

.20 Adjust alignment of piping at pumps to ensure flexibility, adequacy of pipe movement, absence of noise or vibration transmission.

3.3 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Materials and installation procedures for electric heating and cooling controls.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

1.3 QUALITY ASSURANCE

.1 Health and Safety Requirements: do construction occupational health and safety in accordance Do construction occupational health and safety in accordance Team Ontario/BC Health and Safety Plan.

1.4 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

PART 2 PRODUCTS

2.1 TEMPERATURE SENSORS

.1 Temperature sensors supplied, installed and wired by Division 25. Component of EMCS System. Electrical Division to provide box and conduit to ceiling space only.

2.2 PROGRAMMABLE RELAY CONTROLLER

.1 HVAC controller shall be BB-Electronics SG2 Programmable Relay.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 Install control devices.

.2 On outside wall, mount thermostats on bracket or insulated pad 25 mm from exterior wall.

.3 Install remote sensing device and capillary tube in metallic conduit. Conduit enclosing capillary tube must not touch heater or heating cable.

3.3 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 GENERAL

1.1 REFERENCE STANDARDS

.1 Codes and Standards referenced in this section refer to the latest edition thereof.

.2 American Standard for Testing and Materials (ASTM)

.1 ASTM D1784, Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

.2 ASTM D2486, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Hot and Cold Water Distribution Systems.

.3 ASTM F437, Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

.4 ASTM F438, Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

.5 ASTM F439, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

.6 ASTM F441, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40 and 80.

.7 ASTM F493, Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.

.3 Canadian Plumbing Code and local authority having jurisdiction except where specified otherwise.

.4 Canadian Standards Association (CSA)

.1 CSA B137, Series Thermoplastic Pressure Piping Compendium.

.5 Underwriters Laboratories of Canada (ULC)

.1 CAN/ULC S102.2, Surface Burning Characteristics of Flooring, Floor Covering and Miscellaneous Materials and Assemblies.

1.2 SHOP DRAWINGS

.1 Indicate dimensions, construction details and materials for the following:

.1 All valves, fittings and piping.

1.3 PRODUCT DATA

.1 Submit product.

PART 2 PRODUCTS

2.1 TRUE UNION BALL VALVES

.1 True Union Ball Valves to be CPVC, cell classification 24448, with safety-shear stem, polypropylene handle, EPDM O-rings, and union nuts with buttress threads. All valve components shall be replaceable and valve to be approved for potable water systems. All valve seal carriers shall be safety blocked.

.2 Application: All geothermal system piping.

2.2 BALL CHECK VALVES

.1 All ball check valves shall be CPVC, cell classification 24448 with EPDM rubber seat and slip-out true union ends.

.2 Application: All process piping 50mm and under where indicated on the plans.

PART 3 EXECUTION

3.1 INSTALLATION

.1 Install all piping, fittings, valves and specialties in accordance with the manufacturer's recommendations. Hanger spacing as per manufacturer's instructions.

.2 Run all piping straight and true with building lines.

.3 Provide 'ULC' rated fire stops at all fire rated penetrations. Install as per manufacturers instructions

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 The supply and installation of hydronic specialties equipment.

1.2 RELATED SECTIONS

.1 Section 23 05 05 – Installation of Pipework.

.2 Section 23 08 01 – Performance Verification of Mechanical Piping Systems.

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society of Mechanical Consultants (ASME)

.1 ANSI/ASME, Boiler and Pressure Vessels Code.

.3 American Society for Testing and Materials (ASTM)

.1 ASTM A47/A47M, Specification for Ferritic Malleable Iron Castings.

.2 ASTM A278M, Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 345° C.

.3 ASTM A516/A516M, Specification for Pressure Vessel Plates, Carbon Steel, for Moderate and Lower Temperature Service.

.4 ASTM A536, Specification for Ductile Iron Castings.

.5 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.

1.4 SUBMITTALS

.1 Product Data: Submit WHMIS MSDS – Material Safety Data Sheets

.1 Submit shop drawings and product data .

.2 Indicate on product data expansion tanks, air vents, separators, valves, and strainers.

.2 Closeout Submittals:

.1 Submit maintenance data.

1.5 QUALITY ASSURANCE

.1 Health and Safety:

.1 Do construction occupational health and safety in accordance Team North Health and Safety Plan.

1.6 DELIVERY STORAGE AND DISPOSAL

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling.

.2 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling.

PART 2 PRODUCTS

2.1 CANADIAN REGISTRATION NUMBERS (CRN)

.1 Required on all products as per Provincial Regulations and CSA B51.

2.2 DIAPHRAGM TYPE EXPANSION TANK

.1 Horizontal or vertical as indicated steel pressurized diaphragm type expansion tank.

.2 Capacity: as indicated

.3 Size: length and diameter as indicated.

.4 Diaphragm sealed in elastomer or EPDM suitable for 115□C operating temperature.

.5 Working pressure: 860 kPa with ASME stamp and certification.

.6 Air precharged to 84 kPa (initial fill pressure of system) or as indicated.

.7 Saddles for horizontal installation, base mount for vertical installation.

.8 Supports: Provide supports with hold down bolts and installation templates.

.9 Renewable diaphragm.

2.3 AIR SEPARATOR - BOILER MOUNTED

.1 Complete with dip tube.

.2 Working pressure: 860 kPa.

2.4 AIR SEPARATOR - EXPANSION TANK FITTING

.1 Complete with adjustable vent tube and built-in manual vent valve.

.2 Working pressure: 860 kPa.

2.5 COMBINATION LOW PRESSURE RELIEF AND REDUCING VALVE

.1 Adjustable pressure setting: 206 kPa relief, 55 to 172 kPa reducing or as indicated.

.2 Low inlet pressure check valve.

.3 Removable strainer.

PART 3 EXECUTION

3.1 GENERAL

.1 Install as indicated and to manufacturer's recommendations.

.2 Run drain lines and blow off connections to terminate above nearest drain.

.3 Maintain proper clearance to permit service and maintenance.

.4 Should deviations beyond allowable clearances arise, request and follow Consultant's directive.

.5 Check shop drawings for conformance of all tappings for ancillaries and for equipment operating weights.

3.2 STRAINERS

.1 Install in horizontal or down flow lines.

.2 Ensure clearance for removal of basket.

.3 Install ahead of each pump.

.4 Install ahead of each automatic control valve larger than NPS 1 and radiation and as directed.

3.3 AIR VENTS

.1 Install at high points of systems.

.2 Install gate valve on automatic air vent inlet. Run discharge to nearest drain or service sink.

3.4 EXPANSION TANKS

.1 Adjust expansion tank pressure to suit design criteria.

.2 Install lockshield type valve at inlet to tank.

3.5 PRESSURE SAFETY RELIEF VALVES

.1 Run discharge pipe to terminate above nearest drain.

3.6 SUCTION DIFFUSERS

.1 Install on inlet to pumps having suction size greater than 50.

3.7 PERFORMANCE VERIFICATION

.1 Provide copies of test reports for Commissioning Manuals.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 The supply and installation of hydronic specialties equipment.

1.2 RELATED SECTIONS

.1 Section 23 05 05 – Installation of Pipework.

.2 Section 23 08 01 – Performance Verification of Mechanical Piping Systems.

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society of Mechanical Consultants (ASME)

.1 ANSI/ASME, Boiler and Pressure Vessels Code.

.3 American Society for Testing and Materials (ASTM)

.1 ASTM A47/A47M, Specification for Ferritic Malleable Iron Castings.

.2 ASTM A278M, Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 345° C.

.3 ASTM A516/A516M, Specification for Pressure Vessel Plates, Carbon Steel, for Moderate and Lower Temperature Service.

.4 ASTM A536, Specification for Ductile Iron Castings.

.5 ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.

1.4 SUBMITTALS

.1 Product Data: Submit WHMIS MSDS – Material Safety Data Sheets

.1 Submit shop drawings and product data .

.2 Indicate on product data expansion tanks, air vents, separators, valves, and strainers.

.2 Closeout Submittals:

.1 Submit maintenance data.

1.5 QUALITY ASSURANCE

.1 Health and Safety:

.1 Do construction occupational health and safety in accordance Team North Health and Safety Plan.

1.6 DELIVERY STORAGE AND DISPOSAL

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling.

.2 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling.

PART 2 PRODUCTS

2.1 CANADIAN REGISTRATION NUMBERS (CRN)

.1 Required on all products as per Provincial Regulations and CSA B51.

2.2 DIAPHRAGM TYPE EXPANSION TANK

.1 Horizontal or vertical as indicated steel pressurized diaphragm type expansion tank.

.2 Capacity: as indicated

.3 Size: length and diameter as indicated.

.4 Diaphragm sealed in elastomer or EPDM suitable for 115□C operating temperature.

.5 Working pressure: 860 kPa with ASME stamp and certification.

.6 Air precharged to 84 kPa (initial fill pressure of system) or as indicated.

.7 Saddles for horizontal installation, base mount for vertical installation.

.8 Supports: Provide supports with hold down bolts and installation templates.

.9 Renewable diaphragm.

2.3 AIR SEPARATOR - BOILER MOUNTED

.1 Complete with dip tube.

.2 Working pressure: 860 kPa.

2.4 AIR SEPARATOR - EXPANSION TANK FITTING

.1 Complete with adjustable vent tube and built-in manual vent valve.

.2 Working pressure: 860 kPa.

2.5 COMBINATION LOW PRESSURE RELIEF AND REDUCING VALVE

.1 Adjustable pressure setting: 206 kPa relief, 55 to 172 kPa reducing or as indicated.

.2 Low inlet pressure check valve.

.3 Removable strainer.

PART 3 EXECUTION

3.1 GENERAL

.1 Install as indicated and to manufacturer's recommendations.

.2 Run drain lines and blow off connections to terminate above nearest drain.

.3 Maintain proper clearance to permit service and maintenance.

.4 Should deviations beyond allowable clearances arise, request and follow Consultant's directive.

.5 Check shop drawings for conformance of all tappings for ancillaries and for equipment operating weights.

3.2 STRAINERS

.1 Install in horizontal or down flow lines.

.2 Ensure clearance for removal of basket.

.3 Install ahead of each pump.

.4 Install ahead of each automatic control valve larger than NPS 1 and radiation and as directed.

3.3 AIR VENTS

.1 Install at high points of systems.

.2 Install gate valve on automatic air vent inlet. Run discharge to nearest drain or service sink.

3.4 EXPANSION TANKS

.1 Adjust expansion tank pressure to suit design criteria.

.2 Install lockshield type valve at inlet to tank.

3.5 PRESSURE SAFETY RELIEF VALVES

.1 Run discharge pipe to terminate above nearest drain.

3.6 SUCTION DIFFUSERS

.1 Install on inlet to pumps having suction size greater than 50.

3.7 PERFORMANCE VERIFICATION

.1 Provide copies of test reports for Commissioning Manuals.

END OF SECTION

PART 1 GENERAL

1.1 SECTION INCLUDES

.1 Materials, equipment selection, installation and start up for hydronic system pumps.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society of Heating Refrigeration and Air-Conditioning Consultants (ASHRAE).

.1 Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.

.3 Model National Energy Code of Canada for Buildings (MNECB).

.4 Canadian Standards Association (CSA International).

.1 CAN/CSA-B214, Installation Code for Hydronic Heating Systems.

.5 National Electrical Manufacturer’s Association (NEMA)

.1 NEMA MG 1, Motors and Generators.

.6 American National Standards Institute/Hydraulics Institute (ANSI/HI)

.1 1.6 Centrifugal Pump Test Standard.

1.3 SUBMITTALS

.1 Submit shop drawings and product data.

.2 Submit manufacturer's detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories and controllers.

.3 Submit product data of pump curves for review showing point of operation.

.4 Indicate piping, valves and fittings shipped loose by packaged equipment supplier, showing their final location in field assembly.

.5 Provide maintenance data for incorporation into manual.

1.4 HEALTH AND SAFETY

.1 Do construction occupational health and safety in accordance Team Ontario/BC Health and Safety Plan

1.5 WASTE MANAGEMENT AND DISPOSAL

.1 Separate waste material for reuse and recycling.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.

.4 Separate for reuse and recycling and place in designated containers, steel, metal, plastic waste in accordance with Waste Management Plan.

.5 Fold up metal banding, flatten and place in designated area for recycling.

1.6 EXTRA MATERIALS

.1 Furnish following spare parts:

.1 Mechanical seal for each pump.
.2 Packing for each pump.
.3 Set of gaskets for each pump.

PART 2 PRODUCTS

2.1 EQUIPMENT

.1 Do component selection and sizing to CAN/CSA-B214.

2.2 CIRCULATING PUMPS

.1 Volute: cast iron radially split, with screwed or flanged design suction and discharge connections.

.2 Impeller: alloy steel, cast bronze, or cast iron to suit application.

.3 Shaft: stainless steel with bronze sleeve bearing, integral thrust collar.

.4 Coupling: flexible self-aligning.

.5 Motor: as per Section 23 05 13 – Common Motor Requirements for HVAC Equipment and as per manufacturer’s recommendations. Speed and power as indicated in the pump schedule.

.6 Capacity: as indicated in the pump schedule.

.7 Acceptable Product: Grundfos UPS 15-58 FC or approved equal.

PART 3 EXECUTION

3.1 INSTALLATION

.1 In line circulators: install as indicated by flow arrows. Support at inlet and outlet flanges or unions. Install with bearing lubrication points accessible.

.2 Base mounted type: supply templates for anchor bolt placement. Furnish anchor bolts with sleeves. Place level, shim unit and grout. Align coupling in accordance with manufacturer's recommended tolerance. Check oil level and lubricate.

.3 Ensure that pump body does not support piping or equipment. Provide stanchions or hangers for this purpose. Refer to manufacturer's installation instructions for details.

.4 Pipe drain tapping to floor drain.

.5 Install volute venting pet cock in accessible location.

.6 Check rotation prior to start-up.

.7 Install pressure gauge ball valves.

3.2 START-UP

.1 General

.1 In accordance with manufacturer's recommendations.

.2 Procedures:

.1 Before starting pump, check that cooling water system, over-temperature and other protective devices are installed and operative.

.2 After starting pump, check for proper, safe operation.

.3 Check installation, operation of mechanical seals, packing gland type seals. Adjust as necessary.

.4 Check base for free-floating, no obstructions under base.

.5 Run-in pumps for 12 continuous hours.

.6 Verify operation of over-temperature and other protective devices under low- and no-flow condition.

.7 Eliminate air from scroll casing.

.8 Adjust water flow rate through water-cooled bearings.

.9 Adjust alignment of piping and conduit to ensure true flexibility at all times.

.10 Eliminate cavitation, flashing and air entrainment.

.11 Adjust pump shaft seals.

.12 Measure pressure drop across strainer when clean and with flow rates as finally set.

.13 Replace seals if pump used to degrease system or if pump used for temporary heat.

.14 Verify lubricating oil levels.

3.3 PERFORMANCE VERIFICATION (PV) AND COMMISSIONING

.1 General

.1 In accordance with manufacturer's recommendations.

.2 Assumptions: These PV procedures assume that:

.1 Manufacturer's performance curves are accurate.

.2 Valves on pump suction and discharge provide tight shut-off.

.3 Net Positive Suction Head (NPSH):

.1 Application: Measure NPSH for pumps which operate on open systems and with water at elevated temperatures.

.2 Measure using procedures prescribed in the ANSI/HI 1.6.

.3 Where procedures do not exist, discontinue PV, report to Consultant and await instructions.

.4 Mark points of design and actual performance at design conditions as finally set upon completion of TAB.

.5 Commissioning Reports:

.1 Record of point(s) of actual performance at maximum and minimum conditions and for single and parallel operation as finally set at completion of commissioning on pump curves.

.2 Pump performance curves (family of curves).

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Materials and installation for copper tubing and fittings for refrigerant.

1.2 RELATED SECTIONS:

.1 Section 23 05 05 - Installation of Pipework.

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society of Mechanical Consultants (ASME)

.1 ASME B16.22, Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings.

.2 ASME B16.24, Cast Copper Pipe Flanges and Flanged Fittings: Class 150, 300, 400, 600, 900, 1500 and 2500.

.3 ASME B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.

.4 ASME B31.5, Refrigeration Piping and Heat Transfer Components.

.3 American Society for Testing and Materials(ASTM)

.1 ASTM A 307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

.2 ASTM B 280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

.4 Canadian Standards Association (CSA)

.1 CSA B52, Mechanical Refrigeration Code.

.5 Environment Canada (EC)

.1 EPS1/RA/1, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.

.6 Health Canada / Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

.7 Province of Newfoundland and Labrador Boiler, Pressure Vessel and Compressed Gas Regulations

1.4 QUALITY ASSURANCE

.1 Pre-Installation Meeting:

.1 Convene pre-installation meeting one week prior to beginning work of this

Section and on-site installations.

.1 Verify project requirements.

.2 Review installation and substrate conditions.

.3 Co-ordination with other building subtrades.

.4 Review manufacturer's installation instructions and warranty requirements.

.2 Health and Safety:

.1 Do construction occupational health and safety in accordance Team Ontario/BC Health and Safety Plan

.3 Trades people to be journeyperson and graduate from a recognized college refrigeration trade program.

1.5 DELIVERY, STORAGE AND HANDLING

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling.

.4 Separate for reuse and recycling and place in designated containers, steel, metal, plastic waste.

.5 Divert unused metal materials from landfill to metal recycling facility as approved by Consultant

PART 2 PRODUCTS

2.1 TUBING

.1 Processed for refrigeration installations, deoxidized, dehydrated and sealed.

.1 Hard copper: to ASTM B280, type ACR B (nitrogenized).

.2 Annealed copper: to ASTM B280, with minimum wall thickness as per CSA B52 and ASME B31.5.

2.2 FITTINGS

.1 Service: design pressure 2070 kPa and temperature 121°C.

.2 Brazed:

.1 Fittings: wrought copper to ASME B16.22.

.2 Joints: silver solder, 45% Ag - 80% Cu - 5% P and non-corrosive flux for copper to steel or brass; Silfoss-15 for copper to copper.

.3 Flanged:

.1 Bronze or brass, to ASME B16.24, Class 150 and Class 300, tongue and

groove type.

.2 Gaskets: suitable for service.

.3 Bolts, nuts and washers: to ASTM A307, heavy series.

.4 Flared:

.1 Bronze or brass, for refrigeration, to ASME B16.26.

2.3 PIPE SLEEVES

.1 Hard copper or steel, sized to provide 6 mm clearance between sleeve and uninsulated pipe or between sleeve and insulation.

2.4 VALVES

.1 7/8 ODS and under: Class 500, 3.5 MPa, globe or angle non-directional type, diaphragm, packless type, with forged brass body and bonnet, moistureproof seal for below freezing applications, brazed connections.

.2 Over 7/8 ODS: Class 375, 3 MPa, globe or angle type, diaphragm, packless type, back-seating, cap seal, with cast bronze body and forged brass bonnet, moisture-proof seal for below freezing applications, brazed connections, non-rotating, self aligning swivel disc, Teflon seat, -40^{0}C - 163^{0}C.

.3 Ball valves 7 3/8 ODS to 3 1/8 ODS: maximum WP 4MPa, -40^{0}C to 149^{0}C, live loaded stem seal, double “O” ring hermetically sealed body, blowout proof stem, seal cap “O” ring sealed, valve position indicators, forged brass body bonnet, brass cap, triple sealed plated steel item, Teflon ball seals and gasket, extended copper connections, helium leak test to maximum 0.28 g/yr.

.4 Check valves 7/8 ODS to 3 1/8 ODS cast bronze body, brass bonnet, Teflon seat, internal parts removable minimum opening pressure 3.5 kPa, maximum WP 3.5 kPa - 29^{0}C to 149^{0}C, UL and CSA approved.

.5 Check valves 3/8 ODS to 7/8 ODS: brass construction, Teflon seal, removable piston, maximum WP 3.5 kPa, -40^{0}C to 149^{0}C, suitable for high side, low side and hot gas. UL and CSA approved, maximum opening pressure 3.5 kPa.

PART 3 EXECUTION

3.1 MANUFACTURER’S INSTRUCTIONS

.1 Compliance: comply with manufacturer’s written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 GENERAL

.1 In accordance with Section 23 05 05 – Installation of Pipework, supplemented as specified herein.

.2 Install in accordance with CSA B52, EPS1/RA/1 and ASME B31.5.

3.3 BRAZING PROCEDURES

.1 Bleed inert gas into pipe during brazing.

.2 Remove valve internal parts, solenoid valve coils, sight glass.

.3 Do not apply heat near expansion valve and bulb.

3.4 PIPING INSTALLATION

.1 General:

.1 Soft annealed copper tubing: bend without crimping or constriction, hard drawn copper tubing: do not bend. Minimize use of fittings.

.2 Hot gas lines:

.1 Pitch at least 1:240 down in direction of flow to prevent oil return to compressor during operation.

.2 Provide trap at base of risers greater than 1800 mm high and at each 6000 mm thereafter.

.3 Provide inverted deep trap at top of risers.

.4 Provide double risers for compressors having capacity modulation.

.1 Large riser: install traps as specified above.

.2 Small riser: size for 5.1 m/s at minimum load. Connect upstream of traps on large riser.

3.5 PRESSURE AND LEAK TESTING

.1 Close valves on factory charged equipment and other equipment not designed for test pressures.

.2 Leak test to CSA B52 before evacuation to 2MPa and 1MPa on high and low sides respectively.

.3 Test Procedure: Build pressure up to 35 kPa using nitrogen leave for 8 hours.

3.6 FIELD QUALITY CONTROL

.1 Site Tests/Inspection

.1 Close service valves on factory charged equipment.

.2 Ambient temperatures to be at least 13 degrees C for at least 12 hours before and during dehydration.

.3 Use copper lines for largest practical size to reduce evacuation time.

.4 Use two-stage vacuum pump with gas ballast on 2nd stage capable of pulling 5 Pa absolute and filled with dehydrated oil.

.5 Measure system pressure with vacuum gauge. Take readings with valve between vacuum pump and system closed.

.6 Triple evacuate system components containing gases other than correct refrigerant or having lost holding charge as follows:

.1 Twice to 14 Pa absolute and hold for 4 h.

.2 Break vacuum with refrigerant to 14 KPa.

.3 Final to 5 Pa absolute and hold for at least 12 h.

.4 Isolate pump from system, record vacuum and time readings until stabilization of vacuum.

.5 Submit test results to Consultant.

.7 Charging:

.1 Charge system through filter-drier and charging valve on high side. Low side charging not permitted.

.2 With compressors off, charge only amount necessary for proper operation of system. If system pressures equalize before system in fully charged, close charging valve and start up. With unit operating, add remainder of charge to system.

.3 Re-purge charging line if refrigerant container is changed during charging process.

.8 Checks:

.1 Make checks and measurements as per manufacturer's operation and maintenance instructions.

.2 Record and report measurements to Consultant.

.9 Manufacturer's Field Services:

.1 Have manufacturer of products, supplied under this Section, review work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of work with Contract.

.2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

.3 Schedule site visits, to review work , at stages listed:

.1 After delivery and storage of products, and when preparatory work, or other work, on which the work of this Section depends, is complete but before installation begins.

.2 Twice during progress of work at 25% and 60% complete.

.3 Upon completion of the work, after cleaning is carried out.

.4 Obtain reports, within 3 days of review, and submit, immediately, to Consultant.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Materials and installation for copper tubing and fittings for refrigerant.

1.2 RELATED SECTIONS:

.1 Section 23 05 05 - Installation of Pipework.

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society of Mechanical Consultants (ASME)

.1 ASME B16.22, Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings.

.2 ASME B16.24, Cast Copper Pipe Flanges and Flanged Fittings: Class 150, 300, 400, 600, 900, 1500 and 2500.

.3 ASME B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.

.4 ASME B31.5, Refrigeration Piping and Heat Transfer Components.

.3 American Society for Testing and Materials(ASTM)

.1 ASTM A 307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

.2 ASTM B 280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

.4 Canadian Standards Association (CSA)

.1 CSA B52, Mechanical Refrigeration Code.

.5 Environment Canada (EC)

.1 EPS1/RA/1, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.

.6 Health Canada / Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

.7 Province of Newfoundland and Labrador Boiler, Pressure Vessel and Compressed Gas Regulations

1.4 QUALITY ASSURANCE

.1 Pre-Installation Meeting:

.1 Convene pre-installation meeting one week prior to beginning work of this

Section and on-site installations.

.1 Verify project requirements.

.2 Review installation and substrate conditions.

.3 Co-ordination with other building subtrades.

.4 Review manufacturer's installation instructions and warranty requirements.

.2 Health and Safety:

.1 Do construction occupational health and safety in accordance Team Ontario/BC Health and Safety Plan

.3 Trades people to be journeyperson and graduate from a recognized college refrigeration trade program.

1.5 DELIVERY, STORAGE AND HANDLING

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling.

.4 Separate for reuse and recycling and place in designated containers, steel, metal, plastic waste.

.5 Divert unused metal materials from landfill to metal recycling facility as approved by Consultant

PART 2 PRODUCTS

2.1 TUBING

.1 Processed for refrigeration installations, deoxidized, dehydrated and sealed.

.1 Hard copper: to ASTM B280, type ACR B (nitrogenized).

.2 Annealed copper: to ASTM B280, with minimum wall thickness as per CSA B52 and ASME B31.5.

2.2 FITTINGS

.1 Service: design pressure 2070 kPa and temperature 121°C.

.2 Brazed:

.1 Fittings: wrought copper to ASME B16.22.

.2 Joints: silver solder, 45% Ag - 80% Cu - 5% P and non-corrosive flux for copper to steel or brass; Silfoss-15 for copper to copper.

.3 Flanged:

.1 Bronze or brass, to ASME B16.24, Class 150 and Class 300, tongue and

groove type.

.2 Gaskets: suitable for service.

.3 Bolts, nuts and washers: to ASTM A307, heavy series.

.4 Flared:

.1 Bronze or brass, for refrigeration, to ASME B16.26.

2.3 PIPE SLEEVES

.1 Hard copper or steel, sized to provide 6 mm clearance between sleeve and uninsulated pipe or between sleeve and insulation.

2.4 VALVES

.1 7/8 ODS and under: Class 500, 3.5 MPa, globe or angle non-directional type, diaphragm, packless type, with forged brass body and bonnet, moistureproof seal for below freezing applications, brazed connections.

.2 Over 7/8 ODS: Class 375, 3 MPa, globe or angle type, diaphragm, packless type, back-seating, cap seal, with cast bronze body and forged brass bonnet, moisture-proof seal for below freezing applications, brazed connections, non-rotating, self aligning swivel disc, Teflon seat, -40^{0}C - 163^{0}C.

.3 Ball valves 7 3/8 ODS to 3 1/8 ODS: maximum WP 4MPa, -40^{0}C to 149^{0}C, live loaded stem seal, double “O” ring hermetically sealed body, blowout proof stem, seal cap “O” ring sealed, valve position indicators, forged brass body bonnet, brass cap, triple sealed plated steel item, Teflon ball seals and gasket, extended copper connections, helium leak test to maximum 0.28 g/yr.

.4 Check valves 7/8 ODS to 3 1/8 ODS cast bronze body, brass bonnet, Teflon seat, internal parts removable minimum opening pressure 3.5 kPa, maximum WP 3.5 kPa - 29^{0}C to 149^{0}C, UL and CSA approved.

.5 Check valves 3/8 ODS to 7/8 ODS: brass construction, Teflon seal, removable piston, maximum WP 3.5 kPa, -40^{0}C to 149^{0}C, suitable for high side, low side and hot gas. UL and CSA approved, maximum opening pressure 3.5 kPa.

PART 3 EXECUTION

3.1 MANUFACTURER’S INSTRUCTIONS

.1 Compliance: comply with manufacturer’s written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 GENERAL

.1 In accordance with Section 23 05 05 – Installation of Pipework, supplemented as specified herein.

.2 Install in accordance with CSA B52, EPS1/RA/1 and ASME B31.5.

3.3 BRAZING PROCEDURES

.1 Bleed inert gas into pipe during brazing.

.2 Remove valve internal parts, solenoid valve coils, sight glass.

.3 Do not apply heat near expansion valve and bulb.

3.4 PIPING INSTALLATION

.1 General:

.1 Soft annealed copper tubing: bend without crimping or constriction, hard drawn copper tubing: do not bend. Minimize use of fittings.

.2 Hot gas lines:

.1 Pitch at least 1:240 down in direction of flow to prevent oil return to compressor during operation.

.2 Provide trap at base of risers greater than 1800 mm high and at each 6000 mm thereafter.

.3 Provide inverted deep trap at top of risers.

.4 Provide double risers for compressors having capacity modulation.

.1 Large riser: install traps as specified above.

.2 Small riser: size for 5.1 m/s at minimum load. Connect upstream of traps on large riser.

3.5 PRESSURE AND LEAK TESTING

.1 Close valves on factory charged equipment and other equipment not designed for test pressures.

.2 Leak test to CSA B52 before evacuation to 2MPa and 1MPa on high and low sides respectively.

.3 Test Procedure: Build pressure up to 35 kPa using nitrogen leave for 8 hours.

3.6 FIELD QUALITY CONTROL

.1 Site Tests/Inspection

.1 Close service valves on factory charged equipment.

.2 Ambient temperatures to be at least 13 degrees C for at least 12 hours before and during dehydration.

.3 Use copper lines for largest practical size to reduce evacuation time.

.4 Use two-stage vacuum pump with gas ballast on 2nd stage capable of pulling 5 Pa absolute and filled with dehydrated oil.

.5 Measure system pressure with vacuum gauge. Take readings with valve between vacuum pump and system closed.

.6 Triple evacuate system components containing gases other than correct refrigerant or having lost holding charge as follows:

.1 Twice to 14 Pa absolute and hold for 4 h.

.2 Break vacuum with refrigerant to 14 KPa.

.3 Final to 5 Pa absolute and hold for at least 12 h.

.4 Isolate pump from system, record vacuum and time readings until stabilization of vacuum.

.5 Submit test results to Consultant.

.7 Charging:

.1 Charge system through filter-drier and charging valve on high side. Low side charging not permitted.

.2 With compressors off, charge only amount necessary for proper operation of system. If system pressures equalize before system in fully charged, close charging valve and start up. With unit operating, add remainder of charge to system.

.3 Re-purge charging line if refrigerant container is changed during charging process.

.8 Checks:

.1 Make checks and measurements as per manufacturer's operation and maintenance instructions.

.2 Record and report measurements to Consultant.

.9 Manufacturer's Field Services:

.1 Have manufacturer of products, supplied under this Section, review work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of work with Contract.

.2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

.3 Schedule site visits, to review work , at stages listed:

.1 After delivery and storage of products, and when preparatory work, or other work, on which the work of this Section depends, is complete but before installation begins.

.2 Twice during progress of work at 25% and 60% complete.

.3 Upon completion of the work, after cleaning is carried out.

.4 Obtain reports, within 3 days of review, and submit, immediately, to Consultant.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 Materials and installation of low-pressure metallic ductwork, joints and accessories.

1.2 RELATED SECTIONS

.1 Section 07 84 00 – Firestopping

.2 Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment.

.3 Section 23 05 94 – Pressure Testing of Ducted Air Systems.

.4 Section 23 44 00 – HVAC Air Filtration

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society of Heating, Refrigerating and Air-Conditioning Consultants, Inc. (ASHRAE).

.3 American Society for Testing and Materials International, (ASTM).

.1 ASTM A 480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.

.2 ASTM A 635/A635M, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot Rolled.

.3 ASTM A 653/A653M, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.

.4 Department of Justice Canada (Jus).

.1 Canadian Environmental Protection Act (CEPA).

.5 Health Canada/Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

.6 National Fire Protection Association (NFPA).

.1 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.

.2 NFPA 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

.3 NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

.7 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

.1 SMACNA HVAC Duct Construction Standards - Metal and Flexible.

.2 SMACNA HVAC Air Duct Leakage Test Manual.

.3 IAQ Guideline for Occupied Buildings Under Construction, 1st Edition.

.8 Transport Canada (TC).

.1 Transportation of Dangerous Goods Act (TDGA).

1.4 SUBMITTALS

.1 Product Data: submit WHMIS MSDS - Material Safety Data

.1 Sealants.

.2 Tape.

.3 Proprietary Joints.

1.5 QUALITY ASSURANCE

.1 Certification of Ratings:

.1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

.2 Health and Safety:

.1 Do construction occupational health and safety in accordance with Team North Health and Safety Plan

.2 During construction meet or exceed the requirements of SMACNA IAQ Guideline for Occupied Buildings under Construction.

1.6 DELIVERY, STORAGE AND HANDLING

.1 Protect on site stored or installed absorptive material from moisture damage.

.2 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.

.4 Separate for reuse and recycling and place in designated containers steel, metal, plastic waste in accordance with Waste Management Plan.

.5 Place materials defined as hazardous or toxic in designated containers.

.6 Handle and dispose of hazardous materials in accordance with CEPA, TDGA, Regional and Municipal regulations.

.7 Fold up metal and plastic banding, flatten and place in designated area for recycling.

PART 2PRODUCTS

2.1 SEAL CLASSIFICATION

.1 Classification as follows:

Maximum Pressure Pa	SMACNA Seal Class
> 1000	A
750	B
500	C
250	C
125	C

.2 Seal classification:

.1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.

.2 Class B: longitudinal seams, transverse joints and connections made airtight with sealant tape or combination thereof.

.3 Class C: transverse joints and connections made air tight with gaskets, sealant tape or combination thereof. Longitudinal seams unsealed.

2.2 SEALANT

.1 Sealant: oil resistant, polymer type flame resistant duct sealant. Temperature range of minus 30°C to plus 93°C.

2.3 TAPE

.1 Tape: polyvinyl treated, open weave fiberglass tape, 50 mm wide.

2.4 DUCT LEAKAGE

.1 In accordance with SMACNA HVAC Duct Leakage Test Manual.

2.5 FITTINGS

.1 Fabrication: to SMACNA.

.2 Radiused elbows:

.1 Rectangular: Centreline radius: 1.5 times width of duct.

.2 Round: smooth radius or five piece. Centreline radius: 1.5 times diameter.

.3 Mitred elbows, rectangular:

.1 To 400 mm: with single thickness turning vanes.

.2 Over 400 mm: with double thickness turning vanes.

.4 Branches:

.1 Rectangular main and branch: with radius on branch 1.5 times width of duct or 45^0 entry on branch.

.2 Round main and branch: enter main duct at 45^0 with conical connection.

.3 Provide volume control damper in branch duct near connection to main duct.

.4 Main duct branches: with volume control damper.

.5 Transitions:

.1 Diverging: 20^0 maximum included angle.

.2 Converging: 30^0 maximum included angle.

.6 Offsets:

.1 Full short radiused elbows as indicated.

.7 Obstruction deflectors: maintain full cross-sectional area. Maximum included angles: as for transitions.

2.6 GALVANIZED STEEL

.1 Lock forming quality: to ASTM A653, G90 zinc coating.

.2 Thickness, fabrication and reinforcement: to SMACNA.

.3 Joints: to SMACNA or proprietary manufactured duct joint. Proprietary manufactured flanged duct joint to be considered to be a class A seal.

2.7 STAINLESS STEEL

.1 To ASTM A480/A480M, Type 304.

.2 Finish: No 4. finish on exposed side of duct in finished area's, No. 3 finish or lower where concealed.

.3 Thickness, fabrication and reinforcement: to SMACNA.

.4 Joints: to SMACNA and be continuous inert gas welded.

2.8 ALUMINUM

.1 To SMACNA. Aluminum type: 3003-H-14.

.2 Thickness, fabrication and reinforcement: to SMACNA.

.3 Joints: to SMACNA and be continuous weld.

2.9 BLACK STEEL

.1 To ASTM A635/A635M.

.2 Thickness: 1.2 mm

.3 Fabrication: ducts and fittings or SMACNA.

.4 Reinforcement: to SMACNA.

.5 Joints: continuous weld.

2.10 KITCHEN EXHAUST SYSTEMS

.1 Construct in accordance with NFPA 96.

.2 Material: Type 304 stainless steel where exposed, stainless steel where concealed or black sheet where concealed.

.3 Thickness: to NFPA 96.

.4 Fabrication: joints, continuous inert gas welded for stainless steel, ARC welded for black steel.

.5 Reinforcement: to SMACNA.

.6 Drainage: at low point.

.7 Grease filters: to Section 23 44 00 – HVAC Air Filtration.

2.11 HANGERS AND SUPPORTS

.1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct. Maximum size duct supported by strap hanger: 500 mm.

.2 Hanger configuration: to SMACNA.

.3 Hangers: galvanized steel angle with black steel rods to ASHRAE or SMACNA following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
up to 750	25x25x3	6
751 to 1050	40x40x3	6
1051 to 1500	40x40x3	10
1501 to 2100	50x50x3	10
2101 to 2400	50x50x5	10
2401 and over	50 x 50 x 6	10

.4 Upper hanger attachments:

.1 For concrete: manufactured concrete inserts.

.1 Acceptable Product: Myatt, Grinnell, Hunt.

.2 For steel joist: manufactured joist clamp steel plate washer.

.1 Acceptable Product: Myatt, Grinnell, Hunt.

.3 For steel beams: manufactured beam clamps:

.1 Acceptable Product: Myatt, Grinnell, Hunt.

PART 3EXECUTION

3.1 GENERAL

.1 Do work in accordance with NFPA 90A, NFPA 90B, and SMACNA.

.2 Do not break continuity of insulation vapour barrier with hangers or rods. Insulate strap hangers 100 mm beyond insulated duct.

.3 Support risers in accordance with SMACNA.

.4 Install breakaway joints in ductwork on sides of fire separation. Do not place fire stopping material in expansion space between damper sleeve and fire partition.

.5 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.

.6 Manufacture duct in lengths and diameter to accommodate installation of acoustic duct lining.

3.2 HANGERS

.1 Strap hangers: install in accordance with SMACNA.

.2 Angle hangers: complete with locking nuts and washers.

.3 Hanger spacing: in accordance with SMACNA or as follows:

Duct Size (mm)	Spacing (mm)
to 1500	3000
1501 and over	2500

3.3 WATERTIGHT DUCT

.1 Provide watertight duct for:

.1 Dishwasher exhaust.
.2 Fresh air intake.
.3 Minimum 3000 mm from duct mounted humidifier in all directions.
.4 As indicated.

.2 Form bottom of horizontal duct without longitudinal seams. Solder or weld joints of bottom and side sheets. Seal other joints with duct sealer.

.3 Slope horizontal branch ductwork down towards fume hoods served. Slope header ducts down toward risers.

.4 Fit base of riser with 150 mm deep drain sump and NPS 1 ½ drain connected, with deep seal trap and valve and discharging to open funnel drain or service sink or as approved by Consultant.

3.4 KITCHEN EXHAUST SYSTEMS

.1 Install to NFPA 96 and as indicated.

3.5 SEALING AND TAPING

.1 Apply sealant to outside of joint to manufacturer's recommendations.

.2 Bed tape in sealant and recoat with minimum of one coat of sealant to manufacturers recommendations. Sealant and tape to be applied to full perimeter of duct.

3.6 LEAKAGE TESTS/COMMISSIOONING

.1 Refer to Section 23 05 94 - Pressure Testing of Ducted Air Systems.

.2 In accordance with SMACNA HVAC Duct Leakage Test Manual.

.3 Do leakage tests in sections.

.4 Make trial leakage tests as instructed to demonstrate workmanship.

.5 Install no additional ductwork until trial test has been passed.

.6 Test section minimum of 30 m long with not less then three branch takeoffs and two 90º elbows.

.7 Complete test before insulation or concealment.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Materials and installation for duct accessories including flexible connections, access doors, vanes and collars.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 Health Canada/Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

.3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

.1 SMACNA – HVAC Duct Construction Standards – Metal and Flexible.

1.3 QUALITY ASSURANCE

.1 Pre-Installation Meetings:

.1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations.

.1 Verify project requirements.

.2 Review installation and substrate conditions.

.3 Co-ordination with other building subtrades.

.4 Review manufacturer's installation instructions and warranty requirements.

.2 Health and Safety:

.1 Do construction occupational health and safety in accordance with Team North Health and Safety Plan

1.4 DELIVERY, STORAGE AND HANDLING

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, and corrugated cardboard, packaging material in appropriate on-site bins for recycling

.4 Separate for reuse and recycling and place in designated containers steel, metal, and plastic waste.

.5 Divert unused metal materials from landfill to metal recycling facility as approved by Consultant.

PART 2 PRODUCTS

2.1 GENERAL

.1 Manufacture in accordance with SMACNA - HVAC Duct Construction Standards.

2.2 FLEXIBLE CONNECTIONS

.1 Frame: galvanized sheet metal frame 0.66 mm thick with fabric clenched by means of double locked seams.

.2 Material:

.1 Fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at minus 40^0C to plus 90^0C, density of 1.3 kg/m^2.

2.3 ACCESS DOORS IN DUCTS

.1 Non-insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame.

.2 Insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame and 25 mm thick rigid glass fibre insulation.

.3 Gaskets: neoprene.

.4 Hardware:

.1 Hold open devices.
.2 300 x 300 mm glass viewing panels.
.3 Up to 300 x 300 mm: two sash locks complete with safety chain.
.4 301 to 450 mm: four sash locks complete with safety chain.
.5 451 to 1000 mm: piano hinge and minimum two sash locks.
.6 Doors over 1000 mm: piano hinge and two handles operable from both sides.
.1 Hold open devices.
.2 300 X 300 mm glass viewing panels.

2.4 TURNING VANES

.1 Factory or shop fabricated double thickness with trailing edge, to recommendations of SMACNA and as indicated.

2.5 INSTRUMENT TEST PORTS

.1 1.6 mm thick steel zinc plated after manufacture.

.2 Cam lock handles with neoprene expansion plug and handle chain.

.3 28 mm minimum inside diameter. Length to suit insulation thickness.

.4 Neoprene mounting gasket.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 Flexible connections:

- .1 Install in following locations:
  - .1 Inlets and outlets to supply air units and fans.
  - .2 Inlets and outlets of exhaust and return air fans.
  - .3 As indicated.
- .2 Length of connection: 100 mm.
- .3 Minimum distance between metal parts when system in operation: 75 mm.
- .4 Install in accordance with recommendations of SMACNA.
- .5 When fan is running:
  - .1 Ducting on sides of flexible connection to be in alignment.
  - .2 Ensure slack material in flexible connection.

.2 Access doors and viewing panels:

- .1 Size:
  - .1 600 x 600 mm for person size entry.
  - .2 450 x 450 mm for servicing entry.
  - .3 300 x 300 mm for viewing.
  - .4 As indicated.
- .2 Locations:
  - .1 Fire and smoke dampers.
  - .2 Control dampers.
  - .3 Devices requiring maintenance.
  - .4 Required by code.
  - .5 Reheat coils.
  - .6 Elsewhere as indicated.

.3 Instrument test ports.

- .1 General:
  - .1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
- .2 Locate to permit easy manipulation of instruments.
- .3 Install insulation port extensions as required.
- .4 Locations.
  - .1 For traverse readings:
    - .1 Ducted inlets to roof and wall exhausters.
    - .2 Inlets and outlets of other fan systems.

.3 Main and sub-main ducts.

.4 And as indicated.

.2 For temperature readings:

.1 At outside air intakes.

.2 In mixed air applications in locations as approved by Consultant.

.3 At inlet and outlet of coils.

.4 Downstream of junctions of two converging air streams of different temperatures.

.5 And as indicated.

.4 Turning vanes:

.1 Install in accordance with recommendations of SMACNA and as indicated.

3.3 FIELD QUALITY CONTROL

.1 Manufacturer's Field Services:

.1 Have manufacturer's representative of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports.

.2 Manufacturer's Field Services: provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

.3 Schedule site visits, to review Work, at stages listed:

.1 After delivery and storage of products, and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.

.2 Twice during progress of Work at 25% and 60% complete.

.3 Upon completion of the Work, after cleaning is carried out.

.4 Obtain reports, within 3 days of review, and submit, immediately, to Consultant.

3.4 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 GENERAL

1.1 SECTION INCLUDES

.1 Materials and installation for acoustic duct lining.

1.2 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American Society for Testing and Materials International, (ASTM).

.1 ASTM C 423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

.2 ASTM C 916, Standard Specification for Adhesives for Duct Thermal Insulation.

.3 ASTM C 1071, Standard specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

.4 ASTM C 1338, Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.

.5 ASTM G 21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

.3 Department of Justice Canada (Jus).

.1 Canadian Environmental Protection Act (CEPA).

.4 Health Canada/Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

.5 National Fire Protection Association (NFPA).

.1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

.2 NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

.6 Thermal Insulation Association of Canada(TIAC).

.1 National Insulation Standards.

.7 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA).

.1 SMACNA, HVAC DCS HVAC, Duct Construction Standards, Metal and Flexible.

.2 SMACNA IAQ Guideline for Occupied Buildings 95.

.8 Transport Canada (TC).

.1 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.

.9 Underwriter's Laboratories of Canada (ULC).

.1 CAN/ULC-S102, Methods of Test for Surface Burning Characteristics of Building Materials and Assemblies.

1.3 SUBMITTALS

.1 Submit product data.

.2 Submit WHMIS MSDS - Material Safety Data Sheets.

1.4 HEALTH AND SAFETY

.1 Do construction occupational health and safety in accordance with Team Ontario/BC Health and Safety Plan.

1.5 DELIVERY, STORAGE AND HANDLING

.1 Protect on site stored or installed absorptive material from moisture damage.

1.6 WASTE MANAGEMENT AND DISPOSAL

.1 Separate waste materials for reuse and recycling.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.

.4 Place materials defined as hazardous or toxic in designated containers.

.5 Handle and dispose of hazardous materials in accordance with CEPA, TDGA , Regional and Municipal regulations.

.6 Ensure emptied containers are sealed and stored safely.

.7 Fold up metal banding, flatten and place in designated area for recycling.

PART 2 PRODUCTS

2.1 DUCT LINER

.1 General:

.1 Mineral Fibre duct liner: air surface coated mat facing.

.2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50 when tested in accordance with CAN/ULC-S102, NFPA 90A and NFPA 90B.

.3 Fungi resistance: to ASTM C 1338, ASTM G 21.

.2 Rigid:

.1 Use on flat surfaces where indicated

.2 25 mm thick, to ASTM C 1071, Type 2, fibrous glass rigid board duct liner.

.3 Density: 48 kg/m³ minimum.

.4 Thermal resistance to be minimum 0.76 (m². degrees C)/W for 25 mm thickness, 1.15 (m².degrees C)/W for 38 mm thickness, 1.53 (m².degrees C)/W for 50 mm

thickness when tested in accordance with ASTM C 177, at 24 degrees C mean temperature.

.5 Maximum velocity on faced air side: 20.3 m/sec.

.6 Minimum NRC of 0.70 at 25 mm thickness based on Type A mounting to ASTM C 423.

.3 Flexible:

.1 Use on round or oval surfaces.

.2 25 mm thick, to ASTM C 1071 Type 1, fibrous glass blanket duct liner.

.3 Density: 24 kg/m³ minimum.

.4 Thermal resistance to be minimum 0.37 (m².degrees C)/W for 12 mm thickness, 0.74 (m².degrees C)/W for 25 mm thickness, 1.11 (m².degrees C)/W for 38 mm thickness, 1.41 (m².degrees C)/W to 50 mm thickness when tested in accordance with ASTM C 177, at 24 degrees C mean temperature.

.5 Maximum velocity on coated air side: 25.4 m/sec.

.6 Minimum NRC of 0.65 at 25 mm thickness based on Type A mounting to ASTM C 423.

2.2 ADHESIVE

.1 Adhesive: to NFPA 90A and NFPA 90B, ASTM C916.

.2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 29 degrees C to plus 93 degrees C.

.3 Water-based fire retardant type.

2.3 FASTENERS

.1 Weld pins 2.0 mm diameter, length to suit thickness of insulation. Metal retaining clips, 32 mm square.

2.4 JOINT TAPE

.1 Poly-Vinyl treated open weave fiberglass membrane 50 mm wide.

2.5 SEALER

.1 Meet requirements of NFPA 90A and NFPA 90B.

.2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 68 degrees C to plus 93 degrees C.

PART 3 EXECUTION

3.1 GENERAL

.1 Do work in accordance with SMACNA HVAC DCS, NIAC, FGDLS and as indicated except as specified otherwise.

.2 Line inside of ducts where indicated.

.3 Duct dimensions, as indicated, are clear inside duct lining.

3.2 DUCT LINER

.1 Install in accordance with manufacturer's recommendations, and as follows:

.1 Fasten to interior sheet metal surface with 100 % coverage of adhesive to ASTM C 916

.1 Exposed leading edges and transverse joints to be factory coated or coated with adhesive during fabrication.

.2 In addition to adhesive, install weld pins not less than 2 rows per surface and not more than 425 mm on centres impact driven mechanical fasteners to compress duct liner sufficiently to hold it firmly in place.

.1 Spacing of mechanical fasteners in accordance with SMACNA HVAC, DCS, TIAC.

.2 In systems, where air velocities exceed 20.3 m/sec, install galvanized sheet metal noising to leading edges of duct liner.

3.3 JOINTS

.1 Seal butt joints, exposed edges, weld pin and clip penetrations and damaged areas of liner with joint tape and sealer. Install joint tape in accordance with manufacturer's written recommendations, and as follows:

.1 Bed tape in sealer.

.2 Apply two coats of sealer over tape.

.2 Replace damaged areas of liner at discretion of Consultant.

.3 Protect leading and trailing edges of duct sections with sheet metal nosing having 15 mm overlap and fastened to duct.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Fans, window ventilators, exterior, wall and ceiling mounted discharge fans for domestic use.

1.2 RELATED SECTIONS

.1 Section 23 05 13 – Common Motor Requirements for HVAC Equipment.

.2 Section 23 33 00 – Air Duct Accessories.

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 Air Conditioning and Mechanical Contractors Association (AMCA)

.1 AMCA 201, Fans and Systems.
.2 AMCA 300, Reverberant Room Method for Sound Testing of Fans.
.3 AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
.4 AMCA 302, Application of Sone Ratings for Non-Ducted Air Moving Devices.
.5 AMCA 303, Application of Sound Power Level Ratings for Fans.

.3 American National Standards Institute (ANSI)/American Society of Mechanical Consultants (ASME)

.1 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

.4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

1.4 SYSTEM DESCRIPTION

.1 Performance Requirements:

.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.

1.5 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet. Include product characteristics, performance criteria, and limitations.

.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS).

.2 Shop Drawings:

.1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures

.2 Indicate following: dimensions, performance, sound rating, and installation procedure.

.3 Quality assurance submittals: submit following.

.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.2 Instructions: submit manufacturer's installation instructions.

1.6 QUALITY ASSURANCE

.1 Health and Safety Requirements: do construction occupational health and safety in accordance with Team North Health and Safety Plan.

1.7 MAINTENANCE

.1 Extra Materials:

.1 Furnish list of individual manufacturer's recommended spare parts for equipment, include:

.1 Bearings and seals.

.2 Belts

.3 Addresses of suppliers.

.4 List of specialized tools necessary for adjusting, repairing or replacing.

1.8 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.

.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 2 PRODUCTS

2.1 KITCHEN EXHAUST FAN

.1 Shall be inline centrifugal fan

.2 Maximum static pressure 1.88 in water

.3 Approved product: Fantech FG6 or approved equal

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 Install in accordance with manufacturer's recommendations.

3.3 ANCHOR BOLTS AND TEMPLATES

.1 Supply for installation by other divisions.

3.4 CLEANING

.1 Proceed in accordance with Section 01 74 11 - Cleaning.

.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

3.5 COMMISSIONING

.1 Commission in accordance with Section 01 91 13 – General Commissioning (Cx) Requirements.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 Supply, return and exhaust grilles and registers, diffusers and linear grilles, for commercial and residential use.

1.2 REFERENCES

.1 American Society of Heating Refrigerating and Air-Conditioning Consultants (ASHRAE).

.1 ASHRAE 70, Method of Testing for Rating the Performance of Air Ducts and Outlets.

1.3 SYSTEM DESCRIPTION

.1 Performance requirements:

.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

1.4 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheets. Include product characteristics, performance criteria, and limitations.

.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS).

.2 Indicate following:

.1 Capacity

.2 Throw and terminal velocity

.3 Noise criteria

.4 Pressure drop

.5 Neck velocity

.2 Quality assurance submittals: submit following.

.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.2 Instructions: submit manufacturer's installation instructions.

1.5 QUALITY ASSURANCE

.1 Health and Safety Requirements: do construction occupational health and safety in accordance with Team Ontario/BC Health and Safety Plan.

1.6 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

1.7 MAINTENANCE

.1 Extra Materials:

.1 Include:

.1 Keys for volume control adjustment

.2 Keys for air flow pattern adjustment.

PART 2 PRODUCTS

2.1 GENERAL

.1 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity.

.2 Frames:

.1 Full perimeter gaskets.

.2 Plaster frames where set into plaster or gypsum board.

.3 Concealed fasteners.

.3 Concealed manual volume control damper operators as indicated.

.4 Colour: standard or as directed by Consultant.

.5 Acceptable Product: E. H. Price, Titus, Nailor, Carnes, Airvector, Anemostat.

2.2 MANUFACTURED UNITS

.1 Grilles, registers and diffusers of same generic type to be product of one manufacturer.

2.3 SUPPLY GRILLES AND REGISTERS

.1 See Schedule.

2.4 RETURN AND EXHAUST GRILLES AND REGISTERS

.1 See Schedule.

2.5 DIFFUSERS

.1 See Schedule.

2.6 LINEAR GRILLES

.1 See Schedule.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 Install in accordance with manufacturers instructions.

.2 Install with flat head stainless steel or cadmium plated screws in countersunk holes where fastenings are visible.

.3 Bolt grilles, registers and diffusers, in place, in gymnasium and similar game rooms.

.4 Provide concealed safety chain on each grille, register and diffuser in gymnasium and similar game rooms and elsewhere.

3.3 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 Supply, return and exhaust grilles and registers, diffusers and linear grilles, for commercial and residential use.

1.2 REFERENCES

.1 American Society of Heating Refrigerating and Air-Conditioning Consultants (ASHRAE).

.1 ASHRAE 70, Method of Testing for Rating the Performance of Air Ducts and Outlets.

1.3 SYSTEM DESCRIPTION

.1 Performance requirements:

.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

1.4 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheets. Include product characteristics, performance criteria, and limitations.

.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS).

.2 Indicate following:

.1 Capacity

.2 Throw and terminal velocity

.3 Noise criteria

.4 Pressure drop

.5 Neck velocity

.2 Quality assurance submittals: submit following.

.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.2 Instructions: submit manufacturer's installation instructions.

1.5 QUALITY ASSURANCE

.1 Health and Safety Requirements: do construction occupational health and safety in accordance with Team Ontario/BC Health and Safety Plan.

1.6 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

1.7 MAINTENANCE

.1 Extra Materials:

.1 Include:

.1 Keys for volume control adjustment

.2 Keys for air flow pattern adjustment.

PART 2 PRODUCTS

2.1 GENERAL

.1 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity.

.2 Frames:

.1 Full perimeter gaskets.

.2 Plaster frames where set into plaster or gypsum board.

.3 Concealed fasteners.

.3 Concealed manual volume control damper operators as indicated.

.4 Colour: standard or as directed by Consultant.

.5 Acceptable Product: E. H. Price, Titus, Nailor, Carnes, Airvector, Anemostat.

2.2 MANUFACTURED UNITS

.1 Grilles, registers and diffusers of same generic type to be product of one manufacturer.

2.3 SUPPLY GRILLES AND REGISTERS

.1 See Schedule.

2.4 RETURN AND EXHAUST GRILLES AND REGISTERS

.1 See Schedule.

2.5 DIFFUSERS

.1 See Schedule.

2.6 LINEAR GRILLES

.1 See Schedule.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 Install in accordance with manufacturers instructions.

.2 Install with flat head stainless steel or cadmium plated screws in countersunk holes where fastenings are visible.

.3 Bolt grilles, registers and diffusers, in place, in gymnasium and similar game rooms.

.4 Provide concealed safety chain on each grille, register and diffuser in gymnasium and similar game rooms and elsewhere.

3.3 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Filters and filter gauges for various types of mechanical air handling equipment.

1.2 RELATED SECTIONS:

.1 Section 23 73 10 – Air Handling – Built-up.

.2 Section 23 73 11 – Air Handling Units – Packaged.

.3 Section 23 74 00 – Packaged Outdoor HVAC Equipment.

1.3 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American National Standards Institute/National Fire Prevention Association (ANSI/NFPA)

.1 ANSI/NFPA 96, Ventilation Control and Fire Protection of Commercial Cooking Operations.

.3 American Society of Heating, Refrigeration and Air-Conditioning Consultants (ASHRAE)

.1 ASHRAE 52.1, Gravimetric And Dust Spot for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter (ANSI Approved).

.4 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-115.10, Disposable Air Filters for the Removal of Particulate Matter from Ventilating Systems.

.2 CAN/CGSB-115.11, Filters, Air, High Efficiency, Disposable, Bag Type.

.3 CAN/CGSB-115.12, Filters, Air, Medium Efficiency, Disposable, Bag Type.

.4 CAN/CGSB-115.13, Filter Media, Automatic Roll.

.5 CAN/CGSB-115.14, High Efficiency Cartridge Type Supported Air Filters for the Removal of Particulate Matter from Ventilating Systems.

.6 CAN/CGSB-115.15, High Efficiency Rigid Type Air Filters for Removal of Particulate Matter from Ventilating Systems.

.7 CAN/CGSB-115.16, Activated Carbon for Odor Removal from Ventilating Systems.

.8 CAN/CGSB-115.18, Filter, Air, Extended Area Panel Type, Medium Efficiency.

.9 CAN/CGSB-115.20, Polarized Media Air Filter.

.5 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

.6 Underwriters' Laboratories of Canada (ULC)

.1 ULC-S111, Standard Method of Fire Tests for Air Filter Units.

.2 ULC-S649, Exhaust Hoods and Related Controls for Commercial and Institutional Kitchens.

1.4 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheets. Include product characteristics, performance criteria, and limitations.

.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Material Safety Data Sheets (MSDS).

.2 Shop Drawings:

.1 Submit shop drawings.

.1 Indicate following:

.1 Pressure drop.

.2 Installation procedures.

.3 Quality assurance submittals: submit following.

.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.2 Instructions: submit manufacturer's installation instructions.

.4 Closeout Submittals

.1 Provide maintenance data for incorporation into manual.

1.5 QUALITY ASSURANCE

.1 Health and Safety Requirements: do construction occupational health and safety in accordance with Team Ontario/BC Health and Safety Plan.

1.6 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal:

.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling.

1.7 MAINTENANCE

.1 Extra Materials:

.1 Furnish list of individual manufacturer's recommended spare parts for equipment such as frames and filters, addresses of suppliers, list of specialized tools necessary for adjusting, repairing or replacing for inclusion in operating manual.

.2 Spare filters: in addition to filters installed immediately prior to acceptance by Consultant, supply one (1) complete set of filters for each filter unit or filter bank.

PART 2 PRODUCTS

2.1 GENERAL

.1 Media: suitable for air at 100% RH and air temperatures between minus 40 and 50 □C.

.2 Number of units, size as recommended by manufacturer and thickness of panels, overall dimensions of filter bank, configuration and capacities: as indicated.

.3 Pressure drop when clean and dirty, sizes and thickness: as indicated on schedule.

.4 Acceptable Product: Farr, Cambridge, American Air Filter.

2.2 ACCESSORIES

.1 Holding frames: permanent "T" section or channel section construction of galvanized steel or same material as casing/hood, 1.6 mm thick, except where specified otherwise.

.2 Seals: to ensure leakproof operation.

.3 Blank-off plates: as required, to fit all openings and of same material as holding frames.

.4 Access and servicing: through doors/panels on each side and/or from upstream face of filter bank.

2.3 FIBROUS GLASS PANEL FILTERS

.1 Disposable fibrous glass media: to CAN/CGSB-115.10 with adhesive.

.2 Holding frame: 1.2 mm minimum thick galvanized steel with 3 mm diam hinged wire mesh screen.

.3 Performance: minimum average synthetic dust weight arrestance 70 %.

.4 Fire rated: to ULC -S111.

.5 Nominal thickness: 50 mm.

2.4 GREASE FILTERS

.1 Media: washable, 50 mm thick: to ULC- S649 and ANSI/NFPA 96.

.2 Holding frame: 1 mm thick stainless steel V or inclined as indicated.

.3 Stainless steel blank-off plates.

.4 Individual, removable drip trays with handles.

2.5 CARTRIDGE TYPE FILTERS, 80-85 % EFFICIENCY

.1 Media: deep pleated, disposable, high efficiency, to CAN/CGSB-115.14.

.2 Holding frame: galvanized steel with bracing.

.3 Media support: welded wire grid.

.4 Performance: average atmospheric dust spot efficiency 80-85 % to ASHRAE 52.1.

.5 Fire rated: to ULC -S111.

2.6 CARTRIDGE TYPE FILTERS 95 %EFFICIENCY

.1 Media: disposable, high efficiency, to CAN/CGSB-115.15.

.2 Holding frame: galvanized steel with bracing.

.3 Media support: welded wire grid.

.4 Performance: average atmospheric dust spot efficiency 95 % to ASHRAE 52.1.

.5 Fire rated: to ULC -S111.

2.7 HEPA ABSOLUTE PACKAGE FILTERS 99.97 % EFFICIENCY

.1 Media: water resistant fibrous glass.

.2 Holding frame: cadmium plated steel by unit manufacturer.

.3 Housing and sealing system: manufacturers' standard, suitable for pressure application.

.4 Efficiency: minimum 99.97 % overall on hot DOP test, using 0.003 mm particles.

2.8 ROLL TYPE FILTERS

.1 Media: adhesive coated fibrous glass: to CAN/CGSB -115.13.

.2 Holding frame and media support: minimum 2.0 mm thick galvanized steel.

.1 Media enclosure: to contain clean roll of 20 m length of media completely enclosed in sheet metal housing or cover.

.3 Drive mechanism: electric gear reducer motor to wind spool through chain and sprocket assembly. Provide automatic device to prevent reverse rotation of used media roll, and to maintain tension on media in active air stream.

.4 Controls: prewired package to advance media when filter resistance exceeds preselected high limit. Media runout switch to stop travel and indicate runout. Hand-off-auto switch to override controls and advance media.

.5 Performance: average atmospheric dust spot efficiency 80% to ASHRAE 52.1.

2.9 ELECTRONIC AIR CLEANERS

.1 Electronic agglomerator: independently supported and nested collection cells including ionizing wires, grounded struts, positive and negative plates, insulators, ionizer and plate contacts. Insulators: locate out of air stream.

.2 Power pack:

.1 Self-contained, prewired rectifying unit for approximately 12,000V DC for ionizer and 6,000V DC for precipitator.

.2 Overload protection, on-off switch, pilot light indicating operating status and safety accessories.

.3 Control package to be complete with: airflow switch, manual reset, safety switches, warning lights, high voltage warning signs and signal lights.

.4 Efficiency electronic: 98% to ASHRAE 52.1.

2.10 ACTIVATED CARBON TYPE FILTERS

.1 Media:

.1 Regenerative activated carbon from coconut shell: to CAN/CGSB-115.16.

.2 50-55 minute absorption capacity in accordance with standard accelerated chloropicrin test.

.3 Density: 550 kg/m ^{3}.

.4 95 hardness in accordance with Ball abrasion test.

.5 Particle size (Tyler mesh screen): 6.3 x 10 mm.

.6 Quantity of media: 4.25 kg/100 L/s.

.2 Holding frame: removable, non-disposable, corrosion resistant steel.

.3 Filter housing: corrosion resistant steel.

.4 Test element:

.1 Detachable, to indicate extent of saturation of actual installation.

.2 1 per bank.

2.11 FILTER GAUGES - DIAL TYPE

.1 Housing: Die cast aluminum case and bezel, with acrylic cover. Exterior finish coated to withstand 168 hour salt spray corrosion test. Diaphragm actuated, direct reading.

.2 Accuracy: ± 2% of full scale (± 3% on-0-125 PA, and ± 4% on -0-60PA.), throughout range at 21.1ºC.

.3 Pressure Limits: 500 mm Hg to 100 kPa.

.4 Overpressure: Relief plug opens at approximately (1.72 kPa), standard.

.5 Temperature Limits: 6.67 to 60ºC.

.6 Size: 101.6 mm diameter dial face.

.7 Mounting Orientation. Diaphragm in vertical position.

.8 Process Connections: 2- 1/8 female NPT duplicate high and low pressure taps one pair side and one pair back.

.9 Standard Accessories: Two 1/8 NPT plugs for duplicate pressure taps, two ⅛ NPT pipe thread to rubber tubing adapters and three flush mounting adapters with screws.

.10 Range: 0-250 Pa.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION GENERAL

.1 Install in accordance with manufacturer's recommendations and with adequate space for access, maintenance and replacement.

3.3 ACTIVATED CARBON TYPE FILTERS

.1 During testing, adjusting and balancing, install substitute media.

.2 Install permanent media only after all painting is completed.

3.4 REPLACEMENT MEDIA

.1 Replace all media with new upon acceptance.

.2 Filter media to be new and clean, as indicated by pressure gauge, at time of acceptance.

3.5 HEPA FILTERS

.1 Use components and devices recommended by manufacturer to ensure complete integrity and to ensure easy removal and replacement, even when dressed in anti-contamination clothing.

.2 Provide proper permanent facilities for challenging integrity with aerosol injector downstream of pre-filters and test sampling manifold downstream of HEPA filter. Location of injector and sampling manifold to be approved by manufacturer.

.3 During TAB, install substitute media having similar pressure drop.

.4 Before acceptance, perform tests to demonstrate integrity of complete installation.

3.6 FILTER GAUGES

.1 Install type as indicated across each filter bank (pre-filter and final filter) in approved and easy readable location.

.2 Mark each filter gauge with value of pressure drop for clean condition and manufacturer's recommended replacement (dirty) value.

3.7 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

PART 1 GENERAL

1.1 REFERENCES

.1 Codes and standards referenced in this section refer to the latest edition thereof.

.2 American National Standards Institute/Air-Conditioning and Refrigeration Institute (ANSI/ARI)

.1 ANSI/ARI 430, Central Station Air Handling Units.

.3 Canadian General Standards Board (CGSB)

.1 CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating.

.4 Canadian Standards Association (CSA)

.1 CSA B52 Mechanical Refrigeration Code.

.5 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA).

.6 American Bearing Manufacturer’s Association (ABMA)

.1 ANSI/ABMA 9 Load Ratings and Fatique Life for Ball Bearings

.2 ANSI/ABMA 11 Load Ratings and Fatique Life for Roller Bearings.

.7 Air Movement and Control Association (AMCA)

.1 AMCA 210, Laboratory Method of Testing Fans for Aerodynamic Performance Rating (ASHRAE)

.2 AMCA 300 Reverberaut Room Method for Sound Testing of Fans.

.8 American Society of Heating Refrigeration and Air-Conditioning Consultants (ASHRAE).

.1 ASHRAE 68, Laboratory Method of Testing to Determine the Sound Power in a Duct.

.9 National Electrical Manufacturer’s Association (NEMA)

.1 NEMA MG1 Motors and Generators

.2 NEMA ICS 7-1 Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.

.10 Provincial Boiler, Pressure Vessel and Compressed Gas Regulations.

1.2 SHOP DRAWINGS AND PRODUCT DATA

.1 Submit shop drawings and product data

.2 Indicate following: fan, fan curves showing point of operation, motor drive, bearings, filters, mixing box, dampers, VAV, coil, include performance data.

1.3 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities. Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling

.3 Divert unused metal and wiring materials from landfill to metal recycling facility approved by Consultant.

.4 Divert unused paint material from landfill to official hazardous material collections site approved by Consultant.

.5 Do not dispose of unused paint materials into sewer systems, into lakes, streams, onto ground or in other locations where it will pose health or environmental hazard.

1.4 EXTRA MATERIALS

.1 Provide maintenance materials

.2 Provide one spare set of filters.

.3 Provide list of individual manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing or replacing, for placement into operating manual.

.4 Spare filters: in addition to filters installed for startup and commissioning. Immediately prior to acceptance by Consultant, supply 1 complete set of filters for each filter unit or filter bank.

PART 2 PRODUCTS

2.1 GENERAL

.1 Factory assembled components to form units supplying air at designed conditions, as indicated.

.2 Certify ratings: to ARI 430 with ARI seal.

.3 Horizontal and vertical type, as indicated, having air tight modular components, consisting of casing, fan section with motor and drive, filter section, dampers, bypass section, heating coil, cooling coil, humidifier, spray section, mixing box, blender air mixing device or filter mixing box.

.4 Acceptable Product: York, McQuay, Trane, Carrier, Sheldons, Consultanted Air, Venmar.

2.2 CASINGS

.1 Galvanized or phosphate treated steel 1.6 mm thickness outer casing reinforced and braced for rigidity.

.1 Walk-in access doors: provide access for maintenance of internal parts with wired glass 200 x 200 mm viewing port or 200mm diameter polycarbonate double porthole.

.2 Paint steel parts, where not galvanized, with corrosion resistant paint to CGSB 1.181.

.3 Finish structural framed units, inside and out, with rust resistant enamel to Section 09 90 00 – Painting.

.2 Line entire casing with minimum 1 mm thick, solid galvanized, steel liner.

2.3 DRAIN PANS

.1 Construction: stainless steel, plastic or FRP, rounded corners, double wall.

.2 Insulation: extruded foam type, minimum 13 mm thick.

.3 Drain connection: in bottom at low point.

.4 Installation: slope without sag minimum 1% to ensure no standing water at any time or at any point.

.5 Dimensions: minimum 75 mm from upstream face of coil to 150 mm beyond downstream face of coil or eliminator and to include return bends and headers.

2.4 FANS

.1 Cabinet hung or frame mounted AMCA-rated for sound and performance, centrifugal fans with backward inclined or airfoil wheels, selected to operate in stable part of performance curve and heavy duty L10 100,000 hours minimum service self aligning or split pillow block bearings.

.1 Provide internally mounted motor as indicated complete with adjustable V-belt drive and guard.

.2 Motor: see schedule.

.2 Maximum sound power levels, as indicated.

2.5 FILTER BOX

.1 Material to match casing. For flat plus rigid type filter arrangement.

.1 Provide access to filter through hinged door with suitable hardware.

.2 Provide blank-off plates and gaskets to prevent air bypass.

.3 Filters: to Section 23 44 00 – HVAC Air Filtration.

2.6 BLENDER STATIC AIR MIXING DEVICE

.1 General:

.1 Pre-Consultanted device with no moving parts, designed to thoroughly mix warm and cold air streams, to within 3° C at 40 Pa pressure drop and to provide for even velocity distribution profile.

.2 Sizing criteria:

.1 Type: static.

.2 Size: to suit unit mixing box at mixer area to plenum area of 0.4, and minimum flow rate to maximum flow rate of 0.4 plenum, velocity 2.5 m/s

.3 Pressure drop: 40 Pa.

.4 Capacity:

.1 Outside air: as indicated.

.2 Return air: as indicated.

.5 Mixed air temperature: 12° C at outside air to supply air ratio of 0.25.

.2 Construction:

.1 2 mm thick aluminum or 1.6 mm thick stainless steel.

.3 Blender section:

.1 Blender in housing ready for insertion into air handling unit.

.2 50 mm flanges on inlet and outlet.

.3 Complete with 25 mm, 32 kg/m^3 density, fibreglass lining and insulated access door.

.4 Blender mixing box:

.1 General: single unit consisting of dampers, blender, mixing section, with provision for floor mounting.

.2 Construction: stainless steel duct connection flanges, reinforced for rigidity, finished with corrosion resistant paint or zinc coating.

.3 Dampers: parallel blade, low leakage, proportioning type.

.1 Leakage: not more than 50 L/s.m^2 at 750 Pa.

.2 Seals: Neoprene on damper edges, top, bottom, sides of framing.

.4 Blades of 1.6 mm thick steel, 150 mm maximum wide, locked to steel rods in rustproof bushings.

2.7 COILS

.1 Capacity: see schedule.

.2 Ratings: ARI certified.

.3 Construction:

.1 Casings: 1.5 mm thick galvanized sheet steel.

.1 Supports of galvanized steel channel or double angle frames.

.2 Blank-off plates. Insulated sandwich construction.

.2 Non-freeze steam coils: tube-in-tube type with internal perforated steam distributing tubes. Slope tubes to drain condensate.

.1 Tubes: copper, brass or steel.

.2 Fins: aluminum.

.3 Headers: cast iron, steel or cast brass.

.4 Pressure tests: 1.7 MPa.

.3 Steam coils: single tube type.

.1 Tubes: copper, brass or steel.

.2 Fins: aluminum.

.3 Headers: cast iron, steel or cast brass.

.4 Pressure tests: 1.7 MPa.

.4 Hot and Chilled water coils: cleanable fins.

.1 Tubes: copper, brass or steel.

.2 Fins: aluminum plate or spiral wound.

.3 Headers: cast iron, steel or cast brass.

.4 Pressure tests: 1.7 MPa.

.5 Direct expansion refrigerant coils:

.1 Serpentine type, arranged to prevent trapping of oil.

.1 Liquid distributors to ensure even distribution of liquid refrigerant to all circuits.

.2 Silver solder or braze joints in refrigerant tubing.

.3 Evacuate and charge coil with nitrogen and seal before sending to site.

.2 Tubes: copper.

.3 Fins: aluminum, plate or spiral wound.

.4 Headers: copper.

.5 Pressure tests: CSA B52 and carry a Canadian Refrigeration Number. Dehydrated. Sealed with nitrogen charge.

2.8 HEAT RECLAIM DEVICES

.1 Shall be Ecologix ECO-PAC EP30

.1 Flow rate: 800 CFM

.2 Capacity 21000 Btu/hr heating (with 120F water)

.3 115V, 5.5A (Max)

.4 Air-handling unit w/ modulating EC-Motor, Control with 24V signal from central controller. Samples air periodically, with control by fan cycler (Aircycler FR-V). Water coil for hydronic heating, add on DX coil for cooling, additional MERV-13 4” deep air filter.

PART 3 EXECUTION

3.1 INSTALLATION

.1 Install units in accordance with manufacturer's instructions and as indicated.

.2 Ensure adequate clearance for servicing and maintenance.

3.2 FANS

.1 Install fan sheaves required for final air balance.

.2 Install flexible connections at fan inlet and fan outlets.

.3 Install vibration isolators.

3.3 DRIP PANS

.1 Install deep seal P-traps and trap seal primer on drip lines.

.1 Depth of water seal to be 1.5 times static pressure at this point.

3.4 COMMISSIONING

.1 Requirements one day per unit for startup and one day for commissioning.

END OF SECTION

PART 1 GENERAL

1.1 REFERENCES

.1 Codes and Standards referenced in this section refer to the latest edition thereof.

.2 Air-Conditioning and Refrigeration Institute (ARI)
- .1 ARI 325, Standard for Ground Water - Source Heat Pumps.

.3 American National Standards Institute/Air-Conditioning and Refrigeration Institute (ANSI/ARI)
- .1 ANSI/ARI 320, Standard for Water-Source Heat Pumps.

.4 American National Standards Institute/National Fire Protection Association (ANSI/NFPA)
- .1 ANSI/NFPA 90A, Installation of Air Conditioning and Ventilating Systems.

.5 American Society of Heating, Refrigeration and Air-Conditioning Consultants (ASHRAE)
- .1 ASHRAE Standard 15, Safety Code for Mechanical Refrigeration.

.6 Canadian Standards Association (CSA)
- .1 CAN/CSA-C656, Performance Standard for Split-System Central Air-Conditioners and Heat Pumps.
- .2 CAN/CSA-13256-2, Water Source Heat Pumps – Testing and Rating for Performance – Part 2: Water to Water and Brine to Water Heat Pumps.

.7 Environment Canada
- .1 EPS 1/RA/2, Code of Practice for the Reduction of Chlorofluorocarbon Emissions from Refrigeration and Air Conditioning Systems.
- .2 Environment Canada, Ozone-Depleting Substances Alternatives and Suppliers List.

.8 ETL Listing Laboratories (ETL)

1.2 SHOP DRAWINGS AND PRODUCT DATA

.1 Submit shop drawings.

.2 Indicate:
- .1 Capacities.
- .2 ARI Ratings.
- .3 Sound Power levels.
- .4 Installation instructions.
- .5 Start-up Instructions.
- .6 O&M, Instructions.

1.3 WARRANTY

.1 Provide 5 year parts replacement warranty for heat pump including all internal components

PART 2 PRODUCTS

2.1 GENERAL

.1 Furnish and install Water Source Heat Pumps, as indicated on the plans. Equipment shall be completely assembled, piped and internally wired. Capacities and characteristics are listed in the schedule and as shown on the plans.

.2 Heat pumps to be EPS 1/RA/2, CSA approved and carry ARI or CSA certification seal.

2.2 REFRIGERANTS

.1 Refrigerant: R-407 C.

2.3 HEAT PUMPS

.1 . Water to Water Heat Pumps:

.1 Units shall be supplied completely factory built and capable of operation with an entering water temperature range from -6.6 to 43.3°C as standard. All equipment listed in this section must be rated and certified in accordance with ARI/ISO/ASHRAE or CSA/NRTL. The units shall have ARI/ISO, or CSA/NRTL labels. All units shall be factory run tested under normal operating conditions at nominal water flow rates. This testing shall generate a report card to be shipped with each unit stating performance in both heating and cooling modes. Serial numbers will be recorded by factory and furnished to contractor for ease of unit warranty status. Units tested without water flow are not acceptable.

.2 Basic Connection:

.1 All units shall have a minimum of three access panels for serviceability of compressor compartment.

.2 The water to water heat pumps shall be fabricated from heavy gauge galvanized sheet metal. All interior surfaces shall be lined with 12 mm thick, 0.68 kg. acoustic type glass fiber insulation. All insulation must meet NFPA 90A – Latest Edition.

.3 Cabinets shall have separate openings and knockouts for entrances of line voltage and low voltage control wiring. Supply and return water connections for both load and source shall be copper FPT fittings (swivel on distributor class units). All water connections and electrical knockouts must be in the compressor compartment corner post as to not interfere with the serviceability of the unit. All water connections shall be secured to the cabinet eliminating the need for back up wrenches during installation. Extended Operation shall include closed cell insulation on the water circuit piping, water to refrigerant heat exchanger and all refrigerant suction piping for applications with inlet water temperatures below 12.8°C.

.3 Refrigerant Circuit

.1 Compressor shall be Copeland digital scroll compressor, capable of modulating down to 10% capacity with negligible loss in performance. Compressor capacity shall be controlled with a suitable superheat controller with built in synchronization control, designed for use with the Copeland Digital Scroll in conjunction with suitable stepper motor driven electrical control expansion valves.

.2 Units shall have sealed refrigerant circuits including a high efficiency scroll compressor designed for heat pump operation, a thermostatic expansion valve for refrigerant metering, a reversing valve, two coaxial (tube in tube) refrigerant to water heat exchanger and safety controls including a high pressure switch, a low pressure sensor and a low water temperature sensor. Access fittings shall be factory installed on each high and low pressure refrigerant lines to facilitate field service. Activation of any safety device shall prevent compressor operation via lockout device. The lockout shall be reset at the contractor supplied disconnect switch.

.3 The compressor will be mounted on external computer selected isolating springs. Compressor shall have thermal overload protection. Refrigerant to water heat exchangers shall be of copper inner water tube and steel refrigerant outer tube design, rated to withstand 3100 kPa working refrigerant pressure and 3100 kPa working water pressure. Plate heat exchangers are not acceptable.

.4 Reversing valves shall be four-way solenoid activated refrigerant valves which shall fail to heating operation should the solenoid fail to function. The refrigerant

suction piping shall insulated with closed cell insulation to prevent condensation at low evaporating conditions.

.4 Electrical

.1 A control box shall be located within the unit compressor compartment and shall contain a 75VA transformer, 24 volt activated, 2 or 3 pole compressor contactor, terminal block for thermostat wiring and solid-state controller for complete unit operation. Loop pump and heating controls shall be provided on equipment. Electro-mechanical operation will not be accepted. Units shall be name-plated for use with time delay fuses or HACR circuit breakers. Unit controls shall be 24 volt and provide heating or cooling as required by the remote thermostat/sensor.

.5 Solid-State Control System

.1 The units shall have external cabinet mounted:

.1 Compressor “ON” LED to indicate compressor or unit operation.

.2 Unit fault LED to indicate fault modes.

.2 Units shall employ a solid-state control system. The control shall interface with a (Y,O) thermostat, mechanical or electronic. The control system microprocessor board shall be specifically designed to protect against building electrical system noise contamination, EMI, and RFI interference. The control system shall have the following features:

.1 Anti-short cycle time delay on compressor operation, time delay shall be 5 minutes minimum.

.2 Random start on power up mode.

.3 Low voltage protection.

.4 High voltage protection.

.5 Unit shutdown on high or low refrigerate pressures.

.6 Unit shutdown on low water temperature.

.7 Source or Load Water coil low temperature cut-out (selectable for water or anti-freeze).

.8 Option to reset unit at thermostat or disconnect. Fault type shall be retained in memory if reset at thermostat.

.9 Automatic intelligent reset. Unit shall automatically reset 5 minutes after trip if the fault has cleared. Should a fault re-occur 3 times sequentially then permanent lockout will occur.

.10 Ability to defeat time delays for servicing.

.11 Light emitting diodes (LED) to indicate high pressure, low pressure, low voltage, high voltage, low water temperature cut-out, condensate overflow and control status.

.12 The low pressure switch shall not be monitored for the first 120 seconds after a compressor start commences to prevent nuisance safety trips.

.13 Remote fault type indication at thermostat.

.14 Selectable 24V or pilot duty dry contact alarm output.

.15 24V output to cycle a motorized water valve with compressor contactor.

.16 BACnet Interface module for communication with building automation system.

PART 3 EXECUTION

3.1 INTALLATION

.1 Install where indicated and in accordance with manufacturer‘s instructions.

.2 Secure with hold-down bolts.

.3 Make all piping connections.

.4 Nothing to obstruct ready access to all components or to prevent removal of components for servicing.

3.2 DRAIN PANS

.1 Install so that no water can accumulate and arrange so as to be easily accessible for cleaning.

3.3 START-UP AND COMMISSIONING

.1 Manufacturer to certify installation.

.2 Manufacturer to complete start-up test and certify performance.

.3 Manufacturer to provide verbal, video, and written instructions to operating personnel.
.4 Submit written start-up report to Consultant.

END OF SECTION

1.1 GENERAL

.1 The work under this section will include but not be limited to installation of all electrical and instrumentation equipment and materials necessary to provide a complete, fully tested and operational installation. The work will be executed in strict conformity with the drawings, the approved vendors' drawings and these specifications.

1.2 FUNCTIONAL REQUIREMENTS

.1 These specifications are intended to define the minimum system requirements. The functional requirements of the system will take precedence over all other information contained in this division.

.2 It is not the intent of this specification to completely specify all details of design and construction. Suggested changes to these specifications to improve the installation, operation or to effect economy of fabrication at no sacrifice in performance will be considered, provided suitable notation is made.

.3 The selections of all accessories, materials and methods of fabrication not specifically covered by these specifications, but which are necessary to complete the fabrication of the electrical systems, will be the responsibility of the vendor and will be carried out in accordance with good consulting practices.

.4 The vendor will call to the consultant's attention any discrepancies found in the specification. No deviations are to be made from the specifications without prior written permission from the consultant. All deviations from the specifications must be identified in writing at time of submission.

1.3 REGULATIONS, CODES AND PERMITS

.1 The total electrical installation will comply with the latest regulations of the appropriate electrical protection branch having jurisdiction, and with the latest edition and revisions of the Canadian Electrical Code, Part 1 (C22.1), and National Electric Code (NEC 2008) where such regulations do not conflict with the laws in effect, and with the regulations of the appropriate telephone company, power company, Fire Marshall and workers' compensation act.

.2 The electrical contractor will obtain and pay for all permits required by laws and regulations.

.3 After completion of the work, the electrical contractor will certify to the owner that all work has been inspected by the inspection authority having jurisdiction.

1.4 SCOPE OF WORK

.1 Building electrical system for North House project. This includes but is not limited to the following:

- .1 Installation of electrical distribution equipment and materials throughout house.
- .2 Installation of PV generation system
- .3 Installation of grid-tie equipment for interconnection to US DOE village grid

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes.

.1 Methods and procedures for start-up, verification and commissioning, for building Energy Monitoring and Control System (EMCS) and includes:

.1 Start-up testing and verification of systems

.2 Check-out demonstration or proper operation of components.

.3 On-site operational tests

1.2 RELATED SECTIONS

.1 The contractor is to ensure that all related work is co-ordinated among all specification sections, as well as between all Divisions, and that the tender price includes all related work. The referenced sections below are for guidance only and are not necessarily a complete list of related sections.

.2 Section 25 05 01 - EMCS: General Requirements.

1.3 DEFINITIONS

.1 For additional acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements.

.2 AEL (Average Effectiveness Level): ratio between total test period less any system downtime accumulated within that period and test period.

.3 Downtime: results whenever EMCS is unable to fulfill required functions due to malfunction of equipment defined under responsibility of EMCS contractor. Downtime is measured by duration, in time, between time that Contractor is notified of failure and time system is restored to proper operating condition. Downtime not to include following:

.1 Outage of main power supply in excess of back-up power sources, provided that:

.1 Automatic initiation of back-up was accomplished.

.2 Automatic shut-down and re-start of components was as specified.

.2 Failure of communications link, provided that:

.1 Controller automatically and correctly operated in stand-alone mode.

.2 Failure was not due to failure of any specified EMCS equipment.

.3 Functional failure resulting from individual sensor inputs or output devices, provided that:

.1 System recorded said fault.

.2 Equipment defaulted to fail-safe mode.

.3 AEL of total of all input sensors and output devices is at least 99 % during test period.

1.4 DESIGN REQUIREMENTS

.1 Confirm with Consultant that Design Criteria and Design Intents are still applicable.

.2 Commissioning personnel to be fully aware of and qualified to interpret Design Criteria and Design Intents.

1.5 SUBMITTALS

.1 Final Report: submit report to Consultant.

.1 Include measurements, final settings and certified test results.

.2 Bear signature of commissioning technician and supervisor

.3 Report format to be approved by Consultant before commissioning is started.

.4 Revise "as-built" documentation, commissioning reports to reflect changes, adjustments and modifications to EMCS as set during commissioning and submit to Consultant.

.5 Recommend additional changes and/or modifications deemed advisable in order to improve performance, environmental conditions or energy consumption.

1.6 CLOSEOUT SUBMITTALS

.1 Provide documentation, O&M Manuals, and training materials of O&M personnel for review by Consultant before interim acceptance in accordance with Section 25 05 03 – EMCS: Project Record Documents.

1.7 COMMISSIONING

.1 Carry out commissioning under direction of Consultant and in presence of Consultant and Commissioning Co-ordinator.

.2 Inform, and obtain approval from, Consultant in writing at least 14 days prior to commissioning or each test. Indicate:

.1 Location and part of system to be tested or commissioned.

.2 Testing/commissioning procedures, anticipated results.

.3 Names of testing/commissioning personnel.

.3 Correct deficiencies, re-test in presence of Consultant until satisfactory performance is obtained.

.4 Acceptance of tests will not relieve Contractor from responsibility for ensuring that complete systems meet every requirement of Contract.

.5 Load system with project software. Install software for access to EMCS via dial up modem at Consultant's designated site and at Transportation and Works Office in St. John's for use during commissioning and for their use afterwards. Where high speed internet is available, use web browser software, compatible with Windows Vista with access via Internet Explorer (latest edition).

.6 Perform tests as required.

1.8 COMPLETION OF COMMISSIONING

.1 Commissioning to be considered as satisfactorily completed when objectives of commissioning have been achieved and reviewed by Consultant and Commissioning Co-ordinator.

1.9 ISSUANCE OF FINAL CERTIFICATE OF COMPLETION

.1 Final Certificate of Completion will not be issued until receipt of written approval indicating successful completion of specified commissioning activities including receipt of commissioning documentation.

PART 2 PRODUCTS

2.1 EQUIPMENT

.1 Provide sufficient instrumentation to verify and commission the installed system. Provide two-way radios.

.2 Instrumentation accuracy tolerances: higher order of magnitude than equipment or system being tested.

.3 Independent testing laboratory to certify test equipment as accurate to within approved tolerances no more than 2 months prior to tests.

.4 Locations to be approved, readily accessible and readable.

.5 Application: to conform to normal industry standards.

PART 3 EXECUTION

3.1 PROCEDURES

.1 Test each system independently and then in unison with other related systems.

.2 Commission each system using procedures prescribed by the Commissioning Co-ordinator and/or Consultant.

.3 Commission integrated systems using procedures prescribed by Commissioning Co-ordinator and/or Consultant.

.4 Debug system software.

.5 Optimize operation and performance of systems by fine-tuning PID values and modifying CDLs as required.

.6 Test full scale emergency evacuation and life safety procedures including operation and integrity of smoke management systems under normal and emergency power conditions as applicable.

3.2 FIELD QUALITY CONTROL

.1 Pre-Installation Testing.

.1 General: consists of field tests of equipment just prior to installation.

.2 Testing may be on site or at Contractor's premises as approved by Consultant.

.3 Configure major components to be tested in same Consultanture as designed system. Include all required network and control components.

.4 Equip each Building Controller with sensor and controlled device of each type (AI, AO, DI, DO).

.5 Additional instruments to include:

.1 DP transmitters.

.2 VAV supply duct SP transmitters.

.3 DP switches used for dirty filter indication and fan status.

.6 In addition to test equipment, provide inclined manometer, digital micro-manometer, milli-amp meter, source of air pressure infinitely adjustable between 0 and 500 Pa, to hold steady at any setting and with direct output to milli-amp meter at source.

.7 After setting, test zero and span in 10 % increments through entire range while both increasing and decreasing pressure.

.8 Consultant to mark instruments tracking within 0.5 % in both directions as "approved for installation".

.9 Transmitters above 0.5 % error will be rejected.

.10 DP switches to open and close within 2% of setpoint.

.2 Completion Testing.

.1 General: test after installation of each part of system and after completion of mechanical and electrical hook-ups, to verify correct installation and functioning.

.2 Include following activities:

.1 Test and calibrate field hardware including stand-alone capability of each controller.

.2 Verify each A-to-D convertor.

.3 Test and calibrate each AI using calibrated digital instruments.

.4 Test each DI to ensure proper settings and switching contacts.

.5 Test each DO to ensure proper operation and lag time.

.6 Test each AO to ensure proper operation of controlled devices. Verify tight closure and signals.

.7 Test operating software.

.8 Test application software and provide samples of logs and commands.

.9 Verify each CDL including energy optimization programs.

.10 Debug software.

.11 Blow out flow measuring and static pressure stations with high pressure air at 700 kPa.

.12 Provide point verification list in table format including point identifier, point identifier expansion, point type and address, low and high limits and Consultanting units. This document will be used in final startup testing.

.3 Final Startup Testing: Upon satisfactory completion of tests, perform point-by-point test of entire system under direction of Consultant and Commissioning Co-ordinator and provide:

.1 2 technical personnel capable of re-calibrating field hardware and modifying software.

.2 Detailed daily schedule showing items to be tested and personnel available.

.3 Consultant's acceptance signature to be on executive and applications programs.

.4 Commissioning to commence during final startup testing.

.5 O&M personnel to assist in commissioning procedures as part of training.

.6 Commissioning to be supervised by qualified supervisory personnel and Consultant.

.7 Commission systems considered as life safety systems before affected parts of the facility are occupied.

.8 Operate systems as long as necessary to commission entire project.

.9 Monitor progress and keep detailed records of activities and results.

.4 Final Operational Testing: to demonstrate that EMCS functions in accordance with contract requirements.

.1 Prior to beginning of 30 day test demonstrate that operating parameters (setpoints, alarm limits, operating control software, sequences of operation, trends, graphics and CDL's) have been implemented to ensure proper operation and operator notification in event of off-normal operation.

.1 Repetitive alarm conditions to be resolved to minimize reporting of nuisance conditions.

.2 Test to last at least 30 consecutive 24 hour days.

.3 Tests to include:

.1 Demonstration of correct operation of monitored and controlled points.

.2 Operation and capabilities of sequences, reports, special control algorithms, diagnostics, software.

.4 System will be accepted when:

.1 EMCS equipment operates to meet overall performance requirements. Downtime as defined in this Section must not exceed allowable time calculated for this site.

.2 Requirements of Contract have been met.

.5 In event of failure to attain specified AEL during test period, extend test period on day-to-day basis until specified AEL is attained for test period.

.6 Correct defects when they occur and before resuming tests.

.5 Commissioning Co-ordinator and/or Consultant to verify reported results.

3.3 ADJUSTING

.1 Final adjusting: upon completion of commissioning as reviewed by Consultant set and lock devices in final position and permanently mark settings.

3.4 DEMONSTRATION

.1 Demonstrate to Commissioning Manager and/or Consultant operation of systems including sequence of operations in regular and emergency modes, under normal and emergency conditions, start-up, shut-down interlocks and lock-outs.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes.

.1 Requirements and procedures for training program, instructors and training materials, for building Energy Monitoring and Control System (EMCS) Work.

1.2 RELATED SECTIONS

.1 Section 25 05 01 - EMCS: General Requirements.

1.3 DEFINITIONS

.1 CDL - Control Description Logic.

.2 For additional acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements

1.4 SUBMITTALS

.1 Submit training proposal complete with hour-by-hour schedule including brief overview of content of each segment to Consultant 30 days prior to anticipated date of beginning of training.

.1 List name of trainer, and type of visual and audio aids to be used.

.2 Show co-ordinated interface with other EMCS mechanical and electrical training programs.

.2 Submit reports within one week after completion of Phase 1 and Phase 2 training program that training has been satisfactorily completed.

1.5 QUALITY ASSURANCE

.1 Provide competent instructors thoroughly familiar with aspects of EMCS installed in facility.

.2 Consultant reserves right to approve instructors.

1.6 INSTRUCTIONS

.1 Provide instruction to designated personnel in adjustment, operation, maintenance and pertinent safety requirements of EMCS installed.

.2 Training to be project-specific.

1.7 TIME FOR INSTRUCTION

.1 Number of days of instruction to be as specified in this section (1 day = 7 hours including two 15 minute breaks and excluding lunch time).

1.8 TRAINING MATERIALS

.1 Provide equipment, visual and audio aids, and materials for classroom training.

.2 Supply manual for each trainee, describing in detail data included in each training program.

.1 Review contents of manual in detail to explain aspects of operation and maintenance (O&M).

1.9 TRAINING PROGRAM

.1 To be in 2 phases over 6 month period.

.2 Phase 1: 2 day program to begin before 30 day test period at time mutually agreeable to Contractor, Consultant and Commissioning Co-ordinator.

.1 Train O&M personnel in functional operations and procedures to be employed for system operation.

.2 Supplement with on-the-job training during 30 day test period.

.3 Include overview of system Consultanture, communications, operation of computer and peripherals, report generation.

.4 Include detailed training on operator interface functions for control of mechanical systems, CDL's for each system, and elementary preventive maintenance.

.5 Introduction to Direct Digital Controls and BACnet protocol.

.6 Identification of Control Components.

.7 Review of DDC Network Diagram for building.

.8 Review of shop drawings for building.

.9 Detailed discussion of sequences of operation

.10 Walk through of mechanical systems.

.3 Phase 2: 5 day program to begin 8 weeks after acceptance for operators, equipment maintenance personnel and programmers.

.1 Provide multiple instructors on pre-arranged schedule. Include at least

.1 Operator training: provide operating personnel, maintenance personnel and programmers with condensed version of Phase 1 training.

.2 Equipment maintenance training: provide personnel with 2 days training within a 5 day period in maintenance of EMCS components, maintenance and calibration of sensors and controls.

.3 Programmers: provide personnel with 2 days training within a 5 day period in following subjects in approximate percentages of total course shown:

.1 Software and Consultanture: 10%

.2 Application programs: 15%

.3 Controller programming: 50%

.4 Trouble shooting and debugging:10%

.5 Colour graphic generation: 15%

.6 Display and interpret summaries

.7 Command points

.8 Modify points and point groups

.9 Define trend logs

.10 Schedule and print reports

1.10 ADDITIONAL TRAINING

.1 List courses offered by name, duration and approximate cost per person per week. Note courses recommended for training supervisory personnel.

1.11 MONITORING OF TRAINING

.1 Consultant/ Consultant to monitor training program and may modify schedule and content.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 General requirements for building Energy Monitoring and Control System (EMCS) that are common to NMS EMCS Sections.

1.2 RELATED SECTIONS

.1 The contractor is to ensure that all related work is co-ordinated among all specification sections, as well as between other Divisions, and that the tender price includes all related work. The referenced sections below are for guidance only and are not necessarily a complete list of related sections.

.2 Section 09 00 00 - Interior Painting.

.3 Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

.4 Section 25 01 12 - EMCS: Training.

.5 Section 25 05 02 - EMCS: Submittals and Review Process.

.6 Section 25 05 03 - EMCS: Project Record Documents.

.7 Section 25 05 54 - EMCS: Identification.

.8 Section 25 05 60 - EMCS: Field Installation.

.9 Section 25 08 20 - EMCS: Warranty and Maintenance.

.10 Section 25 10 01 - EMCS: Local Area Network (LAN).

.11 Section 25 10 02 - EMCS: Operator Work Station (OWS).

.12 Section 25 30 01 - EMCS: Building Controllers

.13 Section 25 30 02 - EMCS: Field Control Devices.

.14 Section 25 90 01 - EMCS: Site Requirements, Applications and Systems Sequences of Operation.

1.3 REFERENCES

.1 American National Standards Institute (ANSI)

.1 ANSI/ISA 5.5, Graphic Symbols for Process Displays.

.2 American National Standards Institute (ANSI)/ Institute of Electrical and Electronics Consultants (IEEE).

.1 ANSI/IEEE 260.1, American National Standard Letter Symbols Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).

.3 American Society of Heating, Refrigerating and Air-Conditioning Consultants, Inc. (ASHRAE).

.1 ASHRAE STD 135, BACNET - Data Communication Protocol for Building Automation and Control Network.

.4 Canadian Standards Association (CSA International).

.1 CAN/CSA-Z234.1, Canadian Metric Practice Guide.

.5 Consumer Electronics Association (CEA).

.1 CEA-709.1-B, Control Network Protocol Specification.

.6 Department of Justice Canada (Jus).

.1 Canadian Environmental Assessment Act (CEAA).
.2 Canadian Environmental Protection Act (CEPA).

.7 Health Canada/Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

.8 Transport Canada (TC).

.1 Transportation of Dangerous Goods Act (TDGA).

.9 National Electrical Manufacturers Association (NEMA)

1.4 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

.1 Acronyms used in EMCS.

.1 AEL - Average Effectiveness Level
.2 AI - Analog Input
.3 AO - Analog Output
.4 BACnet - Building Automation and Control Network
.5 BC(s) - Building Controller(s)
.6 BECC - Building Environmental Control Centre
.7 CAB - Canadian Automated Building (CAB) Protocol
.8 CAD - Computer Aided Design
.9 CDL - Control Description Logic
.10 CDS - Control Design Schematic
.11 COSV - Change of State or Value
.12 CPU - Central Processing Unit
.13 DI - Digital Input
.14 DO - Digital Output
.15 DP - Differential Pressure
.16 ECU - Equipment Control Unit
.17 EMCS - Energy Monitoring and Control System
.18 HVAC - Heating, Ventilation, Air Conditioning
.19 IDE - Interface Device Equipment
.20 I/O - Input/Output
.21 ISA - Industry Standard Consultanture
.22 LAN - Local Area Network
.23 LCU - Local Control Unit
.24 MCU - Master Control Unit
.25 NC - Normally Closed
.26 NO - Normally Open
.27 OS - Operating System
.28 O&M - Operation and Maintenance

.29 OWS - Operator Work Station

.30 PC - Personal Computer

.31 PCI - Peripheral Control Interface

.32 PCMCIA - Personal Computer Micro-Card Interface Adapter

.33 PID - Proportional, Integral and Derivative.

.34 RAM - Random Access Memory

.35 ROM - Read Only Memory

.36 SP - Static Pressure

.37 TCU - Terminal Control Unit

.38 USB - Universal Serial Bus

.39 UPS - Uninterruptible Power Supply

.40 WAN- Wide Area Network

1.5 DEFINITIONS

.1 Point: may be logical or physical.

.1 Logical points: values calculated by system such as setpoints, totals, counts, derived corrections and may include, but not limited to result of and statements in CDL's.

.2 Physical points: inputs or outputs which have hardware wired to controllers which are measuring physical properties, or providing status conditions of contacts or relays which provide interaction which related equipment (stop, start) and value or damper actuators.

.2 Point Name: composed of two parts, point identifier and point expansion.

.1 Point identifier: comprised of three descriptors, "area" descriptor, "system" descriptor and "point" descriptor, for which database to provide 25 character field for each point identifier. "System" is system that point is located on.

.1 Area descriptor: building or part of building where point is located.

.2 System descriptor: system that point is located on.

.3 Point descriptor: physical logical point description. For point identifier "area", "system" and "point" will be shortforms or acronyms. Database must provide 25 character field for each point identifier.

.2 Point expansion: comprised of three fields, one for each descriptor. Expanded form of shortform or acronym used in "area", "system", and "point" descriptors is placed into appropriate point expansion field. Database must provide 32 character field for each point expansion.

.3 Bilingual systems to include additional point identifier expansion fields of equal capacity for each point name for second language.

.1 System to support use of numbers and readable characters including blanks, periods or underscores to enhance user readability for each of the above strings.

.3 Point Object Type: points fall into following object types:

.1 AI (analog input)

.2 AO (analog output)

.3 DI (digital input)

.4 DO (digital output)

.5 Pulse inputs

.4 Symbols and Consultanting unit abbreviations utilized in displays: to ANSI/ISA S5.5.

.1 Printouts: to ANSI/IEEE 260.1.

.2 Refer also to Section 25 05 54 - EMCS: Identification.

1.6 SYSTEM DESCRIPTION

.1 Refer to control schematics, sequences of operation and related Divisions of specifications for system Consultanture.

.2 Work covered by sections referred to above consists of fully operational EMCS, including, but not limited to, following:

.1 Building Controllers.

.2 Control devices as listed in I/O point summaries and/or shown on the control drawings.

.3 OWS

.4 Data communications equipment necessary to affect EMCS data transmission system.

.5 Field control devices.

.6 Software/Hardware complete with full documentation.

.7 Complete operating and maintenance manuals.

.8 Training of personnel.

.9 Acceptance tests, technical support during commissioning, full documentation.

.10 Wiring interface co-ordination of equipment supplied by others.

.11 Miscellaneous work as specified in these sections and as indicated.

.3 Design Requirements:

.1 Design and provide conduit and wiring linking elements of system.

.2 Supply sufficient programmable controllers of types to meet project requirements. Quantity and points contents as reviewed prior to installation.

.3 Location of controllers as reviewed by Consultant prior to installation.

.4 Provide utility and emergency power to EMCS.

.5 Metric references: in accordance with CAN/CSA Z234.1.

.4 Language Operating Requirements:

.1 Provide English interface to system through operator selectable access codes.

.2 Use non-linguistic symbols for displays on graphic terminals wherever possible. Other information to be in English.

.3 Operating system executive: provide primary hardware-to-software interface specified as part of hardware purchase with associated documentation to be in English.

.4 System manager software: include in English system definition point database, additions, deletions or modifications, control loop statements, use of high level

programming languages, report generator utility and other OS utilities used for maintaining optimal operating efficiency.

.5 Include, in English:

.1 Input and output commands and messages from operator-initiated functions and field related changes and alarms as defined in CDL's or assigned limits (i.e. commands relating to day-to-day operating functions and not related to system modifications, additions, or logic re-definements).

.2 Graphic "display" functions, point commands to turn systems on or off, manually override automatic control of specified hardware points. To be in English at specified OWS. Point name expansions in English.

.3 Reporting function such as trend log, trend graphics, alarm report logs, energy report logs, maintenance generated logs.

.6 The network design to be a fully distributed network, with each primary system having its own locally mounted dedicated controller. Any failure in the network shall **not** in any way affect the control of these primary systems. Connecting hardware points from one system to more than one controller is not acceptable. Any points associated with a system are to be connected to one dedicated controller. Each dedicated controller to have a locally mounted control and display device to allow the operator to view and adjust any point on the controller.

.7 All wiring associated with the EMCS communication network as well as all control wiring and conduit associated with the EMCS at 50 volts or less. Wire and conduit above 50 volts by Electrical Division.

.8 BACnet compliance: full compliance to the BACnet standard (ANSA/ASHRAE) 135, BACnet – A Data communication Protocol for Building Automation and Control Networks is mandatory. Down to the field device level, the EMCS system must meet BACnet standards for system Consultanture and administration, and use open communication protocols and user friendly programming and graphics. Install the EMCS installed to communicate at the supervisory layer to the WAN using the BACnet TCP/IP protocol implemented on Ethernet.

.9 The EMCS system for this facility to be accessible by designated personnel via the WAN for monitoring and programming purposes. The EMCS contractor to provide all the required hardware, software, gateways, etc. needed to permit connection of the EMCS to the WAN. This shall include all hardware, software, programming, start-up and commissioning required. The contractor to supply and install all the required hardware and software on the WAN file server to allow for this remote operation monitoring and programming to take place. The contractor to supply and install all the required hardware and software on the operator workstation(s) located in the Consultant's facilities management department. In addition, a remote dial in access directly to the system shall be provided.

1.7 SUBMITTALS

.1 Make submittals in accordance with Section 25 05 02 - EMCS: Submittals and Review Process.

.2 Submit for review:

.1 Equipment list and systems manufacturers within 10 days after award of contract.

.3 Quality Control:

.1 Provide equipment and material from manufacturer's regular production, CSA certified, manufactured to standard quoted plus additional specified requirements.

.2 Where CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.

.3 Submit proof of compliance to specified standards with shop drawings and product data in accordance with Section 25 05 02 – EMCS: Submittals and Review Process. Label or listing of specified organization is acceptable evidence.

.4 In lieu of such evidence, submit certificate from testing organization, approved by third party Consultant registered in Canada, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.

.5 For materials whose compliance with organizational standards/codes/ specifications is not regulated by organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.

.6 Permits and fees: in accordance with general conditions of contract.

.7 Existing devices intended for re-use: submit test report.

1.8 QUALITY ASSURANCE

.1 Have local office for at least 5 years staffed by factory trained personnel capable of installing and providing instruction, routine maintenance and emergency service on systems.

.2 Provide record of successful previous installations submitting tender showing experience with similar installations utilizing computer-based systems.

.3 Have access to local supplies of essential parts and provide 7 year guarantee of availability of spare parts after obsolescence.

.4 Ensure factory qualified supervisory personnel continuously direct and monitor work and attend site meetings.

.5 Health and Safety:

.1 Do construction occupational health and safety in accordance with Team North Health and Safety Plan

.6 Be able to provide factory trained personnel on site within 24 hours notice or provide instructions on maintenance and emergency service on system.

.7 BACnet devices to bear BACnet testing laboratories BTL mark and listed on BACnet manufacturers association web site.

1.9 DELIVERY, STORAGE AND HANDLING

.1 Material Delivery Schedule: provide Consultant with “Materials Delivery Schedule” within 2 weeks after award of contract.

.2 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material in appropriate on-site bins for recycling.

.4 Separate for reuse and recycling and place in designated containers Steel, Metal, Plastic waste.

.5 Place materials defined as hazardous or toxic in designated containers.

.6 Label location of salvaged material's storage areas and provide barriers and security devices.

.7 Ensure emptied containers are sealed and stored safely.

.8 Divert unused metal materials from landfill to metal recycling facility as approved by Consultant.

.9 Fold up metal and plastic banding, flatten and place in designated area for recycling

1.10 EXISTING CONDITIONS - CONTROL COMPONENTS

.1 Utilize existing control wiring and piping as indicated.

.2 Re-use field control devices that are usable in their original configuration provided that they conform to applicable codes, standards and specifications.

.1 Do not modify original design of existing devices without written permission from Consultant.

.2 Provide for new, properly designed device where re-usability of components is uncertain.

.3 Inspect and test existing devices intended for re-use within 30 days of award of contract, and prior to installation of new devices.

.1 Furnish test report to Consultant within 40 days of award of contract listing each component to be re-used and indicating whether it is in good order or requires repair by Consultant.

.2 Failure to produce test report will constitute acceptance of existing devices by Consultant.

.4 Non-functioning items:

.1 Provide with report specification sheets or written functional requirements to support findings.

.2 Consultant will repair or replace existing items judged defective yet deemed necessary for EMCS.

.5 Submit written request for permission to disconnect controls and to obtain equipment downtime before proceeding with Work.

.6 Assume responsibility for existing controls to be incorporated into EMCS after written receipt of approval from Consultant.

.1 Be responsible for items repaired or replaced by Consultant.

.2 Be responsible for repair costs due to negligence or abuse of equipment repaired or replaced by Consultant.

.3 Responsibility for existing devices terminates upon final acceptance of EMCS or

applicable portions of EMCS as approved by Consultant.

.7 Remove existing controls not re-used or not required. Place in approved storage for disposition as directed

PART 2 PRODUCTS

2.1 ACCEPTABLE SYSTEMS, MANUFACTURERS

.1 Alerton, Delta, Automated Logic, Honeywell, Johnson Controls.

.2 Proposed system to have communication capability utilizing BACnet Protocol.

.3 Panel to be NEMA rated to suit environmental requirements.

.4 Panels to have hinged doors equipped with standard keyed-alike cabinet locks, keyed to same key.

.5 Wiring within panels to be contained within properly sized rigid PVC slotted wall wire duct. All wiring within the wire duct to be concealed with a non-slip cover.

.6 Terminations for the connection of power wiring, communication wiring and field mounted devices to be at properly identified terminal blocks mounted within the control panel.

.7 All control panels to be provided with an internally mounted 120 volt duplex power receptacle.

.8 All control panels to be identified with permanently mounted Lamecoid tags to identify the control panel and the systems served by the control panel. Submit schedule of labels with shop drawing submission.

.9 Provide low voltage transformers in panels or elsewhere as required.

.10 Provide adaptors between metric and imperial components.

PART 3 EXECUTION

3.1 MANUFACTURER'S RECOMMENDATIONS

.1 Installation to be to manufacturer's recommendations. Provide printed copies of recommendations with shop drawings or product data.

3.2 PAINTING

.1 Painting to be in accordance with NEMA, supplemented as follows:

.2 Clean and touch up marred or scratched surfaces of factory finished equipment to match original finish.

.3 Restore to new condition, finished surfaces which have been damaged too extensively to be primed and touched up to make good.

.4 Clean and prime exposed hangers, racks, fastenings, and other support components.

.5 Paint all unfinished equipment installed indoors to NEMA.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes.

.1 Methods and procedures for shop drawings submittals, preliminary and detailed review process include review meetings for building Energy Monitoring and Control System (EMCS).

1.2 RELATED SECTIONS

.1 The contractor is to ensure that all related work is co-ordinated among all specification sections as well as between all Divisions, and that the tender price includes all related work. The referenced sections below are for guidance only and are not necessarily a complete list of related sections.

.1 Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

.2 Section 25 05 01 - EMCS: General Requirements.

1.3 DEFINITIONS

.1 Acronyms and definitions: refer to Section 25 05 01 - EMCS: General Requirements.

1.4 DESIGN REQUIREMENTS

.1 Preliminary Design Review: to contain following contractor and systems information.

.1 Location of local office.

.2 Description and location of installing and servicing technical staff.

.3 Location and qualifications of programming design and programming support staff.

.4 List of spare parts.

.5 Location of spare parts stock.

.6 Names of sub-contractors and site-specific key personnel.

.7 Sketch of site-specific system Consultanture.

.8 Specification sheets for each item including memory provided, programming language, speed, type of data transmission.

.9 Descriptive brochures.

.10 Sample CDL and graphics (systems schematics).

.11 Response time for each type of command and report.

.12 Item-by-item statement of compliance.

.13 Proof of demonstrated ability of system to communicate utilizing BACnet protocol.

1.5 SUBMITTALS

.1 Submit preliminary design document within 30 working days after contract award for review by Consultant.

.2 Shop Drawings to consist of 3 hard copies and 1 soft copy of design documents, shop drawings, product data and software.

.3 Hard copy to be completely indexed and coordinated package to assure compliance with contract requirements and arranged in same sequence as specification and cross-referenced to specification section and paragraph number.

.4 Soft copy to be in AutoCAD - latest version and Microsoft Word latest version format, or PDF structured using menu format for easy loading and retrieval on OWS.

.5 Submittals shall consist of:

.1 Data sheets of all products.

.2 Wiring and piping interconnection diagrams including panel and device power, and sources.

.3 List of materials of all proposed devices and equipment.

.4 Software documentation:

.5 Sequence of operation, in text form.

.6 Application programs.

.7 Point Schedules

.8 Controls schematics and system diagrams.

.9 Project installation schedule.

.10 Names of subtrades working for EMCS contractor.

.11 Mounting support details for components installed in airflow, waterflow and steam systems.

.6 Submit shop drawings in a package which contains the various schedules and drawings which completely describe the control system installed. At a minimum the shop drawing package to contain the following items described in Section 1.4.8 to 1.4.28 as follows:

.7 Network drawing showing the network connection of all network control units, programmable control units, terminal control units and operator workstations to indicate the location of each of these elements.

.8 Schematic control diagram for each system being controlled. Where there are typical systems a drawing to be provided for each system. This drawing to be on a AB size sheet (11 x 17) and shall include a title block which includes as a minimum the drawing title, drawing number, project title, contractor's name, contractor's address, contractor's phone and fax numbers, contractor's project number and a section to provide a record for revision information.

.9 The schematic control diagram to include a bill of materials which provides a list of all part numbers and descriptions for the control components on the drawing list to include field equipment as well as panel mounted components.

.10 The schematic control diagram to include a complete wiring diagram for all electrical connections, including motor starters, heating coils, coiling coils etc.

.11 The schematic control diagram to include a layout of the control panels for each system. This layout to show the mounting of all panel equipment, including transformers, power supplies, controllers, transducers, sensors, relays, contactors and any other panel mounted equipment.

.12 The contractor to include with the shop drawing submittal drawings, showing all wiring details for the connections of sensors, transducers, relays and contactors these details to show terminal numbers and be referenced to the appropriate schedules and drawings.

.13 The contractor to supply with the shop drawing package a complete point schedule to show every point connected to the system. This schedule to be in tabular format and provide the point identification, point type, wire tag, termination details reference, referenced drawings, device mounting location and device code numbers.

.14 The point schedule to provide at a minimum the following information on the software attributes of the point:

.1 Tag name – ex. EPT-1
.2 Point type – ex. AO-3
.3 System name – ex. A/C-1
.4 Object name – H-VLV.
.5 Expanded ID- Heating control valve
.6 Units of measurement - %.

.15 The point schedule to provide at a minimum the following information on the digital controller to which the point is connected:

.1 Controller type – ex. Unitary controller
.2 Controller address ex. 256.
.3 Cable destination – the termination at the controller, ex. AO-1.
.4 Terminal numbers – the termination at the controller.

.16 The point schedule to provide at minimum the following information on the control panel:

.1 Panel identification
.2 Panel location
.3 Reference drawing

.17 The point schedule to provide at a minimum the following information on any intermediate device which may be associated with the point:

.1 Type of wiring or tubing used
.2 Device part number
.3 Location of the device.
.4 Reference details.

.18 The point schedule to provide at a minimum the following information on any field device which may be associated with the point;

.1 Type of wiring or tubing used
.2 Device part number
.3 Location of the devices
.4 Reference details

.19 The contractor to supply with the shop drawing package a complete room schedule, to show the equipment associated with the room controls. Schedule to be in tabular format and provide the room number and location, terminal unit number, part numbers for the terminal unit controller, sensors and actuators. Included on this schedule terminal unit type, size, minimum flow and maximum flow.

.20 Sequence of operation for each system controlled. Sequence to be in complete conformance with the sequence of operations included with this specification. Any changes require the approval of the Consultant in writing. Sequence to include all modes

of operation including fail safe, emergency and fire modes.

.21 Valve schedule including design flow, CV, size, type, actuator, pressure drop and maximum shut off pressure differential for each control valve.

.22 Damper schedule including design air flow, size, type actuator and torque requirements for each control damper.

.23 Provide one permanent, not fading, as built copy of each control drawing, enclosed by an aluminium frame with glass cover, or sealed by plastic laminate in rigid metal bound frame. To be installed at each respective control panel location.

.24 Catalogue cut sheets of all equipment used. This includes, but is not limited to DDC panels, peripherals, sensors, actuators, dampers, control air system components, etc.

.25 Range and scale information for all transmitters and sensors. This sheet to clearly indicate one device and any applicable options. Where more than one device to be used is on a single sheet, submit two sheets, individually marked.

.26 Hardware data sheets for all operator workstations, local access panels, and portable operator terminals.

.27 Software manuals for all applications programs to be provided as a part of the operator workstations, portable operator terminals, programming devices, and so forth for

1.6 PRELIMINARY SHOP DRAWING REVIEW

.1 Submit preliminary shop drawings within 30 working days of award of contract and include following:

.1 Specification sheets for each item. To include manufacturer's descriptive literature, manufacturer's installation recommendations, specifications, drawings, diagrams, performance and characteristic curves, catalogue cuts, manufacturer's name, trade name, catalogue or model number, nameplate data, size, layout, dimensions, capacity, other data to establish compliance.

.2 Detailed system Consultanture showing all points associated with each controller including, signal levels, pressures where new EMCS ties into existing control equipment.

.3 Spare point capacity of each controller by number and type.

.4 Controller locations.

.5 Auxiliary control cabinet locations.

.6 Single line diagrams showing cable routings, conduit sizes, spare conduit capacity between control centre, field controllers and systems being controlled.

.7 Valves: complete schedule listing including following information: designation, service, manufacturer, model, point ID, design flow rate, design pressure drop, required Cv, Valve size, actual Cv, spring range, pilot range, required torque, actual torque and close off pressure (required and actual).

.8 Dampers: sketches showing module assembly, interconnecting hardware, operator locations, operator spring range, pilot range, required torque, actual torque.

.9 Flow measuring stations: complete schedule listing designation, service, point ID, manufacturer, model, size, velocity at design flow rate, manufacturer, model and range of velocity transmitter.

.10 Compressor schematic and sizing data.

1.7 DETAIL SHOP DRAWING REVIEW

.1 Submit detailed shop drawings within 60 working days after award of contract and before start of installation and include following:

.1 Corrected and updated versions (hard copy only) of submissions made during preliminary review.

.2 Wiring diagrams.

.3 Piping diagrams and hook-ups.

.4 Interface wiring diagrams showing termination connections and signal levels for equipment to be supplied by others.

.5 Shop drawings for each input/output point, sensors, transmitters, showing information associated with each particular point including:

.1 Sensing element type and location.

.2 Transmitter type and range.

.3 Associated field wiring schematics, schedules and terminations.

.4 Pneumatic schematics and schedules.

.5 Complete Point Name Lists.

.6 Setpoints, curves or graphs and alarm limits (high and low, 3 types critical, cautionary and maintenance), signal range.

.7 Software and programming details associated with each point.

.8 Manufacturer's recommended installation instructions and procedures.

.9 Input and output signal levels or pressures where new systems ties into existing control equipment.

.6 Control schematics, narrative description, CDL's fully showing and describing automatic and manual procedure required to achieve proper operation of project, including under complete failure of EMCS.

.7 Graphic system schematic displays of air and water systems with point identifiers and textual description of system, and typical floor plans as specified.

.8 Complete system CDL's including companion English language explanations on same sheet but with different font and italics. CDL's to contain specified energy optimization programs.

.9 Listing of and example of specified reports.

.10 Listing of time of day schedules.

.11 Mark up to-scale construction drawing to detail control room showing location of equipment and operator work space.

.12 Type and size of memory with statement of spare memory capacity.

.13 Full description of software programs provided.

.14 Sample of "Operating Instructions Manual" to be used for training purposes.

.15 Outline of proposed start-up and verification procedures. Refer to Section 25 01 11 – EMCS: Start-up, Verification and Commissioning.

1.8 QUALITY ASSURANCE

.1 Preliminary Design Review Meeting: Convene meeting within 45 working days of award of contract to:

.1 Undertake functional review of preliminary design documents, resolve

inconsistencies.

.2 Resolve conflicts between contract document requirements and actual items (e.g.: points list inconsistencies).

.3 Review interface requirements of materials supplied by others.

.4 Review "Sequence of Operations".

.2 Contractor's factory trained programmer to attend meeting.

.3 Consultant retains right to revise sequence or subsequent CDL prior to software finalization without cost to Consultant.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes.

.1 Requirements and procedures for final control diagrams and operation and maintenance (O&M) manual, for building Energy Monitoring and Control System (EMCS) Work.

1.2 RELATED SECTIONS

.1 Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

.2 Section 25 05 01 - EMCS: General Requirements.

.3 Section 25 05 02 - EMCS: Submittals and Review Process.

1.3 DEFINITIONS

.1 BECC - Building Environmental Control Centre.

.2 OWS - Operator Work Station.

.3 For additional acryonyms and definitions refer to Section 25 05 01 - EMCS: General Requirements

1.4 SUBMITTALS

.1 Submit Record Documents, As-built drawings, Operation and Maintenance Manual to Consultant's Representative in English.

.2 Provide soft copies and hard copies in hard-back, 50 mm 3 ring, D-ring binders.

.1 Binders to be 2/3 maximum full.

.2 Provide index to full volume in each binder.

.3 Identify contents of each manual on cover and spine.

.4 Provide Table of Contents in each manual.

.5 Assemble each manual to conform to Table of Contents with tab sheets placed before instructions covering subject.

1.5 AS-BUILTS

.1 Provide 1 copy of detailed shop drawings generated in Section 25 05 02 - EMCS: Submittals and Review Process and include:

.1 Changes to contract documents as well as addenda and contract extras.

.2 Changes to interface wiring.

.3 Routing of conduit, wiring and control air lines associated with EMCS installation.

.4 Locations of obscure devices to be indicated on drawings.

.5 Listing of alarm messages.

.6 Panel/circuit breaker number for sources of normal/emergency power.

.7 Names, addresses, telephone numbers of each sub-contractor having installed equipment, local representative for each item of equipment, each system.

.8 Test procedures and reports: provide records of start-up procedures, test procedures, checkout tests and final commissioning reports as specified in Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

.9 Basic system design and full documentation on system configuration.

.2 Submit for final review by Consultant's Representative.

.3 Provide before acceptance 4 hard and 1 soft copy incorporating changes made during final review.

1.6 O&M MANUALS

.1 Custom design O&M Manuals (both hard and soft copy) to contain material pertinent to this project only, and to provide full and complete coverage of subjects referred to in this Section.

.2 Provide 2 complete sets of hard and soft copies prior to system or equipment tests.

.3 Include complete coverage in concise language, readily understood by operating personnel using common terminology of functional and operational requirements of system. Do not presume knowledge of computers, electronics or in-depth control theory.

.4 Functional description to include:

.1 Functional description of theory of operation.

.2 Design philosophy.

.3 Specific functions of design philosophy and system.

.4 Full details of data communications, including data types and formats, data processing and disposition data link components, interfaces and operator tests or self-test of data link integrity.

.5 Explicit description of hardware and software functions, interfaces and requirements for components in functions and operating modes.

.6 Description of person-machine interactions required to supplement system description, known or established constraints on system operation, operating procedures currently implemented or planned for implementation in automatic mode.

.5 System operation to include:

.1 Complete step-by-step procedures for operation of system including required actions at each OWS.

.2 Operation of computer peripherals, input and output formats.

.3 Emergency, alarm and failure recovery.

.4 Step-by-step instructions for start-up, back-up equipment operation, execution of systems functions and operating modes, including key strokes for each command so that operator need only refer to these pages for keystroke entries required to call up display or to input command.

.6 Software to include:

.1 Documentation of theory, design, interface requirements, functions, including test and verification procedures.

.2 Detailed descriptions of program requirements and capabilities.

.3 Data necessary to permit modification, relocation, reprogramming and to permit new and existing software modules to respond to changing system functional requirements without disrupting normal operation.

.4 Software modules, fully annotated source code listings, error free object code files ready for loading via peripheral device

.5 Complete program cross reference plus linking requirements, data exchange requirements, necessary subroutine lists, data file requirements, other information necessary for proper loading, integration, interfacing, program execution.

.6 Software for each Controller and single section referencing Controller common parameters and functions.

.7 Maintenance: document maintenance procedures including inspection, periodic preventive maintenance, fault diagnosis, repair or replacement of defective components, including calibration, maintenance, repair of sensors, transmitters, transducers, controller and interface firmware, plus diagnostics and repair/replacement of system hardware.

.8 System configuration document:

.1 Provisions and procedures for planning, implementing and recording hardware and software modifications required during operating lifetime of system.

.2 Information to ensure co-ordination of hardware and software changes, data link or message format/content changes, sensor or control changes in event that system modifications are required.

.9 Programmer control panel documentation: provide where panels are independently interfaced with BECC, including interfacing schematics, signal identification, timing diagrams, fully commented source listing of applicable driver/handler.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes.

.1 Requirements and procedures for identification of devices, sensors, wiring, tubing, conduit and equipment, for building Energy Monitoring and Control System (EMCS) Work and nameplates, materials, colours and lettering sizes.

1.2 RELATED SECTIONS

.1 Section 25 05 01 - EMCS: General Requirements.

1.3 REFERENCES

.1 Canadian Standards Association (CSA International).

.1 CSA C22.1, The Canadian Electrical Code, Part I, Safety Standard for Electrical Installations.

1.4 DEFINITIONS

.1 For acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements.

1.5 SYSTEM DESCRIPTION

.1 Language Operating Requirements: provide identification for control items in English.

1.6 SUBMITTALS

.1 Submittals in accordance with Section 25 05 02 – EMCS: Submittals and Review Process supplemented and modified by requirements of this Section.

.2 Submit to Consultant's Representative for approval samples of nameplates, identification tags and list of proposed wording.

PART 2 PRODUCTS

2.1 NAMEPLATES FOR PANELS

.1 Identify by plastic laminate, 3 mm thick melamine, matt white finish, black core, square corners, lettering accurately aligned and engraved into core, mechanically attached with self-tapping screws.

.2 Sizes: 25 x 67 mm minimum.

.3 Lettering: minimum 7 mm high, black.

.4 Inscriptions: machine engraved to identify function.

2.2 NAMEPLATES FOR FIELD DEVICES

.1 Identify by plastic encased cards attached by plastic tie.

.2 Sizes: 50 x 100 mm minimum.

.3 Lettering: minimum 5 mm high produced from laser printer in black.

.4 Data to include: point name and point address, make, model number.

.5 Companion cabinet: identify interior components using plastic enclosed cards with point name and point address.

2.3 NAMEPLATES FOR ROOM SENSORS

.1 Identify by stick-on labels using point identifier.

.2 Location: as directed by Consultant's Representative.

.3 Letter size: to suit, clearly legible.

2.4 WARNING SIGNS

.1 Equipment including motors, starters under remote automatic control: supply and install orange coloured signs warning of automatic starting under control of EMCS.

.2 Sign to read: "Caution: This equipment is under automatic remote control of EMCS" as reviewed by Consultant's Representative.

2.5 WIRING

.1 Supply and install numbered tape markings on wiring at panels, junction boxes, splitters, cabinets and outlet boxes.

.2 Colour coding: to CSA C22.1. Use colour coded wiring in communications cables, matched throughout system.

.3 Power wiring: identify circuit breaker panel/circuit breaker number inside each EMCS panel.

2.6 PNEUMATIC TUBING

.1 Numbered tape markings on tubing to provide uninterrupted tracing capability.

2.7 CONDUIT

.1 Colour code EMCS conduit.

.2 Pre-paint box covers and conduit fittings.

.3 Coding: use fluorescent orange paint and confirm colour with Consultant's Representative during "Preliminary Design Review".

PART 3 EXECUTION

3.1 NAMEPLATES AND LABELS

.1 Ensure that manufacturer's nameplates, CSA labels and identification nameplates are visible and legible at all times.

3.2 EXISTING PANELS

.1 Correct existing nameplates and legends to reflect changes made during work.

END OF SECTION

PART 1 GENERAL

1.1 RELATED SECTIONS

.1 Section 07 84 00 – Firestopping.

.2 Section 21 05 01 – Common Work Results-Mechanical.

.3 Section 21 07 19 – Thermal Insulation of Piping.

.4 Section 22 13 17 – Drainage Waste and Vent Piping – Cast Iron and Copper.

.5 Section 23 05 05 – Installation of Pipework.

.6 Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment.

.7 Section 23 07 13 – Thermal Insulation of Ducting.

.8 Section 23 21 13.02 – Hydronic Systems:Steel.

.9 Section 23 23 00 – Copper Tubing and Fittings Refrigerant.

.10 Section 25 05 01 – EMCS: General Requirements.

.11 Section 26 05 00 – Common Work Results-Electrical.

1.2 REFERENCES

.1 American National Standards Institute (ANSI)

.1 ANSI/ASME B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

.2 ANSI C2, National Electrical Safety Code.

.3 ANSI/NFPA 70, National Electrical Code.

.2 Canadian Standards Association (CSA)

.1 CSA C22.1, Canadian Electrical Code, Part 1.

.2 CAN/CSA C22.3 No.1, Overhead Systems.

.3 CSA C22.3 No. 7, Underground Systems.

1.3 SYSTEM DESCRIPTION

.1 Electrical:

.1 Provide power wiring from emergency power panels where emergency power is provided to EMCS field panels. If no emergency power provided, install UPS Device. Circuits to be for exclusive use of EMCS equipment. Panel breakers to be identified on panel legends tagged and locks applied to breaker switches.

.2 Hard wiring between field control devices and EMCS field panels.

.3 Communication wiring between EMCS field panels and OWS's including main control centre BECC.

.4 Modify existing starters to provide for EMCS as indicated in I/O Summaries and as indicated.

.5 Refer to wiring diagrams included as part of flow diagrams. Trace existing control wiring installation and provide updated wiring schematics including additions and/or deletions to control circuits for approval by Consultant's Representative before commencing work.

.6 All control wiring and conduit is by Electrical Contractor with final connections by division 25 contractor.

.2 Pneumatic:

.1 Pneumatic tubing, valves and fittings for field control devices.

.3 Mechanical:

.1 Pipe taps required for EMCS equipment will be supplied and installed by Mechanical Division.

.2 Wells and control valves shall be supplied by EMCS Contractor and installed by Mechanical.

.3 Installation of air flow stations, dampers, and other devices requiring sheet metal trades to be mounted by Mechanical. Costs to be carried by designated trade.

.4 VAV Terminal Units.

.1 Air flow probe for VAV boxes to be supplied and installed under Mechanical Division. Air flow dp sensor, actuator and associated VAV controls to be supplied and installed by EMCS contractor. Tubing from air probe to dp sensor as well as installation and adjustment of air flow sensors and actuators to be the responsibility of EMCS contractor. Coordinate air flow adjustments with balancing trade.

.5 Structural:

.1 Special steelwork as required for installation of work.

1.4 PERSONNEL QUALIFICATIONS

.1 Qualified factory trained supervisory personnel to:

.1 Continuously direct and monitor all work.

.2 Attend site meetings.

1.5 EXISTING CONDITIONS

.1 Repair all surfaces damaged during execution of work.

.2 Turn over to Consultant's Representative existing materials removed from work not identified for re-use.

PART 2 PRODUCTS

2.1 PIPING

.1 Domestic H&CWS: refer to Section 22 11 18-Domestic Water Piping Copper.

.2 Sanitary, storm water: refer to Section 22 13 17- Drainage Waste and Vent Piping – Cast Iron and Copper.

.3 Hot water heating, chilled water: refer to Section 23 21 13.02 – Hydronic Systems: Steel.

.4 Condenser water: refer to Section 23 21 13 02– Hydronic Systems: Steel.

.5 Refrigeration: refer to Section 23 23 00 - Copper Tubing and Fittings Refrigerant.

.6 Sleeves, escutcheons: refer to Section 23 05 05 – Installation of Pipework.

.7 Hangers and supports: refer to Section 23 05 29– Hangers and Supports for HVAC Piping and Equipment.

.8 Insulation: refer to Section 21 07 19 – Thermal Insulation for Piping and 23 07 13 – Thermal Insulation for Ducting.

2.2 SPECIAL SUPPORTS

.1 Structural grade steel, primed and painted after construction and before installation.

2.3 PIPING FOR PNEUMATIC CONTROL SYSTEMS

.1 Copper:

.1 Tubing: Type L Hard Drawn

.1 Fittings: wrought copper solder type to ANSI/ASME B16.22, and 95.5 antimonial tin solder. At instruments use compression fittings.

.2 At panels and junction boxes where there is a transition from plastic to copper use bulkhead fittings.

.2 Plastic:

.1 Flame retardant, black PVC with minimum burst strength 1.3 MPa at 23EC installed in conduit.

.2 Fittings: compression or barbed type as required.

2.4 WIRING

.1 As per requirements of Electrical Divisions.

.2 For 50V and above copper conductor with chemically cross-linked thermosetting polyethylene insulation rated RW90 and 600V. Colour code to CSA 22.1.

.3 For wiring under 50 volts use FT6 rated wiring where wiring is not run in conduit. All other cases use FT4 wiring.

.4 Sizes:

.1 120V Power supply: to match or exceed breaker, size #12 minimum.

.2 Wiring for safeties/interlocks for starters, motor control centres, to be stranded, #14 minimum.

.3 Field wiring to digital device: #18AWG or 20AWG stranded twisted pair.

.4 Analog input and output: shielded #18 minimum solid copper or #20 minimum stranded twisted pair. Wiring must be continuous without joints.

.5 More than 4 conductors: #22 minimum solid copper.

.5 Terminations:

.1 Terminate wires with screw terminal type connectors suitable for wire size, and number of terminations.

2.5 CONDUIT

.1 As per requirements of Electrical Division.

.2 Electrical metallic tubing to CSA C22.2 No. 03. Flexible and liquid tight flexible metal conduit to CSA C22.2 No.56. Rigid steel threaded conduit to CSA C22.2 No. 45.

.3 Junction and pull boxes: welded steel.

.1 Surface mounting cast FS: screw-on flat covers.

.2 Flush mounting: covers with 25 mm minimum extension all round.

.4 Cabinets: sheet steel, for surface mounting, with hinged door, latch lock, 2 keys, complete with perforated metal mounting backboard. Panels to be keyed alike for similar functions and or entire contract as approved.

.5 Outlet boxes: 100 mm minimum, square.

.6 Conduit boxes, fittings:

.1 Bushings and connectors: with nylon insulated throats.

.2 With push pennies to prevent entry of foreign materials.

.7 Fittings for rigid conduit:

.1 Couplings and fittings: threaded type steel.

.2 Double locknuts and insulated bushings: use on sheet metal boxes.

.3 Use factory "ells" where 90 degree bends required for 25 mm and larger conduits.

.8 Fittings for thin wall conduit:

.1 Connectors and couplings: steel, set screw type.

2.6 WIRING DEVICES, COVER PLATES

.1 Conform to CSA.

.2 Receptacles:

.1 Duplex: CSA type 5-15R.

.2 Single: CSA type 5-15R.

.3 Cover plates and blank plates: finish to match other plates in area.

2.7 SUPPORTS FOR CONDUIT, FASTENINGS, EQUIPMENT

.1 Solid masonry, tile and plastic surfaces: lead anchors or nylon shields.

.1 Hollow masonry walls, suspended drywall ceilings: toggle bolts.

.2 Exposed conduits or cables:

.1 50 mm diameter and smaller: one-hole steel straps.

.2 Larger than 50 mm diameter: two-hole steel straps.

.3 Suspended support systems:

.1 Individual cable or conduit runs: support with 6 mm diameter threaded rods and support clips.

.2 Two or more suspended cables or conduits: support channels supported by 6 mm diameter threaded rod hangers.

PART 3 EXECUTION

3.1 INSTALLATION

.1 Install equipment, components so that manufacturer's and CSA labels are visible and legible after commissioning is complete.

3.2 PIPING

.1 Domestic H&CWS: refer to Section 22 11 18 –Domestic Water Piping Copper.

.2 Sanitary, storm water: refer to Section 22 13 17- Drainage Waste and Vent Piping – Cast Iron and Copper.

.3 Hot water heating, chilled water: refer to Section 23 21 13.02 – Hydronic Systems:Steel.

.4 Condenser water: refer to Section 23 21 13.02 – Hydronic Systems:Steel.

.5 Refrigeration: refer to Section 23 23 00 - Copper Tubing and Fittings Refrigerant..

.6 Insulation: refer to Section 21 07 19 – Thermal Insulation for Piping and 23 07 13 – Thermal Insulation for Ducting.

3.3 MECHANICAL PIPING

.1 Install piping in accordance with Section 23 05 05 – Installation of Pipework.

3.4 SUPPORTS

.1 Install special supports as required and as indicated.

3.5 PNEUMATIC CONTROL SYSTEMS

.1 General:

.1 Install tubing in accessible concealed locations, straight, parallel and close to building structure with required grades for drainage and venting.

.2 Install drip legs and drains at low points.

.3 Tubing to be free from surface damage.

.4 Tubing NOT to pass through or touch unheated ducts or enclosures.

.5 Do not cover pneumatic tubing with insulation.

.6 Test tubing, check joints after connection to system.

.2 Copper tubing:

.1 Not to come into contact with dissimilar metal. Use non-metallic stand-offs on air handling systems.

.2 Install dielectric couplings where dissimilar metals are connected.

.3 Plastic tubing:

.1 Inaccessible locations: install plastic tubing in conduit.

.2 Inside panels: install in tube trays or racks, or clip individually to back of panel.

.3 Multiple tube bundles: install in tube trays, conduit or armoured flexible cable.

3.6 ELECTRICAL GENERAL

.1 Do complete installation in accordance with requirements of:

.1 Electrical Divisions, this specification.

.2 CSA 22.1 Canadian Electrical Code, latest edition.

.3 ANSI/NFPA 70.

.4 ANSI C2.

.2 Fully enclose or properly guard electrical wiring, terminal blocks, high voltage (above 50 V) contacts and mark to prevent accidental injury.

.3 Do underground installation to CAN/CSA C22.3 No.7, except where otherwise specified.

.4 Conform to manufacturer's recommendations for storage, handling and installation.

.5 Check factory connections and joints. Tighten where necessary to ensure continuity.

.6 Install electrical equipment between 1000 and 2000 mm above finished floor wherever possible and adjacent to related equipment.

.7 Protect exposed live equipment such as panel, mains, outlet wiring during construction for personnel safety.

.8 Shield and mark live parts "LIVE 120 VOLTS" or other appropriate voltage.

.9 Install conduits, and sleeves prior to pouring of concrete.

.10 Holes through exterior wall and roofs: flash and make weatherproof.

.11 Make necessary arrangements for cutting of chases, drilling holes and other structural work required to install electrical conduit, cable, pull boxes, outlet boxes.

.12 Install cables, conduits and fittings which are to be embedded or plastered over, neatly and closely to building structure to minimize furring.

3.7 CONDUIT SYSTEM

.1 Communication wiring shall be installed in conduit. Provide complete conduit system to link Building Controllers to BECC. Conduit sizes to suit wiring requirements and to allow for future expansion capabilities specified for systems. Maximum conduit fills not to exceed 40%. Design drawings do not show conduit layout.

.2 Install conduits parallel or perpendicular to building lines, to conserve headroom and to minimize interference.

.3 Do not run exposed conduits in normally occupied spaces unless otherwise indicated or unless impossible to do otherwise. Obtain approval from Consultant's Representative before starting such work. Provide complete conduit system to link field panels and devices with main control centre. Conduit size to match conductors plus future expansion capabilities as specified.

.4 Locate conduits at least 150 mm from parallel steam or hot water pipes and at least 50 mm at crossovers.

.5 Bend conduit so that diameter is reduced by less than 1/10th original diameter.

.6 Field thread on rigid conduit to be of sufficient length to draw conduits up tight.

.7 Limit conduit length between pull boxes to less than 30 m.

.8 Use conduit outlet boxes for conduit up to 32 mm diameter and pull boxes for larger sizes.

.9 Fastenings and supports for conduits, cables, and equipment:

.1 Provide metal brackets, frames, hangers, clamps and related types of support structures as indicated and as required to support cable and conduit runs.

.2 Provide adequate support for raceways and cables, sloped vertically to equipment.

.3 Use supports or equipment installed by other trades for conduit, cable and raceway supports only after written approval from Consultant's Representative.

.10 Install polypropylene fish cord in empty conduits for future use.

.11 Where conduits become blocked, remove and replace blocked sections.

.12 Pass conduits through structural members only after receipt of Consultant's Representative's written approval.

.13 Conduits may be run in flanged portion of structural steel.

.14 Group conduits wherever possible on suspended or surface channels.

.15 Pull boxes:

.1 Install in inconspicuous but accessible locations.

.2 Support boxes independently of connecting conduits.

.3 Fill boxes with paper or foam to prevent entry of construction material.

.4 Provide correct size of openings. Reducing washers not permitted.

.5 Mark location of pull boxes on record drawings.

.6 Identify AC power junction boxes, by panel and circuit breaker.

.16 Install terminal blocks or strips indicated in cabinets to Electrical Division.

.17 Install bonding conductor for 120 volt and above in conduit.

3.8 WIRING

.1 Install multiple wiring in ducts simultaneously.

.2 Do not pull spliced wiring inside conduits or ducts.

.3 Use CSA certified lubricants of type compatible with insulation to reduce pulling tension.

.4 Tests: use only qualified personnel. Demonstrate that:

.1 Circuits are continuous, free from shorts, unspecified grounds.

.2 Resistance to ground of all circuits is greater than 50 Megohms.

.5 Provide Consultant’s Representative with test results showing locations, circuits, results of tests.

.6 Remove insulation carefully from ends of conductors and install to manufacturer's recommendations. Accommodate all strands in lugs. Where insulation is stripped in excess, neatly tape so that only lug remains exposed.

.7 Wiring in main junction boxes and pull boxes to terminate on terminal blocks only, clearly and permanently identified. Junctions or splices not permitted for sensing or control signal covering wiring.

.8 Do not allow wiring to come into direct physical contact with compression screw.

.9 Install ALL strands of conductor in lugs of components. Strip insulation only to extent necessary for installation.

3.9 WIRING DEVICES, COVER PLATES

.1 Receptacles:

.1 Install vertically in gang type outlet box when more than one receptacle is required in one location.

.2 Cover plates:

.1 Install suitable common cover plate where wiring devices are grouped.

.2 Use flush type cover plates only on flush type outlet boxes.

3.10 STARTERS, CONTROL DEVICES

.1 Install and make control connections as indicated. Power connections above 50V by Electrical Division.

.2 Install correct over-current devices.

.3 Identify each control wire, terminal for external connections with permanent number marking identical to diagram.

.4 Performance Verification:

.1 Operate switches and controls to verify functioning.

.2 Perform start and stop sequences of contactors and relays.

.3 Check that interlock sequences, with other separate related starters, equipment and auxiliary control devices, operate as specified.

3.11 GROUNDING

.1 Install complete, permanent, continuous grounding system for equipment, including conductors, connectors and accessories.

.2 Install separate grounding conductors in conduit within building.

.3 Install ground wire in all PVC ducts and in tunnel conduit systems.

.4 Tests: perform ground continuity and resistance tests, using approved method appropriate to site conditions.

3.12 TESTS

.1 General:

.1 Perform following tests in addition to tests specified Section 25 08 20 - EMCS: Warranty and Maintenance.

.2 Give 14 days written notice of intention to test.

.3 Conduct in presence of Consultant's Representative and authority having jurisdiction.

.4 Conceal work only after tests satisfactorily completed.

.5 Report results of tests to Consultant's Representative in writing.

.6 Preliminary tests:

.1 Conduct as directed to verify compliance with specified requirements.

.2 Make needed changes, adjustments, replacements.

.3 Insulation resistance tests:

.1 Megger all circuits, feeders, equipment for 120 - 600V with 1000V instrument. Resistance to ground to be more than required by Code before energizing.

.2 Test insulation between conductors and ground, efficiency of grounding system to satisfaction of Consultant's Representative and authority having jurisdiction.

3.13 IDENTIFICATION

.1 Refer to Section 25 05 54- EMCS: Identification.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes.

.1 Requirements and procedures for warranty and activities during warranty period and service contracts, for building Energy Monitoring and Control System (EMCS).

1.2 RELATED SECTIONS

.1 Section 25 05 01 - EMCS: General Requirements.

1.3 REFERENCES

.1 Canada Labour Code (R.S., c. L-2)/Part I - Industrial Relations.

.2 Canadian Standards Association (CSA)

.1 CSA Z204 – Guidelines for Managing Indoor Quality in Buildings

1.4 DEFINITIONS

.1 OWS - Operator Work Station.

.2 For additional acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements.

1.5 SUBMITTALS

.1 Submit detailed preventative maintenance schedule for system components to Consultant.

.2 Submit detailed inspection reports Consultant.

.3 Submit dated, maintenance task lists to Consultant and include the following sensor and output point detail, as proof of system verification:

.1 Point name and location.

.2 Device type and range.

.3 Measured value.

.4 System displayed value.

.5 Calibration detail

.6 Indication if adjustment required,

.7 Other action taken or recommended.

.4 Submit network analysis report showing results with detailed recommendations to correct problems found.

.1 Maintain records and logs of each maintenance task on site.

.2 Organize cumulative records for each major component and for entire EMCS chronologically.

.3 Submit records to Consultant, after inspection indicating that planned and systematic maintenance have been accomplished.

.5 Revise and submit to Consultant in accordance with "As-built drawings" documentation and commissioning reports to reflect changes, adjustments and modifications to EMCS made during warranty period.

1.6 MAINTENANCE SERVICE DURING WARRANTY PERIOD

.1 Provide services, materials, and equipment to maintain EMCS for warranty period of one year after date of substantial completion. Provide detailed preventative maintenance schedule for system components as described in Submittal article.

.2 Emergency Service Calls:

- .1 Initiate service calls when EMCS is not functioning correctly.
- .2 Qualified control personnel to be available during warranty period to provide service to "CRITICAL" components whenever required at no extra cost.
- .3 Furnish Consultant with telephone number where service personnel may be reached at any time.
- .4 Service personnel to be on site ready to service EMCS after receiving request for service.
- .5 Perform work continuously until EMCS restored to reliable operating condition.

.3 Operation: foregoing and other servicing to provide proper sequencing of equipment and satisfactory operation of EMCS based on original design conditions and as recommended by manufacturer.

.4 Work requests: record each service call request, when received separately on approved form and include:

- .1 Serial number identifying component involved.
- .2 Location, date and time call received.
- .3 Nature of trouble.
- .4 Names of personnel assigned.
- .5 Instructions of work to be done.
- .6 Amount and nature of materials used.
- .7 Time and date work started.
- .8 Time and date of completion.

.5 Provide system modifications in writing.

- .1 No system modification, including operating parameters and control settings, to be made without prior written approval of Consultant.

1.7 SERVICE CONTRACTS

.1 Provide in-depth technical expertise and assistance to Consultant and Commissioning Manager in preparation and implementation of service contracts and in-house preventive maintenance procedures. Service contracts duration is for the warranty period.

.2 Service Contracts to include:

- .1 Annual verification of field points for operation and calibration.
- .2 4 visits per year.

.3 2 responses to emergency calls during day, per year.

.4 2 responses to emergency calls during silent hours, per year.

.5 Silent hours defined as 1630 h – 0800 h and on weekends and statutory holidays.

.6 Complete inventory of installed system.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 FIELD QUALITY CONTROL

.1 Perform as minimum (3) three minor inspections and one major inspection (more often if required by manufacturer) per year. Provide detailed written report to Consultant/ Consultant as described in Submittal article.

.2 Perform inspections during regular working hours, 0800 to 1630 h, Monday through Friday, excluding statutory holidays.

.3 Following inspections are minimum requirements and should not be interpreted to mean satisfactory performance:

.1 Perform calibrations using test equipment having traceable, certifiable accuracy at minimum 50% greater than accuracy of system displaying or logging value.

.2 Check and calibrate random sample of 10% field input/output devices in accordance with Canada Labour Code - Part I and CSA Z204.

.3 Provide dated, maintenance task lists, as proof of execution of complete system verification.

.4 Minor inspections to include, but not limited to:

.1 Perform visual, operational checks to BC's, peripheral equipment, interface equipment and other panels.

.2 Check equipment cooling fans as required.

.3 Visually check for mechanical faults, air leaks and proper pressure settings on pneumatic components.

.4 Review system performance with Operations Supervisor and/or Consultant/ Consultant to discuss suggested or required changes.

.5 Major inspections to include, but not limited to:

.1 Minor inspection.

.2 Clean OWS(s) peripheral equipment, BC(s), interface and other panels, micro-processor interior and exterior surfaces.

.3 Check signal, voltage and system isolation of BC(s), peripherals, interface and other panels.

.4 Verify calibration/accuracy of each input and output device and recalibrate or replace as required (as per 3.1. 3.2).

.5 Provide mechanical adjustments, and necessary maintenance on printers.

.6 Run system software diagnostics as required.

.7 Install software and firmware enhancements to ensure components are operating at most current revision for maximum capability and reliability.

.1 Perform network analysis and provide report as described in Submittal article.

.6 Rectify deficiencies revealed by maintenance inspections and environmental checks.

.7 Continue system debugging and optimization.

.8 Testing/verification of occupancy and seasonal-sensitive systems to take place during four (4) consecutive seasons, after facility has been accepted, taken over and fully occupied.

.1 Test weather-sensitive systems twice: first at near winter design conditions and secondly under near summer design conditions.

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 System requirements for Local Area Network (LAN) for Building Energy Monitoring and Control System (EMCS).

.2 Related Sections:

.1 Section 25 05 01 – EMCS: General Requirements.

1.2 REFERENCES

.1 Canadian Standards Association (CSA International).

.1 CSA T529, Telecommunications Cabling Systems in Commercial Buildings (Adopted ANSI/TIA/EIA-568-A with modifications.

.2 CSA T530, Commercial Building Standard for Telecommunications Pathways and Spaces (Adopted ANSI/TIA/EIA – 569-A with modifications.

.2 Institute of Electrical and Electronics Consultants (IEEE)/Standard for Information Technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements.

.1 IEEE Std 802.3TM, Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.

.3 Telecommunications Industries Association (TIA)/Electronic Industries Alliance (EIA).

.1 TIA/EIA-568, Commercial Building Telecommunications Cabling Standards Set, Part 1 General Requirements, Part 2 Balanced Twisted- Pair Cabling Components, Part 3 Optical Fiber Cabling Components Standard.

.2 TIA/EIA-569-A, Commercial Building Standard for Telecommunications Pathways and Spaces.

.4 Treasury Board Information Technology Standard (TBITS).

.1 TBITS 6.9, Profile for the Telecommunications Wiring System in Government Owned and Leased Buildings-Technical Specifications.

1.3 DEFINITIONS

.1 Acronyms and definitions: refer to Section 25 05 01 – EMCS: General Requirements.

1.4 SYSTEM DESCRIPTION

.1 Data communication network to link Operator Workstations and Master Control Units (MCU) in accordance with CSA T529, TIA/EIA-568, CSA T530 and TIA/EIA-569-A.

.1 Provide reliable and secure connectivity of adequate performance between different sections segments of network.

.2 Allow for future expansion of network, with selection of networking technology

and communication protocols.

.2 Data communication network to included, but not limited to:

.1 EMCS-LAN.

.2 Modems.

.3 Network interface cards.

.4 Network management hardware and software.

.5 Network components necessary for complete network.

1.5 DESIGN REQUIREMENTS

.1 EMCS Local Area Network (EMCS-LAN).

.1 High Speed, high performance, local area network over MS/TP with MCUs and OWSs communicate with each other directly on peer to peer basis in accordance with IEEE 802.3/Ethernet Standard.

.2 EMCS-LAN to be: BACnet Protocol

.3 Each EMCS-LAN to be capable of supporting at least 50 devices.

.4 Support of combination of MCUs and OWSs directly connected to EMCS-LAN.

.5 High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, upload/download information between network devices. Bit rate to be 10 Megabits per second minimum.

.6 Detection and accommodation of single or multiple failures of either OWSs, MCUs or network media. Operational equipment to continue to perform designated functions effectively in event of single or multiple failures.

.7 Commonly available, multiple sourced, networking components and protocols to allow system to co-exist with other networking applications including office automation.

.2 Dynamic Data Access.

.1 LAN to provide capabilities for OWSs, either network resident or connected remotely to access point status and application report data or execute control functions for other devices via LAN.

.2 Access to data to be based upon logical identification of building equipment.

.3 Network Medium.

.1 Network medium: twisted cable, shielded twisted cable, or fibre optic cable compatible with network protocol to be used within buildings. Fibre optic cable to be used between buildings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

PART 1 GENERAL

1.1 SUMMARY

.1 Section Includes:

.1 Materials and installation for building automation controllers including:

.1 Master Control Unit (MCU).

.2 Local Control Unit (LCU)

.3 Equipment Control Unit (ECU).

.4 Terminal Control Unit (TCU).

1.2 RELATED SECTIONS

.1 Section 25 05 01 - EMCS: General Requirements.

.2 Section 25 05 02 - EMCS: Submittals and Review Process.

.3 Section 25 05 03 - EMCS: Project Records Documents.

.4 Section 25 30 02 - EMCS: Field Control Devices.

.5 Section 25 90 01 – EMCS: Site Requirements, Applications and Systems Sequences of Operation.

1.3 REFERENCES

.1 American Society of Heating, Refrigeration, and Air-Conditioning Consultants, Inc. (ASHRAE).

.1 ASHRAE, Applications Handbook, SI Edition.

.2 ASHRAE Standard 135 – BAC net – A Data Communications Protocol for Building Automation and Control Networks.

.3 ASHRAE Standard 135.1 Method of Test Conformance to BAC net.

.2 Canadian Standards Association (CSA)

.1 C22.2 No.205, Signal Equipment.

.3 Institute of Electrical and Electronics Consultants (IEEE)

.1 IEEE C37.90.1, Surge Withstand Capabilities Test for Protective Relays and Relays Systems.

1.4 DEFINITIONS

.1 Acronyms used in this section include: see Section 25 05 01 - EMCS: General Requirements.

1.5 SYSTEM DESCRIPTION

.1 General: Network of controllers comprising of MCU(‘s), LCU(‘s), ECU(‘s) or TCU(‘s) to be provided as indicated in System Consultanture Diagram to support building systems and associated sequence(s) of operations as detailed in these specifications.

.1 Provide sufficient controllers to meet intents and requirements of this section.

.2 Controllers quantity, and point contents to be approved by Consultant’s Representative at time of preliminary design review.

.2 Controllers: stand-alone intelligent Control Units:

.1 Incorporate programmable microprocessor, non-volatile program memory, RAM, power supplies, as required to perform specified functions.

.2 Incorporate communication interface ports for communication LANs to exchange information with other Controllers.

.3 Capable of interfacing with operator interface device.

.4 Execute its logic and control using primary inputs and outputs connected directly to its onboard input/output field terminations or slave devices, and without need with other controller. Secondary input used for reset such as outdoor air temperature may be located in other Controller(s).

1.6 DESIGN REQUIREMENTS

.1 To include:

.1 Scanning of AI and DI connected inputs for detection of change of value and processing the detection of alarm conditions.

.2 Perform On-Off digital control of connected points, including the resulting required states generated through programmable logic output.

.3 Perform Analog control using programmable logic, (including PID) with adjustable dead bands and deviation alarms.

.4 Control of systems as described in sequence of operations.

.5 Execution of optimization routines as listed in this section.

.2 Total spare capacity for MCUs and LCUs: at least 25% of each point type distributed throughout the MCUs and LCUs.

.3 Field Termination and Interface Devices.

.1 To conform to CSA C22.2 No. 205.

.2 Electronically interface sensors and control devices to processor unit.

.3 Include, but not be limited to, following:

.1 Programmed firmware or logic circuits to meet functional and technical requirements.

.2 Power supplies for operation of logic devices and associated field equipment.

.3 Lockable wall cabinet.

.4 Required communications equipment and wiring .

.5 Leave controlled system in "fail-safe" mode in event of loss of communication with, or failure of, processor unit.

.6 Input/Output interface to accept as minimum AI, AO, DI, DO functions as specified.

.7 Wiring terminations: use conveniently located screw type or spade lug terminals.

.4 AI interface equipment to:

.1 Convert analog signals to digital format with 12 bit analog-to-digital resolution.

.2 Provide for following input signal types and ranges:

.1 4 - 20 mA;

.2 0-10V DC

.3 10 K ohm.

.3 Meet IEEE C37.90.1 surge withstand capability.

.4 Have common mode signal rejection greater than 60 dB to 60 Hz.

.5 Where required, dropping resistors to be certified precision devices which complement accuracy of sensor and transmitter range specified.

.5 AO interface equipment:

.1 Convert digital data from controller processor to acceptable analog output signals using 12 bit digital-to-analog resolution.

.2 Provide for following output signal types and ranges:

.1 4 - 20 mA.

.2 0 - 10 V DC.

.3 Meet IEEE C37.90.1 surge withstand capability.

.6 DI interface equipment:

.1 Able to reliably detect contact change of sensed field contact and transmit condition to controller.

.2 Meet IEEE C37.90.1 surge withstand capability.

.3 Accept pulsed inputs up to 2 kHz.

.7 DO interface equipment:

.1 Respond to controller processor output, switch respective outputs. Each DO hardware to be capable of switching up to 0.5 amps at 24 V AC.

.2 Switch up to 5 amps at 220 V AC using optional interface relay.

.4 Controller's and associated hardware and software: operate in conditions of 0EC to 44EC and 20 % to 90 % non-condensing RH.

.5 Controllers (MCU, LCU): mount in wall mounted cabinet with hinged, keyed-alike locked door.

.1 Provide for conduit entrance from top, bottom or sides of panel.

.2 ECUs to be mounted in equipment enclosures or separate enclosures.

.3 Mounting details as approved by Consultant's Representative for ceiling mounting.

.6 Cabinets to provide protection from water dripping from above, while allowing sufficient airflow to prevent internal overheating.

.7 Provide surge and low voltage protection for interconnecting wiring connections.

1.7 SUBMITTALS

.1 Make Submittals in accordance with Section 25 05 02 – EMCS: Submittals and Review Process.

.1 Submit product data sheets for each product item proposed for this project.

1.8 MAINTENANCE PROCEDURES

.1 Provided manufacturers recommended maintenance procedures for insertion in Section 25 05 03 – EMCS: Project Record Documents.

PART 2 PRODUCTS

2.1 MASTER CONTROL UNIT (MCU)

.1 Primary function of MCU is to provide co-ordination and supervision of subordinate devices. Supervisory role shall include coordination of subordinate devices in the execution of optimization routines such as demand limiting or enthalpy control.

.2 Include high speed communication LAN Port for Peer to Peer communications with OWS(s) and other MCU level devices. Include support for Open System Protocols, BACnet.

.3 MCU shall have local I/O capacity as follows;

- .1 To have at least 16 I/O points of which minimum to be 2AO, 6AI, 4DI, 4DO.
- .2 LCU's to be added to support system functions as indicated in I/O Summary List.

.4 Central Processor Unit (CPU)

- .1 Processor to consist of at minimum a 16 bit microprocessor capable of supporting software to meet specified requirements.
- .2 CPU idle time to be more than 30 % when system configured to maximum input and output with worst case program use.
- .3 Minimum addressable memory to be at manufacturer's discretion but to support at least all performance and technical specifications. Memory to include:
  - .1 Non-volatile EEPROM to contain operating system, executive, application, sub-routine, other configurations definition software. Tape media not acceptable.
  - .2 Battery backed (72 hr minimum capacity) RAM (to reduce the need to reload operating data in event of power failure) RAM to contain CDLs, application parameters, operating data or software that is required to be modifiable from operational standpoint such as schedules, setpoints, alarm limits, PID constants and CDL and hence modifiable on-line through operator panel or remote operator's interface. RAM to be downline loadable from OWS, CAB-Gateway, or locally installed floppy disk.
- .4 Include uninterruptible clock accurate to plus or minus 5 secs/month, capable of deriving month/day/hour/minute/second, with rechargeable batteries for minimum 72 hr operation in event of power failure.

.5 Local Operator Terminal (OT)

- .1 OT to:
  - .1 Have integral access/display panel where immediate access to OWS is not available.
  - .2 Support operator's terminal for local command entry, instantaneous and historical data display, programs additions and modifications.
  - .3 Simultaneously display minimum of 16 points with full English identification to allow operator to view single screen dynamic displays depicting entire mechanical systems.
- .2 Functions to include, but not be limited to, following:
  - .1 Start and stop points.
  - .2 Modify setpoints.
  - .3 Modify PID loop setpoints.

.4 Override PID control.

.5 Change time/date.

.6 Add/modify/start/stop weekly scheduling.

.7 Add/modify setpoint weekly scheduling.

.8 Enter temporary override schedules.

.9 Define holiday schedules.

.10 View analog limits.

.11 Enter/modify analog warning limits.

.12 Enter/modify analog alarm limits.

.13 Enter/modify analog differentials.

.3 OT to provide access to real and calculated points in controller to which it is connected or to any other controller in network. This capability not to be restricted to subset of predefined "global points" but to provide totally open exchange of data between OT and any other controller in network.

.4 Operator access to OTs to the same as OWS user password. Password changes to automatically be downloaded to controllers on network.

.5 OT to provide prompting to eliminate need for user to remember command format or point names. Prompting to be consistent with user's password clearance and types of points displayed to eliminate possibility of operator error.

.6 Identity of real or calculated points to be consistent with network devices. Use same point identifier as at OWS's for access of points at OT to eliminate cross-reference or look-up tables.

2.2 LOCAL CONTROL UNIT (LCU)

.1 Provide multiple control functions for typical built-up and package HVAC, hydronic and electrical systems.

.2 Minimum of 16 I/O points of which minimum be 4 AOs, 4 AIs, 4 DIs, 4 DOs.

.3 Points of one Building System to be connected to one controller as listed in I/O Summary designations.

.4 Microprocessor capable of supporting necessary software and hardware to meet specified requirements. As per MCU requirements (section 2.3.4) above with the following additions:

.1 Include as minimum 2 interface ports for connection to local computer terminal.

.2 Design so that shorts, opens or grounds on any input or output will not interfere with other input or output signals.

.3 Physically separate line voltage (50V and over) circuits from DC logic circuits to permit maintenance on either circuit with minimum hazards to technician and equipment.

.4 Include power supplies for operation of LCU and associated field equipment.

.5 In event of loss of communications with, or failure of, MCU, LCU to continue to perform control. Controllers that use defaults or fail to open or close positions not acceptable.

.6 Provide conveniently located screw type or spade lug terminals for field wiring.

.7 LCU to have 25 % spare input and 25 % output point capacity without addition of cards, terminals, etc.

2.3 TERMINAL/EQUIPMENT CONTROL UNIT (TCU/ECU)

.1 Microprocessor capable of supporting necessary software and hardware to meet TCU/ECU functional specifications.

.1 The TCU definition to be consistent with those defined in ASHRAE HVAC Applications Handbook.

.2 Controller to communicate directly with EMCS through EMCS LAN and provide access from EMCS OWS for setting occupied and unoccupied space temperature setpoints, flow setpoints, and associated alarm values, permit reading of sensor values, field control values (% open) and transmit alarm conditions to EMCS OWS.

.3 VAV Terminal Controller

.1 Microprocessor based controller with integral flow transducer, including software routines to execute PID algorithms, calculate airflow for integral flow transducer and measure temperatures as per I/O Summary required inputs. Sequence of operation to ASHRAE HVAC Applications Handbook.

.2 Controller to support point definition; in accordance with section 25 05 01 – EMCS: General Requirements.

.3 Controller to operate independent of network in case of communication failure.

.4 Controller to include damper actuator and terminations for input and output sensors and devices.

2.4 SOFTWARE

.1 General:

.1 Include as minimum: operating system executive, communications, application programs, operator interface, and systems sequence of operation - CDL's.

.2 To include "firmware" or instructions which are programmed into ROM, EPROM, EEPROM or other non-volatile memory.

.3 Include initial programming of all Controllers, for entire system.

.2 Program and data storage:

.1 Store executive programs and site configuration data in ROM, EEPROM or other non-volatile memory.

.2 Maintain CDL and operating data such as setpoints, operating constants, alarm limits in battery-backed RAM or EEPROM for display and modification by operator.

.3 Programming languages:

.1 Control Description Logic software to be programmed using English like or graphical, high level, general control language.

.2 Structure software in modular fashion to permit simple restructuring of program modules if future software additions or modifications are required. GO TO constructs not allowed.

.4 Operator terminal interface:

.1 MCU to perform operating and control functions specified Section 25 10 02 - EMCS: Operator Work Stations (OWS), including:

.1 Multi-level password access protection to allow user/manager to limit

workstation control.

.2 Alarm management: processing and messages.

.3 Operator commands.

.4 Reports.

.5 Displays.

.6 Point identification.

.5 Pseudo or calculated points:

.1 Software to have access to any value or status in controller or other networked controller so as to define and calculate pseudo point from other values/status of controller. When current pseudo point value is derived, normal alarm checks must be performed or value used to totalize.

.2 Inputs and outputs for any process to be able to include data from controllers to permit development of network-wide control strategies. Processes also to permit operator to use results of one process as input to any number of other processes (eg. cascading).

.6 Control Description Logic (CDL):

.1 Capable of generating on-line project-specific control loop algorithms (CDLs). CDLs to be software based, programmed into RAM or EEPROM and backed up to OWS. Consultant must have access to these algorithms for modification or to be able to create new ones and to integrate these into CDLs on BC(s) from OWS.

.2 Write CDL in high level language that allows algorithms and interlocking programs to be written simply and clearly. Use parameters entered into system (eg. setpoints) to determine operation of algorithm. Operator to be able to alter operating parameters on-line from OWS or BC(s) and to tune control loops.

.3 Perform changes to CDL on-line.

.4 Control logic to have access to values or status of all points available to controller including global or common values, allowing cascading or inter-locking control.

.5 Energy optimization routines such as enthalpy control, supply temperature reset, etc. to be LCU or MCU resident functions and form part of CDL.

.6 MCU to be able to perform following pre-tested control algorithms:

.1 Two position control.

.2 Proportional Integral and Derivative (PID) control.

.3 Automatic control loop tuning.

.7 Control software to provide the ability to define the time between successive starts for each piece of equipment to reduce cycling of motors.

.8 Provide protection against excessive electrical-demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

.9 Power Fail Restart: Upon detection of power failure system to verify availability of emergency power as determined by emergency power transfer switches and analyze controlled equipment to determine its appropriate status under emergency power conditions and start or stop equipment as defined by I/O Summary. Upon resumption of normal power as determined by emergency power transfer switches, MCU to analyze status of controlled equipment, compare with normal occupancy scheduling, turn equipment on or off as

necessary to resume normal operation.

.7 Event and Alarm management: The system to use a management by exception concept for Alarm Reporting. This is a system wide requirement. This approach will insure that only principal alarms are reported to OWS. Events which occur as a direct result of the primary event to be suppressed by the system and only events which fail to occur to be reported. Such event sequence to be identified in I/O Summary and sequence of operation. Examples of above are, operational temperature alarms limits which are exceeded when main air handler is stopped, or General Fire condition shuts air handlers down, only Fire alarm status shall be reported. The exception is, when an air handler which is supposed to stop or start fails to do so under the event condition.

.8 Energy management programs: The following programs shall include specific summarizing reports, to include the date stamp indicating sensor details which activated and or terminated the feature.

.1 MCU in coordination with subordinate LCU, TCU, ECU to provide for the following energy management routines:

.1 Time of day scheduling.
.2 Calendar based scheduling.
.3 Holiday scheduling.
.4 Temporary schedule overrides.
.5 Optimal start stop.
.6 Night setback control.
.7 Enthalpy (economizer) switchover.
.8 Peak demand limiting.
.9 Temperature compensated load rolling.
.10 Fan speed/flow rate control.
.11 Cold deck reset.
.12 Hot deck reset.
.13 Hot water reset.
.14 Chilled water reset.
.15 Condenser water reset.
.16 Chiller sequencing.
.17 Night purge.

.2 Programs to be executed automatically without need for operator intervention and be flexible enough to allow customization.

.3 Apply programs to equipment and systems as specified or requested by the Consultant's Representative.

.9 Function/Event Totalization: features to provide predefined reports which show daily, weekly, and monthly accumulating totals and which include high rate (time stamped) and low rate (time stamped) and accumulation to date for month.

.1 MCUs to accumulate and store automatically run-time for binary input and output points.

.2 MCU to automatically sample, calculate and store consumption totals on daily, weekly or monthly basis for user-selected analog or binary pulse input-type points.

.3 MCU to automatically count events (number of times pump is cycled off and on) daily, weekly or monthly basis.

.4 Totalization routine to have sampling resolution of 1 min or less for analog inputs.

.5 Totalization to provide calculations and storage of accumulations up to 99,999.9 units (eg. kWH, litres, tonnes, etc.).

.6 Store event totalization records with minimum of 9,999,999 events before reset.

.7 User to be able to define warning limit and generate user-specified messages when limit reached.

2.5 LEVELS OF ADDRESS

.1 Upon operator's request, EMCS to present status of any single 'point', 'system' or point group, entire 'area', or entire network on printer or OWS as selected by operator.

.1 Display analog values digitally to 1 place of decimals with negative sign as required.

.2 Update displayed analog values and status when new values received.

.3 Flag points in alarm by blinking, reverse video, different colour, bracketed or other means to differentiate from points not in alarm.

.4 Updates to be change-of-value (COV)-driven or if polled not exceeding 2 second intervals.

2.6 POINT NAME SUPPORT

.1 Controllers (MCU, LCU) to support point naming convention as defined in Section 25 05 01 – EMCS: General Requirements.

PART 3 EXECUTION

3.1 LOCATION

.1 Location of Controllers to be approved by Consultant's Representative.

3.2 INSTALLATION

.1 Install Controllers in secure enclosures as indicated.

.2 Provide necessary power from local 120 V branch circuit panel for equipment.

.3 Install tamper locks on breakers of circuit breaker panel.

.4 Use Uninterruptible Power Supply (UPS) and emergency power when equipment must operate in an emergency and co-ordinating mode.

END OF SECTION

PART 1 GENERAL

1.1 RELATED SECTIONS

.1 Section 33 56 13 - Aboveground Fuel Storage Tanks.

.2 Section 25 05 02 - EMCS: Submittals and Review Process.

.3 Section 25 05 03 - EMCS: Project Records Documents.

1.2 REFERENCES

.1 American National Standards Institute (ANSI)

.1 ANSI C12.7, Requirements for Watthour Meter Sockets.

.2 ANSI/IEEE C57.13, Requirements for Instrument Transformers.

.2 Canadian Standards Association

.1 CSA Type 1 Enclosure

.2 CSA Type 4X Enclosures

.3 CSA Type 12 Enclosures

1.3 SUBMITTALS

.1 Submit shop drawings and manufacturer's installation instructions in accordance with Section 25 05 02 - EMCS: Submittals and Review Process.

.2 Include:

.1 Information as specified for each device.

.2 Manufacturer's detailed installation instructions.

.3 Pre-Installation Tests

.1 Submit samples at random from equipment shipped, as requested by Consultant's Representative, for testing before installation. Replace devices not meeting specified performance and accuracy.

.4 Manufacturer's Instructions

.1 Submit manufacturer's installation instructions for specified equipment and devices.

1.4 CLOSEOUT SUBMITTALS

.1 Submit operating and maintenance data for inclusion in operation and maintenance manual in accordance with Section 25 05 03 - EMCS: Project Records Documents.

PART 2 PRODUCTS

2.1 GENERAL

.1 Control devices of each category to be of same type and manufacturer.

.2 External trim materials to be corrosion resistant. Internal parts to be assembled in watertight, shockproof, vibration-proof, heat resistant assembly.

.3 Operating conditions: 0 - 32 EC with 10 - 90 % RH (non-condensing) unless otherwise specified.

.4 Terminations: use standard conduit box with slot screwdriver compression connector block unless otherwise specified.

.5 Transmitters to be unaffected by external transmitters (eg. walkie talkies).

.6 Account for hysteresis, relaxation time, maximum and minimum limits in applications of sensors and controls.

.7 Outdoor installations: use weatherproof construction in CSA 4X enclosures.

.8 Devices to be installed in user occupied space must not exceed Noise Criteria (NC) of 35. Noise generated by any device must not be detectable above space ambient conditions.

2.2 TEMPERATURE SENSORS

.1 General: except for VAV box control to be resistance or thermocouple type to following requirements:

.1 Thermisters 10 K ohm, + 0.2^{o} C accuracy, less than 0.1^{o} C drift over 10 year span. Power supply 5 V dc, 10-35 Vdc, 24 Vac..

.2 RTD's: 1000 ohm at 0 EC (plus or minus 0.2 ohms) platinum element with strain minimizing construction, 3 integral anchored leadwires. Coefficient of resistivity: 0.00385 ohms/ohmEC.

.3 Immersion wells: NPS 3/4, stainless steel spring loaded construction, with heat transfer compound compatible with sensor. Insertion length 100 mm as indicated.

.2 Sensors:

.1 Room type: wall mounting, in slotted type covers, LCD display ^{o}C or ^{o}F, with guard as indicated. Dual set point momentary push button, override switch.

.2 Room type for VAV boxes: as for room type, above. Include setpoint adjustment, local indication, push button override for night set back function.

.3 General purpose duct type: suitable for insertion into ducts at any angle, insertion length 460 mm.

.4 Averaging duct type: continuous filament with minimum immersion length 6000 mm. Bend probe at field installation time to 100 mm radius at any point along probe without degradation of performance.

.5 Outside air type: complete with probe length 100 - 150 mm long, non-corroding shield to minimize solar and wind effects, threaded fitting for mating to 13 mm conduit, weatherproof construction in CSA 4X enclosure.

.6 Immersion type: spring loaded probe, NPT ½ fitting insertion to suit pipe size.

2.3 TEMPERATURE TRANSMITTERS

.1 Requirements:

.1 Input circuit: to accept 3-lead, 100 ohm at 0 deg C, platinum resistance detector type sensors.

.2 Power supply: 575 ohms at 24 V DC into load of 575 ohms. Power supply effect less than 0.01 deg C per volt change.

.3 Output signal: 4 - 20 mA into 500 ohm maximum load.

.4 Input and output short circuit and open circuit protection.

.5 Output variation: less than 0.2 % of full scale for supply voltage variation of plus or minus 10 %.

.6 Combined non-linearity, repeatability, hysteresis effects: not to exceed plus or minus 0.5 % of full scale output.

.7 Maximum current to 100 ohm RTD sensor: not to exceed 22.5 mA.

.8 Integral zero and span adjustments.

.9 Temperature effects: not to exceed plus or minus 1.0 % of full scale/ 50 EC.

.10 Long term output drift: not to exceed 0.25 % of full scale/ 6 months.

.11 Transmitter ranges: Select narrowest range to suit application from following:

.1 Minus 50 EC to plus 50 EC, plus or minus 0.5 EC.

.2 0 to 100 EC, plus or minus 0.5 EC.

.3 0 to 50 EC, plus or minus 0.25 EC.

.4 0 to 25 EC, plus or minus 0.1 EC.

.5 10 to 35 EC, plus or minus 0.25EC.

2.4 HUMIDITY SENSORS

.1 Requirements:

.1 Range: 5 - 95 % RH minimum.

.2 Operating temperature range: -40°C to 85°C.

.3 Absolute accuracy:

.1 Duct sensors: plus or minus 5 %.

.2 Room sensors: plus or minus 2 % .

.4 Sheath: stainless steel with integral shroud for specified operation in air streams of up to 10 m/s.

.5 Maintenance: by simple field method such as washing with solvent or mild detergent solution so as to remove anticipated airborne contaminants.

.6 Maximum sensor non-linearity: plus or minus 0.5% RH with defined curves.

.7 Room sensors: wall mounted as indicated.

.8 Duct mounted sensors: locate so that sensing element is between 1/3 and 2/3 distance across any duct dimension.

.9 Sensors to be unaffected by external transmitters such as walkie-talkies. Demonstrate to Consultant's Representative.

.10 Power supply: 18-35 Vdc, 18-32 Vac with temperature sensor.

2.5 HUMIDITY TRANSMITTERS

.1 Requirements:

.1 Input signal: from 1000 ohm RTD.

.2 Output signal: 4 - 20 mA into 1000 ohm maximum load, 0-5 Vdc, 0-10 Vdc.

.3 Input and output short circuit and open circuit protection.

.4 Output accuracy: not to exceed 0.1 % of full span.

.5 Output linearity error: plus or minus 1.0 % maximum of full scale output.

.6 Integral zero and span adjustment.

.7 Temperature range: 0-70°C, -40°C to 85°C for outside air.

.8 Long term output drift: not to exceed 0.25 % of full scale output/ 6 months.

2.6 PRESSURE/CURRENT (P/I) TRANSMITTERS

.1 Requirements:

.1 Range: as indicated in I/O summaries.

.1 Pressure sensing elements: bourdon tube, bellows or diaphragm type.

.2 Internal materials: suitable for continuous contact with industrial standard instrument air, compressed air, water, steam, as applicable.

.2 Output signal: 4 - 20 mA, 0-5V, 0-10V.

.3 Output variations: + 1 % full scale for supply voltage variations of plus or minus 10 %.

.4 Combined non-linearity, repeatability, and hysteresis effects: not to exceed plus or minus 1% of full scale output over entire range.

.5 Integral zero and span adjustment.

.6 Temperature effects: not to exceed plus or minus 1.5 % full scale/ 50 EC.

.7 Over-pressure input protection to at least twice rated input pressure.

.8 Output short circuit and open circuit protection.

.9 Pressure ranges: see I/O Summaries.

.10 Accuracy: plus or minus 1 % of full scale.

.11 LCD Display.

2.7 DIFFERENTIAL PRESSURE (KPA) TRANSMITTERS

.1 Requirements:

.1 Internal materials: suitable for continuous contact with industrial standard instrument air, compressed air, water, steam, as applicable.

.2 Output signal: 4 - 20 mA, 0-5V, 0-10V.

.3 Output variations: + 1 % full scale for supply voltage variations of plus or minus 10 %.

.4 Combined non-linearity, repeatability, and hysteresis effects: not to exceed plus or minus 1 % of full scale output over entire range.

.5 Integral zero and span adjustment.

.6 Temperature effects: not to exceed plus or minus 1.5 % full scale/ 50 EC.

.7 Over-pressure input protection to at least twice rated input pressure.

.8 Output short circuit and open circuit protection.

.9 The unit to have a NPT connections. The enclosure shall be an integral part of the unit.

.10 LCD Display.

2.8 DIFFERENTIAL PRESSURE (PA) TRANSMITTERS

.1 Requirements:

.1 Output signal: 4 - 20 mA in 400 ohms, 0-5V into 5K ohms minimum, 0-10 V into 10K ohms minimum.

.2 Output variations: + 1% full scale for supply voltage variations of plus or minus 10%.

.3 Integral zero and span adjustment.

.4 Temperature effects: not to exceed plus or minus 3% full scale/ 50 C.

.5 Output short circuit and open circuit protection.

.6 The unit to have a NPT ½ conduit connection. The enclosure shall be an integral part of the unit.

.7 Pressure ranges: see I/O Summaries.

.8 LCD Display.

2.9 FAN SYSTEM STATIC PRESSURE SENSORS

.1 As per 2.10

2.10 FAN SYSTEM STATIC PRESSURE TRANSMITTERS

.1 Requirements:

.1 Output signal: 4 - 20 mA in 400 ohms, 0-5V into 5K ohms minimum, 0-10 V into 10K ohms minimum.

.2 Output variations: + 1% full scale for supply voltage variations of plus or minus 10%.

.3 Integral zero and span adjustment.

.4 Temperature effects: not to exceed plus or minus 3% full scale/ 50 C.

.5 Output short circuit and open circuit protection.

.6 The unit to have a NPT ½ conduit connection. The enclosure shall be an integral part of the unit.

.7 Pressure ranges: see I/O Summaries.

.8 LCD Display.

2.11 DUCT SYSTEM VELOCITY PRESSURE SENSORS

.1 Requirements:

.1 Multipoint static and total pressure sensing element with self-averaging manifold with integral air equalizer and straightener section.

.2 Maximum pressure loss: 37 Pa at 1000 m/s.

.3 Accuracy: plus or minus 1 % of actual duct velocity.

2.12 FAN SYSTEM VELOCITY PRESSURE TRANSMITTERS

.1 Requirements:

.1 Output signal: 4 - 20 mA linear into 500 ohm maximum load.

.2 Calibrated span: not to exceed 25 % of duct velocity pressure at maximum flow.

.3 Accuracy: 0.4 % of span.

.4 Repeatability: within 0.1 % of output.

.5 Linearity: within 0.5 % of span.

.6 Deadband or hysteresis: 0.1 % of span.

.7 External exposed zero and span adjustment.

.8 The unit to have a NPT ½ conduit connection. The enclosure shall be an integral part of the unit.

2.13 TURBINE FLOW METERS

.1 Requirements:

.1 Flow range: as specified in I/O summaries.
.2 Pressure rating: 1035 kPa (gauge) at 38 EC.
.3 Temperature rating: 5 to 260 EC.
.4 Repeatability: plus or minus 0.1 %.
.5 Accuracy and linearity: plus or minus 0.5 %.
.6 Flow rangability: at least 10:1.
.7 Output voltage: 30 to 300 mV peak-to-peak into 10 Kohm load.
.8 Body material: brass, bronze or cast iron.
.9 Ends:
.1 NPS 2 and under: screwed or flanged
.2 NPS 2 1/2 and over: flanged.

2.14 FREQUENCY-TO-DC TRANSMITTERS FOR TURBINE METERS

.1 Requirements:

.1 Input: greater than 5000 ohm.
.1 Range: greater than 100 mV less than 20 V peak-to-peak, 200 through 400 Hz.
.2 Span adjustment: fully adjustable.
.3 Zero adjustment: 0 to 10% of output.
.4 Output: 4 to 20 mA into 500 ohm load.
.5 Load effect: plus or minus 0.1 % of span zero to maximum load resistance.
.6 Linearity and repeatability: plus or minus 0.05 % of span.
.7 Power input: 24 V DC plus or minus 10 %.
.8 Input, output and power input transformer isolated.
.9 Enclosure: general purpose CSA 1.

2.15 PRESSURE AND DIFFERENTIAL PRESSURE SENSORS AND SWITCHES

.1 Requirements:

.1 Range: as indicated in I/O summaries.
.1 Pressure sensing elements: bourdon tube, bellows or diaphragm type.
.2 Adjustable setpoint and differential.
.3 Switch: snap action type, rated at 120V, 15 amps AC or 24 V DC.
.4 Sensor assembly: to operate automatically and reset automatically when conditions return to normal. Over-pressure input protection to at least twice rated input pressure.
.5 Accuracy: within 2% repetitive switching.
.6 Provide sensor pressure and accuracy ratings:
.1 Chilled and condenser water: 860 kPa.
.2 Hot water: 860 kPa.
.3 Low pressure steam, compressed air: 1050 kPa. Range: 0 to 200 kPa. Accuracy: plus or minus 3 kPa.
.4 Medium pressure steam, compressed air: 1050 kPa. Range: 0 to 700 kPa. Accuracy: plus or minus 7 kPa.
.5 High pressure steam: 2100 kPa. Range: 0 to 2100 kPa. Accuracy: plus or minus 14 kPa.

.6 High temperature water: 2700 kPa. Range: 0-2700 kPa. Accuracy: plus or minus 25 kPa.

.7 For fan operation: Range: 0 to 3000 Pa. Adjustable differential: 10 to 300 Pa.

.7 Provide sensors with isolation valve and snubber between sensor and pressure source on liquid service.

.8 Sensors on steam and high temperature hot water service: provide pigtail syphon.

2.16 TEMPERATURE SWITCHES

.1 Requirements:

.1 Range: see I/O summaries.

.2 Temperature sensor: liquid, vapour or bimetallic type. Operate automatically. Reset automatically, except as follows:

.1 Freeze protection: manual reset. Optional if software does not auto restart.

.2 Fire detection: manual reset. Optional if software does not auto restart.

.3 Duct Heater: high limit manual reset in addition to automatic reset.

.3 Adjustable setpoint and differential.

.4 Accuracy: plus or minus 1 EC.

.5 Snap action rating: 120V, 15 amps or 24V DC as required. Switch to be DPST for hardwire and EMCS connections.

.6 Type as follows:

.1 Room: for wall mounting on standard electrical box with or without protective guard as indicated.

.2 Duct, general purpose: insertion length = 460 mm.

.3 Thermowell: stainless steel, with compression fitting for NPS 3/4 thermowell. Immersion length: 100 mm.

.4 Freeze detection: continuous element with 6000 mm insertion length, duct mounting, to detect coldest temperature in any 300 mm length.

.5 Strap-on: with helical screw stainless steel clamp.

2.17 TANK LEVEL SWITCHES

.1 Requirements:

.1 Indicate high/low water level and to alarm.

.2 For mounting on top of tank.

.3 Maximum operating temperature: 120 EC.

.4 Mechanical switch or snap action contacts rated 15 amp at 120 V.

.5 Adjustable setpoint and differential.

2.18 LIQUID LEVEL SWITCHES

.1 Requirements:

.1 Liquid level activated switch sealed in waterproof and shockproof enclosure.

.2 Complete with float, flexible cord, weight. Instrument casing to be suitable for immersion in measured liquid.

.3 N.O./N.C. Contacts rated at 15 amps at 120V AC. CSA approval for up to 250 volt 10 amps AC.

2.19 WIND VELOCITY TRANSMITTERS

.1 Requirements:

.1 3-cup anemometer and airfoil vane mounted on common vertical axis, designed for mast mounting.

.2 Anemometer:

.1 Range: 0-160 km/h.

.2 Threshold: 3.0 km/h.

.3 Accuracy: +/- 2%.

.3 Airfoil vane

.1 Anemometer range: 0-360° with infinite resolution potentiometer with no loss of reading at transition point.

.2 Starting threshold: 1.1 m/s.

.3 Accuracy: +/- 0.5%.

.4 Output signal: 4 to 20 mA into 500 ohm load.

.5 Provide two output signals: velocity, direction.

.6 Mast: aluminum, size and height as indicated. Provide at least 3 stainless steel guys, turnbuckles, anchor bolts. Follow manufacturers installation guidelines. Lightning protection as indicated on electrical drawings.

2.20 SOLAR SENSORS

.1 Monitor solar irradiation as indicated.

.2 Pyranometer, black and white, producing proportional 0-50 mV signal. Include converter for 4-20 mA signal.

2.21 CURRENT/PNEUMATIC (I/P) TRANSDUCERS

.1 Requirements:

.1 Input range: 4 to 20 mA.

.2 Output range: proportional 20-104 kPa.

.3 Housing: dustproof or panel mounted.

.4 Internal materials: suitable for continuous contact with industrial standard instrument air.

.5 Combined non-linearity, repeatability, hysteresis effects: not to exceed plus or minus 2 % of full scale over entire range.

.6 Integral zero and span adjustment.

.7 Temperature effect: plus or minus 2.0 % full scale/ 50 EC or less.

.8 Regulated supply pressure: 206 kPa maximum.

.9 Air consumption: 16.5 ml/s maximum.

.10 Integral gauge manifold c/w gauge (0-206 kPa).

2.22 SOLENOID CONTROL AIR VALVES

.1 Coil: 120V AC or 24V DC, as indicated.

.2 Complete with manual over-ride.

.3 Shall have the capacity to pass .07 l/s air at 104 kPa differential.

2.23 AIR PRESSURE GAUGES

.1 Diameter: 38 mm minimum.

.2 Range: zero to two times operating pressure of measured pressure media to nearest standard range.

2.24 ELECTRICAL RELAYS

.1 Requirements:

- .1 Double voltage, DPDT, plug-in type with termination base.
- .2 Coils: rated for 120V AC or 24V DC. Other voltage: provide transformer.
- .3 Contacts: rated at 5 amps at 120 V AC.
- .4 Relay to have visual status indication

2.25 SOLID STATE RELAYS

.1 Requirements:

- .1 CSA approved.
- .2 Suitable to the application as recommended by manufacturer.
- .3 Voltage range: 75-265 VAC
- .4 Panel mounting.
- .5 Suitable for AC or DC loads.
- .6 Output surge absorbing element for inductive on/off loads.
- .7 Input capacitor/resistor circuit for pulse noise absorption.
- .8 For input inductive noise use twisted-pair wires for electromagnetic noise and shielded cable for static noise.

2.26 CURRENT TRANSDUCERS

.1 Requirements:

- .1 Range: in accordance with Equipment Schedules.
- .2 Purpose: measure line current and produce proportional signal in one of following ranges:
  - .1 4-20 mA DC.
  - .2 0-5 volt DC.
  - .3 0-10 volts DC.
  - .4 2-10 volts DC.
- .3 Frequency insensitive from 10 - 80 hz.
- .4 Accuracy to 0.5% full scale.
- .5 Zero and span adjustments. Field adjustable range to suit motor applications.
- .6 Adjustable mounting bracket to allow for secure/safe mounting inside the MCC or starter enclosure.

2.27 CURRENT SENSING RELAYS

.1 Requirements:

- .1 Complete with metering transformer ranged to match load, plug-in base and shorting shunt to protect current transformer when relay is removed from socket.
- .2 Suitable for single or 3 phase metering into single relay.

.3 To have adjustable latch level, adjustable delay on latch and minimum differential of 10 % of latch setting between latch level and release level.

.4 3-Phase application: provide for discrimination between phases.

.5 To have adjustable latch level to allow detection of worst case selection. To be powered from control circuit of motor starter being metered. Relay and base to be mounted in adjacent auxiliary cabinet only if control circuit power to be brought into auxiliary cabinet. Adjustments to be acceptable from auxiliary cabinet.

.6 Relay contacts: capable of handling 10 amps at 240 V AC.

2.28 CONTROL DAMPERS

.1 Construction: blades, 152 mm wide, 1219 mm long, maximum. Modular maximum size, 1219 mm wide x 2438 mm high. Multiple sections to have stiffening mullions and jack shafts.

.2 Materials

.1 Frame: 2.3 mm minimum thickness galvanized steel.

.2 Blades: galvanized steel with two sheets 0.5 mm thick or otherwise reinforced to ensure specified low leakage when fully closed.

.3 Bearings: oil impregnated sintered bronze. Provide thrust bearings for vertical blades.

.4 Linkage and shafts: zinc plated steel.

.5 Seals: replaceable neoprene or stainless steel spring on sides, top, bottom of frame, along all blade edges and blade ends.

.3 Performance:

.1 Capacity: refer to I/O Summaries.

.2 0.02 L/s.m 2 maximum allowable leakage against 1000 Pa static pressure.

.3 Temperature range: minus 50°C to plus 100°C.

.4 Arrangements: dampers mixing warm and cold air to be parallel blade, mounted at right angles to each other, with blades opening to mix air stream.

2.29 PNEUMATIC CONTROL DAMPER OPERATORS

.1 Requirements:

.1 Piston type with spring return for "fail-safe" in Normally Open or Normally Closed position, as indicated.

.2 Operator: size so as to control dampers against maximum pressure or dynamic closing pressure (whichever is greater).

.3 Adjustable spring and stroke external stops to limit strokes in either direction.

.4 Full relay type positioner with interconnecting linkage for mechanical feedback of actual damper position.

.5 Multiple section dampers over 1200 mm long: to be driven from both ends.

2.30 ELECTRONIC CONTROL DAMPER OPERATORS

.1 Requirements

.1 Push-pull proportional type as indicated.

.2 Spring return for "fail-safe" in Normally Open or Normally Closed position as indicated.

.3 Operator: size so as to control dampers against maximum pressure or dynamic closing pressure (whichever is greater).

.4 Power requirements: 5 VA maximum at 24 V AC.

.5 Operating range: 4-20 mA. 0-10 V DC, 2-10 V DC..

2.31 CONTROL VALVES

.1 Requirements:

.1 NPS 2 and under: bronze with screwed ends.

.2 NPS 2 1/2 and over: cast iron with flanged ends.

.3 Trim: type 316 stainless steel.

.4 Leakage: 0.5 % of rated flow maximum.

.5 Two or three port as indicated. Normally Open or Normally Closed, as indicated.

.6 Flow characteristics: linear or equal percentage as indicated.

.7 Rangeability: 50:1 minimum.

.8 Performance: Capacity refer to I/O Summaries and Valve Schedule.

2.32 PNEUMATIC VALVE ACTUATORS

.1 Requirements:

.1 Construction: steel, cast iron, aluminum.

.2 Diaphragm: moulded Buna-N rubber, nylon reinforced.

.3 Spring return to normal position.

.4 Spring range adjustment and position indicator.

2.33 ELECTRONIC/ELECTRIC VALVE ACTUATORS

.1 Requirements:

.1 Construction: steel, cast iron, aluminum.

.2 Control voltage: 0-5, 0-10, 2-10V DC, or 4-20 mA.

.3 Positioning time: to suit application, 90 sec maximum.

.4 Spring return to normal position as indicated.

2.34 WATTHOUR METERS AND CURRENT TRANSFORMERS

.1 Requirements:

.1 Include three phases, test and terminal blocks for watthour meter connections and connections to FID for monitoring of current. Provide three potentiometer transformers for 600 V 4 wire systems for watthour meter use. Accuracy: plus or minus 0.25 % of full scale. For chiller applications: To have instantaneous indicator with analog or digital display.

.2 Watthour meter sockets: to ANSI C12.7.

.3 Potentiometer and current transformers: to ANSI/IEEE C57.13.

.4 Potential transformers: provide two primary fuses.

.5 Demand meters: configure to measure demand at 15 minute intervals.

2.35 SURFACE WATER DETECTORS

.1 Requirements:

.1 Provide alarm on presence of water on floor.

.2 Expendable cartridge sensor.

.3 Internal waterproof switch.

.4 One set of dry contacts 2 amps at 24 V.

.5 Unaffected by moisture in air.

.6 Self-powered.

2.36 PANELS

.1 Either free-standing or wall mounted enameled steel cabinets with hinged and key-locked front door.

.2 To be modular multiple panels as required to handle requirements with additional space to accommodate future capacity as required by Consultant's Representative without adding additional cabinets.

.3 Panels to be lockable with same key.

2.37 CONTROL AIR COMPRESSOR STATIONS

.1 Requirements: Provide 2 high pressure, compressors, receiver mounted, base mounted, each complete with belts, guards, intake muffler, replaceable cartridge intake cleaner, starter, pressure switches, alternator.

.2 Capacity: size to maintain air pressure, meet all control air requirements on 25 % maximum running time.

.3 Receiver: size to suit running time. Complete with automatic drain, pressure relief valve, pressure gauge ASME code rated for 1400 kPa.

.4 Vibration isolation: 5 % transmissibility.

.5 Refrigerated air drier:

.1 2 continuous operating type, complete with refrigerant evaporator, mechanical condensate separator, installed with 2 isolating valves. Designed for 1400 kPa maximum operating pressure.

.2 Capacity: sized for full capacity of air compressors, to reduce dewpoint to minus 10EC when dehydrating at 700 kPa. Maximum pressure drop 19 kPa at rated capacity.

.3 Provide 2 filter and PRV assemblies, with isolating valves and filter element, having 99% efficiency in removal of 0.5 micron diameter solid particles and oil aerosols and with indication of degree of saturation. Piping to be such that one dryer is always in circuit and active.

2.38 ELECTRONIC VAV TERMINAL CONTROL BOX

.1 Terminal box sized to deliver air quantities as per mechanical VAV Box Schedule.

.2 Box complete with factory installed averaging air velocity sensor.

.1 Provide removable air flow sensor with minimum 4 point sensing with +/- 5% accuracy at 10 deg C to 35 deg C and 40 to 1000 l/s.

.3 Box to include direct damper shaft mounted actuator, of the non stall, full linear with position feedback type. Actuator to de-energize when at desired position.

.4 Box to be complete with power transformer and control wiring to damper actuator and termination terminals for room sensors and other specified sensors and auxiliary devices.

.5 Box to include VAV Controller as described in Section 25 30 01-EMCS: Building Controllers with appropriate mounting plate and protective cover.

2.39 ELECTRONIC AIR FLOW MEASUREMENT STATIONS AND TRANSMITTERS

.1 Each station to contain an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. The velocity sensing elements to be of the thermal, temperature compensated thermistor type, with linearizing means. The sensing elements to be distributed across the duct cross section in the quantity and pattern set forth for measurements and instruments of ASHRAE and SMACNA for the traversing of ducted air flows. The resistance to air flow through the airflow measurement station not to exceed 20 Pa gauge at an airflow of 10 m/s. Station construction suitable for operation at airflows of up to 25 m/s over a temperature range of 5 to 50 degrees C, and accuracy plus or minus 3 percent over a range of 0.625 to 12.5 m/s scaled to air volume.

.2 Transmitters to produce a linear, temperature compensated 4-20 mAdc output corresponding to the required velocity pressure measurement. The transmitter to be a 2-wire, loop powered device with local indication where indicated. The output error of the transmitter not to exceed 0.5 percent of the calibrated measurement.

2.40 FUEL TANK LEVEL SENSOR

.1 Provide suitable electronic, ULC approved oil tank level sensor to measure product and water level in oil tank specified in Section 33 56 13 – Aboveground Fuel Storage Tanks. Components in oil tank to be of stainless steel construction, electrical enclosures CSA rated. Float type probes to be provided with riser to suit oil tank c/w suitable tapping adaptor and S.S. guide tube with foot.

.2 Sensor to communicate with EMCS system for oil and water level in tank.

PART 3 EXECUTION.

3.1 INSTALLATION

.1 Install field control devices, conduit and wire in accordance with manufacturers recommended methods, procedures and instructions. Wiring and conduit above 50 volts by electrical Division. Coordinate requirements with Electrical Contactor.

.2 Temperature transmitters, humidity transmitters, current-to-pneumatic transducers, solenoid air valves, controllers, relays: install in CSA 2 enclosures or as required for specific applications. Provide for electrolytic isolation in all cases when dissimilar metals make contact.

.3 Support field-mounted transmitters, sensors on pipe stands or channel brackets.

.4 Install wall mounted devices on plywood panel properly attached to wall.

3.2 TEMPERATURE AND HUMIDITY SENSORS

.1 Stabilize to ensure minimum field adjustments or calibrations.

.2 To be readily accessible and adaptable to each type of application so as to allow for quick easy replacement and servicing without special tools or skills.

.3 Outdoor installation:

- .1 Protect from solar radiation and wind effects by stainless steel shields.
- .2 Install in CSA 4X enclosures.

.4 Duct installations

- .1 Do not mount in dead air space.
- .2 Location to be within sensor vibration and velocity limits.
- .3 Securely mount extended surface sensor used to sense average temperature.
- .4 Thermally isolate elements from brackets and supports so as to respond to air temperature only.
- .5 Support sensor element separately from coils, filter racks.

.5 Averaging duct type temperature sensors:

- .1 Sensor length to be not less than 1000 mm per square metre of duct cross-sectional area.
- .2 Use multiple sensors where single sensor does not meet minimum length ratio. Wire multiple sensors in series for freeze protection applications.
- .3 Wire multiple sensors separately for temperature measurement.
- .4 Use either software averaging algorithm to derive overall average for control purposes or separate inputs, based on site requirements.

.6 Thermowells: install for piping installations. Where pipe diameter is less than well insertion length, locate well in elbow. Thermowell to restrict flow by less than 30%.

3.3 PANELS

.1 Arrange for conduit and tubing entry from top, bottom or either side.

.2 Use modular multiple panels if necessary to handle all requirements, with space for additional 20% PCU or FID if applicable without adding additional panels. Space to accommodate maximum capacity of associated controller (ECU, LCU, MCU, PCU, TCU).

.3 Wiring and tubing within panels: locate in trays or individually clipped to back of panel.

.4 Identify wiring and conduit clearly.

3.4 MAGNEHELIC PRESSURE INDICATORS

.1 Install adjacent to fan system static pressure sensor and duct system velocity pressure sensors (as approved by the Consultant's Representative).

.2 Locations to be as indicated or specified.

3.5 PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

.1 Install isolation valve and snubber on sensors between sensor and pressure source. In addition, protect sensing elements on steam and high temperature hot water service with pigtail syphon between valve and sensor.

3.6 I/P TRANSDUCERS

.1 Install air pressure gauge on outlet.

3.7 PRESSURE GAUGES

.1 Install on pneumatic systems only.

.2 Install pressure gauges on pneumatic devices, I/P, pilot positioners, motor operators, switches, relays, valves, damper operators, valve actuators.

.3 Install pressure gauge on output of controller and auxiliary cabinet pneumatic devices.

3.8 AIR PRESSURE GAUGES

.1 Install on pneumatic systems only.

.2 Install on pneumatic devices including I/P's, pilot positioners, motor operators.

3.9 PNEUMATIC VALVE ACTUATORS

.1 Install full relay type positioner having interlocking linkage for mechanical feedback of actual valve position on all modulating valves except radiation and unit heaters.

3.10 TANK LEVEL SWITCHES

.1 Mount in top of tank in threaded coupling.

3.11 LIQUID LEVEL SWITCHES

.1 Suspend float in sump from flexible cord and with weight mounted not more than 50 mm above switch.

3.12 IDENTIFICATION

.1 Identify field devices properly.

.2 Refer to Section 25 05 54 - EMCS: Identification.

3.13 AIR FLOW MEASURING STATIONS

.1 Cap manifold until cleaning of ducts is completed.

3.14 TESTING

.1 Calibrate and test field devices for accuracy and performance. Submit report detailing tests performed, results obtained to Consultant’s Representative for approval. Consultant’s Representative will verify results at random. Provide testing equipment and manpower necessary for this verification.

3.15 COMMISSIONING

.1 Refer to Section 25 08 20 - EMCS: Warranty and Maintenance.

END OF SECTION

PART 1 GENERAL

1.1 DESCRIPTION

.1 This specification describes a high performance variable frequency drive (VFD) used to control the speed of a NEMA design B induction motor.

.2 Load filters shall be supplied with all drives.

.3 A building automation system serial communication module and EMCS communication card shall be supplied with all drives.

1.2 REFERENCES

.1 Referenced Standards:

- .1 Institute of Electrical and Electronic Consultants (IEEE)
  - .1 Standard 519 Guide for Harmonic Content and Control..
- .2 Underwriters laboratories (ULC)
  - .1 UL508C Power Conversion Equipment
- .3 National Electrical Manufacturer's Association (NEMA)
  - .1 ICS 7.0, AC Adjustable Speed Drivers
- .4 International ElectroTechnical Commission (IEC)
  - .1 IEC 61800 Adjustable Speed Electrical Power Drive Systems
- .5 International Standards Organization (ISO)
  - .1 ISO-9001 Quality Management Systems

1.3 SUBMITTALS

.1 Submittals shall include the following information:

- .1 Outline dimensions, conduit entry locations and weight.
- .2 Customer connection and power wiring diagrams.
- .3 Complete technical product description include a complete list of options provided.
- .4 Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).
  - .1 The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input line filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE standard 519. All VFD's shall include a minimum of 5% impedance reactors, no exceptions.

1.4 QUALITY ASSURANCE

.1 The VFD manufacturing facility shall be ISO 9001 certified. The VFD shall be UL listed, Canadian UL listed, CSA listed, IEEE listed, and NEMA listed.

.2 All printed circuited boards shall be completely tested and burned-in before being assembled into the completed VFD. The VFD shall then be subjected to a preliminary functional test, burn-in, and computerized final test. The burn-in shall be at 40°C, at full

rated load, or cycled load. Drive input power shall be continuously cycled for maximum stress and thermal variation. Conformal coating of boards shall be included for each drive.

.3 The drive shall be designed to provide 250 000 hours mean time before failure (MTBF) when the specified preventative maintenance is performed.

.4 VFD manufacturer shall have an analysis laboratory to evaluate the failure of any component. The failure analysis lab shall allow the manufacturer to perform complete electrical testing, x-ray components, and decap or delaminate components and analyze failures within the component.

PART 2 PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES

.1 The VFD package as specified herein shall be enclosed in a NEMA Type 1 or optional NEMA 12 enclosure, completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.

.1 Environmental operating conditions: 0 to 40°C continuous duty. VFD's that can operate at 40° C intermittently (during a 24 hour period) are not acceptable and must be oversized. Altitude 0 to 1000m above sea level, less than 95% humidity, non-condensing.

.2 Enclosure shall be type NEMA 1 and shall be UL listed as a plenum rated VFD. VFD's without these ratings are not acceptable.

.2 All VFD's shall have the following standard features:

.1 All VFD's shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFD's.

.2 The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Hand" and "Auto" modes. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.

.3 There shall be a built-in time clock in the VFD keypad. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays.

.4 The VFD's shall utilize pre-programmed application macros specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time.

.5 The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

.6 The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.

.7 The VFD shall have an integral 5% impedance reactor to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFD's with only one DC reactor shall add AC line reactors.

.8 The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.

.9 The VFD shall be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.

.10 If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communication bus.

.3 All VFD's to have the following adjustments:

.1 Two (2) PID Setpoint controllers shall be standard in the drive. Two (2) programmable analog inputs shall accept current or voltage signals.

.2 Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to frequency, motor speed, output voltage, output current, motor torque, motor power (kW), DC bus voltage, active reference, and other data.

.3 Six (6) programmable digital inputs. There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications) the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. The keypad shall display "start enable 1 (or 2) missing". The safety status shall also be transmitted over the serial communications bus. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC.

.4 Three (3) programmable digital Form-C relay outputs. The relays shall include programmable on and off delay times and adjustable hysteresis. Default settings shall be for run, not faulted (fail safe), and run permissive. The relays shall be rated for maximum switching current 6 amps at 30 VDC and 250 VAC and 0.4 A at 120 VDC; Maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs shall be true form C type contacts; open collector outputs are not acceptable.

.5 The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.

.6 The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows the highest carrier frequency without derating the VFD or operating at high carrier frequency only at low speeds.

.4 Serial Communications

.1 The VFD shall have an RS-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2 bus, and Siemens Building Technologies FLN, protocols for LonWorks, BACnet, Profibus, Ethernet, and DeviceNet shall be available. Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority. Use of non-certified protocols is not allowed.

.2 Serial communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The EMCS shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus – keypad "Hand" or "Auto" selected, bypass selected, the ability to change the PID setpoint, and the ability to force the unit to bypass. The EMCS system shall also be able to monitor if the motor is running in the VFD mode or bypass mode (if bypass is specified) over serial communications. A minimum of 15 field parameters shall be capable of being monitored.

.3 The VFD shall allow the EMCS to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any VFD function.

.5 EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembles to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

.6 BYPASS FEATURES – Features to be furnished and mounted by the drive manufacturer. All features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

.1 A complete factory wired and tested bypass system consisting of an output contactor and bypass contactor. Overload protection shall be provided in both drive and bypass modes.

.2 Door interlocked, padlockable circuit breaker that will disconnect all input power from the drive and all internally mounted options.

.3 Fast acting fuses exclusive to the VFD – fast acting fuses allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection, maintaining bypass capability. Bypass designs, which have no such fuses, or that incorporate fuses common to both the VFD and the bypass will not be accepted. Three contactor bypass schemes are not acceptable.

.4 The drive / bypass shall provide single-phase motor protection in both the VFD and bypass modes.

.5 The following indicating lights (LED type) shall be provided. A test mode or push to test feature shall be provided.

.1 Power-on (Ready)

.2 Run enable (safeties) open

.3 Drive mode select damper opening

.4 Bypass mode selected

.5 Drive running

.6 Bypass running

.7 Drive fault

.8 Bypass fault

.9 Bypass H-O-A mode

.10 Automatic transfer to bypass selected

.11 Safety open

.12 Damper opening

.13 Damper end-switch made

.6 The following relay (form C) outputs from the bypass shall be provided:

.1 System started

.2 System running

.3 Bypass override enabled

.4 Drive fault

.5 Bypass fault (motor overload or underload (broken belt))

.6 Bypass H-O-A position

.7 The digital inputs for the system shall accept 24V or 115VAC (selectable). The bypass shall incorporate internally sourced power supply and not require an external control power source.

.8 Dedicated digital input that will transfer motor from VFD mode to bypass mode upon dry contact closure for fireman's override. Two modes of operation are required.

.1 One mode forces the motor to bypass operation and overrides both the VFD and bypass H-O-A switches and forces the motor to operate across the line (test mode). The system will only respond to the digital inputs and motor protections.

.2 The second fireman's override mode remains as above, but will also defeat the overload and single-phase protection for bypass and ignore all keypad and digital inputs to the system (run until destruction).

.9 The VFD shall include a "run permissive circuit" that will provide a normally open contact whenever a run command is provided (local or remote start command in VFD or bypass mode). The VFD system (VFD or bypass) shall not operate the motor until it receives a dry contact closure from a damper or valve end-switch. When the VFD system safety interlock (fire detector, freezestat, high static pressure switch, etc) opens, the motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.

.10 Class 20 or 30 (selectable) electronic motor overload protection shall be included.

.11 There shall be an internal switch to select manual or automatic bypass.

.12 There shall be an adjustable current sensing circuit for the bypass to provide loss of load indication (broken belt) when in the bypass mode.

PART 3 PART 3 – EXECUTION

3.1 INSTALLATION

.1 Installation shall be the responsibility of the EMCS contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

.2 Power wiring shall be completed by the electrical contractor. Three copper conductors and a ground wire are required. Separate the input power wiring from the output power wiring in individual metallic conduit. Do not combine. Provide a separate metallic conduit for control wiring. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.2 START-UP

.1 Certified factory start-up shall be provided for each drive by a factory authorized service center in accordance with Section 26 05 00 Common Work Results - Electrical. A certified start-up form shall be filled out for each drive with a copy provided to the Consultant, and a copy kept on file at the manufacturer.

3.3 PRODUCT SUPPORT

.1 Factory trained application Consultanting and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A 24/365 technical support line shall be available on a toll-free line.

3.4 WARRANTY

.1 Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time and expenses. There shall be 365/24 support available via a toll free phone number.

END OF SECTION

PART 1 GENERAL

1.1 DESIGN DOCUMENTATION

.1 Design documentation for each system to include, as a minimum:

.1 Narrative type of Sequence of Operation.

.2 Control Description Logic (CDL).

.3 Input/Output Summary Schedules.

.4 Schematics.

1.2 EMCS LANGUAGE DESIGN CRITERIA

.1 Language: refer to Section 25 05 01 EMCS: General Requirements.

.2 Levels of EMCS Language

.1 Level 1: alarm and operational messages to convey alarm conditions or operational messages.

.2 Level 2: full names of equipment and control points. The various systems, their equipment and components and all control points are named in accordance with this section.

.3 Level 3: system, equipment, component and control point descriptors: unique, alphanumeric identifiers derived from full names of corresponding system component and control point.

.4 Level 4: commands: represent various computer functions and routines.

.1 Operational commands - relate to building operations and building system controls.

.2 Computer system commands - relate to computer maintenance, upgrading or development software used to improve and maintain the application software for the building site.

.5 Level 5: machine language. Languages specific to each manufacturer's product, used internally to perform its functions and routines.

.3 Additional Equipment, Components and/or Control Points. Where additional equipment, components and/or control points are required on specific projects, the following procedures shall be adopted:

.1 Full names of the equipment, component and control points shall be not more than 40 characters, including numerals.

.2 SYSTEM descriptors shall be not more than 10 alphanumeric characters. INPUT and OUTPUT descriptors shall be not more than 10 alphanumeric characters. The letters shall be based upon the English/French language full name, and should, where possible, be the first letter of each word of the full name.

.4 The descriptor shall be unique.

.5 Descriptors and expansions: table lists standardized system identifiers and point identifiers.

.1 Table:

Identifiers and Expansions

English Identifier (10 characters max)	English Expansion (40 characters max)
OAD	Outside air damper
OAT	Outside air temperature
OAH	Outside air humidity
OAV	Outside air volume
RAD	Return air damper
RAT	Return air temperature
RAH	Return air humidity
RASP	Return air static pressure
MAD	** Mixed air dampers **
MAT	Mixed air temperature
MAPSP	Mixed air plenum static pressure

** MAD shall be used for applications where outside air and return air dampers are controlled from one (1) only output signal.

EAD	Exhaust air damper
PFPD	Pre-filter pressure drop
PFALM	Pre-filter pressure drop alarm
FFPD	Final filter pressure drop
FFALM	Final filter pressure drop alarm
HCVLV	Heating coil valve
HCVLVC	Heating coil valve control
HCVLVS	Heating coil valve status
BPD	Heating coil face and bypass damper
HCFA	Heating coil freeze alarm
CCVLV	Cooling coil valve
CCVLVC	Cooling coil valve control
CCVLVS	Cooling coil valve status
SVLV	Steam valve
SVLVC	Steam valve control
SVLVS	Steam valve status
SF#-C	Supply fan # control
SF#-S	Supply fan # status
SF#-VSD	Supply fan # VSD control
SF#-VSDF	Supply fan # VSD fault
SAV	Supply air volume
SAVC	Supply air volume control
SAT	Supply air temperature
SAH	Supply air humidity
SAVP	Supply air velocity pressure
SASP	Supply air static pressure

RF#-C	Return fan #control
RF#-S	Return fan # status
RF#-VSD	Return fan # VSD control
RF#-VSDF	Return fan # VSD fault
RAV	Return air volume
RAVC	Return air volume control
RAT	Return air temperature
RAH	Return air humidity
RAVP	Return air velocity pressure
RASP	Return air static pressure
EF#-C	Exhaust fan # control
EF#-S	Exhaust fan s# status
EXAT	exhaust air temperature
EXAV	exhaust air volume
Chiller #1:	
CH1F	flow rate
CH1LWT	leaving chilled water temperature
CH1LWP	Leaving chilled water pressure
CH1EWT	Entering chilled water temperature
CH1EWP	Entering chilled water pressure
CD1EWT	Entering condenser water temperature
CD1EWP	Entering condenser water pressure
CD1LWT	Leaving condenser water temperature
CD1LWP	Leaving condenser water pressure
CHP1F	Chilled water pump #1 flow rate
CHP1DP	Chilled water pump #1 discharge pressure
CHP1S	Chilled water pump #1 status
CP3C	Circulating pump #3 control
CP3F	Circulating pump #3 flow rate
CP3DP	Circulating pump #3 discharge pressure
CP3S	Circulating pump #3 status
HTA	High temperature alarm
LTA	Low temperature alarm
HTCO	High temperature cutout
LTCO	Low temperature cutout
HLA	High level alarm
LLA	Low level alarm
HLCO	High level cutout
LLCO	Low level cutout
HWF	Heating water flow rate
HWST	Heating water supply temperature
HWRT	Heating water return temperature
STP	Steam pressure
STF	Steam flow rate

RM-T	Room temperature
RM-H	Room humidity
RM-SP	Room static pressure (add reference point)

Examples of specific space conditions:

RM-TNPER 2	Space temperature, North Perimeter, 2nd floor
RM-SPSPER I9	Space static pressure, South Perimeter, 19th floor
RM-HEINT 9	Space humidity, East Interior, 9th floor
AFS	Air Flow Switch
AFM	Air Flow Monitor
F	Flow
P	Pressure
ST	Supply temperature
RT	Return temperature
FA	Fire alarm
FTA	Fire trouble alarm
CW	Chilled water system
CD	Condenser Water System
HWH	Hot water heating system
RADN	Radiation system
CDR	Condensate return system
HPS	Steam - High pressure system
LPS	Steam - Low pressure system
DCW	Domestic cold water system
DHW	Domestic hot water system
DHWR	Domestic hot water system Recirculation
SANP	Sanitary sewage - pumped system
STMP	Storm water - pumped system
SPRD	Sprinkler - Dry pipe system
SPRW	Sprinkler - Wet pipe system
FSTP	Fire standpipe & hose system
VBA	Volume Box Control Assembly

1.3 I/O SUMMARY SCHEDULES

.1 General:

.1 The EMCS contractor shall provide a complete I/O summary schedule similar to the one listed below, listing and describing all I/O's in detail. Contractor's standard schedule may be used provided all relevant information is provided.

.2 PCU no: identifies the PCU to which all points in the I/O Summary Schedule are wired.

.3 Building/Area: unique label given to each building forming part of a multi-building facility.

.4 Area/System Label: unique label given to each area of the building or to each system.

.1 Column 1: Point no: I/O Summary Schedule reference number.

.2 Column 2: Point label: unique label for each point in the system. Point labels may be repeated for other buildings or systems.

.3 Column 3: Description: describes the point label in expanded terms.

.4 Column 4: Type: (eg. AI, AO, DI, DO).

.5 Column 5: Eng. Units: Describes the Consultanting units used (eg. for AI, AO: C, kPa, Amp Volt. For DI, DO: OFF, ON).

.6 Column 6: Access level: Defines the level of access for varying complexity of functions. Usually associated with password feature. Usually assigned value between 0 (lowest) and 4 (highest).

.7 Column 7: Sensor type: describes in 2 or 3words.

.8 Column 8: Assoc. Point: Identifies/ describes points for purposes of alarm suppression, software interlocks.

.9 Column 9: Type: defines the type of alarm (eg. CR = CRITICAL, CA = CAUTIONARY, M = MAINTENANCE).

.10 Column 10: DI/DO, NO/NC: defines the NORMAL condition of alarm. (NC = NORMALLY CLOSED. NO = NORMALLY OPEN).

.11 Column 11: Limits: Defines alarm levels (eg. L2 = Low alarm, Level2. H1 = High alarm, Level1).

.12 Column 12: Alarm Mess: Defines alarm message number. This number is related to pre-composed message detailing the problem and describing the required action.

.13 Column 13: Maint Mess: defines maintenance message number. This number as related to pre-composed message detailing the problem and describing the required action.

.14 Column 14: Set Point: Defines the design set-point of the control loop.

.15 Column 15: Dead band: defines the range above or below the set-point at which no change in output signal is to occur.

.16 Column 16: Dev alarm limit: defines the limit on deviation of the measured value from the set-point (sometimes also referred to as the "error limit").

.17 Column 17: NC/NO: defines NORMAL condition when de-energized. NC - NORMALLY CLOSED. NO = NORMALLY OPEN. DA/RA: defines the form of action. DA = direct acting. RA = REVERSE ACTING.

.18 Column 18: Contacts: NO/NC: defines NORMAL condition when de-energized. NC = NORMALLY CLOSED. NO = NORMALLY OPEN.

.19 Column 19: Delay Succ starts: defines the time limits (usually in seconds). To prevent overheating of motors or equipment from frequent re-starting.

.20 Column 20: Heavy motor delay: defines the time (usually up to 60seconds). To prevent heavy electrical load from simultaneous starting of large consumption equipment.

.21 Column 21: auto-reset: A = AUTOMATIC. M=MANUAL.

.22 Column 22: Programs:

.1 Examples of Applications Programs include: Night set-back; optimum start/stop; demand limiting (load shedding).

.2 Optimization routines (eg. chiller optimization, supply air temperature optimization, enthalpy control) should be described as part of CDL's.

.3 Parameters for all application programs should be provided separately as part of the design documentation (eg. the Systems Operation Manual).

.4 Note requirements for computer totalization, recording, print-out of accumulated value of a point over a period of time. If totalization depends upon a number of analog points, include for pseudo energy points.

.5 Run time totals: for calculation of operation of digital points.

.6 Optimum start/stop: Example: HVAC unit to start before scheduled occupancy, based upon HVAC unit capacity, heat loss, interior and exterior environmental conditions, etc.

.1 Schedule:

INPUT/OUTPUT							SCHEDULE PCU NO.			(see 1.3.2)	
PROJECT NO.			BLDG/AREA					NAME		(see 1.3.3)	
PROJECT NAME			AREA/SYSTEM					NAME		(see 1.3.3)	
POINT IDENTIFICATION										ALARMS	
1	2	3	4	5	6	7	8	9	10	11	
Point. No	Point Label	Descrip	Type	Eng. Unit	Access Level	Sensor type	Assoc Point	Type (M,CR)	DI/D0 NO/NC	Limits	

MESSAGES								DI/DO		
12	13	14	15	16	17	18	19	20	21	22
Alarm Limit	Maint	Set-Point MO/MA	Dead band start	Dev. alarm delay	NO/NC DA/RA	Cont's NO/NC	Delay succ.	Heavy Motor	Auto reset	Prog

1.4 CONTROL NARRATIVE SEQUENCE OF OPERATIONS

.1 Typical Hospital AHU Operation:

.1 The air-handling unit supply fan and associated return fan and exhaust fans shall normally operate on a preset daily schedule. When the unit is off, the outside air damper and exhaust air damper shall be closed, the return air damper shall be open, the heating coil valve shall be closed, the cooling coil valve shall be closed, the steam humidifier valve shall be closed, the heating coil pump shall be on. All temperatures and humidity sensors shall continue to monitor, but the high and low limits shall not alarm.

.2 To start the system, the EMCS controller shall command the system on. The outside air damper shall open. When the outside air damper end switch is closed, the supply fan shall start. The return fan shall start after a slight time delay. The return, exhaust and outdoor air dampers shall modulate to maintain the minimum fresh air position (set at 25%). The supply and return fan VSD's shall be gradually ramped to maintain the static pressure setpoint. (Set point to be determined on site after air balancing.)

.3 Should the supply or return fans current sensors fail to prove proper operation within a suitable time period after a start command (initially set at 60 seconds) an alarm signal shall be raised.

.4 Minimum outside air shall be maintained at 25% of design airflow by a software algorithm using inputs from the systems air flow measuring station(s), averaging temperature sensors located in the mixed air and return air streams, and the

outdoor temperature sensor. The outside air algorithm shall not permit mixed air temperature to drop below 12°C.

.5 For all systems, the fresh air supply and return airflows shall be measured by flow measuring stations located in the ducts or fan inlets as indicated. Multiple flow stations on a systems fresh air supply or return will have to be totalized to obtain total system airflow.

.6 For temperature control in heating mode, the EMCS controller shall modulate the mixed air dampers and heating coil valve in sequence to maintain the supply air temperature setpoint (initially set at 13°C).

.7 For temperature control in the cooling mode, the EMCS controller shall modulate the mixed air dampers in the economizer mode to maintain the supply air temperature setpoint. When the outside air temperature rises above the economizer lock-out setpoint (initially set at 18°C), the outside air dampers shall revert to the minimum position to deliver 25% fresh air. On a further call for cooling, the EMCS controller shall modulate the cooling coil valve to maintain supply air setpoint.

.8 If the outdoor temperature falls below the cooling lockout setpoint (initially set at 13°C), the EMCS controller prevents the cooling coil valve from opening.

.9 If the outdoor temperature rises above the heating lockout setpoint (initially set at 18°C), the EMCS controller prevents the heating coil valve from opening.

.10 The system shall alarm if the supply air temperature falls below the low temperature alarm setpoint (initially set at 10°C) or rises above the high temperature alarm setpoint (initially set at 25°C).

.11 The systems EMCS controller shall employ a supply air temperature reset function which shall automatically reset the supply air temperature setpoint based on a statistical analysis of zone heating/cooling demands throughout the areas served by the system. The reset algorithm shall readjust leaving air temperature as necessary to maintain return relative humidity setpoint as sensed by the relative humidity sensors in the return air stream, and the relative humidity in Class 1 critical care areas below 60%.

.12 Should the heating coil pump fail as sensed by the pumps current sensing relay, an alarm shall be raised to warn the operator of the failure and instruct him to bring the standby pump on-line. Flow switches shall also be installed in the hot water supply line to each AHU heating coil to monitor flow and signal an alarm should a no flow or low flow condition exist when ambient air temperatures are below freezing.

.13 Prefilter bank and final filter bank status shall be monitored by the EMCS controller via differential pressure switches. An alarm signal to change filters shall be raised at a set differential pressure. (To be determined on site after air balancing.)

.14 The supply and return fans variable speed drives (VSD's) shall receive their signal from the EMCS controller to adjust the speed of the fan motor to maintain the required static pressure in the system. The supply and return fan status shall be monitored via current sensing relays, and any VSD faults shall be monitored/alarmed by the EMCS controller.

.15 The EMCS controller will modulate the humidifier steam valve to maintain the return air humidity setpoint (initially set at 40% R.H.). The controller will signal the humidifier steam valve to close if the supply air humidity exceeds the supply air humidity high level setpoint of 85% R.H. or if the supply fan should fail (indicated by current sensing relay and differential pressure switch).

.16 Some systems serve areas which have reduced or no occupancy during nights and weekends. These areas shall be scheduled to receive reduced or shut off

airflows during these periods. Air flows to these areas shall be controlled via zone dampers and measured via airflow stations or by volume regulating boxes. The schedule of occupied/unoccupied periods shall be co-ordinated with the Consultant. The zones to have occupied/unoccupied schedules include:

.1 Administration Area

.2 Support Areas

.3 Surgery Suite

.4 Lab/D.I./Pharmacy Areas

.5 E.R./Clinics Area

During reduced airflow hours, the duct pressure sensors, VAV boxes, duct airflow stations, zone dampers and supply/return fan variable speed drives to be utilized to maintain the required system airflows and differential pressures.

.17 The air handling systems shall be required to operate in a fire mode of operation as signaled automatically via the fire alarm system or manually via the fire department control panel. In general, during the fire mode of operation, the following shall occur:

.1 When a confirmed fire/smoke condition exists in a fire zone, as detected by the fire alarm system, the supply air to that zone shall be shut off by closing the smoke or combination fire/smoke dampers in the ducts supplying air to the zone or by shutdown of the supply fan (depending on the fire zone). Refer to fire alarm cause/affect chart.

.2 Return and exhaust air from the affected zone shall be maintained. The return air damper in the air handling units mixing box shall go fully closed and the exhaust air damper shall go fully open to exhaust 100% of the return air to the outside. This will maintain the area under negative pressure.

.3 For other fire zones not affected by the fire/smoke condition, (other than zones within the area of refuge), the air handling units serving these areas shall be shutdown.

.4 For the area of refuge, the return/exhaust fans serving these zones shall be shutdown while the supply fan(s) shall be kept running to pressurize the space. Supply air shall be 100% outside air (i.e. the AHU's mixing box return damper shall go fully closed).

.5 Should a fire/smoke condition occur within a fire zone inside the area of refuge, all smoke dampers in ducts feeding that zone shall close.

.6 Should smoke be detected by the smoke detection in the air supply of an air handling unit, that unit shall be shut down and the smoke dampers in the area served by that unit shall close.

.18 Miscellaneous Safeties and Alarms:

The supply and return fans shall stop and an alarm signal raised upon the following conditions:

.1 Smoke detector senses smoke

.2 Temperature low limit sensor detects temperature below 5°C

.3 Supply duct static pressure exceeds +1000 Pa.

.4 Return duct static pressure exceeds –1000 Pa.

.2 Outside Air Units (Hospitals)

.1 For AHUs which are 100% fresh air heat recovery units, basic unit control logic is the same as other units. However, these units shall employ a "cold corner" defrost control on the plate exchanger for freeze protection. A multi blade

damper and modulating 24 V damper actuator are used to deflect cold air away from the cold corner based on the cold corner leaving air temperature. These units are also equipped with heat exchanger bypass dampers. These dampers to be controlled based on the heat exchanger leaving air temperature to prevent over-recovery. When the temperature leaving the heat exchanger on the supply air side exceeds its setpoint (initially set at 13°C), the bypass damper shall be modulated open.

.2 These systems are interconnected by bypass ducts c/w a normally closed damper. Should one of the units be taken out of service, the bypass damper shall open to allow the operating unit to handle air from the "off" units duct system. The airflow monitors and motorized dampers in the supply and return ducts shall be utilized to proportion the available air.

.3 Should one of the units be taken out of service, the corresponding interlocked return fan shall be shutdown (and visa versa). These units, which are operating in parallel, shall be provided with the necessary logic to ensure that each unit delivers 50% of the airflow despite minor variations in system pressures at each unit.

.3 Room Temperature Control

.1 Reheat or Radiation Only

.1 In rooms served only by duct reheat coils or radiation, a drop in room temperature as sensed by the rooms wall mounted temperature controller, causes the radiation or reheat coil valve to modulate/open to maintain the space temperature setpoint. (Operator adjustable within defined limits.)

.2 Space temperatures shall be set back during unoccupied periods by the EMCS system on a schedule to be approved by the Consultant. An override switch/pushbutton on the face of each room temperature controller shall permit a timed override of the night setback in each room.

.2 Radiation and Reheat

.1 In rooms served by both duct reheat coils and radiation, a drop in room temperature as sensed by the room wall mounted temperature controller, causes the radiation heating valve to open. On a further drop in room temperature, the reheat coil valve shall be modulated open to maintain the space temperature setpoint (operator adjustable within defined limits).

.2 Space temperatures shall be set back during unoccupied periods by the EMCS system on a schedule to be approved by the Consultant. An override switch/pushbutton on the face of each room temperature controller shall permit a timed override of the night setback in each room.

.3 VAV Box Control with optional radiation/reheat

.1 In rooms served by VAV boxes, the box damper shall be closed if the associated air handling unit is off and reheat/radiation heater valves shall be open. Prior to start of the system, the VAV box damper shall open to its minimum position.

.2 On a call for cooling, the VAV box controller shall modulate the damper open to maintain the space temperature setpoint (Operator adjustable within defined limits). On a call for heating, the VAV box controller shall modulate the damper to its minimum position. On a further call for heat, the controller shall open the room's radiation heating valve (if applicable) to maintain space temperature setpoint. If the temperature still remains

below setpoint, the controller shall modulate the reheat coil valve (if applicable) to maintain room temperature setpoint.

.3 For two position only boxes (occupied/unoccupied), the sequence of operation is similar to above. The operating position of the box shall be controlled centrally on a schedule by the EMCS system or by a local room occupancy switch.

.4 Space temperatures shall be set back during unoccupied periods by the EMCS system on a schedule to be approved by the Consultant. An override switch/pushbutton on the face of each room temperature controller shall permit a timed override of the night setback in each room.

.4 Penthouse/Electrical Room Heating/Ventilation Control

.1 When the room space temperature, as sensed by the wall mounted temperature controller, exceeds its setpoint of 24°C, the outside air damper shall open. On a further rise in room temperature, the exhaust fan shall start. On a drop in room temperature, the reverse sequence shall occur.

.2 When the space temperature drops below the heating setpoint of 15°C, the unit heater control valve shall open and the unit heater fan shall start.

.5 Unit Heater/Cabinet Heater Control Sequence

.1 On a call for heat as sensed by the room temperature controller, the heater control valve shall open and the fan shall start.

.2 Fan speed shall be manually adjustable from within cabinet enclosure (where applicable).

.6 Hot Water Heating Heat Exchanger Control

.1 One of the hot water heating primary pumps shall run continuously to circulate hot water through the primary heating loop. The pumps shall be alternated on a timed shared basis and the lag pump shall start should the lead pump fail.

.2 The heat exchanger steam valves shall be modulated as required to maintain the leaving hot water temperature at its setpoint. The leaving water temperature setpoint shall be reset based on an outside air temperature schedule.

.3 The exchangers must be able to operate in parallel or in isolation should one of the exchanger circuits be down for maintenance. Normal operation is for one heat exchanger to carry the load.

.7 Main Secondary Heating Loop Temperature/Pressure Control

.1 One of the hot water heating secondary pumps shall run continuously to circulate hot water through the secondary heating loop. The three pumps shall be alternated on a time shared basis and the lag pump shall start should the lead pump fail.

.2 One, two or three of the secondary pumps shall be run at a time as required to maintain the set differential pressure in the secondary loop as sensed by the differential pressure sensor. Sensor to be located near the far end of the heating loop.

.3 The hot water mixing valve shall be modulated as required to maintain the hot water supply temperature at its setpoint. The setpoint of the hot water supply temperature shall be reset based on an outside air temperature schedule.

.8 Reheat/Perimeter Heating Loop Temperature Control
(Typical for Administration/Support Area, Central Area, Patient Area)

.1 One of the two dedicated hot water heating pumps shall run continuously to circulate hot water through the heating loop. The pumps shall be alternated on a time shared basis and the lag pump shall start should the lead pump fail.

.2 The hot water mixing valve shall be modulated as required to maintain the hot water supply temperature at its setpoint. The setpoint of the hot water supply temperature shall be reset based on an outside air temperature schedule.

.9 High Pressure Steam Boilers

.1 Each coil tube steam boiler is provided with its own factory installed control panel and each boiler can be operated in a stand alone mode.

.2 However, normal operation is for all three boilers to interface with the EMCS system for operating setpoints, firing rates and lead/lag control sequencing. Each boiler shall have four points communicating with the EMCS, (for pressure, enable, firing rate and common alarm).

.3 The operators shall be able to change lead boilers, set point and sequence patterns at the local control panel (located near the boilers) or via the operator workstation.

.4 The system shall be controlled full modulation 4-20 mA for the firing rate and the logic shall determine the most efficient rate of firing prior to selecting the next boiler in sequence.

.5 On a boiler trip or alarm condition, the lead/lag system shall automatically start the next boiler in the sequence and alarm the trip condition.

.6 Status and elapsed time shall be provided for call for heat, low fire and maximum firing rate.

.7 The lead/lag system shall incorporate the ability for each boiler to be run under local (boiler) control panel only for testing purposes.

.8 The lead/lag system shall reset to commissioned operating conditions in the event of power interruption and automatically re-start and control the boilers to return to normal operation.

.10 Domestic Hot Water Heat Exchanger Control

.1 One of the domestic hot water pumps shall run continuously to circulate DHW from the tanks through the heat exchanger and back to tanks. The pumps shall be alternated on a timed schedule and the lag pump shall start should the lead pump fail.

.2 The heat exchanger steam valves shall be modulated as required to maintain the leaving water temperature at its setpoint of 70°C.

.3 The exchangers must be able to operate in parallel (normal) or in isolation should one of the exchanger circuits be down for maintenance. Normal operation is for one of the heat exchangers to operate to carry the load.

.11 Isolation Room Controls

.1 A volumetric air control system shall be used to control airflow offset, airflow tracking between supply and exhaust air variable volume boxes, provide stable room pressure and room environment, monitor room air pressure and environmental conditions and be capable of communications link with the EMCS.

.2 Volumetric control shall be capable of direct pressure reset applications.

.3 Isolation room control system to be complete with a EMCS based volumetric controller, velocity sensors for both supply and exhaust air flow, room pressure sensors to monitor pressure between both isolation room/anteroom and anteroom/hospital space, remote alarm panel, filter alarms for HEPA filters, and integration with room temperature control loop.

.4 Volumetric control shall receive signal from velocity sensors to regulate flow via control regulation of variable volume box dampers. Volumetric control to reset airflow differential setpoint through the direct pressure reset control loop.

.5 Room pressure sensor to be a through the wall device with one end monitoring the space and the other monitoring either the anteroom or the adjacent building corridor. Wall mounted room monitor controller shall receive differential pressure readings from each room pressure sensor at frequent intervals and display current value on the LCD display.

.6 Room monitor controller shall be complete with LCD display, key switch control for change in containment state (positive (+), negative (-), or neutral (no isolation), check and reset control, set point adjustment and alarm mute. Unit shall be complete with sensor cable.

.7 Sequence of Operation:

.1 When room monitor/controller is in the positive (+) room pressurization mode, (Protective Isolation) volumetric controller to adjust supply and exhaust air volume boxes to maintain a 10% higher supply than exhaust airflow differential.

.2 When room monitor/controller is in the negative (-) room pressurization mode Infectious Isolation) volumetric controller to adjust supply and exhaust air volume boxes to maintain a 10% higher exhaust than supply airflow differential.

.3 When room monitor/controller is in the neutral (no isolation) mode, volumetric controller to adjust supply and exhaust airflow to maintain a 0% airflow differential.

.4 Filter alarm signal to sound when static differential pressure across the supply airflow HEPA filter exceeds setpoint (initially set at 300 pa).

.5 Reheat coil valve to be modulated as required to maintain isolation room space temperature as sensed by room temperature sensor. Space temperature to be set back to an unoccupied setpoint (initially set at 18°C) when the room is not in use.

.6 Isolation control to signal building automation system when any alarm condition exists.

.12 Physiotherapy Area In-floor Radiation Temperature Control

.1 The heating water circulation pump shall be commanded to run when the space temperature controller calls for heating. Failure of the pump shall raise an alarm.

.2 The three way mixing valve shall modulate to maintain the supply water temperature to the in-floor heating loop at its setpoint (initially set at 35°C) as sensed by the water temperature sensor. Should the supply water temperature ever reach a high limit of 50°C, an alarm shall be raised and the three way valve shall revert to its normal position (preventing any hot water from entering the in-floor loop).

.3 The two-way heating valve shall modulate as required to satisfy the space temperature setpoint.

.13 Library/Work Room In-floor Radiation Temperature Control

.1 The heating water circulation pump shall be commanded to run when any of the space temperature controllers call for heating. Failure of the pump shall raise an alarm.

.2 The three way mixing valve shall modulate to maintain the supply water temperature to the in-floor heating loop at its setpoint (initially set at 38°C) as sensed by the water temperature sensor. Should the supply water temperature reach a high limit of 50°C, an alarm shall be raised and the three way valve return to its normal position (preventing any hot water from entering the in-floor loop).

.3 The modular heating loop valves shall be modulated as required to maintain the space temperature setpoint as sensed by the room temperature controller.

.14 Miscellaneous Equipment Alarm/Status Points

.1 The following equipment shall be monitored by the EMCS: (Refer also to I/O list)

.1 Deaerator control panel (common alarm)

.2 Surge tank control panel (common alarm)

.3 Air compressor control panel (common alarm)

.4 High pressure steam header (pressure status/alarm)

.5 Low pressure steam header (pressure status/alarm)

.6 Data room air conditioning unit (common alarm)

.7 Domestic cold water pressure status.

.8 Domestic water filters differential pressure.

.9 Medical Gas Common Alarms

.15 Patient Area In-floor Radiant Heating Loop Temperature Control

.1 One of the two dedicated hot water heating pumps shall run continuously to circulate hot water through the heating loop during the heating system. Above a preset outside air temperature (initially set at 20°C), both pumps shall be off. During operation, both pumps shall be alternated on a run time shared basis, and the lag pump shall start should the lead pump fail.

.2 The hot water mixing valve shall be modulated as required to maintain the supply temperature of the in-floor radiant heating loop at its setpoint (initially set at 35°C).

.16 Patient Area Rooms (with in-Floor Radiation) Temperature Control

.1 The modular heating loop valve serving the room shall be opened on a drop in room temperature as sensed by the room wall mounted temperature controller. On a further drop in room temperature, the reheat coil valve shall be modulated open to maintain the space temperature set point (operator adjustable within defined limits).

.17 Boiler Room Ventilation/Combustion Air

.1 This heating and ventilation unit provides combustion and ventilation air to the boiler room. The units supply fan shall be commanded to start when any one of the three boilers are operating or on a call for space cooling as sensed by the space temperature sensor. The units heating coil pump shall be interlocked to start when the fan starts.

.2 Prior to start up, the pressure relief dampers in the boiler room shall open. The EMCS system shall incorporate logic to modulate the fresh air and return dampers as required to satisfy the combustion air requirements with 1, 2 or 3 boilers running or the ventilation/cooling requirements to satisfy space temperature.

.3 For temperature control, the EMCS controller shall modulate the heating coil valve to maintain the supply air temperature setpoint (initially set at 15°C). Should the outside air temperature be below 3°C, the heating coil pump shall run (whether the fan is running or not) and the heating coil valve shall go fully open and the units face and by-pass dampers shall modulate to maintain the supply air temperature setpoint.

.4 Should the heating coil pump fail, an alarm shall be raised to notify the operator to manually change over to the spare pump. Should the supply air temperature drop below 5°C, the unit shall be shut down and an alarm raised. A flow switch shall also be installed in the hot water supply line to the AHU heating coil to monitor flow and signal an alarm should a no flow or low flow condition exist when ambient air temperatures are below freezing.

.5 Should the H&V unit fail to run or be down for maintenance, the boiler room relief damper shall open as required to provide cooling (heat relief) or permit combustion air into the room when one or more of the boilers are running.

.6 The units filter bank shall be monitored by the EMCS system via a differential pressure switch. An alarm signal to change the filters shall be raised at a set differential pressure.

.18 Critical Care Area Environmental Control Sequence

.1 Each critical care area room, including OR's, LDRP's, Recovery, CCU rooms, Special Procedure, Endoscopy, Nursery, shall be provided with approved, flush mounted, polished stainless steel monitoring/alarm panels mounted within the space at a location approved by the Consultant's Representative. Panel shall have concealed continuous hinges and keyed cylinder lock. Panels shall display room temperature, humidity and pressurization, contain an occupancy override push button, and temperature/humidity setpoint switches, and abnormal temperature/humidity, pressurization indicators.

.2 Occupied Mode:

.1 Supply/Return air flow rates, as sensed by the velocity sensors in the volume control boxes are maintained constant and independent of duct status pressure fluctuations by a volume regulating damper in the volume control boxes.

.2 A subtract software algorithm maintains a constant difference between the supply and return airflows equal to the difference in the design airflows shown on the floor plans.

.3 An alarm shall be raised should flow rates depart from setpoint by more than 5%. A flashing pilot light on the room panel shall alert room users to an abnormal airflow condition.

.4 On a drop in room temperature, the reheat coil valve shall modulate to maintain the setpoint space temperature as sensed by the room temperature sensor.

.5 OR's and LDRP's to have a "Full Heat" push button in the panel to permit full open operation of the heating control valve.

.6 A room humidity transmitter shall control the output of the booster humidifier serving the space. A duct mounted humidity transmitter located downstream of the booster humidifier shall act as a humidity high limit shut off to close the steam valve should the duct relative humidity reach 80%.

.7 (In the CCU suite, only one booster humidifier is provided in the common duct serving the suite and the humidity transmitter shall be mounted in the common return duct).

.8 For rooms provided with HEPA filters on the supply air, a differential pressure switch shall be used to signal an alarm when the HEPA filter pressure drop reaches the change out pressure.

.3 Unoccupied Mode:

.1 Supply airflow shall be reduced to 25% of their design valves. “Full Heat” and humidifiers shall be deactivated, and reheat coils controlled as normal to provide space heating. Return airflows shall be reduced to the supply airflow rate minus the airflow offset. Unoccupied space temperatures shall be 20°C.

.4 Pre-Occupancy Mode:

.1 At a pre-determined time in advance of occupancy, airflows shall increase to their design airflows, humidifiers shall be reactivated, and reheat coils shall be controlled to bring the space temperature to its normal occupied setpoint. “Full Heat” switches shall remain deactivated.

.19 Gas Scavenging Air Pressure Alarm

.1 Each room provided with a gas scavenging exhaust tube shall incorporate a static pressure switch in the general exhaust duct at the point where the scavenging tube is connected. The switch shall be field set to signal an alarm should the negative pressure in the duct drops below the set value. The alarm shall be signaled locally in the room and at the main EMCS control console.

.20 Cafeteria/Servery Air Volume Control

.1 The cafeteria/servery area is provided with a constant volume of supply air during the occupied periods. A volume control box is employed on the return air duct from the space to control the return air volume. When the kitchen exhaust hood fan is off, all the air is returned via the return air system. When the kitchen exhaust hood fan is on, the volume control box on the return air duct shall reduce the return air flow by the amount of air exhausted. This shall maintain the pressure balance in the cafeteria/servery area. The volume control box shall be interlocked with the exhaust hood fan.

.21 Lab Multi-Purpose Room Pressure Control

.1 The Lab multi-purpose room contains a bio-safety cabinet (BSC) that is used intermittently. The BSC recirculates 70% of its air through an internal HEPA filter, but 30% of the air is exhausted via roof fan. This fan shall be interlocked to run whenever the BSC fan is running. A volume control box shall be utilized on the return air duct from the room to reduce the return airflow rate when exhaust fan is on. The return air shall be reduced by an amount equal to the exhaust air rate. This shall maintain a proper pressure balance for the room. Supply air to the room shall be maintained at a constant flow rate by a volume control box.

.22 Chemo Prep/I.V. Additives Room Environmental Control Sequence

.1 Chemo Prep Room and I.V. Additives Room in the Pharmacy area are treated as clean rooms and must be maintained under positive pressure when in use. Each room must be provided with a pressure monitoring status and alarm panel in the adjacent ante-room.

.2 Supply and return air flow rates, as sensed by the velocity sensers in the volume control boxes are maintained constant and independent of duct status pressure fluctuations by a volume regulating damper in the volume control boxes.

.3 A subtract software algorithm maintains a constant difference between the supply and return airflows equal to the difference in the design airflows shown on the floor plans.

.4 For the Chemo Prep Room, which contains a Bio Safety Cabinet (BSC) which shall be interlocked with its exhaust fan, the volume control boxes on supply and return shall modulate to maintain an adequate make-up air supply to the room while still keeping the room at a slight positive pressure (initially set at 25 pa), as monitored by the static pressure transmitters.

.5 An alarm shall be raised should the room's positive static pressure be lost for any extended time. Time delays shall be incorporated to prevent nuisance alarms due to opening/closing of the door. A flashing pilot light on the room's alarm panel shall indicate an abnormal airflow/pressure condition.

.6 On a drop in room temperature, the reheat coil valve shall modulate to maintain the set point space temperature as sensed by the room temperature sensor.

.23 Fuel Oil Tank Monitoring/Fuel Metering

.1 The fuel oil tank shall be provided with suitable level probes to measure oil and water levels.

.2 The EMCS system shall monitor both oil and water levels in the tank and signal alarms at set high/low oil levels, high water level.

.3 The EMCS system shall incorporate the necessary software to monitor fuel consumption based on fuel tank level changes over time and provide reports of fuel consumption over any given time period. Fuel consumption to be reconciled with fuel deliveries. The EMCS shall provide automatic fuel delivery reports after every fill up.

.4 The EMCS system shall also provide for a local (outside adjacent the oil tank) audible and visual alarm of high oil levels to help prevent overfilling. Alarm components outside to be housed in NEMA 4X enclosure.

.5 The EMCS system shall also monitor the vacuum pressure in the interstitial space on the tank and signal an alarm on low vacuum pressure.

1.5 INPUT/OUTPUT POINT SUMMARY TABLE

.1 The input/output table summarizes the Input/Output (I/O) points for the various systems as outlined within the EMCS specifications and control schematic drawings. However, the tables are not all inclusive as they do not list the typical room temperature sensors, reheat coil valves, radiator valves, unit heater/force flow valves, terminal unit control assemblies, infloor heating manifold loop valves, etc. The number and location of these devices can be found on the floor plans and/or listed in relevant schedules. All points and field devices required to accomplish the specified sequence of operation shall be provided. Any discrepancies in I/O counts between the points list, specs and drawings shall be reported to the Consultant's Representative.

1.6 CHILLER INTERFACE

.1 The EMCS system shall interface with the common chiller management panel supplied with the chillers to track all the basic chiller/condenser functions monitored by that panel. The EMCS shall be able to map a minimum of 32 I/O points per chiller/condenser. Coordinate with the chiller supplier for details of points monitored and hook up requirements.

PART 2 PRODUCTS (NOT APPLICABLE)

PART 3 EXECUTION (NOT APPLICABLE)

END OF SECTION

.4 Installation of data and cable distribution system throughout house.

5. Co-ordination with Mechanical and Central Home Automation system for installation of equipment

1.5 SUBMITTALS

.1 Submit shop drawings on all equipment. Shop drawings are to be reproducible transparencies with one copy of the original. Where shop drawings are not prepared due to standardized manufacture of the product submit no more than two (2) original data sheets or brochures. Shop drawings will be issued before purchasing equipment for approval by the owner or owner's representative.

.2 The electrical contractor will mark up two sets of bluelines on a daily basis showing all deviations from the drawings. These sets will be available for inspection by the owner or owner's representative at any time during construction. Upon completion of the job, forward one set to the consultant for record drawing purposes, and leave one set on site.

.3 Before final acceptance of the work, the electrical contractor will furnish the consultant with one completely detailed set of as-built drawings, showing final locations and connections for all electrical and control work carried out by the electrical contractor. Such as-built drawings will include all pertinent notes and dimensions necessary to show clearly the location and physical characteristics of all conduit, conductors and connections.

1.6 IDENTIFICATION

.1 Provide printed labels with 1/4" high white letters on a black background on all receptacles and switches installed identifying the circuit and panel for the power source.

.2 Provide printed labels with 3/4" mm high white letters on a black background on all lighting panels, disconnect, and electrical distribution equipment identifying the voltage, amperage, and phase. Include the identity of the feeder circuit where applicable.

.3 Provide a typewritten legend identifying the circuits and their use for all lighting panels.

.4 Provide and install wire labels at each end of every wire, and at each splice. Submit wire marking methods for approval before proceeding.

Part 2. PRODUCT

2.1 MATERIAL

.1 All materials are to be new, conform with the latest standards of the Underwriters Laboratory and Canadian Standards Association, and bear CSA approval for the use and location for which they are intended. All materials used are to meet with the owner's approval.

.2 It will be the responsibility of the electrical contractor to determine what s/he must expedite to keep abreast of the construction schedule.

.3 When the electrical contractor desires to use makes of material other than those specified, they will be subject to the approval of the owner, or owner's representative, on points of design, efficiency, quality, appearance, delivery and reputation.

.4 Provide three spare fuses of each type used in the completion of this work.

.5 The wire marking method will be with the proper size white heat shrink tubing marked clearly and legible with permanent thermal printing or approved equal.

2.3 CONDUIT AND WIRING

.1 Electrical metallic tubing (EMT): to CSA C22.2, Electrical Metallic Tubing, with set screw couplings.

.2 Liquid tight flexible metal conduit with Interlocking armour over conductors and an outer covering of thermoplastic polyvinyl chloride material.

.3 Fittings and boxes will match the conduit system being used.

.4 All conductors are to be stranded copper unless otherwise noted. Power conductors are to be a minimum of #12 AWG. Control conductors are to be a minimum of #14 AWG, unless specified otherwise.

.5 All wire used throughout the installation will be RW90 crosslink insulated, rated for a minimum of 600 V, unless otherwise specified.

.6 Power conductors are to be colour coded as required by the Canadian Electrical Code.

.7 The electrical contractor must provide and install wire labels at each end of every wire, and at each splice.

.8 Aluminium conductors not permitted for any wiring.

2.4 TECK CABLE

.1 Teck cable with the following:

.1	Copper grounding conductor.
.2	Copper circuit conductors, size as indicated.
.3	Chemically cross-linked thermosetting polyethylene insulation rated type RW90, 600V.
.4	Polyvinyl chloride material inner jacket.
.5	Interlocking aluminum armour.
.6	Overall covering of thermoplastic polyvinyl chloride material.
.7	Watertight connectors, approved for TECK cable, glands and seals as required.

2.5 RECEPTACLES

.1 15 A, 120 V receptacles to be specification grade.

.2 Receptacles of one manufacturer throughout project.

.3 GFI receptacles, 125 V, 15 A, U ground, with the following features:
- .1 Duplex receptacle.
- .2 White in colour.
- .3 Indicator light.
- .4 Test and reset buttons.
- .5 5 mA threshold.
- .6 Approved Product: Arrow Hart GF5242, Hubbell GF5262, or approved equal.

.4 All interior recepacles shall be Tamper resistant receptacles in accordance with NEC 406.11, 125 V, 15 A, U ground, with the following features:
- .1 Duplex receptacle.
- .2 White in colour.
- .3 Approved Product: Arrow Hart 6352I, Hubbell HBLSG62I, or approved equal.

2.6 COVER PLATES

.1 Cover plates for wiring devices with the following:
- .1 Custom solid surface coverplate for all kitchen receptacles. As approved by consultant.
- .2 Stainless steel, 1/16" thick cover plates for wiring devices mounted in flush-mounted outlet box.
- .3 Stainless steel, 1/16" thick cover plates for wiring devices mounted in recessed outlet boxes in floor panels.
- .3 Sheet steel utility box cover for wiring devices installed in surface-mounted utility boxes.
- .4 Weatherproof double lift spring-loaded cast aluminum cover plates, complete with gaskets for duplex receptacles located in inclement areas.
- .5 Approved Product: Arrow Hart, Hubbell, or approved equal.

Part 3. EXECUTION

3.1 INSTALLATION

.1 The electrical contractor will be responsible for keeping his work area clean and free from debris and waste material at all time. The interior of all boxes, control panels, etc. will be cleaned of dust, dirt and loose materials, to the satisfaction of the owner. Any damage caused by the work is to be repaired to the satisfaction of the owner. Plug and seal all penetrations.

.2 Work will be scheduled so that the sites will be out of service for the least amount of time possible.

.3 The wires will be identified with the terminal block number, or according to the panelboard, circuit number and function. As built drawings will be marked up to show wire numbers.

.4 Sequence phase bussing on panelboards with odd numbered breakers on left and even on right, with each breaker identified by permanent number identification as to circuit number and phase.

3.2 CONDUIT, CABLE, RUNWAYS AND FITTINGS

.1 Pull an adequately sized insulated ground conductor in all conduits.

.2 All conduits will be supported independently of junction boxes, fittings, devices, etc.

.3 Conceal conduits except in mechanical and electrical service rooms.

.4 Install all conduits free from dents and flaws.

3.3 CONVENIENCE OUTLETS AND SWITCHES

.1 Cover plates:

.1 Protect cover plate finish with paper or plastic film until painting and other work is finished.

3.4 TESTING, START-UP AND COMMISSIONING

.1 The contractor will provide field technical services during start-up and commissioning. The installation is to be verified before components are energized.

.2 It will be the responsibility of the electrical contractor to perform all preliminary tests prior to functional tests being performed on the system.

.3 The electrical contractor will perform a continuity check on all conductors to ensure the termination was done correctly.

.4 After consulting with the owner, the consultant, and the supplier, schedule the start-up and commissioning. Provide personnel on site to assist during start up and commissioning to ensure the entire installation is fully functional.

END OF SECTION

Part 1 General

1.1 SUMMARY

.1 Section Includes:

.1 General requirements that are common to sections found in Division 26 – Electrical, 27 – Communications and 28 - Electronic Safety and Security.

.2 This section supplements the requirements of Division 1.

1.2 REFERENCES

.1 2008 National Electrical Code (NEC)

.1 NEC Article 110, Requirements for Electrical Installations
.2 NEC Article 240, Overcurrent Protection
.3 NEC Article 250, Grounding and Bonding
.4 NEC Article 300, Wiring Methods
.5 NEC Article 310, Conductors for General Wiring
.6 NEC Article 400, Flexible Cords and Cables
.7 NEC Article 410, Luminaires, Lampholders, and Lamps
.8 NEC Article 411, Lighting Systems Operating on 30V or Less
.9 NEC Article 422, Appliances
.10 NEC Article 445, Generators
.11 NEC Article 690, Solar Photovoltaic Systems

.2 2008 International Residential Code (IRC)

.1 IRC-E Chapters 33-42, Electrical Module

.3 2009 Solar Decathlon Rules & Regulations (SDR&R)

.1 SDR&R Rule 4-5, Generators
.2 SDR&R Rule 8, Energy
.3 SDR&R Contest 10, Net Metering

.4 2009 Solar Decathlon Building Code (SDBC)

.1 SDBC Section 6, Electrical

.5 Canadian Standards Association (CSA International)

.1 CSA C22.1-06, Canadian Electrical Code, Part 1 (20th Edition), Safety Standard for Electrical Installations.
.2 CAN3-C235-83 (R2000), Preferred Voltage Levels for AC Systems, 0 to 50,000 V.

.6 Health Canada / Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

.7 Team North Health & Safety Plan as Approved by the U.S. D.O.E

.8 Within these specifications reference is made to the following standards:

.1 UL – Underwriters Laboratory
.2 CSA - Canadian Standards Association.

.3 CEMA - Canadian Electrical Manufacturers Association.

.4 NEMA - National Electrical Manufacturers Association.

.5 IEEE - Institute of Electrical and Electronic Engineers.

.6 IPCEA - Insulated Power Cable Engineers Association.

1.3 DESIGN REQUIREMENTS

.1 Operating voltages: to NEC200-690

.2 Motors, electric heating, control and distribution devices and equipment to operate satisfactorily at 60 Hz within normal operating limits established by above standard.

.1 Equipment to operate in extreme operating conditions established in above standard without damage to equipment.

.3 Language operating requirements: provide identification nameplates and labels for control items in English.

1.4 DRAWINGS AND SPECIFICATIONS

.1 Should any discrepancies occur in the drawings and/or the specifications, which leaves doubt as to the true intent and the meaning of the drawings, and/or specifications, obtain a ruling from the Consultant before continuing work.

.2 Electrical drawings indicate the circuit number and route to be followed by conduit and/or wire and do not show all structural and mechanical details. In some cases, conduit or wiring is not shown or is shown diagrammatically on a schematic or riser diagram. Install each conduit and wire to provide a complete operating component or system and to conserve headroom within furring spaces, etc.

.3 In order to provide sufficient details and maximum degree of clarity on the drawings, the symbols used for various electrical devices, particularly wall-mounted devices, take up more space on the drawings than the device does on the wall. In these instances, locate the device on the wall as indicated on detail floor plans or elevations and/or with primary regard for convenience of operations rather than stringing the devices out along the wall so as to coincide with the scale location of electrical symbols.

1.5 QUALIFICATIONS

.1 Qualifications: electrical Work to be carried out by qualified, licensed electricians or apprentices in accordance with authorities having jurisdiction and as per the conditions of Provincial Act respecting manpower vocational training and qualification.

.1 Employees registered in provincial apprentices program: permitted, under direct supervision of qualified licensed electrician, to perform specific tasks.

.2 Permitted activities: determined based on training level attained and demonstration of ability to perform specific duties.

1.6 CARE, OPERATION AND START-UP

.1 Instruct operating personnel in the operation, care and maintenance of systems, system equipment and components.

.2 Arrange and pay for services of manufacturer's factory service engineer to supervise start-up of installation, check, adjust, balance and calibrate components and instruct operating personnel.

.3 Provide these services for such period, and for as many visits as necessary to put equipment in operation, and ensure that operating personnel are conversant with all aspects of its care and operation.

.4 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.

.5 Operating Personnel shall be contacted at the beginning of the project and encouraged to come on site at least once a week for the duration of the project. During these periods, they shall be given full explanation of the various systems as the project progresses.

.6 Two weeks prior to substantial inspection, operating personnel shall be given instruction for a period of three (3) days with minimum of two (2) hours per day. Instruction to be provided during regular work hours.

Part 2 Products

2.1 UNIFORMITY OF EQUIPMENT

.1 Unless otherwise specifically requested, uniformity of manufacture shall be maintained for any particular item or type of equipment throughout the building.

2.2 MATERIALS AND EQUIPMENT

.1 Equipment or material specified by technical description only, to be of the best commercial quality obtainable for the purpose.

.2 All electrical equipment, materials and systems specified and shown on the drawings shall be new and be certified by an accredited standards development organization (SDO) by the Underwriters Laboratory (UL) and shall be granted by an OSHA approved testing laboratory.

.3 Where authorized SDO certified equipment and material is not available, submit such equipment and material to authority having jurisdiction/ inspection authorities for special approval before delivery to site.

.4 Pre-assemble control panels and component assemblies.

2.3 ALTERATIONS

.1 Any prices submitted for additional work or alterations shall include a price breakdown for all labour and material and where required, shall be justified by invoices, time sheets, etc. No extras will be allowed without prior written authorization from the Consultant.

2.4 ELECTRIC MOTORS, EQUIPMENT AND CONTROLS

.1 Verify installation and co-ordination responsibilities related to motors, equipment and controls, as indicated.

.2 Control wiring and conduit: in accordance with Section 26 05 21 – Wires and Cables (0-1000 V) except for conduit, wiring and connections below 50 V which are related to control systems specified in mechanical sections and as shown on mechanical drawings.

2.5 MECHANICAL EQUIPMENT

.1 Check mechanical drawings for sizes and locations of all motors, controls, and other equipment requiring electrical wiring and connections.

.2 Review mechanical specifications to ensure compliance with all clauses requiring work by the electrical contractor.

2.6 WIRING TERMINATIONS

.1 Ensure lugs, terminals; screws used for termination of wiring are suitable for either copper or aluminium conductors.

2.7 WIRING IDENTIFICATION

.1 Identify wiring with permanent indelible identifying markings, either numbered or coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring.

.2 Maintain phase sequence and colour coding throughout.

.3 Colour code: to CSA C22.1, red, black, blue with neutral white.

.4 Use colour-coded wires in communication cables, matched throughout system.

2.8 CONDUIT AND CABLE IDENTIFICATION

.1 Colour code conduits, boxes and metallic sheathed cables.

.2 Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 5 foot intervals.

.3 Colours: 1 inch wide prime colour and ¾ inch wide auxiliary colour.

	Prime	Auxiliary
Up to 250 V	Gray	
Standby Power	Gray	Red
Up to 600 V	Gray	Green
Television	Green	Blue
Structured Wiring System	Green	Black
Low Voltage Lighting Systems	Black	
DC emergency Lighting	Black	Red
Security Systems	Black	Blue
Fire Alarm	Red	

2.9 FINISHES

.1 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel.

.1 Paint outdoor electrical equipment RAL 9001 finish to EEMAC Y1-1-1955.

.2 Paint indoor switchgear and distribution enclosures RAL 9001 to EEMAC 2Y-1-1958.

.2 Clean and touch up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.

.1 Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

Part 3 Execution

3.1 INSTALLATION

.1 Do complete installation in accordance with CSA C22.1 except where specified otherwise.

.2 Do overhead and underground systems in accordance with CSA C22.3 No.1 except where specified otherwise.

3.2 LOCATION OF OUTLETS

.1 Locate outlets in accordance with Section 26 05 32 - Outlet Boxes, Conduit Boxes and Fittings.

.2 Do not install outlets back-to-back in wall; allow minimum 6 in. horizontal clearance between boxes.

.3 Change location of outlets at no extra cost or credit, providing distance does not exceed 12 in, and information is given before installation. Obtain information from Consultant prior to rough in of outlet.

.4 Determine direction of door swings from architectural drawings or on site, not from electrical drawings. Locate light switches, fire alarm manual stations, and disconnect devices in mechanical room, on latch side of each door or as detailed on elevations or detail floor plans.

3.3 MOUNTING HEIGHTS

.1 Mounting height of equipment is from finished floor to bottom of equipment unless specified or indicated otherwise.

.2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation.

.3 Install electrical equipment at following heights unless indicated otherwise.

- .1 Local switches: as indicated in interior elevations.
- .2 Wall receptacles: as indicated on interior elevations
- .3 Panelboards: as required by Code and as indicated in interior elevations
- .4 Communication outlets: as indicated in interior floorplan
- .5 Floor receptacles as indicated in interior floor plan
- .6 Television outlets: as indicated in interior floor plan.
- .7 Wall mounted speakers: as indicated in interior elevations

3.4 CO-ORDINATION OF PROTECTIVE DEVICES

.1 Ensure circuit protective devices such as over current trips, relays and fuses are installed to required values and settings.

3.5 SETTING OUT THE WORK

.1 Thoroughly examine the drawings and specifications and especially check figure dimensions immediately after awarding of the contract. Report any discrepancies to the Consultant. No pleas as to the action or direction of the Consultant will be submitted in justification of any errors in construction where departure is made from the drawings, specifications or contract.

.2 In setting out the Work, make reference to the Electrical, and Architectural and Interior drawings. Consult with respective trades in setting out of location of the conduit runs, lighting fixtures, panel assemblies, etc. so that conflicts are avoided and symmetrical even spacing is maintained.

.3 Conduit shall be laid out to avoid interference with other trades and to maintain maximum headroom. In the ceiling space, conduit shall be arranged to conserve space, to be serviceable and to avoid crossovers.

.4 Where outlets occur in exterior walls, utilize vapour boxes.

.5 No structural member shall be cut or drilled without the knowledge and consent of the Structural Consultant.

3.6 FIELD QUALITY CONTROL

.1 Conduct and pay for the following tests:

- .1 Power generation and distribution system including phasing, voltage, grounding and load balancing.
- .2 Circuits originating from branch distribution panels.
- .3 Lighting and its control.
- .4 Motors, heaters and associated control equipment including sequenced operation of systems where applicable.
- .5 Systems: fire alarm system, communications.
- .6 Insulation resistance testing:
  - .1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.
  - .2 Megger 350-600 V circuits, feeders and equipment with a 1000 V instrument.
  - .3 Check resistance to ground before energizing. If ground resistance is less than .2 megohms on any lighting, power or control circuit, such circuits shall be considered as being defective and must be replaced.

.2 Carry out tests in presence of Engineer and/or Consultant.

.3 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.

.4 Manufacturer's Field Services:

- .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports.
- .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
- .3 Schedule site visits, to review Work.
- .4 Where specifically called for in specialized portions of the installation the Contractor shall arrange and pay for the services of the manufacturer's personnel to supervise the initial start-up of the installation and to check, adjust, balance and calibrate all components, including all related wiring, controls, etc. and to instruct the Owner's operating personnel.

.5 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.

.6 In co-operation with the Mechanical trade, take clip-on ammeter readings on all phases of all mechanical equipment motors with motors operating under full load conditions. Test readings to be submitted to Mechanical section and to the Consultant.

.7 During construction and up to substantial performance of the work, Contractor shall be required to make accessible any equipment or wiring for inspection purposes.

.8 On the request of the Consultant, Contractor shall have a member of his supervisory staff available to assist the Consultant in inspecting the work.

.1 These services shall be provided for such period and for as many visits as may be necessary to put the applicable portion of the installation into complete working order and to ensure that the operating personnel are fully conversant with all aspects of the operation, care and maintenance thereof. In general, this shall include all communication equipment.

.9 Submit all test results for Consultant's review.

3.7 CLEANING

.1 Clean and touch up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.

.2 Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

.3 At all times during construction, keep the site free from debris boxes, packing, etc., resulting from the work of the Divisions 26, 27 and 28.

.4 At the completion of the Work, the electrical installation shall be left in a clean and finished condition to the satisfaction of the Consultant.

END OF SECTION

Part 1 General

1.1 REFERENCES

.1 CSA C22.2 No .0.3-[96], Test Methods for Electrical Wires and Cables.

.2 CAN/CSA-C22.2 No. 131-[M89(R1994)], Type TECK 90 Cable.

.3 NEL Article 400, Flexible Cords and Cables

1.2 PRODUCT DATA

.1 Submit product data in accordance with Section 26 05 00 – Common Work Results – Electrical.

1.3 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Collect and separate plastic, paper packaging and corrugated cardboard .

.3 Fold up metal banding, flatten and place in designated area for recycling.

Part 2 Products

2.1 BUILDING WIRES

.1 Conductors: stranded for 10 AWG and larger. Minimum size: 12 AWG.

.2 Copper conductors: size as indicated, with 600 V insulation of chemically cross-linked thermosetting polyethylene material rated RW90.

2.2 TECK CABLE

.1 Cable: to CAN/CSA-C22.2 No. 131, NEL 518.3, and NEL 690.31

.2 Conductors:

.1 Grounding conductor: copper.

.2 Circuit conductors: copper, size as indicated.

.3 Insulation:

.1 Chemically cross-linked thermosetting polyethylene rated type RW90, 1000 V.

.4 Inner jacket: polyvinyl chloride material.

.5 Armour: interlocking galvanized steel.

.6 Overall covering: polyvinyl chloride material.

.7 Fastenings:

.1 One hole malleable iron straps to secure surface cables 2 in. and smaller. Two hole steel straps for cables larger than 2 in.

.2 Channel type supports for two or more cables at 60 in. centers.

.3 Threaded rods: ¼ in. dia.to support suspended channels.

.8 Connectors:

.1 Watertight, or explosion-proof (where applicable) approved for TECK cable.

2.3 MINERAL-INSULATED CABLES

.1 Not allowed.

2.4 CONTROL CABLES

.1 Type LVT: 2 soft annealed copper conductors, sized as indicated, with thermoplastic insulation, outer covering of thermoplastic jacket, and optional armour of closely wound aluminum wire.

.2 Low energy 300 V control cable: solid annealed copper conductors sized minimum #16 AWG, with PVC insulation, flamer retardant to 105 degrees C. Alcatel Securex or approved equivalent.

2.5 FIRE ALARM CABLE

.1 Conductors: 300V rated multiconductor, insulated, colour coded, copper conductor, minimum size to be #16 B & S gauge for device loops and #14 for signal circuits.

.2 Insulation: 105C flame retardant PVC

.3 Outer Jacket: 105C flame retardant PVC Red.

.4 Armour: Interlocking Aluminum without overall Jacket. For drops to devices in suspended ceilings from conduit system.

.5 Certified by CSA as fire alarm and signal cable type FAS 105 to CSA C22.2 #208

2.6 NON-METALLIC SHEATHED CABLE

.1 Not Permitted.

Part 3 Execution

3.1 INSTALLATION OF BUILDING WIRES

.1 Install wiring as follows:

.1 In conduit systems in accordance with Section 26 05 34.

.2 In cabletroughs in accordance with Section 26 05 36

3.2 INSTALLATION OF TECK CABLE 0 -1000 V

.1 Install cables.

.1 Group cables wherever possible on channels.

.2 Terminate cables in accordance with Section 26 05 20- Wire and Box Connectors - 0 - 1000 V.

3.3 INSTALLATION OF CONTROL CABLES

.1 Install control cables in conduit.

.2 Ground control cable shield at one end only.

END OF SECTION

Part 1 General

1.1 RELATED SECTIONS

.1 Section 26 05 00 - Common Work Results - Electrical.

1.2 REFERENCES

.1 American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)

.1 ANSI/IEEE 837-[1989(R1996)], Qualifying Permanent Connections Used in Substation Grounding.

.2 Canadian Standards Association, (CSA International)

.3 NEC 250.52, Grounding Electrode System

1.3 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Remove from site and dispose of all packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material for recycling.

.4 Divert unused metal materials from landfill to metal recycling facility as approved by Engineer.

.5 Fold up metal banding, flatten and place in designated area for recycling.

Part 2 Products

2.1 EQUIPMENT

.1 Rod electrodes: copper clad steel stainless steel ¾ in. dia. by 18 in. long.

.2 Grounding conductors: bare stranded copper, tinned, soft annealed, size as indicated.

.3 Insulated grounding conductors: green, type TWH.

.4 Ground bus: copper, size 2 in. x ¼ in. x 48 in., complete with insulated supports, fastenings, connectors.

.5 Non-corroding accessories necessary for grounding system, type, size, material as indicated, including but not necessarily limited to:

.1 Grounding and bonding bushings.
.2 Protective type clamps.
.3 Bolted type conductor connectors.
.4 Thermit welded type conductor connectors.
.5 Bonding jumpers, straps.
.6 Pressure wire connectors.

2.2 MANUFACTURERS

.1 Standard of Acceptance for equipment: Burndy Corp., Erico Inc., McGraw Edison (Canada) Ltd. or approved alternate.

Part 3 Execution

3.1 INSTALLATION GENERAL

.1 Install complete, permanent, continuous grounding system including, electrodes, conductors, connectors, accessories. Where EMT is used, run ground wire in conduit and make secure electrical connection between conduit and ground wire with ground hub. System is to conform to the requirements of the Consultant and the local authorities having jurisdiction.

.2 Install connectors in accordance with manufacturer's instructions.

.3 Protect exposed grounding conductors from mechanical injury.

.4 Use mechanical connectors for grounding connections to equipment provided with lugs.

.5 Soldered joints not permitted.

.6 Install bonding wire for flexible conduit, connected at both ends to grounding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.

.7 Install flexible ground straps for bus duct enclosure joints, where such bonding is not inherently provided with equipment.

.8 Make grounding connections in radial configuration only, with connections terminating at single grounding point. Avoid loop connections.

3.2 ELECTRODES

.1 Use electrode components and copper conductors as indicated on the drawings.

.2 Make special provision for installing electrodes that will give acceptable resistance to ground value where rock or sand terrain prevails. Ground as indicated.

3.3 EQUIPMENT GROUNDING

.1 Install grounding connections to typical equipment included in PV systems and inverters.

3.4 GROUNDING BUS

.1 Install copper grounding bus mounted on insulated supports on wall of Room 101.

.2 Ground items of electrical equipment in Room 101 to ground bus with individual bare stranded copper connections size 2/0AWG.

3.5 BONDING

.1 Ensure proper bonding of

.2 new systems and provide bonding where required as follows: Bond non-current carrying metal parts together with size #6 AWG copper equipotential conductor. Run conductor from separate lug or service neutral bar to, but not necessarily limited to, the following indoor systems and equipment:

.1 Hot water heating system.

.2 Domestic cold water piping.

.3 Fuel system piping.

.4 Sprinkler piping.

3.6 FIELD QUALITY CONTROL

.1 Perform tests in accordance with Section 26 05 00 – Electrical Common Work Results.

.2 Perform ground continuity and resistance tests using method appropriate to site conditions and to approval of Consultant and local authority having jurisdiction over installation.

.3 Perform tests before energizing electrical system.

.4 Disconnect ground fault indicator during tests.

END OF SECTION

Part 1 General

1.1 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Remove from site and dispose of all packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard packaging material for recycling.

.4 Divert unused metal materials from landfill to metal recycling facility as approved by Consultant.

.5 Fold up metal banding, flatten and place in designated area for recycling.

Part 2 Products

2.1 SUPPORT CHANNELS

.1 Unistrut to be mounted to roof truss. Confirm size and dimension on site.

.2 U-Shape 1-3/4” x 1-3/4” surface mounted to underside of roof panel.

.3 U-Shape 1-3/4” x 1-3/4” surface mounted to battons, with in floor panel.

Part 3 Execution

3.1 INSTALLATION

.1 Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.

.2 Fasten exposed conduit or cables to building construction or support system using straps.

- .1 One-hole steel straps to secure surface conduits and cables 2 inches and smaller.
- .2 Two-hole steel straps for conduits and cables larger than 2 inches.
- .3 Beam clamps to secure conduit to exposed steel work.

.3 Suspended support systems.

- .1 Support individual cable or conduit runs with ¼” dia threaded rods and spring clips.
- .2 Support 2 or more cables or conduits on channels supported by ¼” dia threaded rod hangers where direct fastening to building construction is impractical.

.4 For surface mounting of two or more conduits use channels at 6’ on centre spacing.

.5 Provide metal brackets, frames, hangers, clamps and related types of support structures where indicated or as required to support conduit and cable runs.

.6 Ensure adequate support for raceways and cables dropped vertically to equipment where there is no wall support.

.7 Do not use wire lashing or perforated strap to support or secure raceways or cables.

.8 Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trade and approval of Consultant.

.9 Install fastenings and supports as required for each type of equipment cables and conduits, and in accordance with manufacturer's installation recommendations.

.10 Equipment and conduits to be installed to maintain head room, neat mechanical appearance and sized to support equipment loads as required.

END OF SECTION

Part 1 General

1.1 SHOP DRAWINGS AND PRODUCT DATA

.1 Submit shop drawings and product data for cabinets in accordance with Section 26 05 00 – Common Work Results – For Electrical.

1.2 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Collect and separate plastic, paper packaging and corrugated cardboard. Fold up metal banding, flatten and place in designated area for recycling.

Part 2 Products

2.1 JUNCTION AND PULL BOXES

.1 Welded steel construction with screw-on flat covers for surface mounting.

.2 Covers with 1 in. minimum extension all around, for flush-mounted pull and junction boxes.

2.2 CABINETS

.1 Cabinet for main load centre to be Square D QOC42UF or QOC42US as appropriate to suit QO142L225G.

.2 All cabinet shall be approved for the type of wiring and equipment to be housed therein.

.3 Terminal strips:

.1 Below 50 volts - screw terminal type, Armaco T12-2 or Cinch Series 500.

.2 Above 50 volts - 250 volt screw terminal type with barriers between each set of terminals with individual terminal points for each conductor, Weidmuller SAK 2.5 #2796.2 terminals C/W rail, end plates and holding clamps.

.4 Signage:

.1 Number identify terminal strips with permanent numbers.

.2 Provide wiring diagram on inside of terminal cabinet door showing units and conductors connected to terminal cabinets.

Part 3 Execution

3.1 JUNCTION, PULL BOXES AND CABINETS INSTALLATION

.1 Install pull boxes in inconspicuous but accessible locations.

.2 Mount cabinets with top not higher than 6 feet above finished floor.

.3 Only main junction and pull boxes are indicated. Install pull boxes so as not to exceed 90 feet of conduit run between pull boxes and as per the requirement of the Canadian and National Electrical Code.

.4 Terminate conduit in cabinet with locknuts and Bushings and/or locknuts and grounding bushing where required.

.5 Terminate wiring on screw tight terminal blocks or strips.

3.2 IDENTIFICATION

.1 Provide equipment identification in accordance with Section 26 05 00 - Common Work Results - Electrical.

.2 Install size 2 identification labels indicating system name voltage and phase.

END OF SECTION

Part 1 General

1.1 REFERENCES

.1 Canadian Standards Association (CSA)

- .1 CAN/CSA C22.2 No. 18-98, Outlet Boxes, Conduit Boxes, and Fittings and Associated Hardware.
- .2 CSA C22.2 No. 45-M1981 (R1992), Rigid Metal Conduit.
- .3 CSA C22.2 No. 56-1977(R1999), Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
- .4 CSA C22.2 No. 83-M1985 (R1999), Electrical Metallic Tubing.
- .5 CSA C22.2 No. 211.2-M1984 (R1999), Rigid PVC (Unplasticized) Conduit.
- .6 CAN/CSA C22.2 No. 227.3-M91 (R1999), Flexible Nonmetallic Tubing.
- .7 NEC Article 314.16 (C), Conduit Bodies.

1.2 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Ensure emptied containers are sealed and stored safely for disposal away from children.

.3 Collect and separate plastic, paper packaging and corrugated cardboard.

Part 2 Products

2.1 CONDUITS

.1 Rigid metal conduit: to CSA C22.2 No. 45, galvanized steel threaded.

.2 Electrical metallic tubing (EMT): to CSA C22.2 No. 83, with couplings.

.3 Rigid pvc conduit: to CSA C22.2 No. 211.2.

.4 Flexible metal conduit: to CSA C22.2 No. 56,

.5 liquid-tight flexible metal.

.6 Non metallic duct: rigid PVC, FRE duct and “superduct”

2.2 CONDUIT FASTENINGS

.1 One hole steel straps to secure surface conduits 2 in and smaller. Two hole steel straps for conduits larger than 2 in.

.2 Beam clamps to secure conduits to exposed steel work.

.3 Channel type supports for two or more conduits at 6 feet oc.

.4 Threaded rods, ¼ in dia., to support suspended channels.

2.3 CONDUIT FITTINGS

.1 Fittings: manufactured for use with conduit specified. Coating: same as conduit.

.2 Factory "ells" where 90º bends are required 1 in and larger conduits.

.3 Set screw connectors and couplings for EMT except where not allowed by the Canadian Electrical Code. Water-tight fittings for all outdoor and weatherproof EMT requirements.

2.4 EXPANSION FITTINGS FOR RIGID CONDUIT

.1 Weatherproof expansion fittings with internal bonding assembly suitable for 4 in linear expansion.

.2 Watertight expansion fittings with integral bonding jumper suitable for linear expansion and 1-1/4 in deflection in all directions.

.3 Weatherproof expansion fittings for linear expansion at entry to panel.

Part 3 Execution

3.1 INSTALLATION

.1 Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.

.2 Conceal conduits except in mechanical and electrical service rooms and areas of open structure.

.3 Where surface conduits are used in finished areas of open ceiling structure, conduit is to be inconspicuous and tucked neatly along structural members – hidden if possible. Finish of conduit and boxes in these areas to match architectural finish of ceiling.

.4 Use rigid galvanized steel threaded conduit except where specified.

.5 Use electrical metallic tubing (EMT) except where subject to mechanical injury.

.6 Install and attach surface mounted conduit with clamps for exposed runs.

.7 Use liquid tight flexible metal conduit for connections to motors or vibrating equipment.

.8 Minimum conduit size for lighting and power circuits: 1 in.

.9 Bend conduit cold. Replace conduit if kinked or flattened more than 1/10th of its original diameter.

.10 Mechanically bend steel conduit over 1 in dia.

.11 Field threads on rigid conduit must be of sufficient length to draw conduits up tight.

.12 Install fish cord in empty conduits.

.13 Run 2-1 in spare conduits up to ceiling space and 2-1 in spare conduits down to ceiling space from each flush panel. Terminate these conduits in 12x12x4 in junction boxes in ceiling space.

.14 Clean out conduit before installation of conductors. Where conduits become blocked, remove and replace blocked section. Do not use liquids to clean out conduits.

.15 Alter routing to avoid structural obstructions keeping crossovers to a minimum.

.16 Seal conduit with fiberglass where conduits leave heated area and enter unheated area.

.17 Division 7 shall provide Flashing and pitch-pockets making watertight joints where conduits pass through roof or waterproofing membranes.

.18 Install CSA approved expansion fittings complete with grounding jumpers where conduits cross building expansion joints. Provide bends or offsets in conduit adjacent to building expansion joints where conduit is installed above suspended ceilings.

.19 If plastic sleeves are used in fire rated walls or floors, remove before conduit installation.

.20 All conduits shall enter properly and be secured to all fittings, outlet boxes, panel tubs, etc., by means of locknuts and bushings. All unused openings shall be sealed with a threaded plug.

3.2 SURFACE CONDUITS

.1 Run parallel or perpendicular to building lines.

.2 Group conduits wherever possible on suspended surface channels.

.3 Do not pass conduits through structural members except as indicated.

.4 Do not locate conduits less than 3 in parallel water lines with minimum of 1 in at crossovers.

3.3 CONCEALED CONDUITS

.1 Run parallel or perpendicular to building lines.

.2 Where conduit is located in wall cavities in occupied spaces, route to avoid contact with plumbing and other services to the drywall and studs. The plumbing and other services are being installed clear of drywall and studs and electrical conduit can provide a solid connection to transmit noise from the plumbing to the drywall if routed without adequate clearance.

END OF SECTION

Part 1 General

1.1 REFERENCES

.1 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

.2 NEC Article 410, Luminaires, Lampholders, and Lamps

1.2 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet. Include product characteristics, performance criteria, and limitations.

.2 Shop Drawings:

.1 Submit shop drawings for Consultant’s approval.

1.3 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

.2 Waste Management and Disposal: separate waste materials for reuse and recycling.

Part 2 Products

2.1 MATERIALS

.1 Control system: by one manufacturer and assembled from compatible components.

2.2 REMOTE CONTROL SWITCHES

.1 As per manufacturer’s specifications.

2.3 LOW VOLTAGE RELAYS

.1 Electrically operated by momentary impulse, mechanically latched until activated.

.2 Two coil solenoid type with one coil to close relay contacts and one coil to open relay contacts.

.3 Operating voltage: 24 V, AC

.4 Load contacts: 20 A, 347 V, AC.

.5 Auxiliary contacts for pilot light.

.6 Coloured pre-stripped leads.

2.4 MANUAL CONTROL

.1 2 no. individual remote control switches as indicated.

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 Locate and install equipment in accordance with manufacturer's recommendations and as indicated in Architectural drawings.

3.3 FIELD QUALITY CONTROL

.1 Actuate control units in presence of Consultant to demonstrate lighting circuits are controlled as designated.

.2 Manufacturer's Field Services:

.1 Schedule site visits, to review Work.

3.4 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

.1 Materials and installation for standard and custom breaker type panelboards.

1.2 RELATED SECTIONS

.1 Section 26 05 00 - Common Work Results - Electrical.

1.3 REFERENCES

.1 CSA C22.2No.29-M1989 (R2000), Panelboards and enclosed Panelboards.

.2 NEC 550.11, Disconnecting Means and Branch Circuit Protective Equipment

.3 NEC 647.4, Wiring Methods

.4 NEC 690.63, Unbalanced Interconnections

1.4 SHOP DRAWINGS

.1 Submit shop drawings in accordance with 26 05 00 - Common Work Results – Electrical.

.2 Drawings to include electrical detail of panel, branch breaker type, quantity, ampacity and enclosure dimension.

.3 Proof of compatible series rated combination groups for breakers and equipment is to be provided with shop drawings.

1.5 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard packaging material for recycling.

.4 Divert unused metal and wiring materials from landfill to metal recycling facility approved by Consultant.

Part 2 Products

2.1 PANELBOARDS

.1 Panelboards: to CSA C22.2No.29 and product of one manufacturer.

.1 In addition to CSA requirements manufacturer's nameplate must show fault current that panel including breakers has been built to withstand.

.2 Main Indoor Panelboard to be Square D Q0142L225G or approved equivalent.

.3 PV Panelboard to be Square D CQ0140L200GRB – 8RD box size or approved equivalent.

2.2 BREAKERS

.1 Main Breaker to be Square D Q0M2150VA or approved equal.

.2 Breaker to be Square D Q0115, Q0215, Q0120, Q0220, Q02020, Q0230, Q0260, Q0290 or approved equivalent.

.3 Arc Fault Breaker to be Square D Q0115AF or approved equivalent.

2.3 EQUIPMENT IDENTIFICATION

.1 Provide equipment identification in accordance with Section 260501 - Common Work Results - Electrical.

.2 Nameplate for each panelboard size 4 engraved as indicated.

.3 Nameplate for each circuit in distribution panelboards size 2 engraved as indicated.

.4 Complete circuit directory with typewritten legend showing location and load of each circuit.

Part 3 Execution

3.1 INSTALLATION

.1 Locate panelboards as indicated and mount securely, plumb, true and square, to adjoining surfaces.

.2 Install surface mounted panelboards on plywood backboards.

.3 Mount panelboards to height specified in Architectural Drawings.

.4 Connect loads to circuits.

.5 Connect neutral conductors to common neutral bus with respective neutral identified.

.6 Mount panelboard vertically with odd numbered breakers on the left and even on the right.

.7 Wherever possible use pull boxes to collect home runs and larger conduits to complete the return of the branch circuits to avoid conduit congestion at the face of walls

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

.1 Switches, receptacles, wiring devices, cover plates and their installation.

1.2 REFERENCES

.1 Canadian Standards Association (CSA International)

- .1 CSA-C22.2 No.42-99(R2002), General Use Receptacles, Attachment Plugs and Similar Devices.
- .2 CSA-C22.2 No.42.1-00, Cover Plates for Flush-Mounted Wiring Devices (Bi-national standard, with UL 514D).
- .3 CSA-C22.2 No.55-M1986(July 2001), Special Use Switches.
- .4 CSA-C22.2 No.111-00, General-Use Snap Switches (Bi-national standard, with UL 20, twelfth edition).

.2 National Electrical Code (NEC)

- .1 NEC Article 404, Switches
- .2 NEC Article 406, Receptacles, Cord Connectors and Attachment Plugs

1.3 SHOP DRAWINGS AND PRODUCT DATA

.1 Submit shop drawings and product data in accordance with Section 26 05 00 - Common Work Results - Electrical

1.4 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Remove from site and dispose of all packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard packaging material for recycling.

.4 Divert unused metal and wiring materials from landfill to metal recycling facility as approved by Engineer.

Part 2 Products

2.1 SWITCHES

.1 15 A, 120 V, single pole, double pole, three-way, four-way switches to: CSA-C22.2 No.55 and CSA-C22.2 No.111.

.2 Manually-operated general purpose ac switches with following features:

- .1 Terminal holes approved for No. 10 AWG wire.
- .2 Silver alloy contacts.
- .3 Urea or melamine molding for parts subject to carbon tracking.
- .4 Suitable for back and side wiring.
- .5 White toggle.

.3 Switches of one manufacturer throughout project.

.4 All switches to be specification grade

.5 Acceptable materials: Hubbell 1201 Series or Cooper 1201 Series or equal.

2.2 RECEPTACLES

.1 See 26 00 00 for receptacle description.

2.3 COVER PLATES

.1 See 26 00 00 for cover plate description

Part 3 Execution

3.1 INSTALLATION

.1 Switches:

.1 Install single throw switches with handle in "UP" position when switch closed.

.2 Install switches in gang type outlet box when more than one switch is required in one location.

.3 Mount toggle switches at height in accordance with Section 26 05 00 - Common Work Results - Electrical as indicated.

.2 Receptacles:

.1 Install receptacles in gang type outlet box when more than one receptacle is required in one location.

.2 Mount receptacles at height in accordance with Section 26 05 00 - Common Work Results - Electrical as indicated.

.3 Where split receptacle has one portion switched, mount vertically and switch upper portion.

.4 Mount Receptacles with u-ground on bottom of receptacle.

.3 Cover plates:

.1 Protect stainless steel cover plate finish with paper or plastic film until painting and other work is finished.

.2 Install suitable common cover plates where wiring devices are grouped.

.3 Do not use cover plates meant for flush outlet boxes on surface-mounted boxes.

END OF SECTION

Part 1 General

1.1 SECTION INCLUDES

.1 Equipment and installation for ground fault circuit interrupters (GFCI).

1.2 REFERENCES

.1 Canadian Standards Association (CSA International)

.1 CAN/CSA-C22.2 No.144-M91(R2001), Ground Fault Circuit Interrupters.

.2 National Electrical Manufacturers Association (NEMA)

.1 NEMA PG 2.2-1999, Application Guide for Ground Fault Protection Devices for Equipment.

.3 National Electrical Code (NEC)

.1 NEC 206.3, General Installation Requirements

1.3 SUBMITTALS

.1 Submittals in accordance with Section 26 05 00 - Common Work Results – Electrical.

.2 Submit product data and shop drawings.

1.4 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Remove from site and dispose of all packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard packaging material for recycling.

.4 Divert unused metal and wiring materials from landfill to metal recycling facility approved by Engineer.

.5 Fold up metal banding, flatten and place in designated area for recycling.

Part 2 Products

2.1 MATERIALS

.1 Equipment and components for ground fault circuit interrupters (GFCI): to CAN/CSA-C22.2 No.144.

.2 Components comprising ground fault protective system to be of same manufacturer.

2.2 BREAKER TYPE GROUND FAULT INTERRUPTER

.1 Single or Two pole ground fault circuit interrupter for 15 A, 120 V, 1 phase circuit c/w test and reset facilities.

2.3 GROUND FAULT PROTECTOR UNIT

.1 Self-contained with 15 A, 120 V circuit interrupter and duplex receptacle complete with:

.1 Solid state ground sensing device.

.2 Facility for testing and reset.

.2 Flush mounted with stainless steel face plate.

.3 Unit to contain self-testing abilities in conformance with CSA and UL 942.

Part 3 Execution

3.1 INSTALLATION

.1 Connect supply and load wiring to equipment in accordance with manufacturer's recommendations.

3.2 FIELD QUALITY CONTROL

.1 Perform tests in accordance with Section 26 05 00 - Common Work Results – Electrical.

.2 Demonstrate simulated ground fault tests.

END OF SECTION

Part 1 General

1.1 REFERENCES

.1 Canadian Standards Association (CSA International).

.1 CAN/CSA C22.2 No.4-M89 (R2000), Enclosed Switches.

.2 CSA C22.2 No.39-M89 (R2003), Fuseholder Assemblies.

.2 National Electrical Code (NEC)

.1 NEC 230.72, Grouping of Disconnects

1.2 SUBMITTALS

.1 Submit product data in accordance with Section 26 05 00 - Common Work Results – Electrical.

1.3 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Collect and separate plastic, paper packaging and corrugated cardboard .

.3 Fold up metal banding, flatten and place in designated area for recycling.

Part 2 Products

2.1 DISCONNECT SWITCHES

.1 Fused switches are indicated on the contract drawings. It is not acceptable to provide fused disconnect switches in lieu of breakers. Confirm locations with contract drawings.

.2 Fusible, non-fusible, horsepower rated disconnect switch in CSA Enclosure 1, 3R, or 4, to CAN/CSA C22.2 No.4 as required; size as indicated.

.3 Mechanically interlocked door to prevent opening when handle in ON position.

.4 Quick-make, quick-break action.

2.2 EQUIPMENT IDENTIFICATION

.1 Provide equipment identification in accordance with Section 260500 - Common Work Results - Electrical.

.2 Indicate name of load controlled on size 4 nameplate.

Part 3 Execution

3.1 INSTALLATION

.1 Install disconnect switches complete with fuses if applicable.

END OF SECTION

General

.1 SCOPE

.1 Work includes the coordination of all equipment and devices as required for project completion in accordance with mechanical scope of the project.

Products

.1 MATERIALS

.1 Install sensors and controllers for Mechanical heating/cooling and ventilation equipment provided by Sections 23 and 25, where specifically indicated on the drawings and/or outlined in Section 23 09 00 and/or indicated on the Mechanical drawings.

.2 Electrical shall supply and install all switches, motor controllers and control apparatus required for satisfactory completion of work as outlined in drawings and specifications. All electrical equipment supplied or installed shall have CSA approval for use in its intended location.

.3 Refer to Mechanical drawings and specs for wiring requirements with reference to sensor, controllers and control wiring of heating equipment.

END OF SECTION

1.1 REFERENCES

.1 2008 National Electrical Code (NEC)

.1 NEC Article 690, Solar Photovoltaic Systems

.2 2008 International Residential Code (IRC)

.1 IRC-E Chapters 33-42, Electrical Module

.3 2009 Solar Decathlon Rules & Regulations (SDR&R)

.1 SDR&R Rule 8, Energy

.4 2009 Solar Decathlon Building Code (SDBC)

.1 SDBC Section 6, Electrical

.5 Canadian Standards Association (CSA International)

.1 CSA C22.1-06, Canadian Electrical Code, Part 1 (20th Edition), Safety Standard for Electrical Installations.

.2 CAN3-C235-83 (R2000), Preferred Voltage Levels for AC Systems, 0 to 50,000 V.

.6 Health Canada / Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

.7 Team North Health & Safety Plan as Approved by the U.S. D.O.E

.8 Within these specifications reference is made to the following standards:

.1 UL – Underwriters Laboratory
.2 CSA - Canadian Standards Association.
.3 CEMA - Canadian Electrical Manufacturers Association.
.4 NEMA - National Electrical Manufacturers Association.
.5 IEEE - Institute of Electrical and Electronic Engineers.
.6 IPCEA - Insulated Power Cable Engineers Association.

Part 2 Products

2.1 MATERIALS AND EQUIPMENT

.1 Day4 Energy 48MC Multicrystalline Solar Modules or approved equal.

.1 Size 3’3” x 4’ -3 ½”, 180 Watt.

.2 Schuco Prosol Monocrystalline Building Integrated Photovoltaics– Colour RAL 9005 or approved equal.

.1 Type A – 102 3/4” x 38” – 377 Watts
.2 Type B – 91” x 38” – 337 Watts
.3 Type C - 95” x 38” – 337 Watts

.3 Xantrex Grid Tie Inverters or approved equal

.1 GT3.8 Kilowatt NA 240/208

.4 All electrical equipment, materials and systems specified and shown on the drawings shall be new and be certified by an accredited standards development organization (SDO) by

the Underwriters Laboratory (UL) and shall be granted by an OSHA approved testing laboratory.

.5 Where authorized SDO certified equipment and material is not available, submit such equipment and material to authority having jurisdiction/ inspection authorities for special approval before delivery to site.

.6 Pre-assemble control panels and component assemblies.

.7 All system components, including: Photovoltaic modules, PV connection boxes, PV inverters, main distributors or housing including all components, measuring technology etc.are to be planned and installed in accordance with legislation, the current technical regulations and the latest technology, taking the system as a whole into account.

.8 The provider must draw up a complete circuit diagram of components and the entire system including all safety devices required for people, systems and buildings: DC mains, AC mains up to interface, Measuring technology incl. recording and assessment, Lightning protection devices, Separator, Protective measures.

.9 Sizing of all cable routes, including space required

.10 Sizing of all cable diameters, including cables supplied by the Consultant.

.11 Registering the system to connect it to the grid,

.12 Complete written documentation and diagrams on the system. Installation of the complete photovoltaic system.

.13 Delivery of all system components and structures to the site free of charge

.14 Appropriate storage of system components

.15 Full assembly of the system taking account of the interchangeable nature of components

.16 Installation documentation In addition to the documentation listed in point 7, the following must be submitted: Assembly diagrams, Installation diagrams, Circuit diagrams, Cabling lists, Wiring diagrams

2.2 ELECTRIC MOTORS, EQUIPMENT AND CONTROLS

.1 Verify installation and co-ordination responsibilities related to motors, equipment and controls, as indicated.

.2 Control wiring and conduit: in accordance with Section 26 05 21 – Wires and Cables (0-1000 V) except for conduit, wiring and connections below 50 V which are related to control systems specified in mechanical sections and as shown on mechanical drawings.

2.3 MECHANICAL EQUIPMENT

.1 Check mechanical drawings for sizes and locations of all motors, controls, and other equipment requiring electrical wiring and connections.

.2 Review mechanical specifications to ensure compliance with all clauses requiring work by the electrical contractor.

2.4 WIRING TERMINATIONS

.1 Ensure lugs, terminals; screws used for termination of wiring are suitable for either copper or aluminium conductors.

2.5 INSTALLATION

.1 Do complete installation in accordance with CSA C22.1 except where specified otherwise.

.2 Do overhead and underground systems in accordance with CSA C22.3 No.1 except where specified otherwise.

2.6 LOCATION OF OUTLETS

.1 Locate outlets in accordance with Section 26 05 32 - Outlet Boxes, Conduit Boxes and Fittings.

.2 Do not install outlets back-to-back in wall; allow minimum 6 in. horizontal clearance between boxes.

.3 Change location of outlets at no extra cost or credit, providing distance does not exceed 12 in, and information is given before installation. Obtain information from Consultant prior to rough in of outlet.

.4 Determine direction of door swings from architectural drawings or on site, not from electrical drawings. Locate light switches, fire alarm manual stations, and disconnect devices in mechanical room, on latch side of each door or as detailed on elevations or detail floor plans.

2.7 CO-ORDINATION OF PROTECTIVE DEVICES

.1 Ensure circuit protective devices such as over current trips, relays and fuses are installed to required values and settings.

2.8 SETTING OUT THE WORK

.1 Thoroughly examine the drawings and specifications and especially check figure dimensions immediately after awarding of the contract. Report any discrepancies to the Consultant. No pleas as to the action or direction of the Consultant will be submitted in justification of any errors in construction where departure is made from the drawings, specifications or contract.

.2 In setting out the Work, make reference to the Electrical, and Architectural and Interior drawings. Consult with respective trades in setting out of location of the conduit runs, lighting fixtures, panel assemblies, etc. so that conflicts are avoided and symmetrical even spacing is maintained.

.3 Conduit shall be laid out to avoid interference with other trades and to maintain maximum headroom. In the ceiling space, conduit shall be arranged to conserve space, to be serviceable and to avoid crossovers.

.4 Where outlets occur in exterior walls, utilize vapour boxes.

.5 No structural member shall be cut or drilled without the knowledge and consent of the Structural Consultant.

2.9 CLEANING

.1 Clean and touch up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.

.2 Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

.3 At all times during construction, keep the site free from debris boxes, packing, etc., resulting from the work of the Divisions 26, 27 and 28.

.4 At the completion of the Work, the electrical installation shall be left in a clean and finished condition to the satisfaction of the Consultant.

END OF SECTION

Part 1 General

1.1 REFERENCES

.1 American National Standards Institute (ANSI)

.1 ANSI C82.1-97, Electric Lamp Ballasts-Line Frequency Fluorescent Lamp Ballast.

.2 American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE)

.1 ANSI/IEEE C62.41-1991, Surge Voltages in Low-Voltage AC Power Circuits.

.3 American Society for Testing and Materials (ASTM)

.1 ASTM F1137-88(1993), Specification for Phosphate/Oil and Phosphate/Organic Corrosion Protective Coatings for Fasteners.

.4 United States of America, Federal Communications Commission (FCC)

.1 FCC (CFR47) EM and RF Interference Suppression.

.5 Underwriters Laboratory (UL)

.1 UL 2388, Flexible Lighting Products, LEDs

.6 National Electrical Code

.1 NEC 700.17, Emergency Illumination

1.2 SHOP DRAWINGS AND PRODUCT DATA

.1 Submit shop drawings in accordance with Section 26 05 00 – Common Work Results – Electrical.

.2 Submit complete photometric data prepared by independent testing laboratory for luminaries where specified, for review by Consultant.

.3 Photometric data to include: Total input watts, candlepower summary, candela distribution, zonal lumen summary, luminaires efficiency, CIE type, coefficient of utilization, lamp type, and lumen rating in accordance with IESNA testing procedures.

.4 Provide digital IES compatible files upon request for incorporation in standard lighting simulation software.

1.3 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials.

.2 Place materials defined as hazardous or toxic waste in designated containers.

.3 Ensure emptied containers are sealed and stored safely for disposal away from children.

1.4 COORDINATION WITH OTHER DIVISIONS

.1 Confirm compatibility and interface of other materials with luminaire and ceiling system. Report discrepancies to the Consultant and defer ordering until certified.

.2 Supply plastic frames, trim rings, and backboxes to other trades, as work requires.

.3 Coordinate with Division 23 to avoid conflicts between luminaries, supports, fittings, and mechanical equipment.

Part 2 Products

2.1 LAMPS

.1 Fluorescent Lamps shall be T5, see Lighting Schedule in Electrical drawings for list of approved products.

.2 LED Lighting, see Lighting Schedule in Electrical drawings for list of approved products.

2.2 BALLASTS

.1 Supply ballast compatible to selected luminaries

.2 Standard of Acceptance or approved equivalent

.1 Canlyte or equivalent.

2.3 FINISHES

.1 Baked enamel finish:

.1 Conditioning of metal before painting:

.1 For corrosion resistance conversion coating to ASTM F1137.

.2 For paint base, conversion coating to ASTM F1137.

.2 Metal surfaces of luminaire housing and reflectors finished with high gloss baked enamel, polyester powdercoat, or alzak aluminum to give smooth, uniform appearance, free from pinholes or defects.

.3 Reflector and other inside surfaces finished as follows:

.1 White, minimum reflection factor 85%.

.2 Colour fastness: yellowness factor not above 0.02 and after 250 hours exposure in Atlas fade-ometer not to exceed 0.05.

.3 Film thickness, not less than 0.03 mm average and in no areas less than 0.025 mm.

.4 Gloss not less than 80 units as measured with Gardner 60 deg gloss meter.

.5 Flexibility: withstand bending over 12 mm mandrel without showing signs of cracking or flaking under 10 times magnification.

.6 Adhesion: 24 mm square lattice made of 3 mm squares cut through film to metal with sharp razor blade. Adhesive cellulose tape applied over lattice and pulled. Adhesion satisfactory if no coating removed.

2.4 LIGHT CONTROL DEVICES

.1 To interface as required with Central Home Automation System, as well as selected fixtures.

.2 Approved products from Canlyte Lightolier

2.5 LUMINAIRE SCHEDULE

.1 Defer to the light fixture schedule on Electrical Drawing E-612.

2.6 EXTERIOR LUMINAIRES

.1 Provide luminaries complete with gaskets forming weatherproof assembly where exposed to weather

.2 Luminaire finishes to be non-corrosive.

.3 Provide low temperature ballasts as required.

Part 3 Execution

3.1 INSTALLATION

.1 Locate and install luminaires as indicated.

3.2 WIRING

.1 Connect luminaires to lighting circuits:

.1 Bx (AC90) may be used for drops to fixtures in suspended ceiling installations. (Maximum 3 meter drop)

.2 Surface mounted luminaries are to be fed via conduit tucked neatly against structural members, and protruding at right angles from such structure for fixture connection. Contractor to ensure conduit is painted as per ceiling finishes.

3.3 LUMINAIRE SUPPORTS

.1 For suspended ceiling installations support luminaires independently of ceiling.

.2 Support luminaires mounted in continuous rows as per manufacturer recommendation.

.3 Support all ceiling mounted luminaries by two hangers per luminaries minimum independent of ceiling structure.

.4 Surface mounted florescent fixtures are not to be supported by T-bar clips.

3.4 LUMINAIRE ALIGNMENT

.1 Align luminaires mounted in continuous rows to form straight uninterrupted line.

.2 Locate luminaries as indicated on Architectural Reflected Ceiling Plan.

END OF SECTION

General

.1 REFERENCES

.1 Government of Canada

.1 TB OSH Chapter 3-03, [1997-01-28], Treasury Board of Canada, Occupational Safety and Health, Chapter 3-03, Standard for Fire protection Electronic Data Processing Equipment.

.2 TB OSH Chapter 3-04, [1994-12-22], Treasury Board of Canada, Occupational Safety and Health, Chapter 3-04, Standard for Fire Alarm Systems.

.2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

.1 Material Safety Data Sheets (MSDS).

.3 Underwriter's Laboratories of Canada (ULC)

.1 CAN/ULC-S531-[2002], Standard for Smoke Alarms.

.4 National Fire Protection Agency

.1 NFPA 72-[2002], National Fire Alarm Code.

.2 NFPA 90A-[2002], Installation of Air Conditioning and Ventilating Systems.

.5 National Electrical Code (NEC)

.1 NEC Article 760, Fire Alarm Systems

.2 MATERIALS

.1 Smoke alarms: to CAN/ULC-S531. To Include CO detector.

.3 POWER SUPPLY

.1 120 V, ac, 60 Hz input, 24 V dc output from rectifier to operate alarm and signal circuits, with standby power of gell cell batteries minimum expected life of 4 years, sized in accordance with NBC. See Solar Decathlon Building Code rules 6-5 and 6-6 for further information.

.4 AUTOMATIC ALARM INITIATING DEVICES

.1 Open-Area Smoke Detectors: provide detectors designed for detection of abnormal smoke densities.

.1 Combine smoke and CO detectors to be connected to AC system, and provided with integral battery back up.

.2 All alarms shall be interconnected and shall sound when one is activated.

.3 Provide necessary control and power modules required for operation integral with control panel.

.4 Equip each detector with visible indicator lamp that will flash when detector is in normal standby mode and glow continuously when detector is activated.

.5 Each detector: plug-in type with tab-lock or twist-lock, quick disconnect head and separate base in which detector base contains screw terminals for making wiring connections.

.5 ALARM INITIATING DEVICE SPACING AND LOCATION

.1 Detector spacing and location: in accordance with manufacturer's recommendations and requirements of NFPA 72.

.2 Located according to Architectural Reflected Ceiling Plan.

.6 WIRING

.1 Wire for 120 V circuits: No. 12 AWG minimum solid copper conductor. Wire for low voltage DC circuits: No. 14 AWG minimum solid copper conductor

.2 Insulation 75 degrees C minimum with nylon jacket.

.3 Colour code wiring.

Execution

.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

.2 INSTALLATION

.1 Locate and install detectors and connect to alarm circuit wiring. Do not mount detectors within 3 feet of air outlets. Maintain at least 24 inch radius clear space on ceiling, below and around detectors.

.3 FIELD QUALITY CONTROL

.1 Site Tests:

.1 Perform tests in accordance with Section 26 05 00 - Common Work Results - for Electrical.

.2 Fire alarm system:

.1 Simulate grounds and breaks on alarm and signalling circuits to ensure proper operation of system.

.4 CLEANING

.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

Team North
University of Waterloo
Ryerson University and
Simon Fraser University
NORTH HOUSE
7 Melville Street South | Cambridge, Ontario | N1S 2H4
(519) 888-4567 Ext. 27652 | mail@team-north.com

5.0 Structural Calculations

BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE INDEX	Project No. 080245	Date 09/03/04
			Designed By CAZ	Scale
			Checked By	Sheet No.

A. DECK FRAMING + FOUNDATIONS

B. WIND

C ROOF FRAMING

D FLOOR FRAMING

E DENSE PACK - 4 POINT SUPPORT FOR CRANING

F LATERAL

G WALLS/POSTS

H BRACKETS @ BASE

J PV RACKING SYSTEM

K FOOTINGS

L HSS FRAME

LICENSED PROFESSIONAL ENGINEER
C. A. ZURELL
PROVINCE OF ONTARIO

This seal applies for the enclosed calculation package for the design of the North House structure.

BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE	Project No. 080245	Date 09/03/04
			Designed By CAR	Scale
			Checked By	Sheet No. A1

DECK $w_2 = 2.4$ kPa

MATERIALS → CEDAR - NOR - ASSUME #1/#2

WEIGHT OF 8'x12' PANEL

→ $\frac{5}{4}$ DECKING → ASSUME 38mm — 0.13 kPa

FRAMING → 2x8 @ 16 → 0.06 kPa

$(0.13+0.06)(2.4 \times 3.6) = 1.64$ kN

369 lbs

÷4 = 92 lbs/PERSON

→ JOISTS $w_D = 0.13$ kPa (CEDAR DECKING)

$l = 8'$ (2.4m) → 2x8 @ 400 o/c ✓

WET

$l = 12'$ (3.66m) → 2x10 @ 400 o/c

→ HEADERS $w_D = 0.13 + 0.08$ (2x10) $= 0.21$ kPa

WET SERVICE

$l = 8'$, T/W = 1.8m → 2-2x10 $\frac{M}{m} =$ 2% OVER ✓

$l = 12'$, T/W = 1.2m → 2-2x12 $\frac{M}{m} =$ 14% OVER ✗

$l = 10'$ (3m), T/W = 1.2m → 2-2x10 $\frac{M}{m_1} =$ 9% OVER ✓
→ OKAY WILL ACCEPT

$l = 8'$, T/W = 1.2m → 1-2x12 OR 2-2x8

BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE DECK FRAMING	Project No. 080245	Date 09/05/11
			Designed By CKZ	Scale
			Checked By	Sheet No. A2

REVISE TO COLD FORMED STEEL
≥ 16 GA (1.5 mm)

$w_L = 2.4\,kPa$

$w_D = 0.5\,kPa$

JOISTS → $l = 8'$ MAX (2.44 m)

@ 600 o/c

$M_f = \frac{(4.2)(0.6)(2.4)^2}{8} = 1.8\,kNm$

$V_f = 3\,kN$

$I = \frac{2.4(0.6)(5)(360)(2400)^3}{384E} = 0.467E6\ \text{mm}^4$

102S41-144ml (2.36 kg/m)

$M_{rx} = 2.9\,kNm$

$I_{xe} = 0.47E6\ \text{mm}^4$

HEADERS $l = 9'$ (2.74)

$T/w = 1.2\,m$

$M_f = 4.8\,kNm$

$I = \frac{5(2.4)(1.2)(360)(2740)^3}{384E} = 1.39E6\ \text{mm}^4$

203S41-144ml (3.57 kg/m)

$M_r = 6.7\,kNm$

$I_{ex} = 2.4E6\ \text{mm}^4$

BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE WIND	Project No. 080245	Date 07/03/09
			Designed By CHR	Scale
			Checked By	Sheet No. B1

CAMBRIDGE - WIND → 0.35 ROUGH TERRAIN
TORONTO ? → q_{50} = 0.53 → 29 m/s →

WASHINGTON → THREE SECOND WIND GUST
= 90 mph (40 m/s)
EXPOSURE B

SEISMIC ? → NO UNLESS VANCOUVER IS TO BE CONSIDERED

BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE ROOF FRAMING	Project No. 080245	Date 09/05/09
			Designed By CAR	Scale
			Checked By	Sheet No. C1

LOADING: SNOW 1.68 kPa

DL 0.2 kPa - SOLAR PANELS (73 kg TOTAL WEIGHT)
0.1 kPa - FRAMING FOR PV

0.1 kPa ROOFING
0.1 kPa RIGID INSUL.
0.1 kPa ~~SHEATHING~~
0.1 kPa JOISTS
0.1 kPa INSULATION
0.1 kPa CEILING
0.1 STUFF
1.0 kPa

JOISTS → $l = 10'$ - 2x10 @ 24" o/c IF NOR
2x8 @ 24" o/c IF SPF

BEAMS $l = 21.8$ m
T/W = 5'-0

$w_L = 1.68$ kPa
$w_D = 1.2$ kPa

89x235
2.0E-3100 LVL OK

$\Rightarrow \frac{M_f}{M_r} = 0.57$

$\frac{\Delta}{\Delta} = 0.89$

BLACKWELL • BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE REDESIGN	Project No. 080245	Date 09/05/11
			Designed By CAL	Scale
			Checked By	Sheet No. C2

LOADING

ROOF { $w_{SNOW} = 1.68 kPa$
$w_{DEAD} = 1.0 kPa$

→ JOISTS → 2×8 @ 24"/c

→ SHEATHING → 12.5 mm PLYWOOD

→ BEAMS $l = 6.8 m$
T/W = 2.26 m

4 PLY 44×184 (OK)

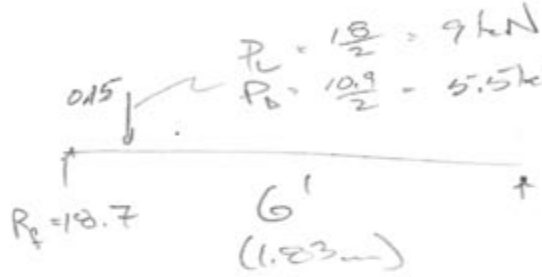
T/W = 4.8 m
S = 18 kN
D = 10.9 kN

28.9 kN

BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE ROOF FRAMING	Project No. 080245	Date 04/03/11
			Designed By CAL	Scale
			Checked By	Sheet No. C

@ DENSEPACK

→ ROOF PANELS FLY OVER



$w_f = 2.75\,kN/m$

$3\frac{1}{2} \times 3\frac{1}{2}$ LVL

$S_x = 117495\,mm^3$ $\qquad F_b = 4805\,psi \times 4.448 \times \frac{1}{25.4^2} = 33\,MPa$

$M_r = \phi F_b S K_{Zb} K_L$

$= 0.9(33)(117495)\left(\frac{12}{3\frac{1}{2}}\right)^{0.136}(1)$

$= 4.1\,kNm$

$V_r = \phi F_v \frac{2A}{3} K_{Zv}$ $\qquad F_v = 530\,psi = 3.65\,MPa$

$= 0.9(3.65)\left(\frac{2}{3}(89 \times 89)\right)(1)$

$= 17.3\,kN$

USE HSS 89 × 89 × 4.8

BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE FLOOR FRAMING	Project No. 4802445	Date 09/03/04
			Designed By CAL	Scale
			Checked By	Sheet No. D1

LOADING LL 2.4 kPa

DL 0.3 kPa FINISHES
0.1 kPa PLYWOOD
0.1 kPa JOISTS
0.1 kPa INSUL
0.1 kPa SHEATHING
0.7 kPa

JOISTS $l = 10'$ (3m) 2x8 @16" o/c
SPF #1/#2

BEAMS $l = 4.8$ m 89x286
T/W = 5'-0 2.0E-5100LVL

$l = 2.4$ m/2.4 m 2 CONTINUOUS
→ 44x184 LVL

→ 4.8 → TRANSPORT → 89x184 LVL

→ BEAM ALONG EDGE SUPPORTING WINDOW

→ $l = 4.8$
T/W = 5'-0
$w_{SDL} = 0.5(3) = 1.5$ kN/m

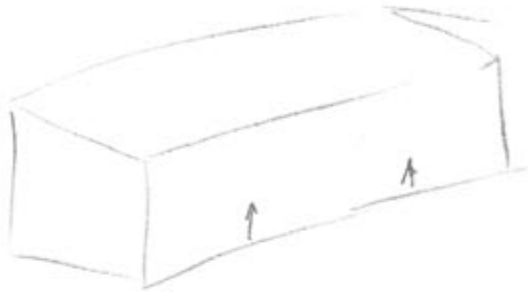
→ 89x286 STILL OK

→ BEAM AT DENSE PACK

$l = 10' = 3$ m
T/W = 1 m
$w_S = 1.8 + 2.4 =$ wi
$w_D = 1.2 + 1 + 1.5 =$

89x184 ok

BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE CRANNING DENSEPACK	Project No. 080245	Date 09/03/04
			Designed By CAZ	Scale
			Checked By	Sheet No. E1



ROOF: 1 kPa

WALLS: 0.5 kPa

FLOOR: 1.0 kPa

P. T/A = 4'×6' → 2.2 m² → $P_D = 4.4 + 2(3)\frac{(0.5)}{2}$

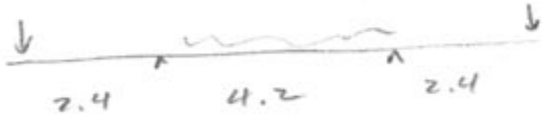
$= 4.4 + 1.5\,kN$

$= 5.9$

$2\times \times 1.4 = 8.3\,kN$

$w = \left(0.5(3) + (1+1)\left(\frac{2}{2}\right)\right) \times 1.4$

$= 4.9\ kN/m$



2× | 89×286 2.0E LVL 3100Fb |

$\frac{w_1}{w_1} = 0.97$

$\frac{\Delta}{\Delta} = 0.87$

OK

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			Designed By CAZ	Scale
			Checked By	Sheet No. F 1

→ IBC → 3 sec GUST - 90mph

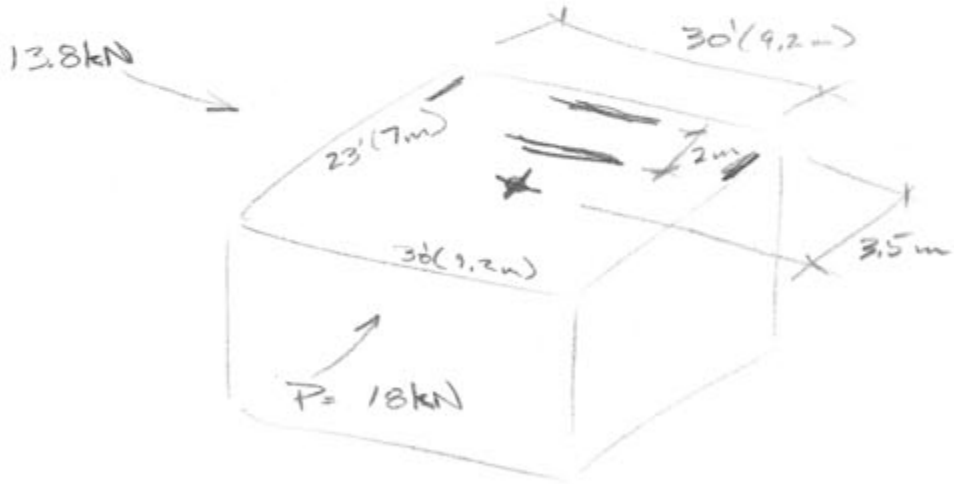
$p_s = \lambda I_w p_{s30}$ $= \lambda = 1$, $I_w = 1$ $p_{s30} = 12.8$ psf → 0.61 kPa

→ OBC → $q = 0.53$ kPa (TORONTO)

$C_e = 0.7$

$C_p C_g = 1.15 + 0.8 = 1.95$

$p = 0.72$ kPa



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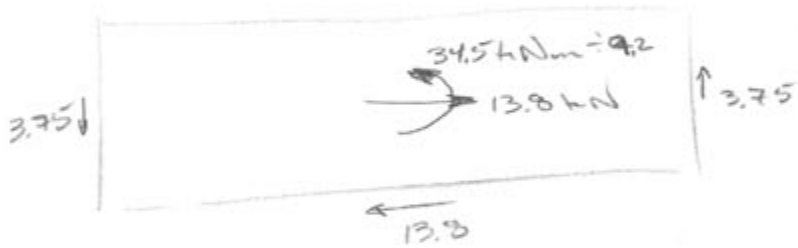
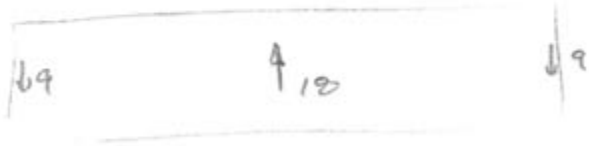
			Designed By CAE	Scale
			Checked By	Sheet No. F2





SHEAR WALL SEGMENT → 6' WIDE × 10' TALL

$P_w = 9\,kN \rightarrow$

$P_f = 12.7\,kN$

$K_D = 1.15$

$K_{SF} = 1$

$J_h = 1$

$J_b = 1.0$ USE BLOCKED PANEL

$J_{hd} = 1.0$

$v_f = \frac{12.7}{1.8} = 7\,kN/m$

→ THEY ARE USING PLYWOOD SHEATHING - 15.5mm

→ 15.5mm PLYWOOD ON SPF STUDS
- BLOCKED.
- NAILS - 3" COMMON NAIL @ 100 % c $v_f = 8.95$

→ COULD ALSO USE
9.5mm PLYWOOD w/ 2½" NAILS @ 75 % c

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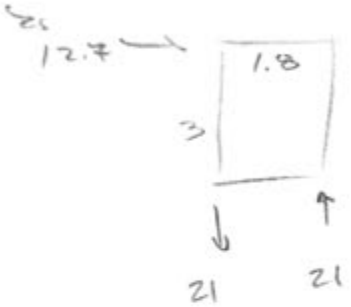
			Checked By	Sheet No. F3

- HOLD DOWNS



DL CONTRIBUTION?

→ LONG DIRECTION

$P_w = 13.8$

$P_f = 19.3\,kN$

$l_{wall} = 5\,m \rightarrow v_f = 3.86\,kN/m$

→ 9.5mm SHEATHING
w 2½" NAILS @ 150mm o/c

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			Checked By	Sheet No. F4

EACH END

$M_o = 38 kNm$

$M_r \Rightarrow$ S/W → WALLS → $(8.2 \times 2 + 1.8 \times 2)(0.5) \cdot 3 = 33 kN$

FLOOR $(9.2 \times 1.8)(0.5) = 8 kN$

ROOF → NEGLECT DUE TO UPLIFT

$M_r = 0.9(33 + 8)(0.8) = 33 kNm$

TIE DOWN FOR BALANCE

$\Rightarrow \frac{38 - 33}{1.8} = 2.8 kN$ (624#)

ABS ALASKAN

⇒ 18" SCREW TYPE

⇒ 15" EARTH ANCHOR - HELICAL

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			Designed By CAL	Scale
			Checked By	Sheet No. G1

→ BUILT UP STUDS @ BEAM LOCATIONS

→ P_f ⇒ $w_L = 1.68$ kPa
$w_D = 1.0$ kPa

T/A = 10' × 11' = 110 ft² = 10.2 m²

$P_f = 10.2(1.5(1.68) + 1.25(1.0))$
$= 38.4$ kN → MIN $\boxed{2\text{-}2\times6}$

→ LINTEL OVER DOORWAYS

→ $3\frac{1}{2} \times 5\frac{1}{2}$ LVL

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			Designed By CKZ	Scale
			Checked By	Sheet No. G

→ COLUMNS @ EDGE OF ROOF

T/A = 2.4m × 3m = 7.2m²

$w_L = 1.65$ kPa

$w_D = 1.2$ kPa

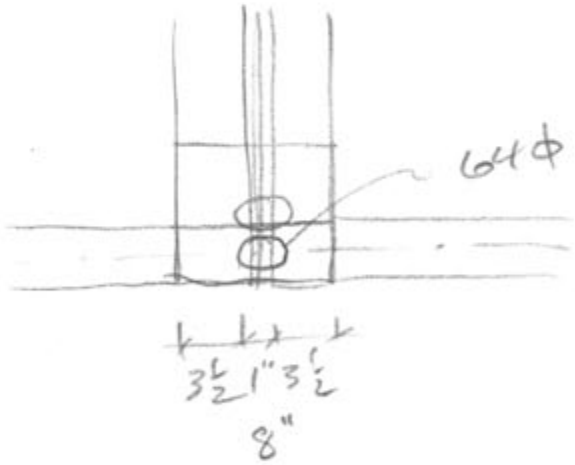
$P_R = 29$ kN

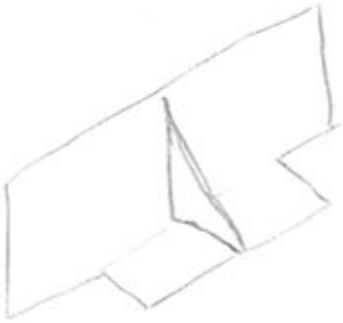
$h = 3$ m

} HSS 64 × 64 × 4 OK

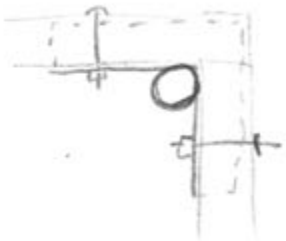
2> BEARING → $q_r = 0.5$ kN/m ON 89 WIDE D.F.L.R

BEARING OK





BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE BRACKETS TO SUPPORT STRUCTURE	Project No. C802445	Date 09/03/10
			Designed By CAZ	Scale
			Checked By	Sheet No. 4



MAX LOAD: G5, J5

ROOF T/A = 10×11 = 110 ft² = 10.2 m²

WALL T/A = 3.5(10) = 35 ft² = 3.2 m²

FLOOR T/A = 10×8' = 80 ft² = 7.5 m²

w_S = 1.68 kPa

w_L = 2.41 kPa

w_D = 1.0 kPa ROOF

0.5 kPa WALLS

0.7 kPa FLOOR

P_L = 18 kN P_S = 17.1 kN P_D = 1(10.2) + 0.5(3.2) + 1.0(7.5) = 19.3 kN

P_T = 19.3 + 18 + 0.5(17.1) = 46 kN

P_f = 1.5(18) + 1.25(19.3) + 0.5(17.1) = 60 kN

M_f = 60(0.044) = 2.64 kNm

Z = 9778 mm³

b = 400, t = 9.9 mm

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			Checked By	Sheet No. J1

$w_{snow} = 1.68$ kPa - CAMBRIDGE

NBCC $q_{50} = 0.53$ kPa - TORONTO → 29 m/s

ASCE-7 $V_{3sec} = 90$ mph - WASHINGTON

AREA = 4.3' × 10' = 43 ft²

$p_{net30} = 5.6$ psf / −14.2 psf (20 ft²)

$p_{net} = p_{net30}(1)(1)(1)$

→ CONTROLLING LOAD → D+S $P = 1.68 + 0.2 = 1.88$ kPa = 39 psf

$w = 4.3'(39) = 168$ plf

∴ ALLOWABLE SPANS = 6' USING DOUBLE-L SUNFRAME SERIES RAIL

→ PURLINS

$l = 10'$ (3 m) $w_L = 1.68$ kPa
T/W = 6' (1.8 m) $w_D = 0.5$ kPa } $w_p = 3.1$ kPa

$w_f = 3.1(1.8)(3)^2/8 = 6.3$ kNm

$EI = 1.91E11$ Nmm²

steel $I = 0.96E6$ — "

→ USE 2x6 SPF #1/#2 PRESSURE TREATED @600 o/c

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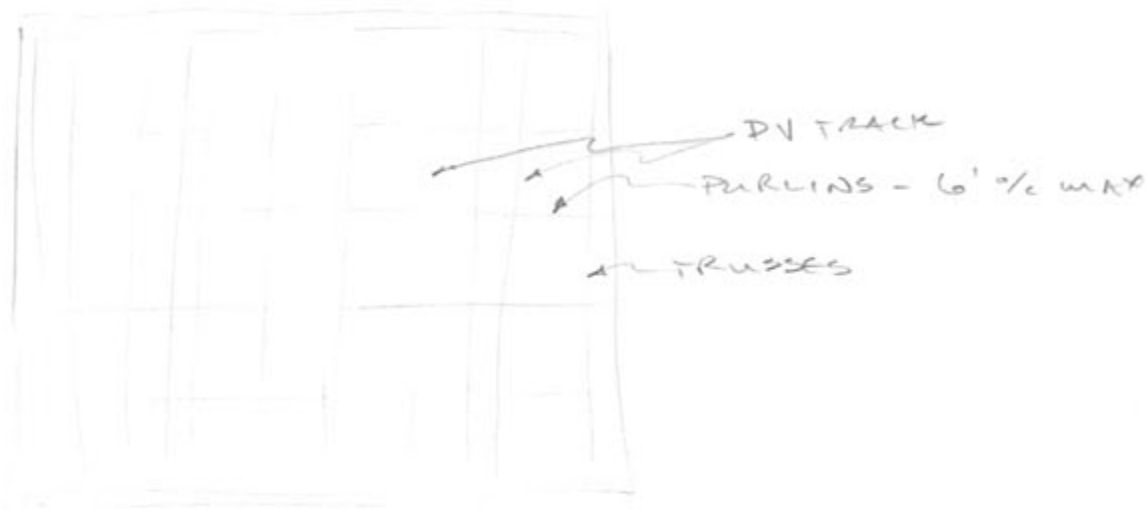
			Designed By CAZ	Scale
			Checked By	Sheet No. J2



PURLINS $\approx l = 7'-5'' = 2.26\,m$

$T/W = 1.8\,m$

$w_L = 1.68$

$w_D = 0.5$

$M_f = 1.6\,kNm$

LL $\left(\frac{l}{360}\right)$ $EI = 164\,E9\,Nmm^2$ $I = 0.82\,E6\,mm^4$

LL $\left(\frac{l}{180}\right)$ $EI = 82\,E9\,Nmm^2$ $I = 0.41\,E6\,mm^4$

HSS 64 x 64 x 3.2

$I = 0.441\,E6\,mm^4$

$M_r = 5.23\,kNm$

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			Designed By CAL	Scale
			Checked By	Sheet No. J3

ROOF "TRUSS"

T/W = 7'-5 = 2.26 m

$w_L = 1.68\,kPa \rightarrow 3.8\,kN/m$

$w_D = 0.5\,kPa \rightarrow 1.2\,kN/m$

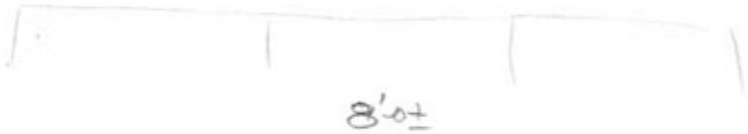
$l = 16' = 4.8\,m$ $\quad M_f = 205\,kNm$

$$I = \frac{5(360)(1.68)(2.26)(4800)^3}{384E}$$

$= 9.866\,mm^4$

080245t1.pop →
VEIRENDEEL TRUSS

OR



$M_f = 5.2\,kNm$

$$I = \frac{5(360)(3.8)(2400)^3}{384E} = 1.246\,mm^4$$

HSS 76 □ x 6.4
$I = 1.31E6\,mm^4$

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			Checked By	Sheet No. J4

RE CHECK ROOF BEAMS FOR ADDITIONAL POINT LOADS

$P_1 = T/A = 2.26 \times 1 = 2.26\ m^2$

$P_L = 1.68(2.26) = 3.8$ kN

$P_D = 0.3(2.26) = 0.7$ kN

$P_2 = T/A = 2.26 \times 2.2 = 5\ m^2$

$P_L = 8.4$ kN

$P_D = 1.5$ kN

$P_3 = T/A = 2.26 \times 2.4$ $P_L = 9.1$ kN

$P_D = 1.6$ kN

$P_4 = T/A = 2.26 \times 1.5$ $P_L = 5.7$ kN

$P_D = 1$ kN

4-44x184 LVL OK

BLACKWELL · BOWICK STRUCTURAL ENGINEERS Suite 405 19 Duncan Street Toronto, Ontario M5H 3H1 T 416-593-5300	Seal	Title NORTH HOUSE FOOTINGS	Project No. 080245	Date 09/04/30
			Designed By CHL	Scale
			Checked By	Sheet No. K1

FOOTINGS

MAX BEARING = 75 kPa

ALONG LINE 4, 5, 7, ~~8~~

@ ~~8~~ → ROOF = T/A = 7'-5 × 7'-11 = 5.4 m²

P_S = 9 kN P_D = 5.4 kN

FLOOR T/A = 7'-5 × 7'-11/2 = 2.7 m²

P_L = 6.5 kN P_D = 2.7 kN

WALL/BLINK → h = 4 m WINDOW BLIND

P_D = 4(2.26)(0.5) + 0.5(2.26)

= 5.6 kN

ADD DECK

P_L = 7.9

P_D = 1.6

P_S = 9 kN P_L = ~~6.5~~ 14.4 P_D = ~~13.7~~ 15.3

P_T = ~~29~~ 34 kN P_f = 45

$\frac{34}{75}$ ⇒ 0.39 m² → 0.62 m × 0.62 m (67 × 67)

~~28~~ × ~~28~~ 30"

@ 7 FLOOR T/A = 7'-5 × 7'-11 = 5.4 m

P_L = 13 P_D = 5.4

P_T = $\frac{18}{75}$ → 0.25 m² ≈ 0.5 × 0.5

@ 4 T/A = 2.26 × 1.1 = 2.5 m²

ROOF: P_S = 4.2 P_D = 2.5

FLOOR P_L = 6 P_D = 2.5

WALL 4(2.26)(0.5) = 4.5

~~DECK~~ P_L = 7.9 P_D = 1.6

P_L = 13.9 P_S = 4.2 P_D = 11.1

P_T = ~~17.6~~ 27 kN

P_f = ~~23~~ 37 kN

~~20" × 20"~~ 2' × 2'

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			Checked By	Sheet No. K2

5 ROOF $P_s = 18$ $P_D = 11$

FLOOR $T/A = 2.26 \times (1.2 + 1)$
$= 5 m^2$

$P_L = 12$ $P_D = 5$

WALLS $(2.26 \times 4)(0.5) = 4.5$

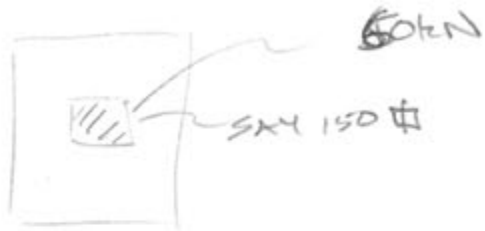
$P_T = 50 kN$

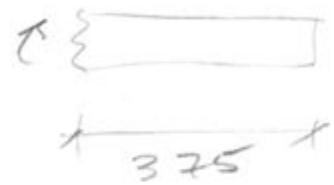
$\frac{50}{75} = 0.67 m^2 \rightarrow 0.82 \times 0.82$ OK

1.5 S + 0.5 L + 1.25 D

$P_f = 60 kN$

DADS 3' x 3' 0.9 x 0.9 m





$M_f = 1.2(75)\frac{(.375)^2}{2} = 6.3 kNm/m$

TRY 76 THICK

$S = \frac{1000(76)^2}{6} = 0.962 E6 mm^3$

$\sigma = \frac{M}{S} = 6.5 MPa$

COMPARE TO $\sigma = \frac{0.85(1700)(1000)}{\left(\frac{31.5^2(1000)}{6}\right)} = 9.7 MPa$
31.5 mm PLY WOOD

OK

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			Checked By	Sheet No. K3

DECK

→ TYPICAL LOADS

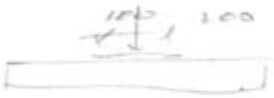
$w_c = 2.4$
$w_s = 0.5$

$T/A = 8' \times 9' = 6.7\,m$

$P_T = 19.4\,kN$ (4.37 kips)

$P_f = 28.3\,kN$

$\frac{19.4}{95} = 0.259 = 0.508 \rightarrow 20''\,\phi$



$M_p = 2.18\,kNm/m$

WEAK DIRECTION 31.5 — PLY WOOD $M_r = 0.95(1700)(1000) = 1.6\,kNm/m$

→ USE 3-185 mm LAYERS LAMINATED

STRONG → $M_r = 2.66\,kNm/m$

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			Checked By	Sheet No. L1

HSS FRAME FOR ERECTION PURPOSES

→ HSS 3×3

	M_r	I	S
HSS 76 □ × 4.8 →	10.8 kN m	1.08E6 mm⁴	28.5E3
HSS 76 □ × 6.4 →	13.5 kN	1.31E6 mm⁴	34.5E3

→ ALONG EDGES → CANT. PICKS UP DECKING

LOAD ON TIP: T/A = 4.5' × 8' = 36 □'
3.3 m²

$P_L = 2.4(3.3) = 7.9\,kN$

$P_D = 0.5(3.3) = 1.6\,kN$

$M_f = 0.3(13.8) = 4.1\,kN\,m$ (WAX)

$\Delta = \frac{7900(300)^3}{3EI} = 0.3\,mm$

→ WITH HOLES

$S_x = \frac{4.8(76)^2}{6} \times 2 = 9242$

I =

$S_x = 28.5E3 - \frac{38[(76)^2-(66.4)^2]}{6} = 19.8E3\ mm^4$

$M_r = 6.2\,kN\,m > M_f$ OK

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6.0 Water Budget

6.1 Detailed Water Budget

Competition Water Use Budget

Time	Activity	Duration (min.)	Volume of Water (L)
Day 1:			
7:30 am – 10:30 am:	Dishwashing	5	9.8
8:30 am – 11:30 am:	Clothes Washing	12	51.3
9:30:00 AM	Shower	10	56.8
11:30:00 AM	Shower	10	56.8
Day 2:			
10:30:00 AM	Shower	10	56.8
3:30 pm – 9:30 pm:	Clothes Washing (2 load)	48	102.6
5:30:00 PM	Shower	10	56.8
9:00:00 PM	Shower	10	56.8
Day 3:			
5:30:00 PM	Shower	10	56.8
6:00:00 PM	Shower	10	56.8
6:30 pm – 9:30 pm:	Dishwashing	5	9.8
Day 4:			
9:30:00 AM	Shower	10	56.8
5:30:00 PM	Shower	10	56.8
6:00:00 PM	Shower	10	56.8
Day 5:			
8:30:00 AM	Shower	10	56.8
3:30 pm – 9:30 pm:	Clothes Washing (2 load)	48	102.6
6:30:00 PM	Shower	10	56.8
Day 6:			
8:00 am – 11:00 am:	Clothes Washing		51.3
8:30 AM	Shower	10	56.8
3:00 pm – 6:00 pm:	Dishwashing	5	9.8
3:30 PM	Shower	10	56.8
4:30 PM	Shower	10	56.8
Day 7:			
10:00 am – 4:00 pm:	Clothes Washing (2 load)	48	102.6
10:30 AM	Shower	10	56.8
11:00 am – 2:00 pm:	Dishwashing	5	9.8
3:00 PM	Shower	10	56.8
Day 8:			
9:00 AM	Shower	10	56.8
9:30 AM	Shower	10	56.8
3:30 am – 9:30 pm:	Clothes Washing (2 load)	48	102.6
4:00 PM	Shower	10	56.8
6:30 pm – 9:30 pm:	Dishwashing	5	9.8
	Totals		1698 litres
			448.27 gal

To be supplied with 2 potable supply water tanks @ 1,230L **(325 gal)**

Total Water Requirements

	Volume of Water (L)
From Potable Tanks	
Competition Water Use	1698
Pond daily evaporation	240
Other	520
From Extra Tank	
Pre-Heat Tank	416
Space Heating	115
DHW	150
Solar Thermal Collectors(3)	30
TOTAL (litres)	3169
TOTAL (gallons)	**836.62**

Water to be supplied on water delivery day

Pond	900
Potable Supply Tank 1	1230
Potable Supply Tank 2	1230
Extra Tank	1066.5

- A shower has been set as a 10 minute, 56.8 L draw of water.
- Dishwashing has been set as a 5 minute, 9.8 L draw of water.
- Clothes washing has been set as a 12 minute 56.8 L draw of water.
  Where consecutive clothes washing competitions are scheduled, a 48 minute 120 L draw of water has been simulated.

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Ryerson University and
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7.0 Summary of Unlisted Electrical Components

7.0 Summary of Unlisted Electrical Components

Schuco Prosol Glass Encapsulated BIPV

Within the North House project, all components comprising electrical scope of work are listed by ULC with the exception of the Schuco Prosol BIPV Panels that form the exterior rainscreen of the building.

Although this product as a total assembly has not been listed, the various sub-components that are used by Schuco to construct this product are UL Listed.

Panels are comprised of 5" mono crystalline cells encapsulated in laminated 6mm glazing (1/4"). [Refer to Section 8.0 of this manual for detailed quotation indicating product components].

Electrical Connectors (Solar Inverter Connectors, and LC Connectors) are by Huber & Suhner (www.hubersuhner.ca). These connectors are listed under UL 94-HB and UL 94-VO. Wire and cable is by Tyco Electronics Corp. Raychem: Spec 44. This product is listed under UL 1385, and UL 1564 / CSA Class 5851, File 41234.

We believe that all components of this product are in isolation Listed, and therefore in aggregate,comprise a appropriate assembly for use in the Solar Decathlon. If further discussion of this matter is required, please contact Team North at mail@team-north.com

Wire and Cable

SPEC 44® Wire and Cable

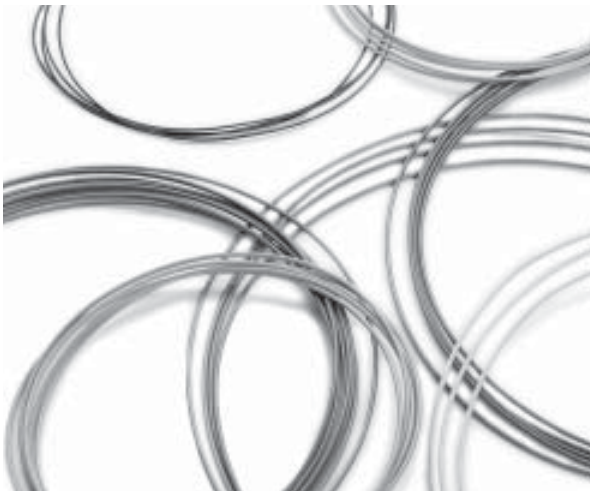
High-performance wire and cable insulation system for –65°C to 150°C

Applications

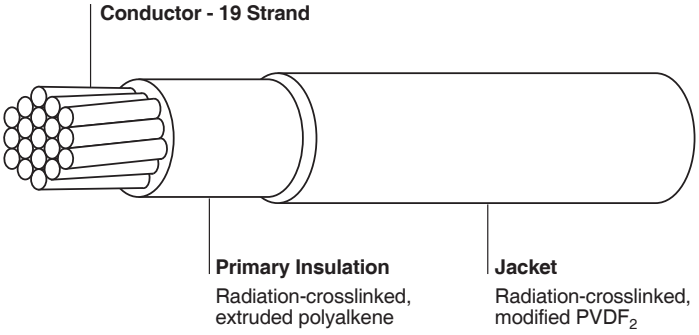
Hookup and signal wire and cable used in aircraft, avionics, military electronics, satellites, helicopters, ships, mass transit, offshore platforms, and automobiles.

Features/Benefits

- Operating temperatures of –65˚C to 150˚C.
- Dual-wall constructions.
- Small size, light weight.
- Exceptional chemical resistance.
- Mechanical ruggedness.
- Excellent shop handling and flexibility.
- Choice of marking with hot stamp or ink jet.
- Pottable insulation system.
- Solderable conductor.
- Resistance to electrical arc tracking in wet or dry conditions.
- Primary wire and cable configurations.
- 600-, 1000-, and 2500-volt constructions.



SPEC 44 Insulation System



Specifications

UL	CSA	Military	Industry	Agency	Raychem
1385	Class 5851 File 41234	MIL-W-81044, MIL-C-27500 (cables)	Lloyds Register of Shipping	VG88929, VG95211, and VG95218 Part 1000	Raychem SPEC 44
1564		Def. Stan. 61-12, Part 18, Issue 2, Type 1		MTV6145-005	
		Def. Stan. 61-12, Part 26		NASA preferred product list	
		British Standard G233		MSV34401	
				Civil Aviation Authority Accessory Approval E11623	
				European Space Agency 3901/011 and 3901/012	

ONLINE CERTIFICATIONS DIRECTORY

YDTU2.E85381
Miscellaneous Tubing, Polymeric - Component

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Miscellaneous Tubing, Polymeric - Component

See General Information for Miscellaneous Tubing, Polymeric - Component

TYCO ELECTRONICS CORP
305 CONSTITUTION DR
MENLO PARK, CA 94025 USA

E85381

Cat. No.	Max V	Max Oper Temp	Shrinkdown Class	Col Recognized	Oil Resistance * Class	Flame Rating
Heat shrinkable silicone rubber (SIR) tubing.						
SRFR	600	200	II	GY	—	#
Heat shrinkable molded parts.						
XXXXXXX-3	600	125	N/A	Black	—	$
XXXXXXX-4	600	125	N/A	Black	—	$
Semi-rigid polyolefin tubing.						
CRN-B, CRN-B-NR, CRN-B-540-0	600	125	I	+	—	##
Heat shrinkable tubing provided in cut lengths.						
SCL, PD	600	125	N/A	+	—	$
TC	600	125	N/A	+	—	$
TAK	600	125	N/A	BR	—	$
TAT-125	600	125	N/A	+	—	$
Semi-Rigid Heat Shrinkable Polyolefin Tubing.						
ES2000	600	125	N/A	BK	—	$
ES1000@	600	125	N/A	CL	—	$
ATUM	600	110	N/A	BK	—	$
PLDW100, PLDW104	600	110	N/A	BK	—	$
RBK-ESS	600	125	N/A	BK,CL	—	$
ES-Cap%	600	125	N/A	BK,CL	—	$
Heat shrinkable modified flexible fluoropolymer tubing.						
RT-555, -555HW-300-0-50MM	600	185	1	BK	—	#
Heat shrinkable flexible polyolefin tubing.						
91385-X	600	125	I	BK	—	#
CGAT	600	80	I	All	—	$
G4	300	125	I	+	—	#
Versafit V4	300	125	I	+	—	#
ZH4	300	125	I	BK	—	#

*-Tubing is considered to comply with the optional oil resistant requirements only if it is so marked.

#-Tubing is considered to comply with the optional VW-1 flammability requirements only if it is so marked.

##-Tubing is considered to comply with the All-Tubing flame test.

$-Flammability rating not determined.

+-All except clear.

@-Clear color tubing catalog number followed by a suffix number 1 thru 4 indicating size.

%-Black color tubing catalog number followed by a suffix number 1 thru 5 indicating size.

X - Represents numbers 1, 2, 3 or 4.

Marking: Company name or "E85381" or tradenames "RAYCHEM", "Thermofit", catalog number, voltage rating, temperature rating in degrees C, and inside diameter (before and after recovery), shall be marked on tags attached to both ends of the tubing, on the shipping spool label or on the smallest unit container.

Last Updated on 2008-03-20

Questions? Notice of Disclaimer Page Top

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8.0 Retail PV Price Quotes

DAY4 ENERGY

12/12/2008

Michael Wassner, Primary Reviewer
Solar Decathlon Organization Committee
c/o Michael Collins PRC 3009
University of Waterloo
200 University Avenue West
Waterloo, Ontario, N2L 3G1

Dear Mr. Wassner,

Day4 Energy is pleased to support Team North and North House in the 2009 Solar Decathlon. As a manufacturer of high performance photovoltaic modules, our ultimate goal is to enable access to solar energy and support initiatives that raise awareness about the power of renewable technologies.

I would like to confirm that the Day4® 48MC photovoltaic modules that will be used by Team North for this competition are accessible at a price not exceeding $10 USD per peak watt at STC. They are currently in production and commercially available.

Sincerely,

Jake Brown
Vice President of Business Development and Marketing

Day4 Energy Inc.
#401, 4621 Canada Way
Burnaby, BC, Canada, V5G 4X8
office 604.297.0444
fax 604.297.0445

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SCHÜCO

Project: North House
Document: QT/1001/0906-3
Page: 1 of 3
Date: 5/11/2009

Recipient: **Mr. Chris Black**
HBAS, MArch Candidate, LEED-AP
Team North
t: 519.888.4567x27652
e: chris.black@team-north.com

Ship to (if other than Recipient):

CUSTOMER SERVICE
William Mendoza
Schuco USA L.P.
240 Pane Road
Newington, CT 06111
Phone: (860) 616-0215
Fax: (860) 616 2359
E-mail: wmendoza@schuco-usa.com

SALES CONTACT:
Helmut Gehle
Phone: (404) 509-1989
E-mail: hgehle@schuco-usa.com

Shipping Method:
EXW Aachen, Germany

Payment Terms:
net 30 if within approved credit limit, otherwise cash in advanced

Pos.	Qty. (PU)	Description		Unit List Price	Total List Price
1	4	Product:	PROSOL® Solar Element Type A	$ 3,478.70	$ 13,914.82
		Dimension:	2609 mm * 965 mm		
		Rated power output:	P_{MPP} = 378,7 watt +/- 10 % (STC),		
		Open circuit voltage:	U_{oc} = 89,2 volt DC V DC (STC),		
		Mpp voltage	U_{MPP} = 73,2 volt DC V DC (STC),		
		Short circuit current:	I_{SC} = 5,8 ampere +/- 10 % (STC),		
		Mpp current	I_{MPP} = 5,2 ampere +/- 10 % (STC),		
		Cell type:	5" mono crystalline black,		
		Cell layout:	19 * 7 = 133 Solar cells,		
		Cell distance:	2 mm horizontally / 2 mm vertically,		
		Edge distance:	99 mm horizontally / 39 mm vertically,		
		Glass setup:	6 mm semi-tempered glass low iron		
		Cell distance:	2 mm horizontally / 2 mm vertically,		
		Edge distance:	99 mm horizontally / 39 mm vertically,		
		Glass setup:	6 mm semi-tempered glass low iron 2 mm resin with solar cells 5 mm semi-tempered glass clear with Full area screen print RAL 9005 (black) on layer 4.		
		Total thickness:	13 mm		
		Electr. connection:	Edge connector, bypass-diodes on the glass edge, 10 mm on the edge. Connectors Huber & Suhner.		
		Weight:	74 kg		
2	8	Product:	PROSOL® Solar Element Type B	$ 3,092.71	$ 24,741.65
		Dimension:	2311 mm * 965 mm		
		Rated power output:	P_{MPP} = 338,5 watt +/- 10 % (STC),		
		Open circuit voltage:	U_{oc} = 79,8 volt DC V DC (STC),		
		Mpp voltage	U_{MPP} = 65,5 volt DC V DC (STC),		
		Short circuit current:	I_{SC} = 5,8 ampere +/- 10 % (STC),		
		Mpp current	I_{MPP} = 5,2 ampere +/- 10 % (STC),		
		Cell type:	5" mono crystalline black,		
		Cell layout:	17 * 7 = 119 Solar cells,		
		Cell distance:	2 mm horizontally / 2 mm vertically,		
		Edge distance:	77 mm horizontally / 39 mm vertically,		
		Glass setup:	5 mm semi-tempered glass low iron 2 mm resin with solar cells 6 mm semi-tempered glass clear with Full area screen print RAL 9005 (black) on layer 4.		
		Total thickness:	13 mm		
		Electr. connection:	Edge connector, bypass-diodes on the glass edge, 10 mm on the edge. Connectors Huber & Suhner.		
		Weight:	66 kg		
Customer Initial:				**Subtotal**	**$ 38,656.47**

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Project: North House
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Date: 5/11/2009

Pos.	Qty. (PU)	Description		Unit List Price	Total List Price
		Subtotal, page 1			**$ 38,656.47**
3	4	Product:	PROSOL® Solar Element Type C	$ 3,114.76	$ 12,459.05
		Dimension:	2413 mm * 965 mm		
		Rated power output:	P_{MPP} = 338,5 watt +/- 10 % (STC),		
		Open circuit voltage:	U_{oc} = 79,8 volt DC V DC (STC),		
		Mpp voltage	U_{MPP} = 65,5 volt DC V DC (STC),		
		Short circuit current:	I_{SC} = 5,8 ampere +/- 10 % (STC),		
		Mpp current	I_{MPP} = 5,2 ampere +/- 10 % (STC),		
		Cell type:	5" mono crystalline black,		
		Cell layout:	17 * 7 = 119 Solar cells,		
		Cell distance:	2 mm horizontally / 2 mm vertically,		
		Edge distance:	128 mm horizontally / 39 mm vertically,		
		Glass setup:	5 mm semi-tempered glass low iron 2 mm resin with solar cells 6 mm semi-tempered glass clear with Full area screen print RAL 9005 (black) on layer 4.		
		Total thickness:	13 mm		
		Electr. connection:	Edge connector, bypass-diodes on the glass edge, 10 mm on the edge Connectors Huber & Suhner		
		Weight:	69 kg		
4	4	Product:	Laminated glass	$ 289.34	$ 1,157.38
		Dimension:	2609 mm * 965 mm		
		Glass setup:	6 mm semi-tempered glass float 0,76 mm PVB Foil 6 mm semi-tempered glass float Full area screen print RAL 9005 (black).		
		Total thickness:	13 mm		
		Weight:	74 kg		
5	4	Product:	Laminated glass	$ 207.14	$ 828.58
		Dimension:	2609 mm * 723 mm		
		Glass setup:	6 mm semi-tempered glass float 0,76 mm PVB Foil 6 mm semi-tempered glass float Full area screen print RAL 9005 (black)		
		Total thickness:	13 mm		
		Weight:	62 kg		
Customer Initial:				**Subtotal**	**$ 53,101.47**

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SCHÜCO

Project: North House
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Page: 3 of 3
Date: 5/11/2009

Pos.	Qty. (PU)	Description		Unit List Price	Total List Price
		Subtotal, page 2			**$ 53,101.47**
6	1	Product:	Laminated glass	$ 217.01	$ 217.01
		Dimension:	2178 mm * 939 mm		
		Glass setup:	6 mm semi-tempered glass float		
			0,76 mm PVB Foil		
			6 mm semi-tempered glass float		
			Full area screen print RAL 9005 (black).		
		Total thickness:	13 mm		
		Weight:	67 kg		

Reference: ISPE reference number 09.13700103.

Delivery time: Approximately 14 weeks after receipt of signed PO and clarification of all technical details. This quote is valid until May 31, 2009. Prices are in USD based on the current USD/EUR exchange rate. Schuco reserves the right to adjust sales prices to reflect exchange rate fluctuations. Actual cell types may vary subject to supply availabilities. Products are subject to supply availability. Schuco USA General Solar Terms and Conditions apply. These items are special ordered and cannot be canceled once an order is placed.

Stuctural calculations are based on standard assumptions. Mounting system design, glass strength and attachment to the building as well as electrical layout and connections have to be performed by an experienced contractor and approved by an engineer in line with local building, weather and code requirements as well as installation sepcific conditions such as, but not limited to, installation altitude, tilt angle, wind loads, etc. We hope this offer meets your expectations. We are looking forward to your response. If you have any questions, please do not hesitate to contact us at your convenience.

I accept this offer and am returning it as purchase order:

Subtotal	**$**	**53,318.48**
Tax		
Packaging	$	600.00
TOTAL VALUE	**$**	**53,918.48**

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9.0 Summary of Reconfigurable Features

9.1 Summary Of Reconfigureable Features

Exteriors

- Vertical wood slats on North Wall are ganged together in a hinged panel where they overlap the full-height shower window. Refer to A-111.
- Exterior shading devices retract and tilt. Refer to A-321.
- Hinged glass panels on the Northwest corner of the house give access to equipment in the unconditioned attic space.
- Three table-mounted umbrellas for employment during inclement weather only.
- Dining tables can be reconfigured to accommodate different sizes and preferences of dinner parties.

Interiors

- Custom bed is vertically retractable to ceiling and operated by mechanized drum winch. Refer to I-501.
- Custom modular sofa can be rearranged to make use of floor area gained by retracting bed to ceiling. Design details not in set.
- Custom work station houses files, printer and has a desktop that lifts and rotates to reveal the laptop computer storage compartment. Design details not in set.
- Custom coffee table houses TV in a horizontal position under glass tabletop. The top then opens to allow the TV tilt into an upright viewing position. Other TV-related/media equipment. Is stored below. Design details not in set.
- The Densepack "Swiss Army Wall" panels on north and west walls are interchangeable. They have a variety of integrated functions – including various hooks, racks, etc. – but are flush when not deployed. Refer to I-502 and I-503.
- Dining table can be extended to seat up to 8 people.
- Interior shades can be drawn for privacy.

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10.0 Grid Interconnection Application

10.1 Grid Interconnect Request Summary Tables

Module Manufacturer	Description	DC rating of Array
Day4	11 x 2 array of MC48-180 on roof	3960
Day4	12 x 2 array of MC48-180 on roof	4320
Schuco	Array of custom BIPV modules 4 x 293.9 W + 2 x 328.5 on West facade	1832.6
Schuco	Array of custom BIPV modules 4 x 293.9 W + 2 x 328.5 on East facade	1832.6
Schuco	Array of custom BIPV modules 4 x 293.9 W on South facade	1175.6

Total connected DC Power of all arrays: 13.1 kW

Manufacturer	Model	Voltage	Rating	Quantity
Xantrex	GT 3.8	240 V AC	3.8 kW	2
Xantrex	GT 2.8	240 VAC	2.8 kW	3

Total connected AC Power of all inverters: 16 kW

PV Equipment Schedule

Module Parameters

Module	**MC-48-180**	**BIPV1**	**BIPV2**	**BIPV3**
Manufacturer	Day4	Schuco	Schuco	Schuco
Wp	180	328.5	293.9	293.9
Power (current) tolerance	+/- 3.5%	+/- 10%	+/- 10%	+/- 10%
Vmp	23.84	68	60.9	60.9
Imp	6.09	4.8	4.8	4.8
Voc	29.10	82.6	73.9	73.9
Isc	6.52	5.4	5.4	5.4
Current temp. coefficient (ma/K)	7.8	0.5%	0.5%	0.5%
Voltage temp. coefficient (V/K)	-0.11	-0.34%	-0.34%	-0.34%
Power temp. coefficient (%/K)	-0.48	-0.5%	-0.5%	-0.5%
Listing	UL 1703, IEC 61215 & 61730	Custom panels, all sub-components UL listed, full panels will be UL certified if required for SD		

Inverter Parameters

Inverter	**Xantrex GT 3.8**	**Xantrex 2.8**
Max AC Power	3800 W	2800 W
Nominal AC output Voltage	240 V	240 V
Max AC output current	15.8 A	11.7 A
Max AC output over-current protection	20 A	15 A
Vdc max	600 V	600 V
MPPT range	195 – 550 V	195 – 550 V
Max DC operating current	20.8 A	15.4 A
Max DC short circuit current	24 A	24 A
Listing	UL1741 1st Edition: 2005 version	UL1741 1st Edition: 2005 version

PV and Electrical Load Centre Calculations

Array Parameters

Array (string) #	**1**	**2**	**3**	**4**
String	(MC48-180 x 11)	(MC48-180 x 12)	(2xBIPV1+4xBIPV3)	BIPV2 x 4
# of strings	2 (1)	2 (1)	2 (1)	1
Orientation	Horizontal	Horizontal	East/West Vertical	South Vertical
Wp nom (@25C)	3960 (1980)	4320 (2160)	3665.2 (1832.6)	1175.6
Wp max (@25C)	4098.6 (2049.3)	4471.2 (2235.6)	4031.8 (2015.9)	1293.2
Voc (@25C)	320.1	349.2	460.8	295.6
Voc max (@ -40C)	398.8	435	562.6	360.9
Vmp min (@ 65C)	271.7	296.4	388.2	255.4
Isc max (@ 25C)	13.5 (6.8)	13.5 (6.8)	11.8 (5.9)	5.9
Isc max (+25%)	16.9 (8.5)	16.9 (8.5)	14.8 (7.4)	7.4
Idc design (+25%)	21.1 (10.6)	21.1 (10.6)	18.4 (9.3)	9.3

Design Calculations and Verification

Array	Inverter	Voc max @ -40 < Inverter Vdc max	Vmp min @ 65 > Inverter MPPT min V	Isc max (@ 25 C + 25%) < Inverter max DC current
(MC48-180 x 11) x 2	Xantrex GT 3.8	398.8 < 600 ☐	271.7 > 195 ☐	16.9 < 20.8 ☐
(MC48-180 x 12) x 2	Xantrex GT 3.8	435 < 600 ☐	296.4 > 195 ☐	16.9 < 20.8 ☐
(2 x BIPV1+4 x BIPV3) x 2	GT 3.8	562.6 < 600 V ☐	398.2 > 195 ☐	14.8 < 15.4 ☐
BIPV2 x 4	GT 2.8	360.9 < 600 V ☐	255.9 > 195 ☐	7.4 < 15.4 ☐

Breaker//Wire Sizing Calculations

Circuit location	Max current (A)	125% Max current (A)	Selected Breaker (A)	Minimum wire gauge	Selected wire gauge
GT 3.8 AC Output	15.8	19.75	20	12 AWG	10 AWG
GT 2.8 AC Output	11.7	14.6	15	14 AWG	10 AWG
String 1 DC output	8.5	10.6	Inverter integrated	14 AWG	10 AWG
String 2 DC output	8.5	10.6	Inverter integrated	14 AWG	10 AWG
String 3 DC output	7.4	9.3	Inverter integrated	16 AWG	10 AWG
String 4 DC output	7.4	9.3	Inverter integrated	16 AWG	10 AWG
PV loadcenter to main loadcentre	59.1	73.8	80 A	4 AWG	3 AWG

Loadcenter Sizing Calculations

Loadcentrer	Connected PV	Connected main	Total Connected	Panel rating selected
PV loadcentre	75 A	80 A	155 A	200 A
Main loadcentre	80 A	150 A	230 A *	225 A

* Total back-fed breakers exceeds panel rating but justified by NEC 690.64(B) due to opposite end placement in panel.

10.2 North House Electrical Equipment Schedule

North House 2009
Equipment Schedule

May 28, 2009

					Total:	54063	**Totals (W):**
					Amps	225.26	Amps
Symbol	Quantity	Description	Product Name	Volts	Equipment Amps	Equipment Watts	Connection Comments
CT	2	Cooktop	Gaggenau VI 221	240	16	7200	
OV	2	Oven	Gaggenau BO 250-611	240	16	3700	
FF	1	Fridge/freezer	Leibherr HC1060	120	15	180	
EF	1	Exhaust fan	Fantech FG6	120	1.02	122.4	
DW	1	Dishwasher	Gaggenau DF 261 760	120	12	2300	
DRY	1	Dryer	Bosch Axxis condensation	240	13	3120	
WSH	1	Washing machine	Bosch Axxis plus	240	12	2880	
AHU	1	AHU – Eco-Pac EP30	Ecologix EP-30	120	5.5	660	
HRV	1	HRV – Fantech SH704	Fantech	120	0.36	40	
HP	2	Hydronic heat pump	Copeland Digital Scroll Comp.	240	23	11040	ZPD34KSE-PFV
VSP	2	Variable speed pump	Grundfos UPS 15-42F/VS	120	0.74	177.6	
PIC	2	PI controller	Johnson controls				
P	4	circ pump	Grundfos UPS 15-58FC/FRC	120	0.75	360	
AUX	1	Backup DHW heating	Bradford White M-2-HE-40S6DS	240		6000	2 x 3000
DC	2	Difference setpoint control	Techmar 156	24		3	
STC	1	Solar controller	Viesmann SCU-124	120	1.2	144	
SP	1	Solar circ. pump	Viesmann	120	0.8	90	
WP	1	jet pump	York Fluid Monarch MJS HP-50	120	9	1080	
GWP	1	Greywater pump	Diamond ½ HP Sewage	120	9	1080	
BWP	1	Blackwater pump	Diamond ½ HP Laundry Tub	120	9	1080	
FM	2	Water flow meter	Omega FTB4605				
FMI	2	Flow meter interface	Omega DPF700				
LC	1	Lighting Controller	Canlyte	120		50	
	6	T5 22”	SV Strip T5 single bulb	120		84	
	3	T5 34”	SV Strip T5 single bulb	120		63	
	18	T5 46”	SV Strip T5 single bulb	120		504	
	4	Closet fluorescent	Lightolier R213U	120		104	2 x 13 W each
	4	Bathroom LED	Philips icolor cove mx	120		48	
	1	Kitchen backsplash LED	Philips icolor flex	120		50	
	4	Living space LED	Philips eW Flex SLX	120		200	
	49	Outdoor lighting	MR16 LED	120		147	
ISC	4	Internal Shades control	Draper SPGC4	120	2	960	
ISM	15	Internal Shade motor	Draper	120	1.3	2340	
ISI	1	Internal shade signal conv.	Draper Digital Network IP interface	120		3	RS485 to Ethernet
ESC	15	External Shade controller	Embedia	120	0.5	900	
ESM	30	External Shade motor	Nysan	120	1.78	6408	
BWM	1	Bed Winch Motor		120		800	
CPU	1	Central Controller	Atom Embedded PC	120		50	
TSD1	1	Touch screen display	Planar PT1501MX	120		30	
TSD2	2	Touch screen display	Embedded automation mPanel	PoE		40	
ACC	1	Ambient Canvas controller	DMX iPlayer3	120		5	
MOD	1	Internet modem					
RTR	1	Wireless hub/router	Dlink DIR-825	120		20	
POW	1	Power/energy monitor	Power Logic BCPM				
CTS	2	Current Transformer Strip	Power Logic CTS				
SEN	2	USB sensor node	BB electronics USB-4711				
WS	1	Weather Station					

10.3 NEC 220 Service and Neutral Ampacity Calculations

NEC 220

NEC 220 Service and Neutral Ampacity Calculations

Conditions: Single family dwelling, heating load is larger than air-conditioning load.
(Heat Pump and/or Electric Space Heating)
(Based on NEC 220.82)

Existing plus Added Loads (less HVAC)

791	sq. ft. @ 3 watts sq. ft	2373	watts
2	Small Appliance Circuits @ 1500 watts ea. **(Minimum 2)**	3000	watts
1	Laundry Circuit(s) @ 1500 watts ea. **(Minimum is 1)**	1500	watts
7200	Cooktop **(Nameplate Rating)**	7200	watts
3700	Oven **(Nameplate Rating)**	3700	watts
6000	Electric Water Heater	6000	watts
5000	Electric Clothes Dryer **(Enter larger: 5000 Watts or Nameplate Rating)**	5000	watts
2300	Dishwasher	2300	watts
1080	Sump Pump	1080	watts
1080	Sewage Pump	1080	watts
1080	Water Pump	1080	watts
800	Bed Winch Motor	800	watts
7308	Exterior Shades and controller	7308	watts
3303	Interior Shades and controller	3303	watts
148	Control System (including hvac controller)	148	watts
	Total Calculated Load (less HVAC)	**45872**	**watts**

Service Demand

General Load:

First 10kw of Total Calculated Load (less HVAC) @ 100%	10000	watts
Remainder of Total Calculated Load (less HVAC) @ 40%	14349	watts
Total General Load	**24349**	**watts**

HVAC Load:

240	Nameplate Heat Pump Compressor load @ 100%	6000	watts
25	(Volts X Amps = Watts)		
	Nameplate Electric Space Heating Load @ 65%	0	watts
	(Nameplate Rating in watts X .65) ((NEC 220.82 (C)(4)(5))		
		6000	**watts**

Total General Load		+	Total HVAC Load		=	Calculated Service Load	
24349	watts	+	**6000**	watts	=	**30349**	watts

Calculated Service Load		÷	Service Voltage		=	Minimum Service Ampacity	
30349	watts	÷	240	volts	=	**126.45**	**amps**

Neutral Conductor Sizing		
1. General + Lighting	4355.55	VA
2. Fastened in Place x 0.75	12113.25	VA
3. Dryer x 0.7	3500	VA
4. Cooking appliances x 0.55	5995	VA
5. Heat and AC	0	VA
6.Air Handler	700	VA
7. Condensing unit	0	VA
8. Largest motor	1080	VA
Total Neutral Load	26663.8	VA
Neutral Amperage	111.1	A

10.4 North House Interconnection Application Form

04-Dec-2008 Solar Decathlon 2009

INTERCONNECTION APPLICATION FORM

_____

team name and lot number

PV SYSTEMS

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)

Total DC power of all arrays is _____ kW (in tenths).

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

INVERTERS

Inverter Manufacturer	Model Number	Voltage	Rating (kVA or kW)	Quantity

Total AC power of all inverters is _____ kVA or kW (in whole numbers).

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Please include the following in the Project Manual:

1) One-line electrical schematic – the loads do not have to be detailed.
2) Calculations of service/feeder net computed load and neutral load (NEC 220)
3) Plan view of the lot showing the house, decks, ramps, tour paths and the service point.
4) Elevation view(s) showing the terminal box (contains the service point), meter, and other service equipment (such as the distribution panel or load center).

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Provide the Team's "Electrical Engineer" contact info in the "Team Officer Contact Info" database on the Yahoo Group. See Rule 3-2.

Please see the "Grid Interconnection Process for Teams" file on the Yahoo Group for more details on the interconnection process and the Terminal Box Mounting Panel.

Team North
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11.0 Energy Analysis Results & Discussion

11.0 Energy Modeling Summary

Energy and mass flows in buildings are inherently dynamic and complex. Any attempt to capture the interactions between various building elements (such as envelope, energy systems, occupants, appliances, etc.) requires sophisticated modeling techniques. Even when a sophisticated, integrated model is available, the predictions rely heavily on stochastic occupant behaviour. From the onset of the North House project computer simulations have been used to assess the performance of the building and its components. The team has used several computer-modeling tools such as TRNSYS, ESP-r, EnergyPlus, WINDOW, THERM and WUFI to assess the performance of different aspects of the design. Where possible, an integrated model of the house was used.

HOUSE FROM AND FABRIC

The North House design attempts to maximize passive solar heating with a large south facing glazing area. The high R-value of the glazing façade results in a net positive solar heat gain during heating months. As a trade-off, this creates an indoor space that is very sensitive to solar gains and can result in severe overheating problems. In order to optimize wintertime passive heating with summertime passive cooling, the North House design incorporates a controllable shading array external of the east-/south-/west- glazed facades. Through the use of new window shading models developed concurrently with the North House project, the effect of window shading was examined. It is evident that the best-case aggressive shading strategy can effectively remove most of the sensible cooling load. In reality, daylighting and occupancy behaviour will likely increase the cooling loads. Simulations incorporating a phase change material model showed a significant reduction in annual total heating/cooling energy. The addition of PCM to the model also resulted in reduced peak cooling loads in the summer and reduced overheating in the winter.

An analysis was carried out investigating over 60 glazing combinations with different types of glass, films, coatings and configurations from double glazed to quintuple glazed to double facades. Based on this investigation, a quad-glazed krypton filled unit was chosen due to an optimum balance of U-Value, SHGC and solar transmittance. Despite specifying a high-performance glazing unit, most of its desired performance may be lost through a poorly designed frame. To limit this, a detailed investigation of curtain wall mullion design was undertaken. Various combinations of window offset depths, layers of insulation, and edge spacer materials were analyzed. The result of this investigation was the production of a high-performance curtain wall system that is approximately 4 times more insulating than a typical aluminium curtain wall. This helps to reduce the overall thermal transmittance of the building envelope leading to smaller heating and cooling loads while improving occupant thermal comfort, despite the absence of perimeter heating.

HEATING/COOLING – CONCURRENT HOUSE MODELS

To gain confidence in model predictions, a concurrent building energy analysis was performed using two distinct computer simulation codes. The models focused mainly on predicting annual space heating and cooling energy, beginning with a very simple model and progressively adding building elements representative of the North House design. Emphasis was placed on establishing the relevant model inputs to reduce the likelihood of discrepancy between the two modeling efforts. The results indicated that the demand for space heating and cooling can be decreased drastically primarily by providing appropriate solar protection and thermal mass.

PHOTOVOLTAICS

The concept of a partial tracking, or repositioning, system was evaluated. An annual solar resource assessment showed that a fixed tilted roof resulted in almost the same power production as a partially tracking array. An investigation into many different arrangments of PV indicated that the single most important variable for PV energy production is the total PV area. Based on these findings, the current PV layout was chosen.

An analysis of the total PV energy production of North House was modeled with PVWatts from NREL. The model looks at the output for the city of Toronto, where the house will be permanently located. Assuming a derate factor of 0.77, the total yearly electrical output of the photovoltaic panels for the house is 10 450 kWh. An estimated 10% of the energy will be lost in the winter if the snow is allowed to accumulate on the roof array. Table 11.0.0.1 shows the data from the simulation, and Figure 11.0.0.1 shows the data graphically.

Table 11.0.0.1 Annual PV Energy Production for Toronto by Facade

Month	Roof (8.28kW)		East (1.83 kW)		West (1.83 kW)		South (1.18 kW)		Total Energy (kWh)
	Peak sun hours (kW/m²/day)	AC energy (kWh)	Peak sun hours (kW/m²/day)	AC energy (kWh)	Peak sun hours (kW/m²/day)	AC energy (kWh)	Peak sun hours (kW/m²/day)	AC energy (kWh)	
January	1.47	262	1.1	42	1.18	45	2.70	79	428
February	2.27	395	1.58	58	1.76	66	3.18	84	603
March	3.19	627	2.13	87	1.78	70	2.89	79	863
April	4.36	811	2.54	97	2.41	92	2.83	70	1070
May	5.60	1052	3.50	141	2.69	103	2.67	62	1358
June	6.14	1075	3.40	126	3.16	115	2.55	53	1369
July	6.02	1062	3.42	127	3.07	112	2.60	54	1355
August	5.15	907	3.05	113	2.84	105	2.96	68	1193
September	4.08	714	2.69	98	2.34	83	3.46	84	979
October	2.55	464	1.61	60	1.64	61	2.97	81	666
November	1.30	204	0.74	20	0.81	23	1.73	43	290
December	1.07	178	0.70	22	0.69	20	1.93	56	276
Ave/ month	3.61	646	2.21	82.7	2.03	74.8	2.70	67.8	870.8
Total	-	7752	-	993	-	897	-	813	10450

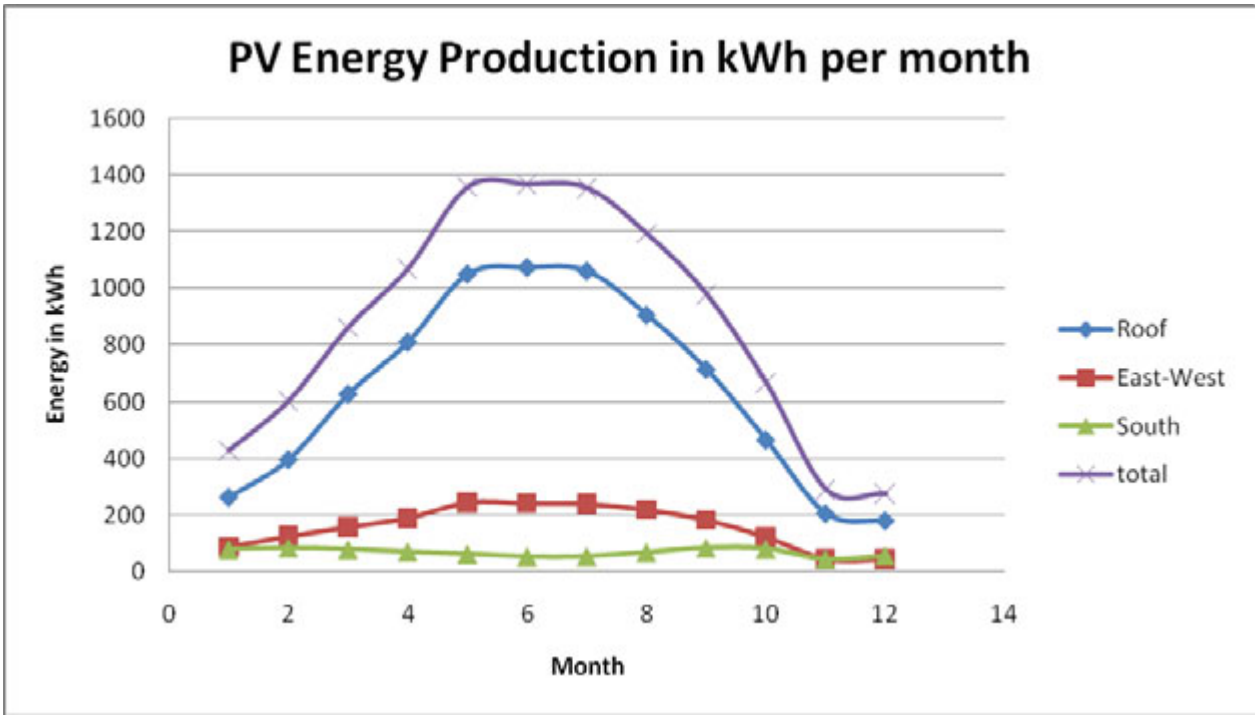


Figure 11.0.0.1 Annual PV Energy Production for Toronto

SOLAR THEMRAL AND DHW

Various calculations and simplified simulations were performed in order to verify the performance of the solar thermal / mechanical system. A TRNSYS model of the three-tank system (current at the time) was assembled. Many of the components used in the system could not be modeled using the available TRNSYS modules. Simplifications were made to the heat pump and heat exchanger bypass loop. Dynamic radiant heating was simulated by increasing tank losses corresponding to monthly heating capacities obtained from an annual house heating/cooling simulation in ESP-r and EnergyPlus. The TRNSYS model aided the team in sizing mechanical equipment (heat pump, tanks, backup heaters) as well as the solar thermal collector array size.

11.1 House Energy Balance

The total energy balance of the North House is based on the performance analyses of the active and passive energy systems incorporated into its design. This is largely an exercise of combining the energy model predictions presented in this report.

Some results may not reflect the conversion efficiencies of certain components. For example, the energy consumption of a dishwasher does not take into account the conversion efficiency of the hot water system. The appliance energy consumption simply reflects the estimated energy use, but may not be indicative of actual energy consumption. Similarly, space cooling is determined based on an average COP of the heat pump and doesn't capture the varying performance levels as a function of the thermodynamic state of the system. Table 11.1.0.1 summarizes how each house component was modeled and whether or not the actual energy conversion efficiency is taken into account.

Table 11.1.0.1: Summary of Modeling Approaches for Consumption and Production Elements

Consumption	
Space Heating	Annual idealized demand profile was predicted by ESP-r and EnergyPlus. Based on these results, an averaged demand value was calculated for each month and applied to the DHW model as a tank loss coefficient. Space heating energy consumption is therefore included in the DHW heat pump electrical input energy.
Space Cooling	Annual energy is based on an idealized demand profile predicted by ESP-r and EnergyPlus. An average coefficient of performance of 3 was assumed for the cooling system.
DHW	This system is modeled in TRNSYS and is coupled to the solar thermal system. Based on a demand profile for hot water use, the energy consumption of this system is represented by the electrical energy input to the heat pumps. Space heating is modeled as a tank loss coefficient based on a monthly averaged space heating demand determined from ESP-r and EnergyPlus.
Appliances and Plug Loads	Energy consumption of appliances is based on product specifications, modified where necessary, for expected double occupancy use. Where hot water is used, the values account for water heating energy but do not reflect the DHW system conversion efficiency. Plug loads are based on anticipated usage schedules and average power draws.
Fans and Pumps	This is a rough estimate based on a Plus energy house in Thening, Austria.
Lighting	Lighting consumption was estimated based on the wattage of the lighting components and an occupancy schedule.

Production	
PV	Electricity production was modeled in TRNSYS and NREL's PVWatts calculator using the selected PV modules and representative areas of the east, west, south façade and roof over a one year simulation period for Toronto. The possible accumulation of snow was neglected. Inverter efficiencies and losses were neglected.
Solar Thermal	This system was modeled in TRNSYS in combination with the DHW model. The reported value is the useful collected heat, some of which will be lost in storage when demand is insufficient to take advantage of the collected heat. The solar thermal system is designed to operate with a larger thermal storage system once the house is situated in its permanent location.

Table 11.1.0.2 shows the list of appliances, plug loads and the estimated energy consumption of each component.

Table 11.1.0.2: List of Appliances and Plug loads and their Estimated Energy Use

Refrigerator		
Liebherr HC1060		
Energy/year	kWh/y	297.0
Dishwasher		
Gaggenau DF 261 760		
Energy/year	kWh/y	190.0
Estimated Energy/year for North House	kWh/y	114.0
Oven		
Gaggenau BO 250-611		
Energy/year	kWh/y	166.4
Cooktop		
Gaggenau VI 221		
Energy/year	kWh/y	254.8
Clothes Dryer		
Bosch Axxis condensation		
Energy/year	kWh/y	419.0
# of cycles in quoted energy consumption	cycles/year	416.0
Estimated actual number of cycles	cycles/year	208.0
Estimated Energy/year	kWh/y	209.5
Clothes Washer		
Bosch Axxis plus		
Energy/year	kWh/y	129.0
# of cycles in quoted energy consumption	cycles/year	392.0

Estimated actual number of cycles	cycles/year	156.0
Estimated Energy/year	kWh/y	51.3
Flat Screen TV		
Samsung LN-R3228W 32"		
Energy/year	kWh/y	127.8
Desktop Computer		
assume average draw of 70W with LCD display		
Energy/year	kWh/y	76.4
Misc. Plug Loads (assume average load of 25W)		
Energy/year	kWh/y	218.4

Figure 11.1.0.1 shows the expected useful energy produced by the photovoltaic arrays and solar thermal system. Ignoring any losses between the PV array and the grid, and any disruptions in production due to shading or snow cover, all of the electricity generated is considered useful. The useful solar thermal energy represents the estimated collected energy which is stored in tanks.

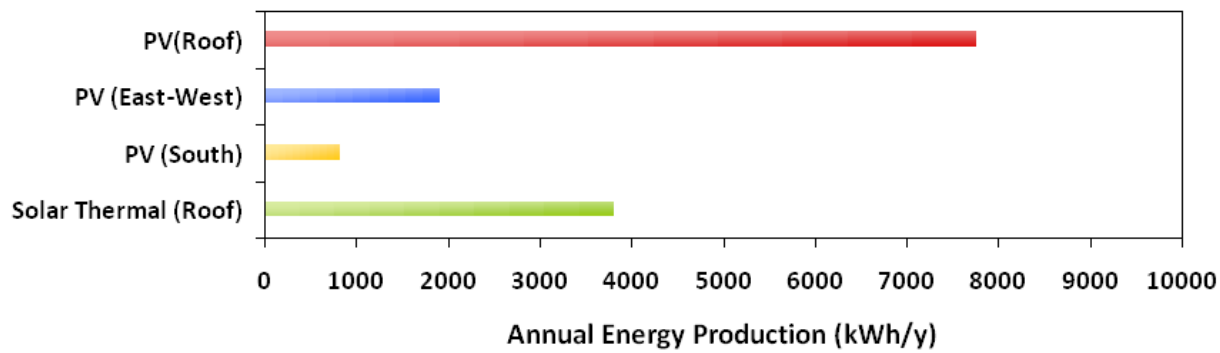


Figure 11.1.0.1: Electrical Energy Produced by PV Array and Useful Energy Produced by Solar Thermal Array

The estimated annual energy consumption of the North House is shown in Figure 11.1.0.2. As stated in Table 11.1.0.1, space heating and hot water energy consumption is represented by the electrical input to the heat pumps, accounting for utilization of the useful solar thermal energy. In other words, given that all of the useful solar thermal energy is utilized, the DHW system still requires 1400 kWh/year to meet the hot water and space heating demand. Thus, all of the estimated values represent annual electricity use.

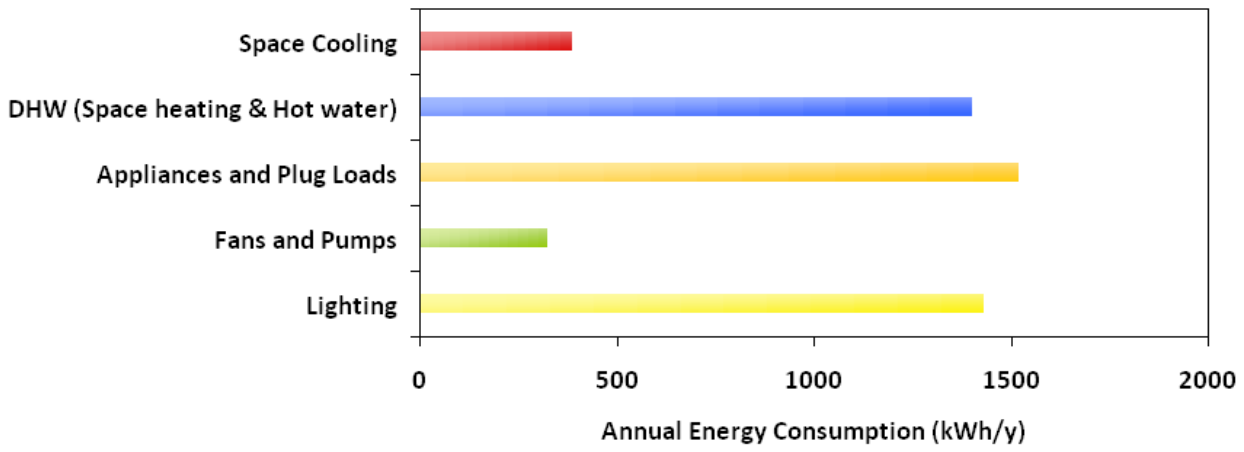


Figure 11.1.0.2: Estimated Annual Energy Consumption

A breakdown of energy consumption by end use is given in Figure 11.1.0.3.

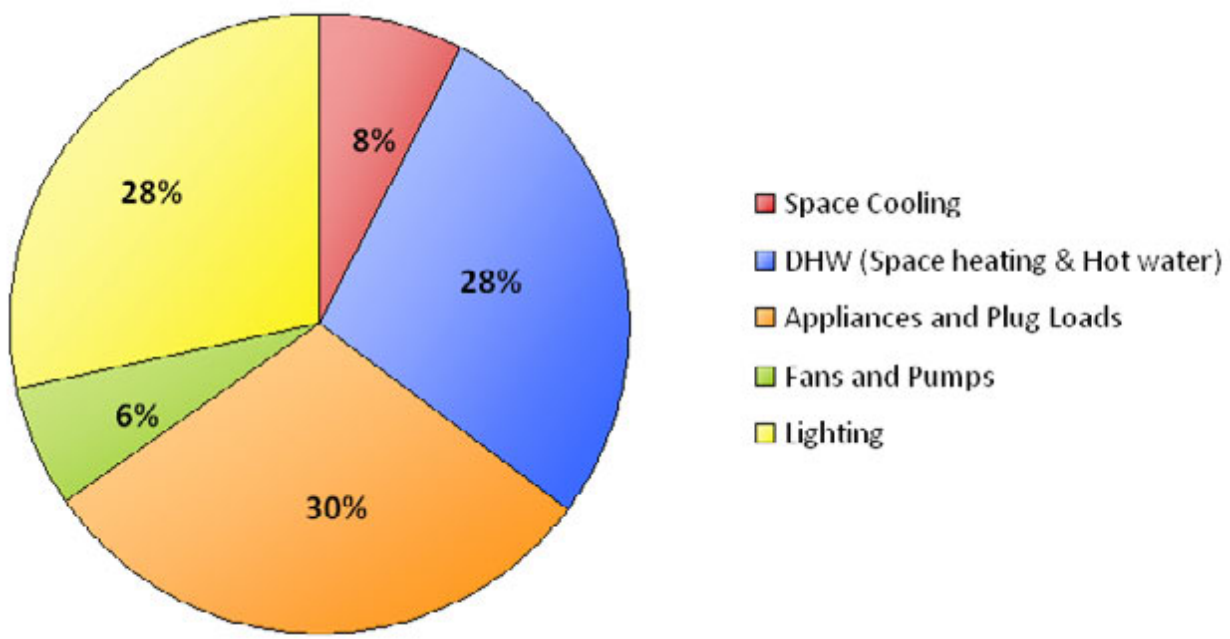


Figure 11.1.0.3: Energy Consumption by End Use

Figure 11.1.0.4 compares the annual produced electricity to the annual electricity demand, keeping in mind that the solar thermal energy is already taken into account in the electrical consumption of the DHW heat pumps.

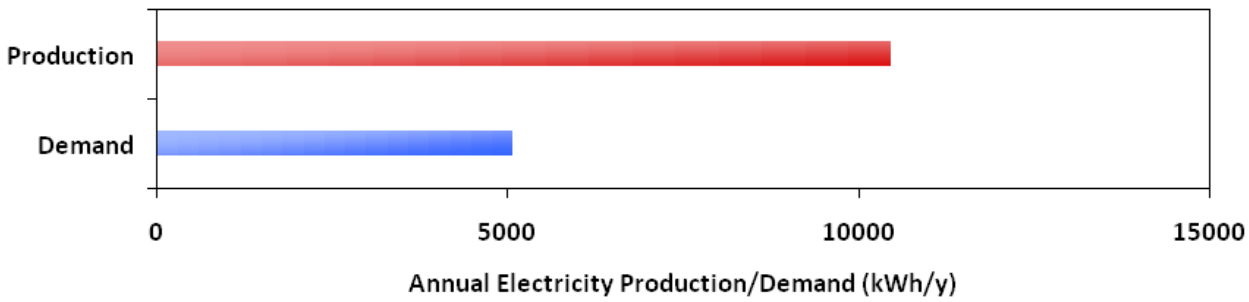


Figure 11.1.0.4: Annual Electricity Production vs. Demand

The total annual energy consumption of 4400 kWh/y equates to about 70 kWh/y per m^2 of conditioned space.

CONCLUSIONS

Although the values presented here are estimates, the house is clearly a net energy producer by a large margin. In reality, annual energy consumption may be higher than the estimates if for example the desired infiltration rate cannot be achieved in practice, or if the external shading system is not used properly.

11.2 Supplementary Material – Detailed Component Models

From the onset of the North House project computer simulations have been used to assess the performance of the building and its components. This has continued overtime on an iterative basis as the design is being refined. The team has used several computer-modeling tools such as TRNSYS, ESP-r, EnergyPlus, WINDOW, THERM and WUFI to assess the performance of different aspects of the design. Where possible, an integrated model of the house was used. The following sections describe the engineering team's modeling efforts and provide justifications for the chosen design.

The following sections outline some of the modeling efforts conducted for North House. Results and conclusions from initial annual building simulations that investigate building form and orientation are presented followed by detailed models of the components of the house, finally the results of refined overall building simulation is presented followed by simulation results from Photovoltaic electrical power production.

11.2.1 HOUSE FORM AND FABRIC

During the initial phase of the North House design, building energy simulation analyses were conducted in ESP-r, considering the fundamental building design elements such as orientation, aspect ratio, glazing area and shading. Although some things have changed since the initial design iteration, the analysis still presents the impact on performance of most of the current design elements.

MODEL SETUP

Figure 11.2.1.1 shows the initial geometry of the North House, as per the preliminary east-west design.

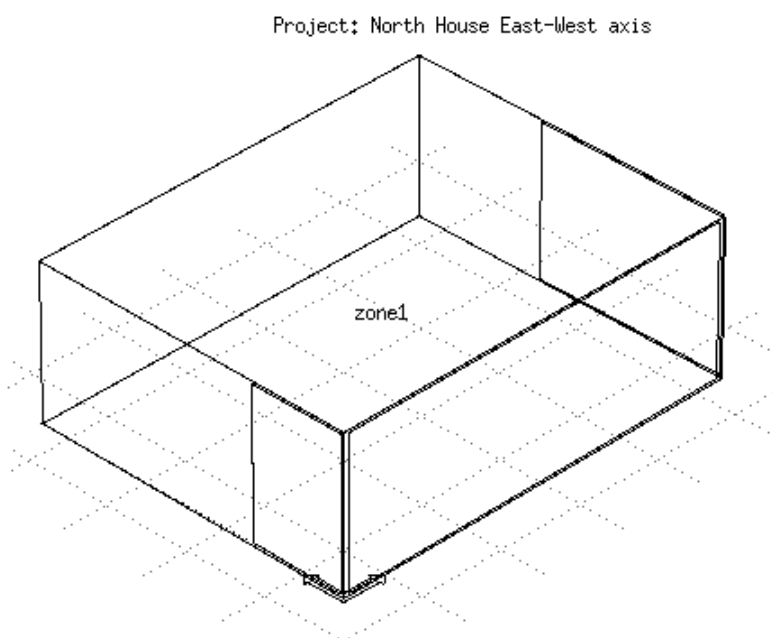


Figure 11.2.1.1: North House ESP-r Model Geometry

Climate:

The climate file chosen is a Toronto CWEC file. CWEC files contain hourly weather observations representing an artificial one-year period specifically designed for building energy calculations. CWEC hourly files represent weather conditions that result in approximately average heating and cooling loads in buildings.

Construction:

Construction	R-value (imp.)	Composition
Walls	R56	per SK-2 W1 spec (from previous)
Roof	R67	per SK-2 R1 spec (from previous)
Floor	R56	per SK-2 F1 spec (from previous)
Windows	R16	two insulated glazing units with evacuated cavities U-value=0.35 W/m^2K, SHGC=0.42

Ventilation:

Ventilation rates significantly affect the heating and cooling loads. Given very high insulation levels, ventilation becomes the dominant mode of energy transfer from outdoor environment conditions, next to solar gain.

Ventilation rate used for case studies assumes 1 ACH (air change per hour) with a 70% HRV (heat recovery ventilator) and 0.1 ACH infiltration from the outside. This is the equivalent of using a total ventilation rate of 0.4 ACH. *Note: This original value is no longer used as it is deemed too high (see Section 11.2.3 for more refined ventilation and infiltration calculations).*

The output of the simulation also depends on the convection model chosen for the interior surfaces. A mixed buoyancy and forced flow model is used to represent mechanical ventilation within the interior zone.

Heating / Cooling Control:

An accurate assessment of the heating/cooling energy consumption requires that the indoor space be conditioned to appropriate comfort levels during the simulation.

The control scheme used in all simulations is based on a basic heating/cooling controller keeping the indoor air temperature between 21°C and 25°C.

Shading Control:

When shading is active in the simulation, the control strategy is to allow solar gain in when the temperature is below 25°C, and to close the slats when an overheating condition is reached (ie. Indoor temp is above 25°C). This represents a best-case scenario without accounting for daylighting and occupancy, which can have a significant impact on the results.

Occupancy:

The simulations assume that two occupants are in the house at all times.

Solar Distribution:

An exact treatment of insolation distribution is performed in ESP-r given a building geometry and window positions. Absorbed solar fluxes are distributed according to sun position. This provides information on which surfaces typically receive the most solar radiation.

Heating/Cooling Efficiency:

The coefficient of performance (COP) for both heating and cooling is assumed to be 1. The peak loads and annual energy consumption are therefore theoretical values that do not take into account any HVAC system performance efficiencies.

EXTERNAL SHADING

The main features of the North House envelope include very high insulation of the opaque wall sections, floor and roof, as well as a large east/south/west glazing area. The high R-value of the double-skin glazing results in a net positive solar heat gain during heating months. In other words, the night-time losses do not outweigh the solar gains on an annual basis. However, the benefits of a thermally benign envelope can easily be offset during summer time due to increased peak cooling loads and total cooling energy consumption. North House design attempts to maximize passive solar heating with a large south facing glazing area. As a trade-off, this creates an indoor space that is very sensitive to solar gains and can result in severe overheating problems.

In order to optimize wintertime passive heating with summertime passive cooling, the North House design incorporates an operable/automated louvered shading array external of the east-/south-/west-glazed facades.

In predicting the annual heating and cooling energy, the main variable is the control of solar gain into the indoor space. Appropriate modeling techniques of the shading array are essential to an accurate load assessment, which in turn affects HVAC equipment selection and sizing.

Based on recent work done at the University of Waterloo, new shading models have been incorporated into ESP-r building energy simulation software. Solar optical as well as thermal models for slat-type shades allow for an explicit treatment of shading layers in any configuration (outside, inside, between glass) and at any slat angle. This makes real-time modeling of operable slat type shades possible, providing designers with a tool for an accurate assessment of slat shading devices on entire building loads.

Recognizing the control and occupant variability in operating shading devices, preliminary simple shading control strategies are used in the case studies contained in this document. The strategy is to maximize solar thermal storage in the heating months and to minimize solar gain during cooling months by controlling the slat angle of an external shading array.

The effect of window shading is examined by considering a base case with no shades, and a case with dynamic operable louvered shades. Both cases employ the use of floor and ceiling PCM. The shading control strategy used is described in the model setup section. Figure 11.2.1.2 and 11.2.1.3 show the annual heating and cooling loads for the two scenarios. It is evident that the best-case aggressive shading strategy can effectively remove most of the sensible cooling load. Daylighting and occupancy behaviour will most likely increase the cooling loads from what is presented here.

To be noted is the reduction in annual heating load in the NO-SHADING case. This is attributed to the fact that even when the louvered slats are open and tracking the direct solar gain, the shades obstruct

the sun to some degree. This presents the benefit of implementing an exterior shade which is retractable.

	Heating Energy (kWh/y)	Cooling Energy (kWh/y)	Total (kWh/y)
Without shading	**834**	**8200**	**9034**
With Dynamic Shading	**2010**	**195**	**2205**

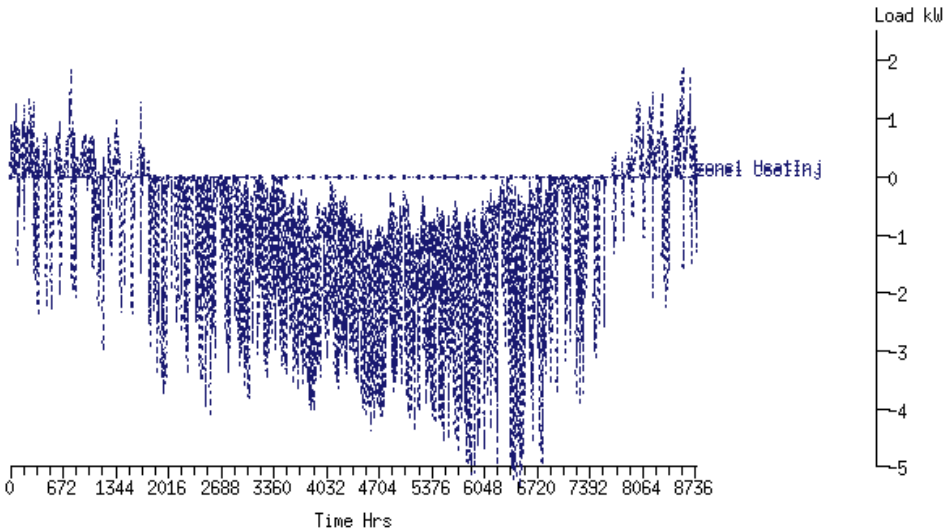


Figure 11.2.1.2: Annual Heating and Cooling Loads – NO SHADING

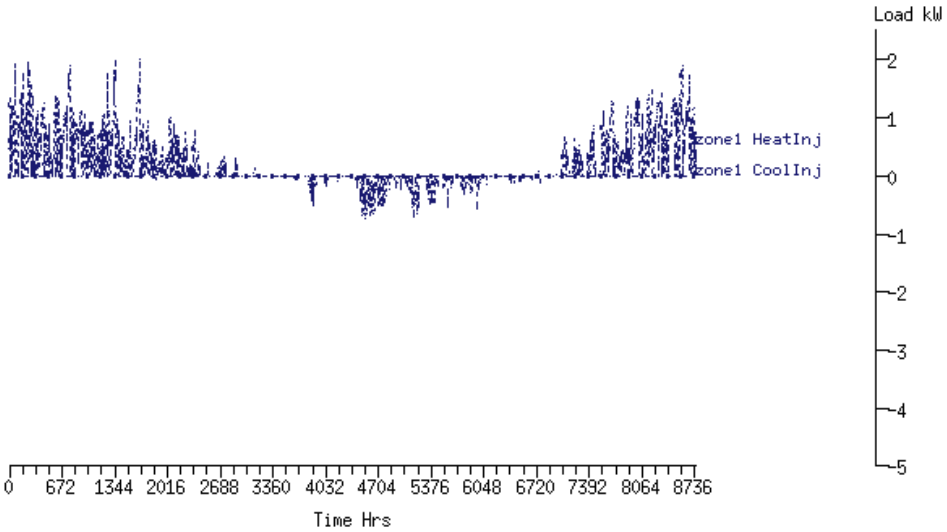


Figure 11.2.1.3: Annual Heating and Cooling Loads – DYNAMIC SHADING

ORIENTATION – East-West vs. North-South

Two house orientations were examined as shown in Figure 11.2.1.4. The two models contain the same construction components and overall glass area. Ventilation, heating/cooling control, shading control, occupancy and solar distribution are identical in both scenarios. Both cases employ the use of floor and ceiling PCM.

Looking at the annual heating and cooling loads, there isn't any significant difference between the two orientations. The large glazing area in the two proposed designs ensures that solar capture during heating months is maximized, while the automatic louvered shades block out excessive solar gain in the summer. Considering only the annual heating/cooling loads analysis, both orientations are suitable. However, to maximize PV-thermal energy production, the east-west orientation provides more south-facing area.

	Heating Energy (kWh/y)	Cooling Energy (kWh/y)	Total (kWh/y)
East-West orientation	**2010**	**195**	**2205**
North-South orientation	**2115**	**210**	**2325**

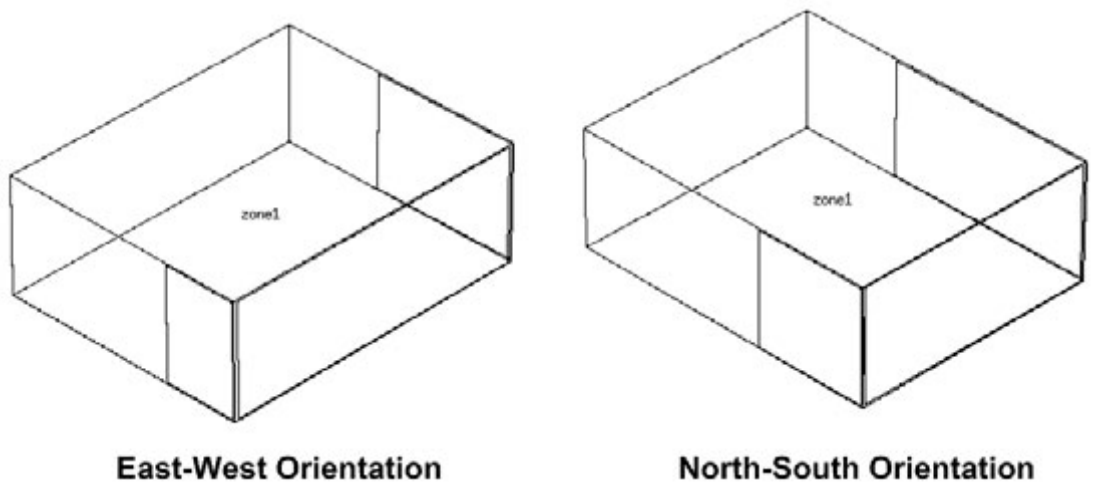


Figure 11.2.1.4: North House Proposed Orientations

WINDOW AREA

HEAT LOSS VS. SOLAR GAIN

Traditionally, choosing the right amount of glazing area in a solar home has been a challenging design problem. Since windows have the lowest resistance value of the house, they act as heat sinks during heating months, especially at night-time. The balance between solar gain capture and night-time heat loss must be examined.

If the nighttime heat losses outweigh the captured solar gain, on an annual basis, the window is a net energy consumer. Given a specific design scenario (layout, window orientation), when analyzed in an annual building energy simulation, the window U-value and the Solar Heat Gain Coefficient (SHGC) can indicate whether the window is a net energy supplier or consumer. These indices alone cannot establish the net performance of the window. The U-value is a measure of the window overall resistance, typically given for winter nighttime conditions. The SHGC is a measure of the solar energy that is transmitted to the indoor space. This includes solar transmission and the inward longwave radiative and convective flow of absorbed solar radiation.

Most windows used today are net energy consumers. The frame design and air-tightness can have a significant impact on the overall window performance, but only the center-of-glass portion of the window is examined here. Given a good frame and large glazing area to frame ratio, the center-of-glass U-value constitutes more than 90% of the entire window U-value.

Annual simulations were performed on the east-west axis orientation varying the window areas as a percentage of the preliminary design layout. Figure 11.2.1.5 shows the configurations. Several cases were run for different windows with progressively lower U-values (or higher R values). The model did not consider shading, thermal mass or PCM.

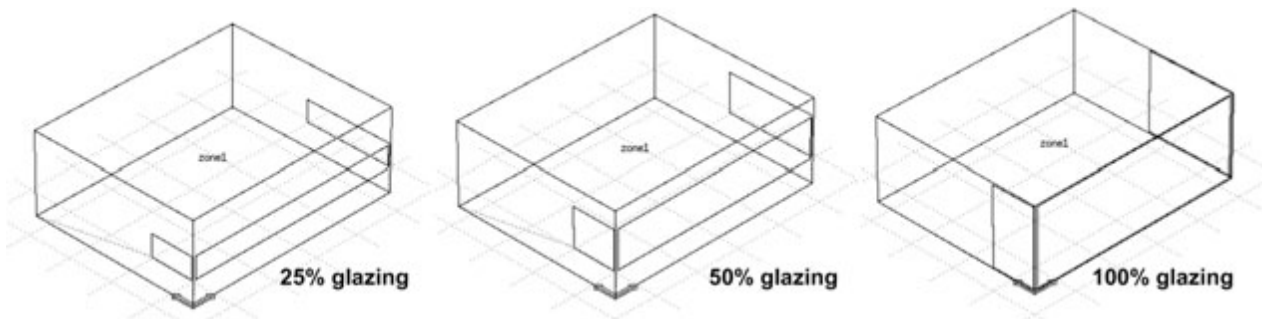


Figure 11.2.1.5: Percent Glazing of East-West Orientation of Proposed Design

Figure 11.2.1.6 summarizes the results of these simulations. Given a U-value of 2.7 W/m^{2}K (double glazing), as the window % area is increased, there is a large increase in the annual heating load. As the U-value is reduced well below 1 W/m^{2}K, the addition of glazing area results in a decrease in heating load. From these results, it is evident that the 100% glazing case is the optimum glazing area to minimize annual heating energy, given that the overall window U-value is below 0.6 W/m^{2}K. Lower U-values amount to more savings in annual heating energy.

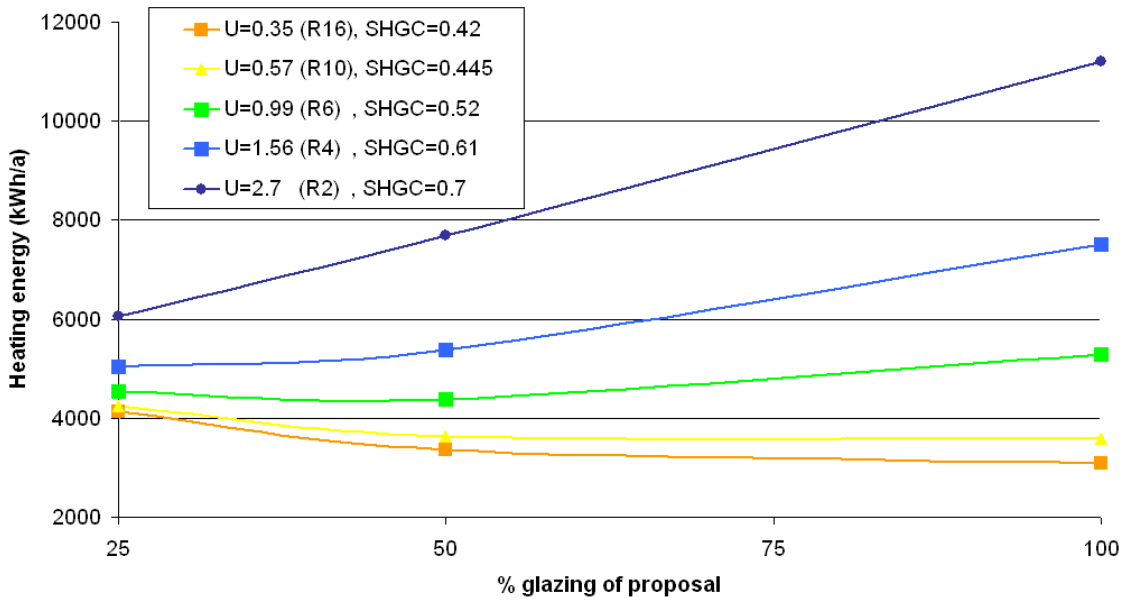


Figure 11.2.1.6: Heating Load vs. Percent Glazing of Proposal for Various Windows

PERCENT GLAZING WITH PCM AND SHADING

Dynamic shading control and PCM in floor and ceiling were employed in subsequent simulations to provide more realistic results. With PCM, the benefits of a large glazing area become greater as more solar gain can be captured and stored.

% glazing	Heating Energy (kWh/y)	Cooling Energy (kWh/y)	Total (kWh/y)
25	3140	100	3240
50	2400	125	2525
100	2010	195	2205

From these results it is evident that the addition of more glazing area has a net positive effect on the building loads. This is counterintuitive, but maximizing solar heat gain capture and storage outweighs the night-time losses with such a high insulating value of the glazing.

Given adequate shading and thermal storage, new window technologies make it possible to have very large glazing areas and still fit the passive solar home criteria.

THERMAL STORAGE – PCM (phase change materials)

The use of thermal mass has traditionally been one of the key design components of solar homes. The effectiveness of this thermal storage system depends strongly on the amount of thermal mass used AND its placement. Well-designed thermal mass helps to stabilize temperatures year-round. It acts to level the heating and cooling loads and reduces peak loads significantly. It prevents overheating in winter and

summer and allows for solar thermal storage and subsequent release, lagging peak temperature and peak solar gain.

This case study examines the use of PCM as a substitute for traditional thermal mass such as masonry and concrete. Phase change materials offer very high latent heat storage capacity in a relatively small package. Placement of PCM in the floor and ceiling were examined, as well as a window cavity enclosed PCM technology. Shading was not employed in the simulations.

Annual simulation results:

	Heating Energy (kWh/y)	Cooling Energy (kWh/y)	Total (kWh/y)
Without PCM	**3450**	**410**	**3860**
PCM in floor and ceiling	**2010**	**195**	**2205**

A more accurate assessment was performed to examine the effect of adding PCM by conducting day-long simulations. A closer look examined the heating and cooling load distributions during the day and night.

Hot / Sunny Summer Day Analysis:

The peak shaving and load leveling effect of PCMs is clearly demonstrated in Figure 11.2.1.7 for a hot and sunny summer day. The cooling load curve is significantly dampened (up to 40%) by the incremental addition of PCM into the floor, ceiling and windows. The reduction in peak cooling load translates into smaller A/C equipment and a more efficient operating point.

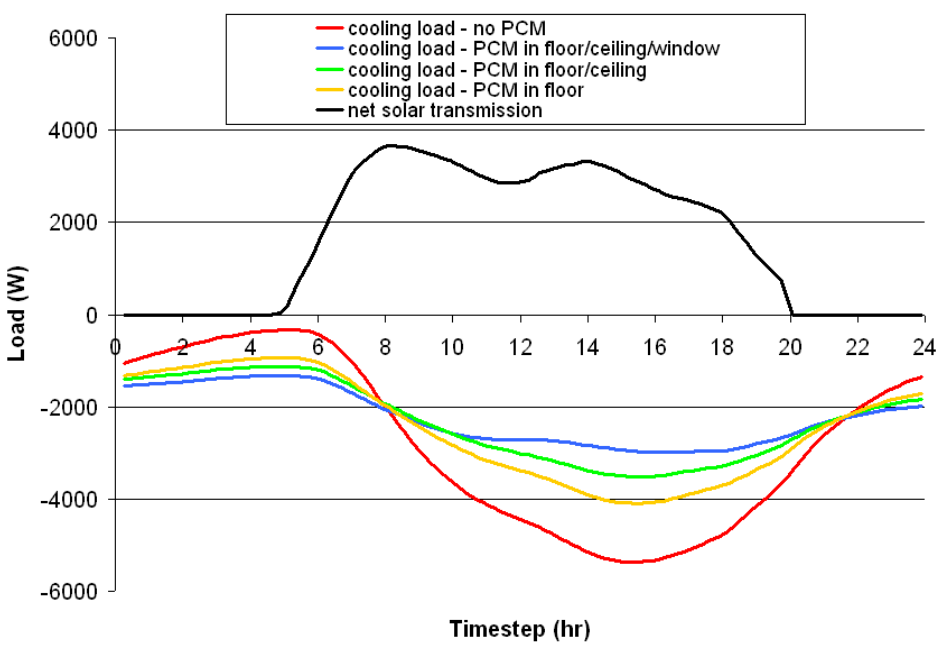


Figure 11.2.1.7: Hot Summer Day with Incremental PCM Additions

Cold / Sunny Winter Day Analysis:

A particular day with cold temperatures and high solar radiation was chosen to examine the effects of PCM on the daily heating/cooling loads. Figure 11.2.1.8 shows the simulation results. It is evident that the house overheats very quickly without the use of PCM, and by noon the indoor air requires cooling. If shading were employed, at this point the slats would close to block the solar gain. With PCM, the house is able to absorb most or all of the solar energy without reaching the overheating condition. In this scenario, the slats can remain open maximizing the solar capture in the indoor space, thus reducing the night time heating load.

Figure 11.2.1.9 shows the effect of adding PCM on the zone air temperature. With PCM, the temperature rise is much slower, preventing overheating.

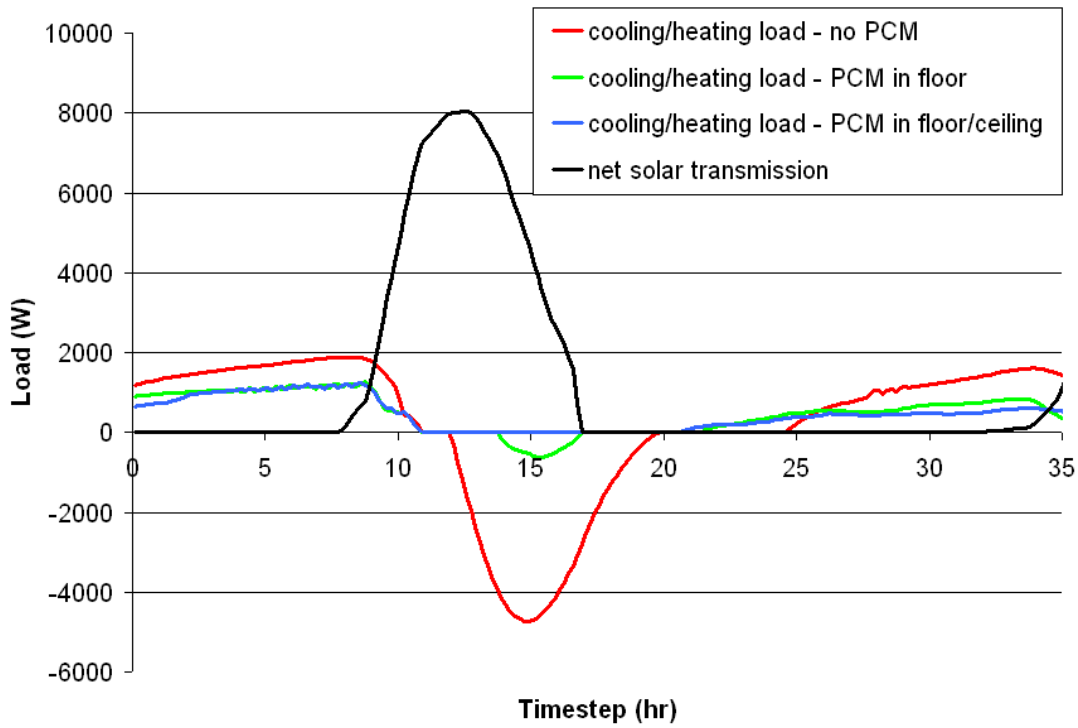


Figure 11.2.1.8: Cold/Sunny Winter Day Zone Air Temperature with Incremental PCM Additions

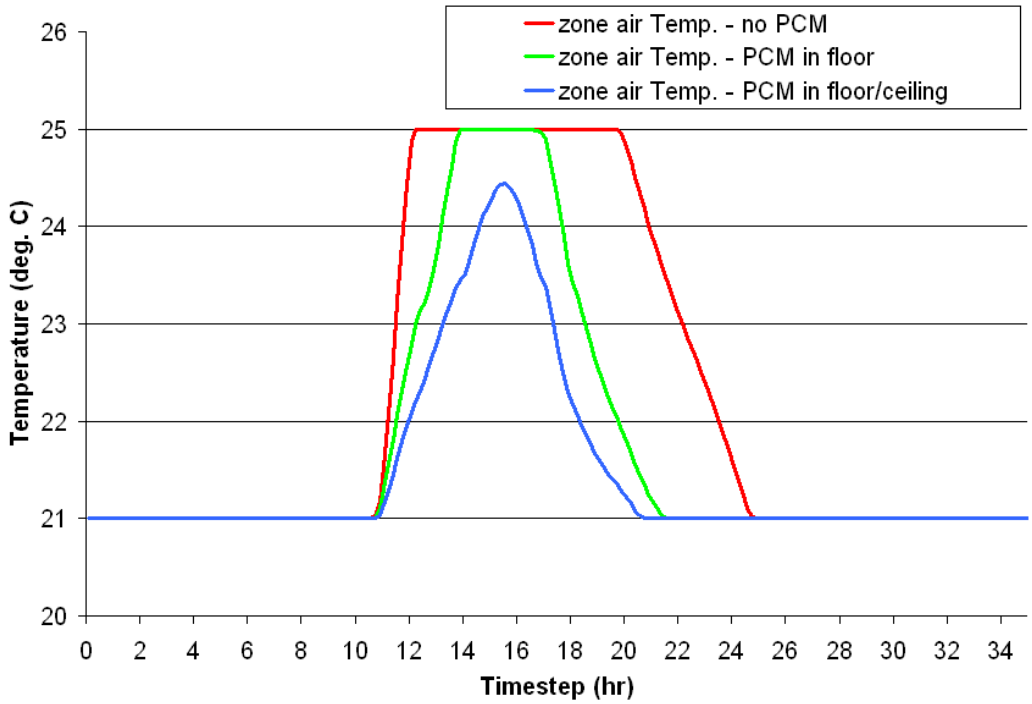


Figure 11.2.1.9: Cold/Sunny Winter Day with Incremental PCM Additions

REFINED MODEL

Based on the latest drawings of the North House prepared for the June 3rd Design Document submission in 2008, another iteration of ESP-r simulations was performed. Figure 11.2.1.10 shows the conditioned space of the North House with total conditioned floor area of 58.5 m^2.

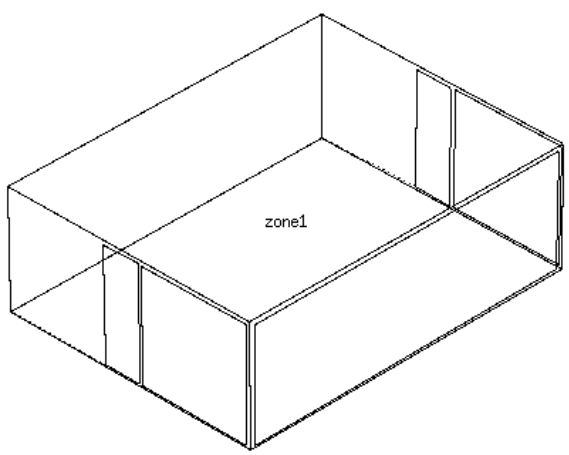


Figure 11.2.10: Refined Conditioned Space Model based on May 27,2008 drawings

Six cases were analyzed, starting with a base case followed by incremental additions in model complexity and house features to subsequent cases.

Each case is summarized below with incremental model changes highlighted.

CASE 1

Conditioned space area	58.5 m^2	Construction	
Ceiling Height	3 m	Walls	R63
Dynamic Shading	NO	Floor	R74
PCM (floor, ceiling)	NO	Roof	R67
Thermal Bridges	NO	Windows	R17, SHGC 0.25
Appliances	NO	Doors	R12
Occupancy (2 people)	YES		
Control Set Points	21-25 deg C 55% RH		
Ventilation (70% HRV efficiency)	0.4 ACH		

CASE 2 -ADD THERMAL BRIDGES

Conditioned space area	58.5 m^2	Construction	
Ceiling Height	3 m	Walls	**R53**
Dynamic Shading	NO	Floor	**R51**
PCM (floor, ceiling)	NO	Roof	**R47**
Thermal Bridges	**YES**	Windows	R17, SHGC 0.25
Appliances	NO	Doors	R12
Occupancy (2 people)	YES		
Control Set Points	21-25 deg C 55% RH		
Ventilation (70% HRV efficiency)	0.4 ACH		

CASE 3 -ADD APPLIANCE LOADS

Conditioned space area	58.5 m^2	Construction	
Ceiling Height	3 m	Walls	R53
Dynamic Shading	NO	Floor	R51
PCM (floor, ceiling)	NO	Roof	R47
Thermal Bridges	YES	Windows	R17, SHGC 0.25
Appliances	**YES**	Doors	R12
Occupancy (2 people)	YES		
Control Set Points	21-25 deg C 55% RH		
Ventilation (70% HRV efficiency)	0.4 ACH		

CASE 4 - ADD DYNAMIC SHADING

Conditioned space area	58.5 m^2	Construction	
Ceiling Height	3 m	Walls	R53
Dynamic Shading	**YES**	Floor	R51
PCM (floor, ceiling)	NO	Roof	R47
Thermal Bridges	YES	Windows	R17, SHGC 0.25
Appliances	YES	Doors	R12
Occupancy (2 people)	YES		
Control Set Points	21-25 deg C 55% RH		
Ventilation (70% HRV efficiency)	0.4 ACH		

CASE 5 - INCREASE GLAZING SHGC TO 0.45

Conditioned space area	58.5 m^2	Construction	
Ceiling Height	3 m	Walls	R53
Dynamic Shading	YES	Floor	R51
PCM (floor, ceiling)	NO	Roof	R47
Thermal Bridges	YES	Windows	**R17, SHGC 0.45**
Appliances	YES	Doors	R12
Occupancy (2 people)	YES		
Control Set Points	21-25 deg C 55% RH		
Ventilation (70% HRV efficiency)	0.4 ACH		

CASE 6- ADD PCM

Conditioned space area	58.5 m^2	Construction	
Ceiling Height	3 m	Walls	R53
Dynamic Shading	YES	Floor	R50
PCM (floor, ceiling)	**YES**	Roof	R47
Thermal Bridges	YES	Windows	R17, SHGC 0.45
Appliances	YES	Doors	R12
Occupancy (2 people)	YES		
Control Set Points	21-25 deg C 55% RH		
Ventilation (70% HRV efficiency)	0.4 ACH		

Appliance loads were estimated based on NatHers (Australian Nationwide House Energy Rating Scheme) data for a single-family dwelling. The resulting internal gains schedule is shown below. Lighting was not considered an internal load as the proposed adaptive LED lighting system presents a relatively small load compared with traditional incandescent or florescent lighting. LED lights will have little or no impact on the heating and cooling energy, due to their extremely high efficiencies with little heat dissipation.

Time	Appliances and Cooking (W)	Lighting (W)	People (W)	Total (W)	Latent load (W)
1	100	0	100	200	70
2	100	0	100	200	70
3	100	0	100	200	70
4	100	0	100	200	70
5	100	0	100	200	70
6	100	0	100	200	70
7	100	0	100	200	70
8	400	0	100	500	370
9	100	0	100	200	170
10	100	0	100	200	70
11	100	0	100	200	70
12	100	0	100	200	70
13	100	0	100	200	70
14	100	0	100	200	70
15	100	0	100	200	70
16	100	0	100	200	70
17	100	0	100	200	70
18	100	0	100	200	120
19	1100	0	100	1200	650
20	250	0	100	350	70
21	250	0	100	350	70
22	250	0	100	350	70
23	100	0	100	200	70
24	100	0	100	200	70

Figure 11.2.1.11 presents the results of ESP-r annual simulations for the six cases outlined. As expected, the base case (case 1) is dominated by cooling. Adding thermal bridges, as calculated in the Building Envelope section of the DD package, increases the heating load somewhat. The addition of appliances reduces heating and increases cooling, resulting in a net total increase. With the addition of dynamic shading, cooling energy is almost eliminated. However, the heating energy is increased as the external shading array, even when tracking solar gain, presents a solar obstruction. The total heating/cooling energy with dynamic shading is reduced by more than half, as compared to case 3. Further gains are possible if the double skin glazing SHGC is increased from 0.25 to 0.45. This would be representative of evacuated glazing units, which, although in the development stage, offer excellent thermal resistance while retaining high solar and visible transmission. Finally, adding PCM to the floor and ceiling results in a significant reduction in heating energy, bringing the total heating/cooling energy to below 2000 kWh/y.

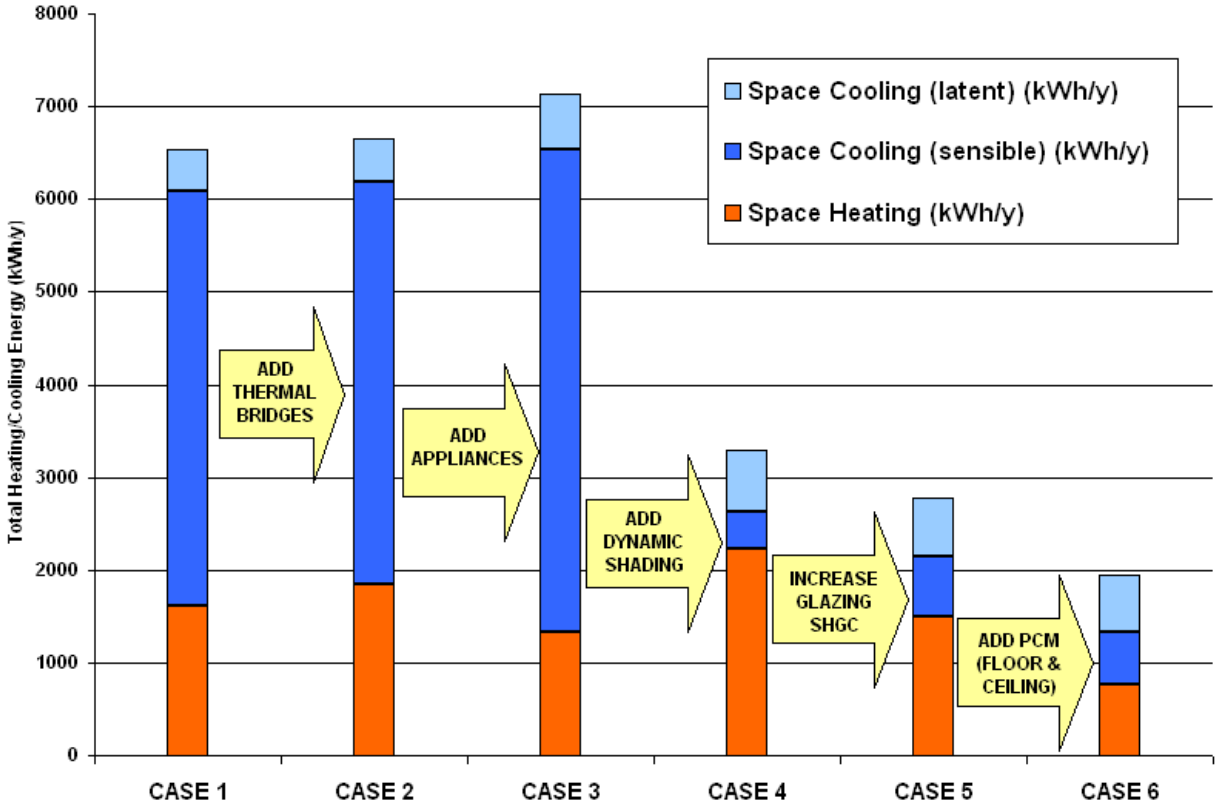


Figure 11.2.1.11: ESP-r Simulation Results for the Refined House Model

CONCLUSIONS

Simulation parameters:

Given a prescribed building envelope, annual energy simulations are very sensitive to operational parameters such as ventilation rates, indoor temperature control (cooling/heating), shading and solar gain control, interior surface convection models, occupancy, and climate.

Shading:

Appropriate shading is a critical part of the North House design. Dynamic shading models developed at UW were used in the simulations. This feature allows for an accurate treatment of operable slat type shades. Given an aggressive shading strategy, the results indicate that the annual cooling load can effectively be eliminated (8200 kWh vs. 194 kWh). Latent loads were not considered in the simulations. An air conditioning system that can run in either dehumidification mode or dehumidification and cooling mode would be an ideal choice.

Orientation:

Due to a very high glazing area, the orientation of the house does not have a significant impact on the annual heating/cooling loads. The east-west configuration provides more south-facing roof area, which will maximize PV power production and roof thermal collection.

Window area:

The windows used in the simulation are representative of a R16 (0.42 SHGC, 0.35 W/m^{2}K U-value) assembly. Although the glazing area represents a heat sink during heating months, the relatively high R-value provides a net benefit for annual energy consumption. The night-time losses are outweighed by solar gain capture. The highest percent glazing area configuration results in the lowest total annual energy consumption.

Thermal mass – PCM:

The use of thermal storage, whether traditional thermal mass, or phase-change materials, is an essential part of a solar home design as it stabilizes heating and cooling loads and temperatures year-round. Given limited space and weight considerations, PCM, as opposed to concrete or masonry, is more suitable for the North House design.

Annual and winter day and summer day simulations were performed to assess the effect of incrementally adding PCM into building constructions. The results show a significant reduction in annual total heating/cooling energy. The addition of PCM not only shaves peak cooling loads in the summer, but also prevents overheating in the winter. By preventing overheating in winter, the shades can remain open and capture more solar gain, thus reducing night-time heating loads.

11.2.2 WINDOW AND WALL SIMULATIONS

Window Simulations

Choosing the appropriate glazing area and properties has traditionally been a challenge for solar homes. Windows typically act as heat sinks during heating periods since it is the least thermally resistive portion of the building envelope. However, unlike the opaque building envelope windows are able to transmit solar radiation and provide heat during the day. If the solar gains of the window are greater than the thermal losses on an annual basis the window can be considered a net heating energy supplier. This is dependent on properties of the window, specifically the U-value and solar heat gain coefficient (SHGC). The U-value is a measure of the window overall thermal transmittance typically for winter night-time conditions, whereas the SHGC is the fraction of solar heat that is transmitted to indoor space. Preliminary annual building simulations have provided ranges of window U-values, SHGCs, and window areas in which the window is a net energy supplier. Both window U-values and SHGC are indices which can be calculated using glazing and frame modeling programs such as Window5 and Therm5.

Glazing Simulations

A focused investigation of optimal glazing properties for North House was performed using Window5 developed by the Lawrence-Berkley National Laboratory (LBNL) and Vision4 developed at the University of Waterloo (UW). Both of these programs provide an in-depth analysis of the spectral properties of the glazing unit as well as its thermal resistance and surface temperatures. The objective of this investigation was to identify practical glazing constructions that have the properties to make it a net energy net supplier. From the annual overall energy simulations, glazings with U-value of 0.57 W/m^2K (R-10) and SHGC of 0.45 or better is a net energy supplier for North House.

Over 60 glazing combinations have been analyzed along with different types of glass, films, coatings and configurations from double glazed to quintuple glazed to double facades. All of the windows were analyzed under NFRC winter 2001 night-time conditions for their U-values. The analysis revealed the sensitivity of some glazing properties with respect to performance. For example, while the placement of low-emissivity (low-e) coatings has minimal effect on the centre-of-glass U-value for high performance glazings, it can significantly affect the SHGC, yet it has no effect on the visible transmittance (VT). The analysis also yielded a priority list of glazing construction which the team periodically referred to during the design process as limitations of each product were discovered.

The glazing that Team North have selected for North House is a quad-glazed krypton filled unit as shown in Figure 11.2.2.1.

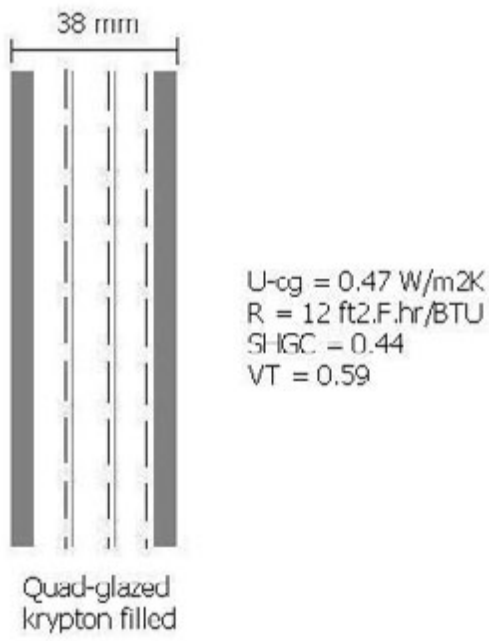


Figure 11.2.2.1: Quad-Glazed Window Properties

The glazing unit features two ¼" (6.35 mm) sheets of glass sandwiching two layers of plastic films to create the quadruple glazed configuration. The films minimize convective heat transfer in the glazing cavity while adding little weight to the overall glazing unit. The two plastic films within the glazing unit are Heat Mirror-88 (HM-88) films from Southwall, which have low-e coatings on one side of the film. The low-e coatings minimize long-wave thermal radiation heat transfer thus providing lower U-values. Similarly, the inner sheet of glass also has a low-e coating on surface 7. Placing the low-e coatings in this configuration limits the amount of long-wave radiation from indoors to outdoors while still allowing significant amounts of solar heat gains transmitted through the glazing. The glazing cavities are filled with krypton gas to reduce the amount of heat transfer between the glazed surfaces as krypton has a lower conductance (k-value) than air and a smaller optimal cavity size to minimize convection, making it suitable for a multi-paned glazing unit.

Overall the technical window properties were considered with other tangible properties including aesthetics and constructability that enabled both the architects and engineers of Team North to design a high performance and aesthetically pleasing glazed façade.

Frame Simulations

Despite specifying a high-performance glazing unit, most of its desired performance may be lost through a poorly designed frame. To limit this a detailed investigation of curtain wall mullion designs was undertaken through a two-dimensional heat transfer modeling program, Therm5, developed by LBNL.

With Therm5, various combinations of window offset depths, layers of insulation, and edge spacer materials were analyzed. The results of this analysis yielded various trends that identified optimal designs and which parameters were significant in achieving a highly insulated window.

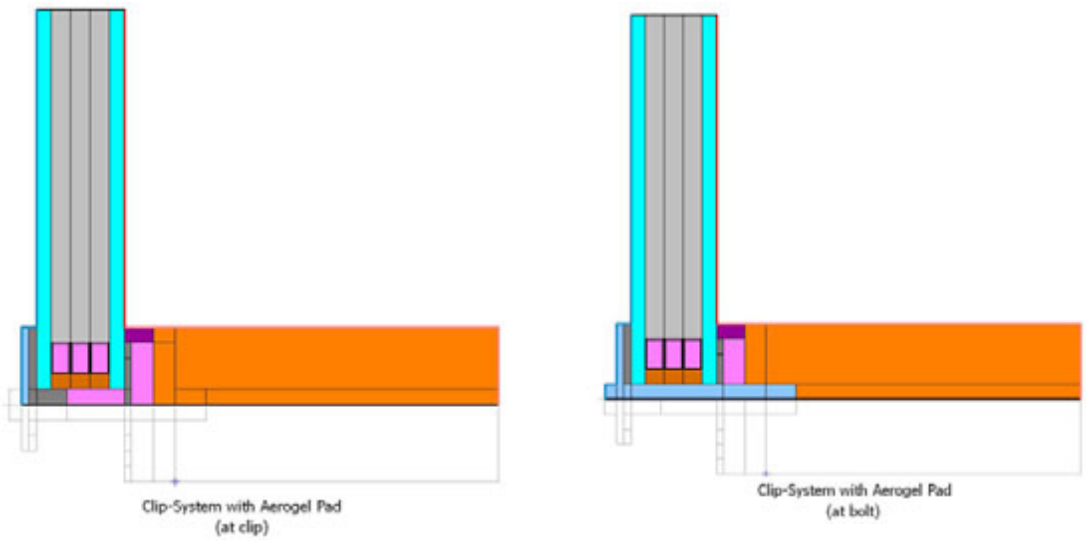


Figure 11.2.2.2: North House Wood Curtain Wall Section

To achieve a highly insulated frame design Team North decided to design all window frames with wood as opposed to aluminum or vinyl. Therm5 simulations were performed to determine the optimal embedment depth of the window into the frame (or rabbet depth), whether addition layers of aerogel insulation was needed, and the optimal edge spacer material (Figure 11.2.2.3). Figure 11.2.2.3 summarizes the frame, edge, and window R-values of various window frames at with different types of spacers and insulation levels for a Quad-glazed four-sided Structural Silicon Glazing (SSG) curtain wall system. The window U-value is calculated using an area-weighted average of the frame, edge, and window U-values.

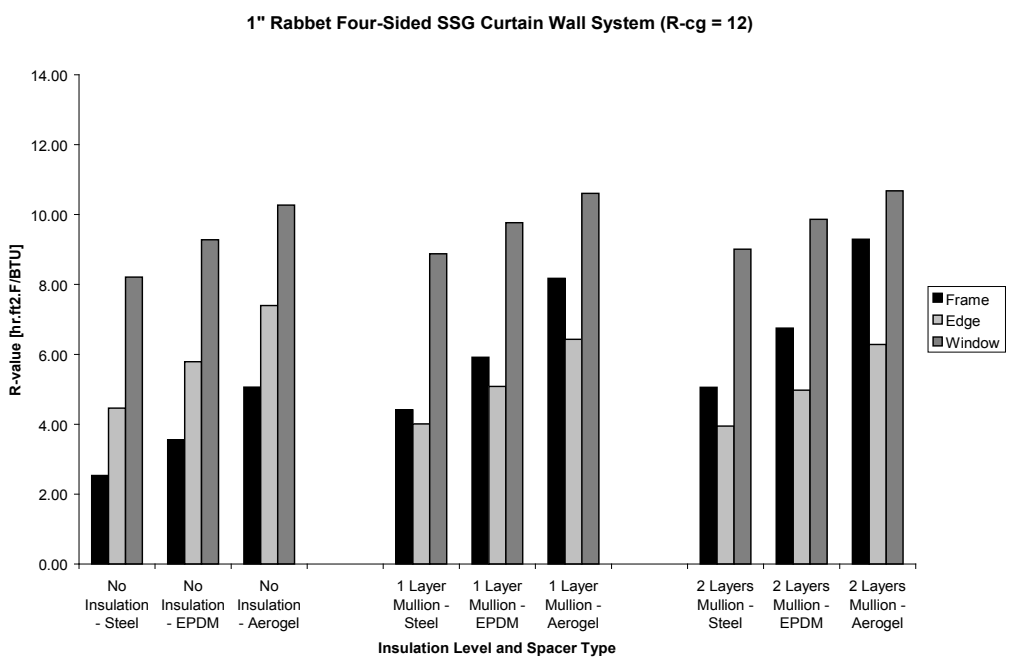


Figure 11.2.2.3: Overall Window Performance of Four-Sided SSG Curtain Wall System

This investigation revealed the optimal rabbet depth is at 1" since the window R-value reaches a maximum at this point. The results also show that additional layers of aerogel insulation provide only incremental gains in R-value, which are less than R1. This is especially well demonstrated as the other properties of the window become more insulated, and is concurrent with the general trend of diminishing returns with additional insulation levels in the building envelope. The most significant component of the window that affects the overall U-value is the conductivity of the spacer material. Switching to a highly insulating edge spacer can significantly increase the thermal resistance of the window for all frame designs.

This type of information advises the team to select windows with better edge spacers and allows for various curtain wall designs to be pursued including a capped curtain wall versus a SSG curtain wall arrangement.

Building Envelope Simulations

Similar to the window simulations, the basic requirements of the opaque building envelope, such as the appropriate insulation levels, were outlined by preliminary overall building simulations. From these requirements various wall, floor, and roof assemblies were created and analyzed for its energy performance. Since the thermal performance of opaque building assemblies is relatively well understood a simple spreadsheet analysis was sufficient to assess the energy performance of the building envelope. The spreadsheet however, does not take into account infiltration or transient effects, which can have a significant influence on the energy performance of the wall. From this simple spreadsheet analysis the optimal design was selected and is shown in Figure 11.2.2.4.

This wall assembly was then analyzed for its hygorthermal performance using WUFI, which performs a one-dimensional transient analysis of both heat and moisture flows across a building assembly. The results of the analysis for an east-facing wall in Toronto is presented in Figure 11.2.2.5.

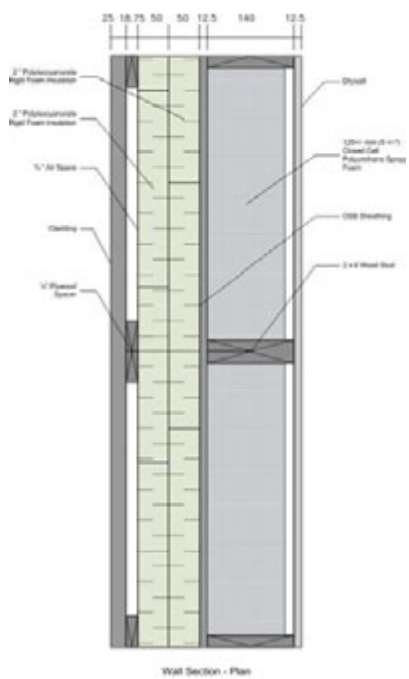


Figure 11.2.2.4: Opaque Wall Assembly

From the simulations the wall sections are unlikely to have any condensation. The relative humidity (RH) of the various layers within the wall rarely goes beyond 80%, with the exception of the cladding, which is expected as it is exposed to rain. The maximum relative humidity of the wall materials are only at 80% because that is the initial RH for all layers during construction. At this high RH the wall dries out during the simulation period of one year. Given the good vapour control ability of the wall, problems with inward vapour drives are unlikely to occur even with a highly absorbent cladding.

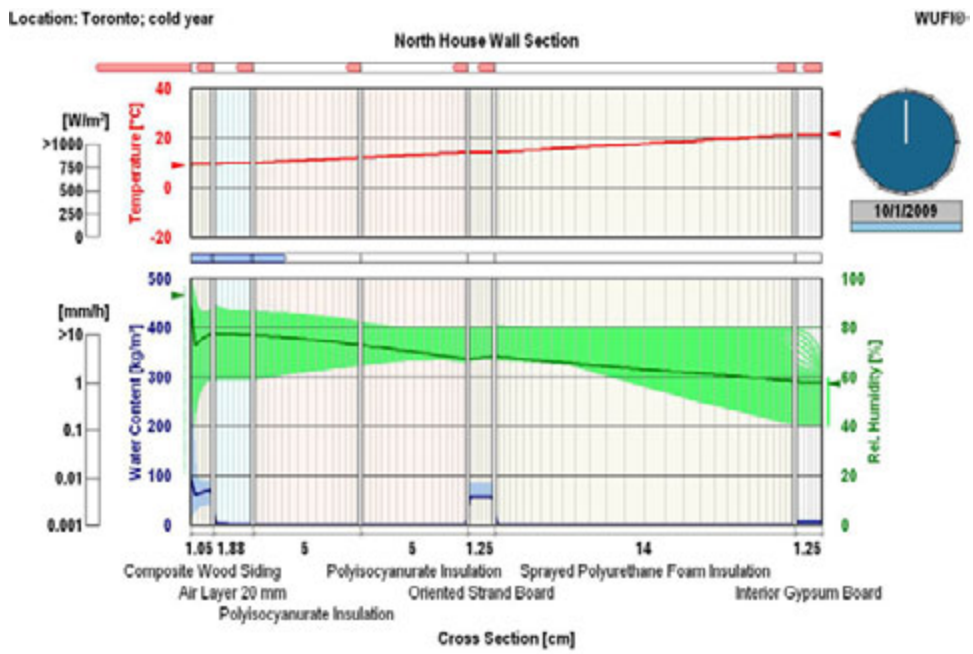


Figure 11.2.2.5: Hygrothermal Performance of North House Wall Assembly

The results of this analysis were consistent for both the floor and roof assemblies since they are based on the same design with minor variations. These assemblies were then further evaluated with other subjective categories including constructability to assess the practicality of the design for the Solar Decathlon competition.

11.2.3 DETAILED ESP-R / ENERGYPLUS MODEL

To gain confidence in model predictions, a concurrent building energy analysis was performed using two distinct computer simulation codes: ESP-r and EnergyPlus. The models focused mainly on predicting annual space heating and cooling energy, beginning with a very simple model and progressively adding building elements representative of the North House design. Emphasis was placed on establishing the relevant model inputs to reduce the likelihood of discrepancy between the two modeling efforts.

Model Inputs

Table 11.2.3.1 summarizes the model inputs. The building geometry and construction are based on the current drawing set. Default exterior convection models, buoyancy driven interior convection models and solar processing models were used in both programs.

Table 11.2.3.1: Model Inputs

LOCATION	CLIMATE FILE	TYPE	Exposure	
Toronto	Toronto	CWEC	Rural	
SET-POINTS				
Air Temperature (Annual)	deg C	21-25		
Air Relative Humidity	%RH	40-55		
Conditioned space				
Floor area			ft^2	670.00
Internal ceiling height			ft	9.66
Space volume			ft^3/min	6472.20
Minimum Ventilation Requirements				
ASHRAE 62.2 standard				
Occupants				2.00
ventilation rate per occupant			ft^3/min	7.50
ventilation rate per sq. ft			ft^3/min	0.01
Total ventilation			ft^3/min	21.70
Total ventilation			ACH	0.20
Infiltration				
Blower test			ACH at 50Pa	0.60
Adjustment factor				15.00
Infiltration			ACH	0.04
Total Minimum Ventilation			ACH	0.24
Bathroom fan				
Exhaust rate			L/s	25.00
			ft^3/min	52.97
			ACH	0.49
Range hood fan				
Exhaust rate			L/s	50.00
			ft^3/min	105.94
			ACH	0.98
HRV				

HRV efficiency	%	70.00
Effective ventilation rate multiplier		0.30
Effective Minimum ventilation rate + Infiltration	ACH	0.10
Effective Bathroom fan ventilation rate	ACH	0.15
Effective Range hood fan ventilation rate	ACH	0.29

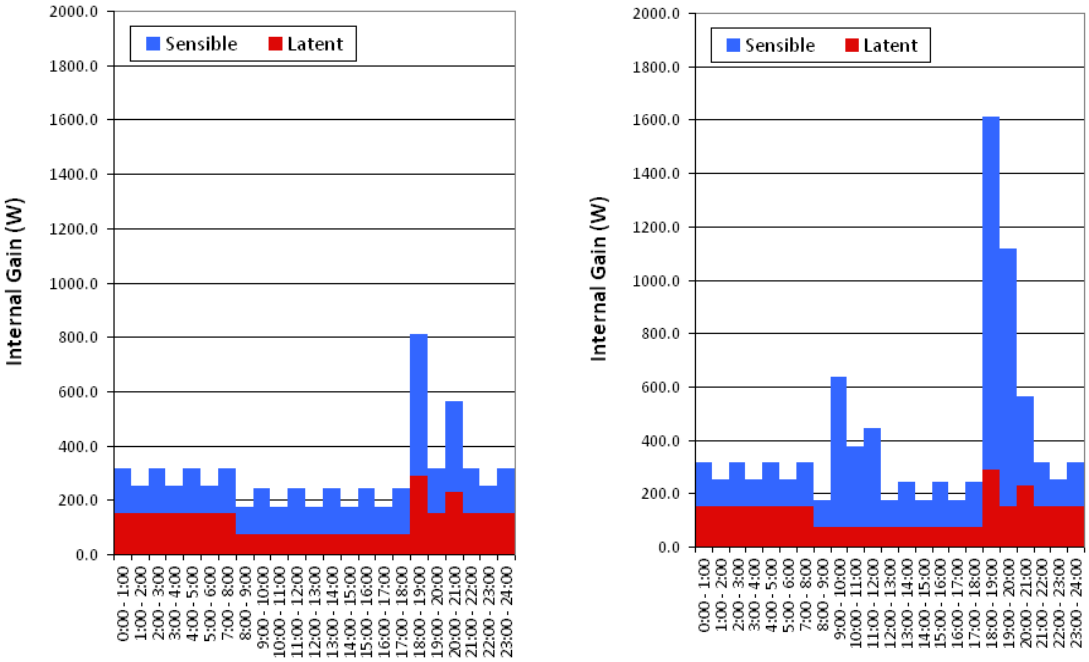
Schedules

Internal gain and ventilation schedules were created to approximate the occupancy of the house. Different internal gain schedules were constructed for weekdays and weekends to account for appliance use such as clothes washer, clothes dryer and oven. The internal gains schedules are based on double occupancy as well as the predicted use of the appliances selected for the house, with appropriate sensible and latent multipliers. The ventilation schedule includes, in addition to the minimum ventilation requirements, a bathroom exhaust fan and a range hood fan that provide additional ventilation during certain hours in the day. Table 11.2.3.2 shows the appliance list with estimated annual and weekly energy use and approximate sensible and latent multipliers. Figures 11.2.3.1 and 11.2.3.2 show the internal gain and ventilation schedules used in the models for weekdays and weekends.

Table 11.2.3.2: Appliance Data

Refrigerator		
Leibherr HC1060		
Energy/year	kWh/y	297.0
Energy/week	kWh/w	5.7
Sensible Energy Multiplier		1.0
Latent Energy Multiplier		0.0
Dishwasher		
Gaggenau DF 261 760		
Energy/year	kWh/y	190.0
Energy/week	kWh/w	3.7
Estimated Energy/year for North House	kWh/y	114.0
Estimated Energy/year for North House	kWh/w	2.2
Sensible Energy Multiplier		0.6
Latent Energy Multiplier		0.2
Oven		
Gaggenau BO 250-611		
Energy/year	kWh/y	166.4
Energy/week	kWh/w	3.2
Sensible Energy Multiplier		1.0
Latent Energy Multiplier		0.0
Cooktop		
Gaggenau VI 221		
Energy/year	kWh/y	254.8
Energy/week	kWh/w	4.9
Sensible Energy Multiplier		0.8
Latent Energy Multiplier		0.2
Clothes Dryer		
Bosch Axxis condensation		
Energy/year	kWh/y	419.0
Energy/week	kWh/w	8.1

Sensible Energy Multiplier		0.2
Latent Energy Multiplier		0.0
# of cycles in quoted energy consumption	cycles/y	416.0
Estimated actual number of cycles	cycles/y	208.0
Estimated Energy/year	kWh/y	209.5
Estimated Energy/week	kWh/w	4.0
Clothes Washer		
Bosch Axxis plus		
Energy/year	kWh/y	129.0
Energy/week	kWh/w	2.5
Sensible Energy Multiplier		0.8
Latent Energy Multiplier		0.0
# of cycles in quoted energy consumption	cycles/year	392.0
Estimated actual number of cycles	cycles/year	156.0
Estimated Energy/year	kWh/y	51.3
Estimated Energy/week	kWh/w	1.0
Other		
Flat Screen TV		
Samsung LN-R3228W 32"		
Energy/year	kWh/y	127.8
Energy/week	kWh/w	2.5
Sensible Energy Multiplier		1.0
Latent Energy Multiplier		0.0
Desktop Computer		
assume average draw of 70W with LCD display		
Energy/year	kWh/y	76.4
Energy/week	kWh/w	1.5
Sensible Energy Multiplier		1.0
Latent Energy Multiplier		0.0
Misc. Plug Loads (assume average load of 25W)		
Energy/year	kWh/y	218.4
Energy/week	kWh/w	4.2



Weekday Weekend

Figure 11.2.3.1: Internal Gains Schedules

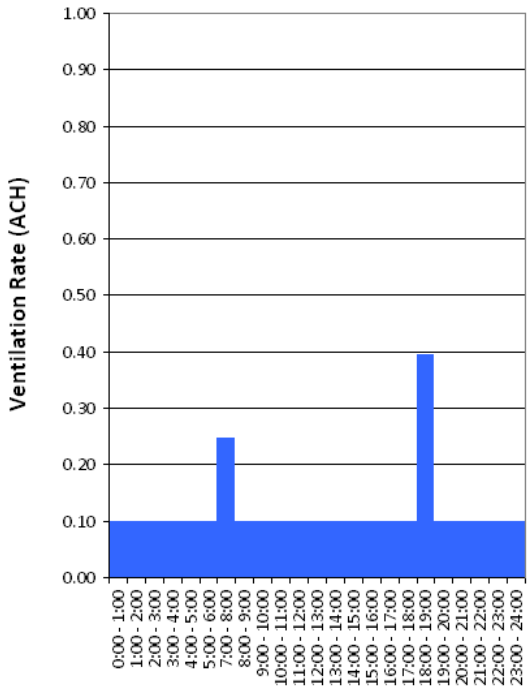


Figure 11.2.3.2: Ventilation Schedule

A shading schedule was generated for the external shading system. The fabric of the shades is assumed to have a solar transmittance of 0.25 which corresponds to a finely woven fabric with little openness.

The schedule, when applied in the simulation, is valid for the summer and swing months from April 1 to September 30. From October 1 to March 31, the external shades are assumed retracted. The daily schedule is shown in Table 11.2.3.3. The fixed daily schedule is not representative of the actual shading control, which will take into account the monthly changes in the solar arc. Rather, it is an approximation of the general control strategy applied for the entire period from April 1 to September 30.

Table 11.2.3.3: Shading schedule.

Time	East	South	West
00:00 – 07:00	OFF	OFF	OFF
07:00 – 09:00	ON	OFF	OFF
09:00 – 12:00	ON	ON	OFF
12:00 – 16:00	OFF	ON	ON
16:00 – 19:00	OFF	OFF	ON
19:00 – 24:00	OFF	OFF	OFF

Results

To gain insight into the impact and significance of major model parameters, simulations were carried out for five cases beginning with a reference case that consisted of the current envelope design with minimum ventilation requirements and cooling/heating set-points. In the remaining cases elements such as a heat recovery ventilator (HRV), occupancy, internal gains, shading and PCM were added consecutively. The HVAC model was not incorporated at this time due to insufficient information on HVAC specifications. The annual heating and cooling values represent the theoretical or idealized energy demand integrated over one year, independent of any mechanical systems. In other words, the instantaneous space heating/cooling load represents the rate of energy injection/extraction required to keep the conditioned space air temperature between the desired set-point range. The integration of these loads over one year represents the idealized annual space heating and cooling energy. From the consumption point of view, this is analogous to heating with a variable electric resistance heater where 1 kWh of electricity equals (for all intensive purposes) 1 kWh of heat. Other mechanical systems such as heat pumps with coefficients of performance greater than one may consume less energy to meet the idealized heating/cooling demand profiles. Table 11.2.3.4 describes the five simulation cases.

Table 11.2.3.4: Simulation Cases

CASE 1 - BASE CONSTRUCTION WITH SETPOINTS		
	YES/NO	NOTES:
HRV	NO	
Ventilation schedule	NO	Use constant 0.24 ACH
Internal gains schedule	NO	set all internal gains to 0
Shading	NO	
HVAC	NO	theoretical heating/cooling requirements
PCM	NO	
CASE 2 - ADD HRV		
	YES/NO	NOTES:
HRV	YES	70% heat recovery
Ventilation schedule	NO	Use constant 0.10 ACH
Internal gains schedule	NO	set all internal gains to 0
Shading	NO	

HVAC	NO	theoretical heating/cooling requirements
PCM	NO	

CASE 3 - ADD SCHEDULES		
	YES/NO	NOTES:
HRV	YES	70% heat recovery
Ventilation schedule	YES	includes bathroom and range hood fans
Internal gains schedule	YES	includes appliances and occupants
Shading	NO	
HVAC	NO	theoretical heating/cooling requirements
PCM	NO	

CASE 4 - ADD SHADING		
	YES/NO	NOTES:
HRV	YES	70% heat recovery
Ventilation schedule	YES	includes bathroom and range hood fans
Internal gains schedule	YES	includes appliances and occupants
Shading	YES	dynamic control - passive heating and cooling
HVAC	NO	theoretical heating/cooling requirements
PCM	NO	

CASE 5- ADD PCM TO FLOOR		
	ON/OFF	NOTES:
HRV	YES	70% heat recovery
Ventilation schedule	YES	includes bathroom and range hood fans
Internal gains schedule	YES	includes appliances and occupants
Shading	YES	dynamic control - passive heating and cooling
HVAC	NO	theoretical heating/cooling requirements
PCM	YES	floor and ceiling

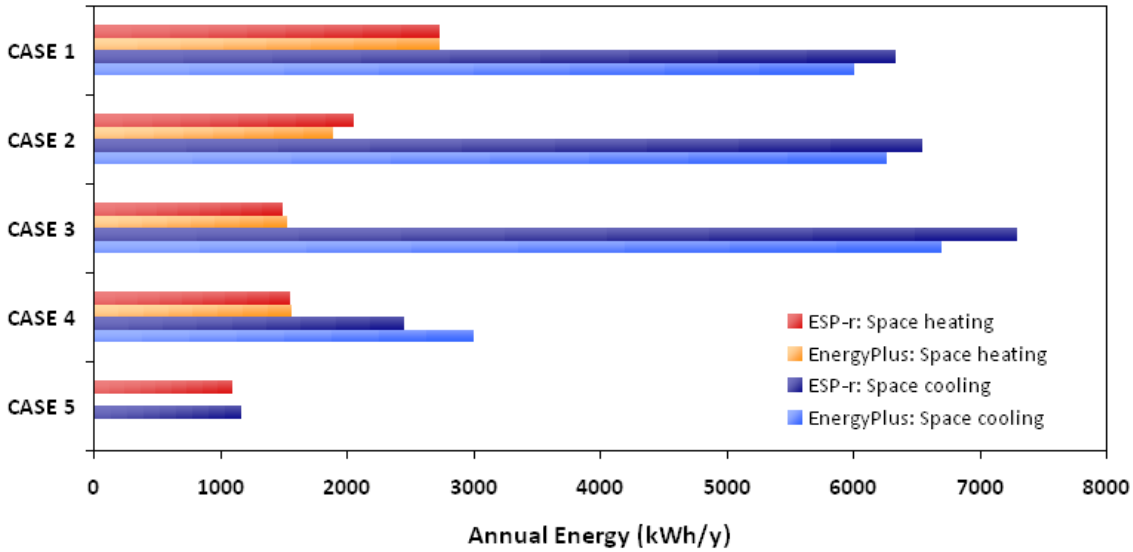


Figure 11.2.3.3: ESP-r and EnergyPlus Simulation Results

ESP-r and EnergyPlus simulation results for annual heating and cooling energy are shown in Figure 11.2.3.3. Predictions from both models match well. As expected, without the use of shading, the cooling energy dominates. The addition of a heat recovery ventilator results in a substantial decrease in heating demand. The addition of schedules increases cooling and decreases heating. Most significant is the addition of a shading schedule for the east, south and west facades. The cooling demand is decreased to roughly a third of the cooling demand without shading. In case 5, the use of PCM placed underneath the top layer of the floor drives down heating and cooling demand further. Case 5 was not modeled in EnergyPlus.

Conclusion

Predictions by both ESP-r and EnergyPlus are in good agreement. The results indicate that the demand for space heating and cooling can be decreased drastically primarily by providing appropriate solar protection and thermal mass. The next phase of modeling will incorporate HVAC components in order to gauge the energy consumption of the mechanical system and compare the results to idealized heating and cooling demand.

11.2.4 PHOTOVOLTAICS AND SOLAR THERMAL

Initial Solar Resource Assessment

Many different PV array configurations were studied. Figure 11.2.4.1 is an initial comparison of yearly energy output for four different layouts. For all cases, the blue part of the columns is the roof output. For the first column, the red is the output from the south facade, and the green and purple are the outputs from the east and west. The green part of the second and fourth columns represent the energy output of the east- and west-facing photovoltaics.

The first column consists of a horizontal roof covered in photovoltaics and a 5 foot high band at the top of the east, west and south facades. The second column represents a roof covered in photovoltaics but tilted 12 degrees towards the south (maximum tilt to stay within solar envelope) with side "PV triangles" (if looking at the west or east facade, the roof creates a triangle with the horizontal plane, the triangle would be filled with PV). The third column represents an area the size of the roof tracking the sun in two axes (zero angle of incidence at all time). This scenario would be almost impossible to produce due to the size of the roof (and it would not fit in the solar envelope). The last column is the same as the second, but for a greater slope of the roof. Columns three and four could not be used during competition but are good for comparison purposes.

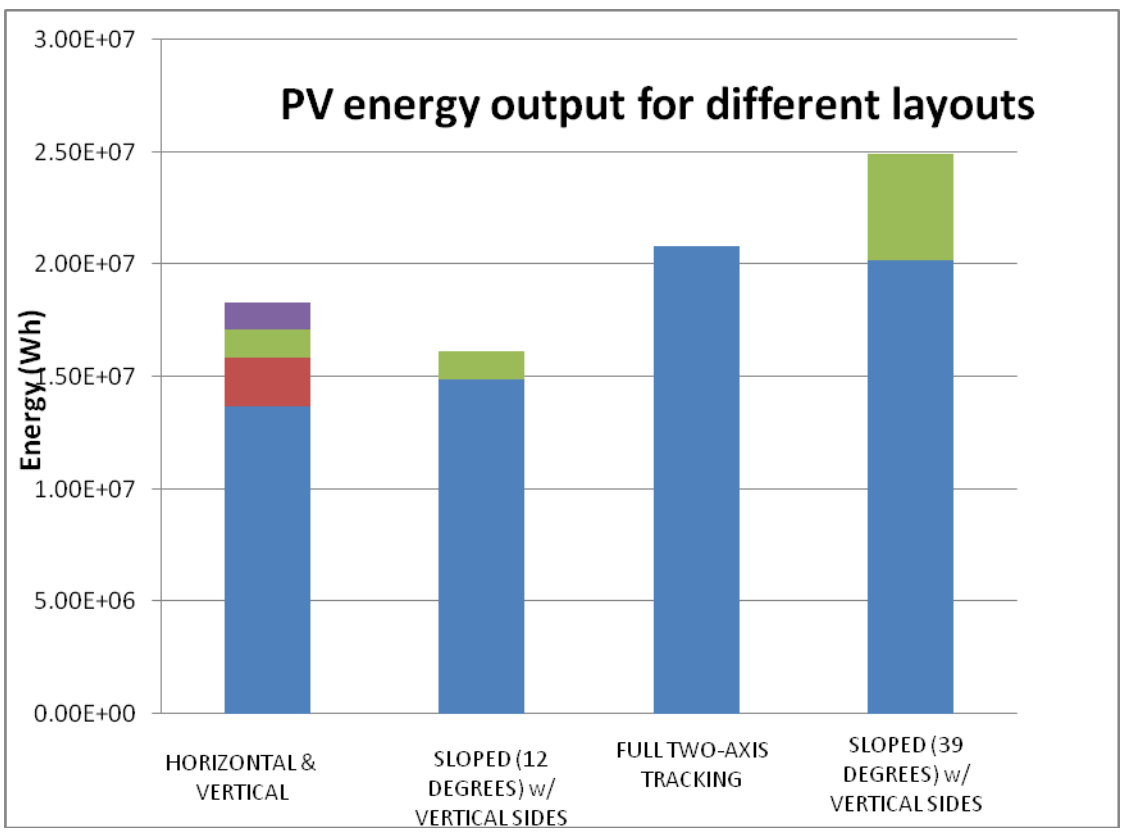


Figure 11.2.4.1: PV Energy Output for Different Layouts

The concept of a "partial tracking" (repositioning) system as seen in Figure 11.2.4.2 was evaluated. The array in this concept is split in four sections. In the morning, the two sections on the west side of the

house would tilt towards the east. At around midday, the two sections on the north side would tilt towards the south. Finally, in the evening, the two sections on the east side of the house would tilt west. The array would stay within the soalr enveloppe at all time. This is an interesting concept but, as shown in Figure 11.2.4.3, was proven to result in almost the exact same power production as a fixed tilted roof at 11.5 degrees (for October 2nd, almost no cloud cover).

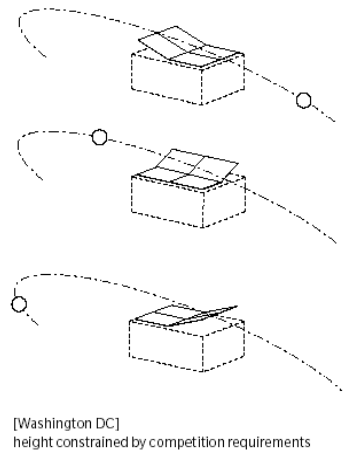


Figure 11.2.4.2: Repositioning System

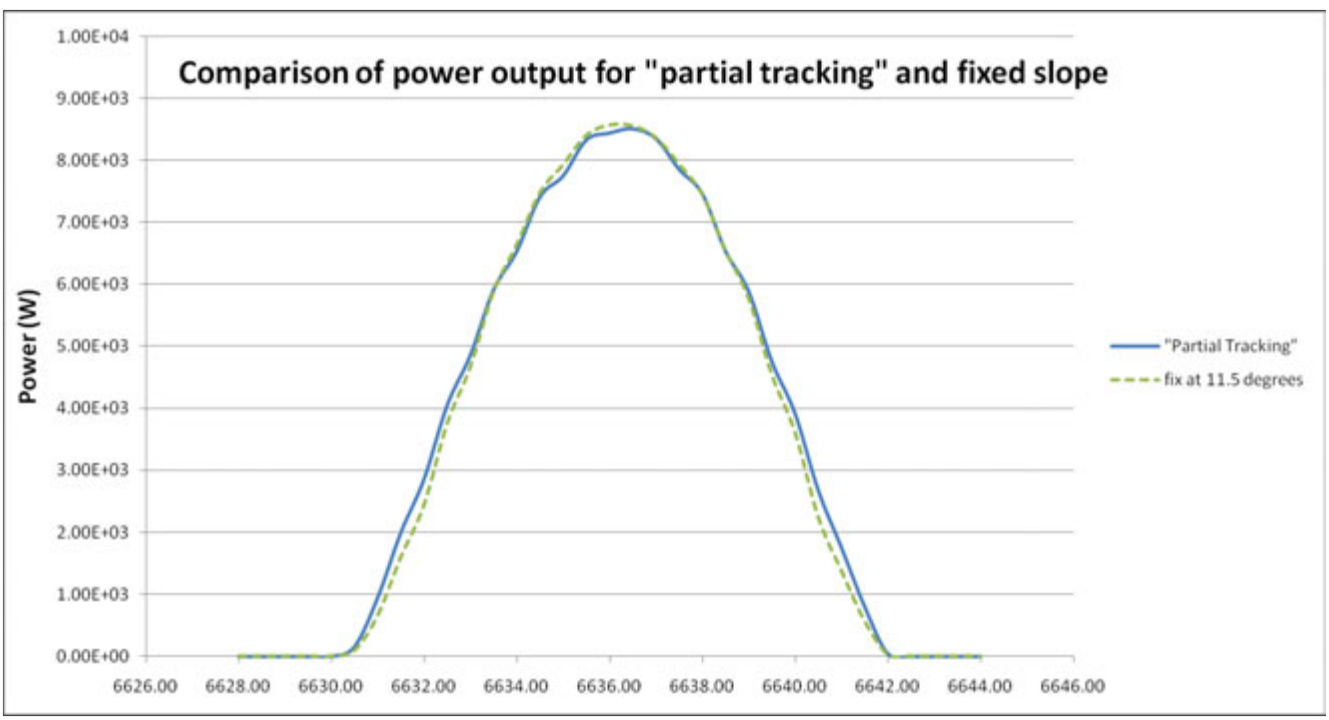


Figure 11.2.4.3: Comparison between Partial Tracking and Fixed Slope

From these analyses, it was found that the single most important variable for PV energy production is the total PV area. Based on these findings, the current PV layout was chosen.

11.2.5 ELECTRICAL PRODUCTION MODEL

Model

The modeling of the photovoltaics was initially done in TRNSYS. All facade PVs were assumed to be Day 4 Energy 36MC panels. The PV/Thermal PVs are Unisolar PVL-68 amorphous "peel and stick" panels.

In this configuration, the roof contained 56 panels divided into 4 strings of 14 panels, which two inverters would handle two strings each. The east- and west- facades each contain 13 panels each attached in series. Only one inverter is needed for these two strings as only one side of the house faces the sun at any given time. The south- façade contains 8 panels in series.

The model assumes no losses in the lines or the inverters. These losses should be fairly small (between 5-10%).

Results

As shown in the following tables, the total PV output for competition is estimated to be 197 kWh. For the year, the total PV output is estimated at 14.9 MWh. The largest contributor to the electrical production is by far the roof. The roof produces roughly 60% of the electricity generated by North House.

Location **Baltimore**
First week of October

	Energy (kWh)
Roof	125.9
East-West	48.7
South	22.8
Total	197.4

Location **Toronto**

	Energy per month (kWh)			
	Roof	East-West	South	Total
January	301.7	130.3	95.2	527.2
February	453.4	191.1	119.2	763.7
March	716.4	294.2	130.8	1141.4
April	918.9	360.1	121.3	1400.3
May	1214.7	450.4	129.2	1794.3
June	1308.4	490.2	125.4	1924.0
July	1306.0	504.8	132.9	1943.7
August	1167.9	462.2	139.5	1769.6
September	825.3	329.2	127.1	1281.6
October	534.6	221.6	111.2	867.5
November	244.4	97.5	56.6	398.5
December	218.9	98.1	69.7	386.8
YEAR	**9210.6**	**3629.8**	**1358.2**	**14198.5**

Figure 11.2.5.1: Initial PV Electricity Production with TRNSYS

These results have since been modified based on selection of Schuco PV panels on the east, west and south facades. The model was refined as well by using the PVWatts model from NREL, because it was considered to be a more versatile model that is better suited for estimating PV electrical energy production. The model is representative of typical output for the city of Toronto, where the house will be permanently located. Assuming a derate factor of 0.77, the total yearly electrical output of the photovoltaic panels for the house is 10450 kWh. An estimated 10% of the energy will be lost in the winter if the snow is allowed to accumulate on the roof array. Table 11.2.5.1 shows the data from the simulation, and figure 11.2.5.2 shows the data graphically.

Table 11.2.5: Estimated Annual PV Electrical Power Production

Month	Roof (8.28kW)		East (1.83 kW)		West (1.83 kW)		South (1.18 kW)		Total Energy (kWh)
	Peak sun hours (kW/m^2/day)	AC energy (kWh)	Peak sun hours (kW/m^2/day)	AC energy (kWh)	Peak sun hours (kW/m^2/day)	AC energy (kWh)	Peak sun hours (kW/m^2/day)	AC energy (kWh)	
1	1.47	262	1.1	42	1.18	45	2.70	79	428
2	2.27	395	1.58	58	1.76	66	3.18	84	603
3	3.19	627	2.13	87	1.78	70	2.89	79	863
4	4.36	811	2.54	97	2.41	92	2.83	70	1070
5	5.60	1052	3.50	141	2.69	103	2.67	62	1358
6	6.14	1075	3.40	126	3.16	115	2.55	53	1369
7	6.02	1062	3.42	127	3.07	112	2.60	54	1355
8	5.15	907	3.05	113	2.84	105	2.96	68	1193
9	4.08	714	2.69	98	2.34	83	3.46	84	979
10	2.55	464	1.61	60	1.64	61	2.97	81	666
11	1.30	204	0.74	20	0.81	23	1.73	43	290
12	1.07	178	0.70	22	0.69	20	1.93	56	276
Ave/ month	3.61	646	2.21	82.7	2.03	74.8	2.70	67.8	870.8
Total	-	7752	-	993	-	897	-	813	10450

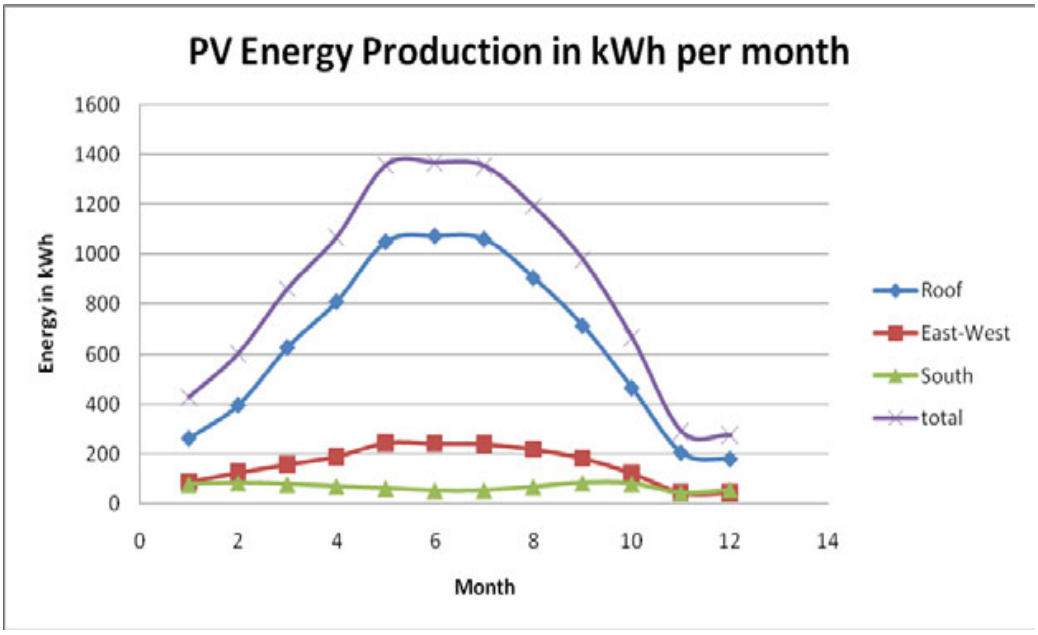


Figure 11.2.5.2: Estimated Annual PV Electrical Energy Production - PVWatts

11.2.6 SOLAR THERMAL AND DHW MODEL

Various calculations and simplified simulations were performed in order to verify the performance of the solar thermal / mechanical system. The details and results of these analyses are provided below. The overall workings and design goals of the system are described in detail in the engineering design narrative, and further detail on the construction and precise layout of the systems can be found in the construction document package.

Simulation Details:

A calendar-based forcing function was set up in TRNSYS, based on the provided approximate schedule of domestic hot water (DHW) competition draws (as summarized below). At the time of modeling, exact appliances were yet to be determined, so the following assumptions were made:

- A shower was set to a 10 minute, 56 L draw of water.
- Dishwashing was set to a 5 minute, 20 L draw of water.
- Clothes washing was set to a 12 minute 60 L draw of water.
    - Where consecutive clothes washing competitions are scheduled, a 48 minute 120 L draw of water was simulated.

Table 11.2.6.1: Hot Water Competition Schedule

Day 1:		Day 5:	
7:30 am – 10:30 am:	Dishwashing	8:30 am:	Shower
8:30 am – 11:30 am:	Clothes Washing	3:30 pm – 9:30 pm:	Clothes Washing (2 load)
9:30 am:	Shower	6:30 pm:	Shower
11:30 am:	Shower		
		Day 6:	
Day 2:		8:00 am – 11:00 am:	Clothes Washing
10:30 am:	Shower	8:30 am:	Shower
3:30 pm – 9:30 pm:	Clothes Washing (2 load)	3:00 pm – 6:00 pm:	Dishwashing
5:30 pm:	Shower	3:30 pm:	Shower
9:00 pm:	Shower	4:30 pm:	Shower
Day 3:		Day 7:	
5:30 pm:	Shower	10:00 am – 4:00 pm:	Clothes Washing (2 load)
6:00 pm:	Shower	10:30 am:	Shower
6:30 pm – 9:30 pm:	Dishwashing	11:00 am – 2:00 pm:	Dishwashing
		3:00 pm:	Shower
Day 4:		Day 8:	
9:30 am:	Shower	9:00 am:	Shower
5:30 pm:	Shower	9:30 am:	Shower
6:00 pm:	Shower	3:30 am – 9:30 pm:	Clothes Washing (2 load)
		4:00 pm:	Shower
		6:30 pm – 9:30 pm:	Dishwashing

A TRNSYS model of the three-tank system (current at the time) was assembled. Unfortunately, the provided TRNSYS modules were not equipped to handle many of the components used in this system, so the following simplifications were made:

- It was not possible to simultaneously model both a heat pump and a heat exchanger bypass loop between the preheat tank (PHT) and the space heating tank (SHT).
    - The COP source file was instead modified to simulate the power consumption and heat delivery of a pump/heat exchanger loop at the appropriate temperatures, while maintaining the appropriate heat pump COP in the normal operating range

- It was also not possible to (easily) incorporate dynamic heating demands on the system, due to limitations on the stratified tank module used.
    - Hydronic heating demand was instead simulated by increasing tank losses in the Hydronic tank as specified in the following table (corresponding to the appropriate peak heating values for each month)

Table 11.2.6.2: Simulated Space Heating Values

	Max (kW)	**Avg (kW / kJ/hr)**	**Approx U_L**
January	1.70	0.50 / 1800	2 + 93
February	1.60	0.42 / 1512	2 + 78
March	1.30	0.23 / 828	2 + 41
October	0.90	0.06 / 216	2 + 9
November	1.10	0.28 / 1008	2 + 51
December	1.54	0.50 / 1800	2 + 93

Resulting Design Decisions:

After performing various simulations over both yearly (simulated month-by-month) and competition periods, with different tank sizes, set-point temperatures, heat pump capacity, etc., the following design decisions were made with respect to the solar thermal / mechanical system:

- A heat pump of about 5 kW capacity could meet all space heating requirements via the hydronic system as well as all DHW requirements, with minimal need for auxiliary backup heating.
    - Discussion with various heat pump suppliers lead us to opt for a digital scroll compressor with a larger nominal capacity of 12 kW, but with the ability to modulate down to 10% with negligible performance loss and an increased COP
    - Note: the desuperheater loop was added to the system afterward, and was thus not taken into account in the modeling

- Two arrays of evacuated tube collectors are sufficient to meet the majority of heating demands throughout the year, with the possibility of frequent overheating and stagnation over the summer
    - A heat dissipater loop was added to the system to take care of this
    - Note: the exact type and model of solar thermal collectors were not known at this point, so typical performance values were used.

- Two 1 kW auxiliary backup heaters in the DHW tank are sufficient
    - We opted for two 3 kW heaters to be safe, as the addition in cost and complexity was minimal

- During the winter months, it is possible that the preheat tank may reach temperatures as low as -10°C
    - As such, it was decided that this tank will contain a 10% propylene glycol solution to prevent freezing

- A DHW tank of about 75 L (20 gallons) should provide sufficient thermal storage to meet two consecutive shower competitions (separated by 30 minutes) with the help of some heat delivered from either the heat pump system or auxiliary backup heaters
    - To be safe, we chose a DHW tank of 150 L (40 gallons)

- A larger preheat tank performs better on all accounts (as expected, since it could provide much more thermal mass)
    - Due to space constraints, a 110 gallon tank was chosen

- Note: for yearly simulation, a 1000 L tank was used, as space will likely be less of a concern in the house's permanent location

- A fairly small space heating tank is sufficient, as the space heating demand is much lower than the DHW demand
  - A 30 gallon tank was chosen, to allow space for sufficient length of copper heat exchanger coils to be inserted (this tank is to be custom-made from a plastic barrel)

Simulation Results:

For the competition week, the following results were predicted:
Approximately 60 kWh of hot water demand, and 11 kWh of heating demand will be required. The system will collect 69 kWh of solar energy and require electrical input of 19 kWh. 16 kWh will be lost or stored. The solar fraction for competition week is 73%.

On a yearly basis, approximately 2.6 MWh of hot water demand, and 1.4 MWh of heating demand will be required. The system will collect 3.8 MWh of solar energy and require electrical input of 1.4 MWh. The average solar fraction is 65%. This should improve if a more thermally massive storage system is used (i.e., borehole storage or a larger tank).

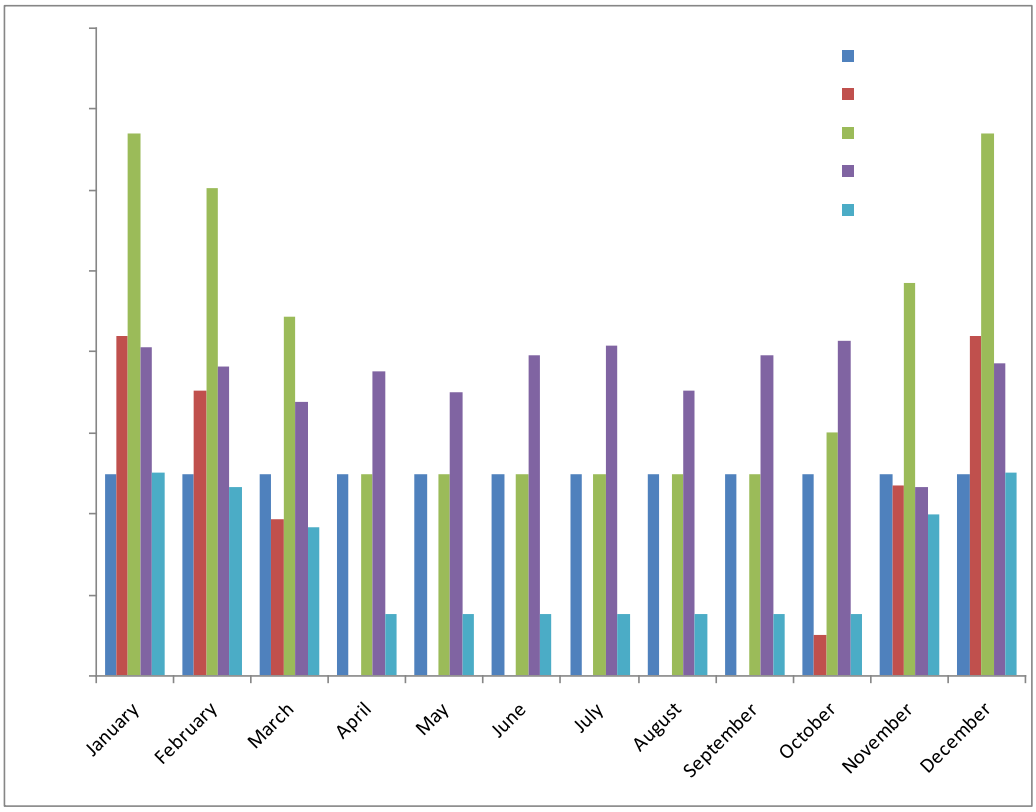


Figure 11.2.6.1: Monthly DHW Model Results

Table 11.2.6.3: DHW Model Results

	Heating Loads			Heating supply		Available	
	Heating	Hot Water	Losses	Electrical	Thermal	Electrical	Thermal
Annual (MWh)	1.4	2.6	1.2	1.4	3.8	14.9	9.4
Competition (kWh)	11	60	17	19	69	210	228

If the solar thermal panel was to continuously run (when there is sufficient sun), the production would far exceed the demand for thermal energy. The thermal output would be 9.4 MWh for the year and 228 kWh for competition week. These numbers are found by continuously running fluid through the collector as long as the temperature of the fluid coming out of the collector is larger than the one going in. In reality, the pump would only run when there is approximately 5°C difference between the inlet and outlet temperatures (as controlled by the typical solar thermal pump controlling unit). These numbers are therefore overestimated, but provide use with a good approximation of the potential for thermal energy production.

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12.0 Design Narratives

12.1 Architectural Design Narrative

The North House Architectural design centres on five key strategies; a House for Climate Extremes which addresses the significant challenge of building for the Canadian climate; Holistic Solar Living which generates a lifestyle that maximally incorporates benefits from the sun; Layers (DReSS) which distributes many aspects of performance and amenity throughout a layered building envelope; Adaptive Living Interface System (ALIS) which empowers the occupant with both house systems control and feedback; and Customizable Components which extends the aspirations of the North House beyond those of a simple residence, and towards a set of component prototypes and long-term research tools.

A House for Climate Extremes

Canada is a country with extreme climatic conditions that pose significant challenges to the traditional approaches to passive solar design. Beyond the drastic seasonal weather changes, many parts of the country frequently experience radical weather shifts within very short periods of time. It is not uncommon to experience snow one day and two days later a 25°C heat wave. These extreme temperature ranges are predicted to become more and more common in the northern regions of this continent.

North House is designed with a passively and mechanically conditioned interior that is wrapped by a highly insulated, layered envelope that modulates the house's response to various climatic, solar and shading conditions. The footprint of the house is compact and efficient, minimizing envelope surface area and maximizing opportunities for east-west passive ventilation. The interior consists of a 'densepack' of service on the north side of the house, opening to a generous and flexible living space that is fully glazed with a specially developed high-performance glazing system. The flexible living space accommodates sleeping, eating and living functions with custom reconfigurable furniture that maximizes openness and multi-functionality. This flexible framework will allow North House to be customized for different living needs, to be adapted to multiple regions across the country and to take advantage of new technologies and developments in envelope and solar technologies. The modular design of North House will also allow the building to be easily divided into component modules for fabrication, transportation, assembly and future expansion to accommodate a variety of familial situations.

Holistic Solar Living

Our team defines Holistic Solar Living as an approach to building and living that incorporates the energy and benefits of the sun in all ways possible. The consideration of day-lighting, passive systems, microclimate generation, maintenance, food production, solar phase-change materials, the use of natural materials produced with the sun's energy, and solar responsiveness are all part of the design approach. The idea that both the house and the occupant are sentient beings, aware and responsive to their environment, both inside and outside, runs through all of the decisions on space planning, design and technology.

North House is designed with an open concept plan wherein the interior and exterior living spaces are conceived as a continuous experience, encouraging the occupant to live in a relationship with the exterior surroundings and landscape. The human psychological and health benefits of natural light, especially in northern climates where winter daylight hours are short, have been noted by environmental psychologists. The adjacency of the kitchen and interior dining space to the outdoor dining facilitate a shady outdoor supper in the summer months. The open concept living, sleeping and dining within the fully glazed south-facing living space allow maximum day-lighting during all hours. High-performance glazing combined with dynamic solar shading and integrated solar power generation result in a house that is projected to be a net energy producer despite the demands of northern climates.

Holistic Solar Living also includes using the sun's energy to grow food in the raised bed garden outside, as well as inside along the east-facing windows. The landscape design provides space for drying and canning to preserve garden produce and limit the need for refrigeration. Species selected for the landscape have been considered for food value, seasonal variation, as well as potential for creating micro-ecologies, inviting birds and desirable insects to the site.

12.1.1 Image of North House installed in the Canadian West

Layers | DReSS (Distributed Responsive System of Skins)

In Canada, anyone who spends time in the outdoors camping, canoeing, or hiking knows that the best way to prepare for unpredictable weather is to dress in layers. Similarly, the North House is structured and constructed in layers, with each layer performing a different task. Together the layers will provide passive solar gain when necessary, shading at other times, will open to the exterior when views are desired, will produce energy, and will be capable of mitigating extreme climatic shifts by closing down when the house is in conditioned mode or opening up to allow the house to breathe and expand during the temperate seasons. We have termed this entire system of layers the Distributed Responsive System of Skins, or the DReSS.

The outermost layer integrates glass encapsulated photovoltaics on the walls, flat-plate photovoltaics and solar hot water technology on the roof, and passive solar heat management in the dynamic shading system. These outer layers are independent of the structure and thermal envelope of the house. The second layer is a high-performance, highly insulated glazing system with a high solar heat gain coefficient to maximize solar gain on the south, and an R60 solid envelope on the north. Operable units on the east and west allow for passive ventilation. Inboard of the glazing system is an interior shade to moderate privacy and view.

The foremost technological strategy that we are employing is extremely high-performance glazing designed to passively heat the house in winter with a dynamic shading system that wraps the glazed volume, and manages overheating. North House graduate student and faculty members have undertaken significant glazing research and have developed a custom wood curtain wall system that is estimated to achieve an assembly thermal resistance of R-8.6. The glazing unit is a quad glazed configuration featuring two sheets of glass sandwiching two layers of plastic films which have selective low-e coatings on surfaces 3, 5, and 7. Placing the low-e coatings in this configuration limits the amount of long-wave thermal radiation transmission from indoors to outdoors while still allowing significant amounts of solar gain through the glazing. To achieve the high performance frame design the team has developed custom wood curtain wall window frames with warm edge spacers.

Current energy modeling indicates that up to 30% of the winter heating load can be delivered by passive solar radiation entering through the high performance glazing (Fig. 3). However, solar radiation entering the building must be mediated by an active shading system in order to avoid overheating. Simulation modeling shows that dynamic shading, combined with phase change materials (PCM's) in the floor and ceiling, significantly decreases the cooling load while taking maximum advantage of passive heating. A dynamic exterior shading system of customized exterior venetian blinds wraps the glazed volume of the house, managing the passive heating and cooling of the building by offering a range of modes and configurations, from full solar penetration to full shading while always allowing the occupant to choose to expose panoramic views of the landscape or close the shades completely.

Adaptive Living Interface System

The Adaptive Living Interface System (ALIS) developed especially for North House is comprised of interactive technologies combined with ambient and haptic information cues, that help the residential occupant to both control the systems of the house, provide feedback on the operation of the house, in this way supporting behavioural transformation towards energy saving living patterns. The ALIS moves beyond automated controls to directly address the needs of residential occupants by providing an easy-to-use ubiquitous interface, supporting residential tasks, integrated with the user's lifestyle and providing meaningful performance feedback.

Three types of user interface components comprise the ALIS. First, we are developing a standard web-based graphical user interface (GUI) that can be accessed from anywhere with an internet connection. This GUI includes traditional application-style tools which provide an overview of building state and performance and which supply alerts according to user-specified events. We are extending the GUI to a set of mobile components for a smartPhone, further extending its ubiquity. Relevant GUI functions will be integrated as well into common personal applications such as Google™ Calendar, email, and social networking sites such as Facebook. Second, we are developing a set of small, peripheral, always-on information components that provide a continuous overview of the house, deliver appropriate alerts, and serve as a quick navigation button into remote controls. Finally, we are exploring ambient and subtle information systems that are integrated into the house itself, and which change their behaviour, as conditions change, in ambient and non-intrusive ways. These subtly cue occupants to change and state in both general and contextually specific ways. For example, the "Ambient Canvas", a dynamically illuminated surface that forms the kitchen backsplash, paints a pattern that changes colour according to house performance and efficiency while forming an aesthetic element within the house in its own right.

Customizable Components

Key to the design of North House are the principles of process-based manufacturing. Process-based manufacturing is widely used in automotive, aerospace, and technology industries, but remains in its infancy within the architectural field. To this end, Team North is collaborating with a custom fabricator to optimize shop-built CAD/CAM production techniques and technologies for the North House prototype, to lighten the structure as much as possible in order to facilitate transport, assembly, disassembly and material use, and to maximize the ease of assembly and disassembly of the house.

Use of shop-built prefabrication and component assemblies will support efficient transportation, assembly and disassembly on the National Mall in Washington. North House is conceived as a prototype of mass-customization, and demonstrates a given range of systems and technologies. Each system, however, has the capacity to be completely removed and replaced with alternative systems – to allow modification, research, and testing long into the future. For example, the demonstrated dynamic shading textile is only one of several possible options that the team has investigated, and every aspect of the installation of the shading system, including mounting, supports, clearances, wiring, and controls, have been designed for easy renovation. Likewise, the roof-mounted PV array, the PV cladding system, and the glazing system, have been designed with equal attention to ease of replacement.

12.2 Lighting Design Narrative

The general strategy for the artificial lighting of North House is to achieve maximum integration with the architecture so that the lighting fixtures become invisible when not in use. North House is designed so that little or no artificial lighting is required while there is daylight: the ample glass on the three perimeter walls of the living space, combined with the dynamic shading system allows for ample day-lighting; the window at the shower on the north wall provides ambient light in the densepack service zone. Artificial lighting is used to complement daylight when necessary and uses a combination of energy efficient fluorescent and LED lighting to maximize amenity, comfort, and appropriate colour rendering and minimize energy use.

In the densepack service zone, the majority of the electric lighting is provided by T5 fluorescent tubes concealed in continuous coves within the dropped wood ceiling. These coves wash the continuous wood storage wall, providing a diffuse source of light which increases the perceived depth of these spaces while avoiding glare. In the bathroom, a high-CRI linear fluorescent source is integrated seamlessly into bathroom mirror, providing fill light for makeup and avoiding harsh shadow lines. In addition, two unique lighting features are introduced. A laylight is included in the shower area, behind which is concealed two distinctly colour temperature (CCT) fluorescent sources, one at 3000K and another at 17000K. The basic 3000K sources are used in everyday use, but the 17000K sources are designed to provide a high intensity light "shower" which, due to its high concentration of blue/white light (470nm), aids in the calibrating of circadian rhythms. This feature is particularly directed towards sufferers of SAD (Seasonal Affective Disorder) who, in northern latitudes, require additional exposure to this specific temperature of light during winter months when natural daylight is limited. The second lighting feature included in the bathroom is a nightlight set on a timed motion sensor, which emits only red light so as not to disturb the occupants' circadian rhythms when using the bathroom at night. This linear source is to be integrated in the same cove as the general fluorescent lighting, allowing the light to be switched from white to red without the clutter of multiple fixtures. Linear fluorescent lamps with red gels operating on standard ballasts keep the cost in check for this feature.

The main living space provides a combination of ambient and task lighting. Ambient lighting is provided by a flexible framework of fluorescent lights located behind a custom-designed diffusing soffit, allowing for easy reconfiguration and response to the variable interior arrangements. Specific task lights drop below the soffit to illuminate work surfaces; the kitchen counter, for example, is illuminated by a combination of pendant LED task lights which hang below the soffit and LED lighting integrated behind translucent Corian panels installed along the length of the counter. A custom sculptural diffuser is suspended from the living room ceiling and masks the presence of an array of remote phosphor LED downlights and sensors and includes lenses that provide decorative and ambient effects above the dining area. The remote phosphor technology of the living space fixtures has a fixture efficacy of over 50 lumens per watt compared to compact fluorescent efficacies of 36 lumens per watt. In addition the remote phosphor technology provides a much broader spectrum of light with an 80+ CRI and L70 50,000 hour life according to IES LM80 practices. The remote phosphor optics eliminate the view of multiple LEDs and prevent multiple fringing and shadows in the space. Task lighting in the living area is provided by a work lamp that can be stored in the mobile workstation. For bedtime reading, a portable LED reading lamp can be clipped on to the bed's suspension cables, which also carry a low voltage current. All of the interior lights are controlled with zone controls and user profiles developed through the Central Home Automation Server (CHAS).

A special feature of the North House is the illuminated "Ambient Canvas" integrated within the backlit Corian panels that run above the kitchen counter. This feature is part of the Adaptive Living Interface System (ALIS), and provides subtle feedback on the energy use of the home using tri-colour RGB LED's, which change colour

to indicate when the house is producing energy from the photovoltaics, or drawing from the grid. The Ambient Canvas can be turned off when the house is in 'Sleep' and 'Away' modes, since feedback is not required at these times, or can be switched to provide high CRI white light through a secondary series of flourescents behind the Corian when the kitchen counter is in use for food production.

Night lighting is kept to a minimum in order to minimize light pollution. The house, being all glass, will be a night lantern in itself: the interior lighting will catch on the exterior and interior shades, and the house will produce a layered and variable glow. Exterior LED lights, set on daylight sensors, are located to illuminate the walking surfaces for safety. A recessed light at the entry door is set on a motion sensor and, when activated, will wash down the handle and latch area of the door.

The lighting choices for North House include careful consideration of life cycle costing and safe disposal. LEDs are used to limit lamp replacement: assuming a useful lamp life of 50000hrs based on IES LM80 recommended practice, and sourcing fixtures with replaceable LED modules, we aim to reduce embodied energy in the source manufacturing. While all fluorescent sources use mercury, our Philips T5 lamp selection has the lowest rated level of mercury at 1.5gm and with a 40,000 hour plus lamp life this light source could match the life of the home. It has been demonstrated that the mercury included in a standard fluorescent lamp is far less than that used to produce the power required for incandescent lighting. Fluorescent recycling programs vary widely by jurisdiction. In the Greater Toronto Area, a number of safe disposal options exist, including a network of Household Hazardous Waste drop-off depots, which direct fluorescent lamps/compact fluorescent light bulbs for recycling to a local company that captures the mercury in fluorescent bulbs and sells it for reuse. In general, we have chosen to restrict our lamp choice to standard lengths and types of fluorescent, and have avoided self ballasted CFLs entirely. By limiting the number of types of lamps needing recycling, we have reduced the need for the occupants to find a variety recycling services

As a general sustainability strategy, we have tried to minimize the impact of manufacturing by using fewer fixtures, and by buying locally manufactured products. Whenever possible, fixtures manufactured in the vicinity of the North House primary location have been specified; in our prototype case, most fixtures are designed and manufactured in a 500mile radius of Toronto. The fixtures themselves especially the T5 fluorescent in the coves are manufactured using very minimal resources as they are hidden from view. By adopting indirect lighting approaches and by using only very precise task lights, we are able to both minimize energy use and reduce the quantity of fixtures required and their associated embodied energy.

12.3 Market Viability Narrative

North House provides clean and independent living for people in northern climates by combining solar power and contemporary design with a lifestyle enhanced by mobile and interactive technologies.

Canadian urbanities are growing, and major growth is planned around new transit infrastructures connecting regional urban areas in all sections of the nation, especially in the Vancouver region of BC and in Southern Ontario where the members of Team North reside. The population of Ontario is projected to grow by thirty percent, or four million people, in the next twenty-five years, while residential construction alone accounts for over 5.6% of Ontario's GDP, and contributed $34.2 billion in GDP to Ontario in 2004. Ontario's new Green Energy Act will impact this sector with regulatory changes and policies that include feed-in tariffs for renewables, streamlined approvals for renewable energy projects, mandatory home energy audits and make changes that position energy efficiency a central tenet of Ontario's Building Code. The North House Prototype is ready to drive the positive change needed in the residential construction sector, as well as in related manufacturing industries, in order for Ontario's new housing to meet and exceed the targets of the Green Energy Act for Ontario. North House is designed to be a grid-tied annual net energy producer, providing excess power to the energy grid by being expressly Net-Energy-Positive.

The 800sf North House prototype is designed for a target market demographic that is identified as a couple in the creative professional sector, living within the Greater Toronto Area. This market sector is generally college educated, aged from the mid 30's to early 40's, with no children. Most likely occupations include Media or Digital Designers, Systems Designers, Corporate Strategists, Media or Film Producers. The annual household income of this couple would be approximately $200,000 or more. This couple would desire modern urban loft style living that, located in urban perimeter, is proximate to transport, natural amenities and recreation, and that is both healthy and energy independent. The occupants would have a mobile lifestyle and would likely have a second home or cottage in the country, so their urban abode could be minimal with little need for extensive storage.

North House is intended to specifically appeal to this new generation of environmentally minded people who are looking for modern, intelligent homes: people who work intensely, but also like to spend time outdoors; people who embrace technology as an integral part of their lives, but who also know the importance of the rituals of daily life, of sitting down with friends and family for good food and lively discussion; people who demand contemporary design, good ergonomics, and personalized elements, but who also revel in the timeless beauty of the natural world. The target market occupant has a contemporary, modern design sensibility and an appreciation of superior quality and attention to detail. They purchase few objects, but all they own is of high quality. They are most likely early adopters of new technologies and are aware of the latest technologies and high performance products. Their character types are inquisitive, competitive and eager to try new things.

North House has developed new technologies for highly insulated glazing systems, paired with dynamic shading and solar power, which transforms the presumption that sustainable houses for the northern climate must be a thick boxes with small amounts of glass. In North House, the occupants have a profound connection to the exterior landscape, and are connected to the changes in light, weather and season. Exterior planters for growing one's own food, and an outdoor eating space, make spending time around the house productive, healthy, environmentally conscious and pleasurable. These amenities would appeal to the target market occupant, whose attitudes towards sustainability would include local organic eating, a focus on health, and on personal well-being.

Appealing to the occupants' busy and mobile lifestyles, North House is designed to close down and save power when its inhabitants are away from home. Remote monitoring and control of the systems of the house through mobile devices, makes the home an always accessible part of the lives of its inhabitants. The configuration of the building-integrated photovoltaics is designed to maximize both power production and serviceability; there is no need to climb on the roof to clear snow off of the solar panels as the BIPV's on the facades continue to harvest energy at a more optimum solar angle during the winter months.

North House maximizes livability and the use of space within its small size. The service module of the house is designed like a ship's cabin, with seamlessly integrated built-in storage and utilities. The main living space maximizes flexibility and user-driven configurability of the living arrangements and environment. Within the loft-like flexible living space, reconfigurable furniture for working, sleeping or entertaining, a retractable bed, and occupant-controlled shading and lighting provide amenity and choice. The kitchen is at the heart of the house, making the rituals of cooking, eating and spending time with others the centre of the meaning of home, while state-of-the-art appliances are integrated within the cabinetry so that the kitchen easily becomes part of the living spaces. User-friendly technologies integrated within the house provide ambient information about its performance, and allow the occupants to be as connected with the operations of the house as they are with the cycles of the sun and weather. The house has a simple, elemental design, and both built components (interior and exterior) and embedded technologies are able to be personalized and modified to suit specific lifestyles, needs, and desires. By empowering the occupants with both knowledge and control, they are better vable to make intelligent choices and to transform their own habits and rituals to live more sustainably and intelligently.

The design strategy of North House allows for the prototype to easily expand to suit different family sizes and house configurations. Since North House is based on customizeable components as opposed to modules, alternate house configurations are possible while still maintaining the same functional diagram of a densepack service and structural module combined with highly-glazed open living and sleeping spaces. Members of Team North are currently undertaking further research and development of alternate and expanded configurations based on the North House prototype, as well as research into the agglomeration of these houses into energy-producing sustainable communities.

12.3.1 Configuration of multiple house types based on North House components

12.3.2 Larger variations of homes based on the North House prototype.

12.4 Engineering Design Narrative

The North House engineering design focuses on delivering a low-energy and highly efficient net-energy-positive solar building that is capable of adapting to the many different climates of Canada. To achieve this, North House optimizes the use of the sun by using passive solar design principles to minimize energy consumption, while deploying distributed building-integrated photovoltaic and solar-thermal technology to maximize energy production. This is complemented by an integrated smart control system, which seeks out the optimal low energy approach to operate the home and still maintain a high degree of occupant comfort.

To achieve this overall goal, numerous technical challenges are met with innovations in the design and construction of North House that, in some cases, defy conventional norms of residential design. Areas of notable technical innovation include:

- Building Orientation and Form
- Passive and Active Building Envelope
- Domestic Hot Water and HVAC System
- Distributed Photovoltaic System
- Integrated Smart Control System

Most of the engineering work has been evaluated through a series of computer models, including overall annual building energy simulations, window heat transfer simulations, PV power production simulations, and HVAC systems integration simulations. These simulations have been made part of the iterative integrated design process intended to optimize and refine all of the components of the house. Results from the simulations gave the team valuable insight regarding the performance of the design, which was considered in conjunction with other design requirements before any decisions were made.

Building Orientation and Form

Contrary to most solar homes that are orientated with a longer façade along the east-west axis to maximize solar exposure to the south, North House takes on a more compact form. This reduces the surface area to internal volume ratio. Most solar homes will have an aspect ratio of 2:1 between the east-west and north-south axis, while North House will have an aspect ratio of only 1.2:1. Although this results in less solar exposure, the beneficial trade-off is the reduction of the amount of energy to heat and cool the larger internal volume of the space. Like most warm-blooded animals, the additional internal volume makes them less susceptible to changes in the environment, allowing them to better adapt to much cooler climates. This form is crucial to operating a low-energy solar home in colder climates since daylight hours are reduced in the winter when heating is needed the most. The reduced solar exposure area is compensated for by installing a full-height floor-to-ceiling curtain wall system on the South, East, and West façades to maximize solar gain.

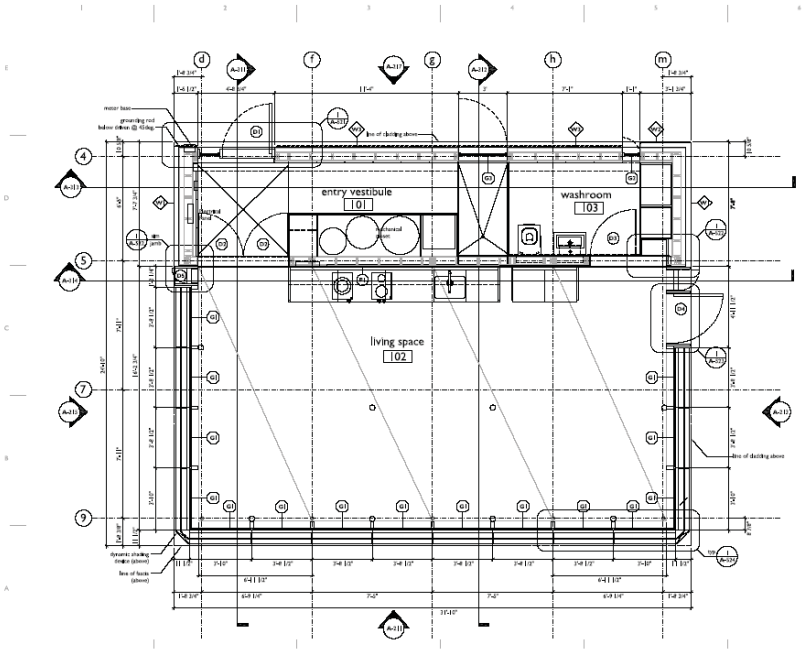

Figure 12.4.1: North House Floor Plan

Passive and Active Building Envelope

The building envelope plays a significant role in the overall passive solar design strategy of North House by carefully controlling energy and mass flows between the exterior and interior of the house. By constructing the envelope out of multiple layers, North House is able to fully utilize various materials to develop a highly insulated and air tight building envelope that is still breathable to avoid condensation even in the most extreme climates. Just like a winter jacket, where the insulation is placed on the outside, most of the insulation in the building assembly is outboard of structural elements; this minimizes thermal bridges and provides a continuous layer of thermal separation. With this building envelope North House has more than three times more insulation than a conventional home.

As part of the highly insulated building envelope, North House uses some of the most insulating high performance windows available in industry. The windows selected for North House are Quad-layered with low-E coatings and has an overall insulating value of R8 and a solar heat gain coefficient of approximately 0.4. This makes these windows approximately 4 times as insulative as a typical curtain wall, yet they still have the look and feel of a typical window. Windows play an important role in the passive solar design of North House, since they are a major source of heat gain for the house during the day. Given the large window area of North House, annual building simulations have shown that the heat gained through these windows can significantly offset the overall annual heating load even in cold climates. In practice, these high-performance windows within a full-height curtain-wall façade become a net energy producer for the house, allowing for more energy to be emitted into the house than it loses

through heat transfer over an annual basis. The solar heat gained during the day is not only used to passively heat the air inside the house, but it is also absorbed into the layer of Phase Change Materials (PCMs) embedded under the finished floor, which release heat during cooler periods, and act in the same manner as traditional thermal mass materials such as concrete and masonry. PCMs were chosen over of traditional of thermal mass materials since they hold many comparative advantages such as compactness, lighter weight, larger heat storage capacity and specific heat phase change temperatures that can be chosen to be optimised for particular set points. PCMs are designed to store and release heat a specific set design temperature, which lies between typical thermal comfort set-points. This means the PCM will not take away any 'free' heat from the air until it has reached the desired temperature range, and thus heat will only be stored once the specified temperature has been reached. The large heat storage capacity of the PCMs help to reduce peak heating and cooling loads by smoothing out the daily variations in interior temperatures.

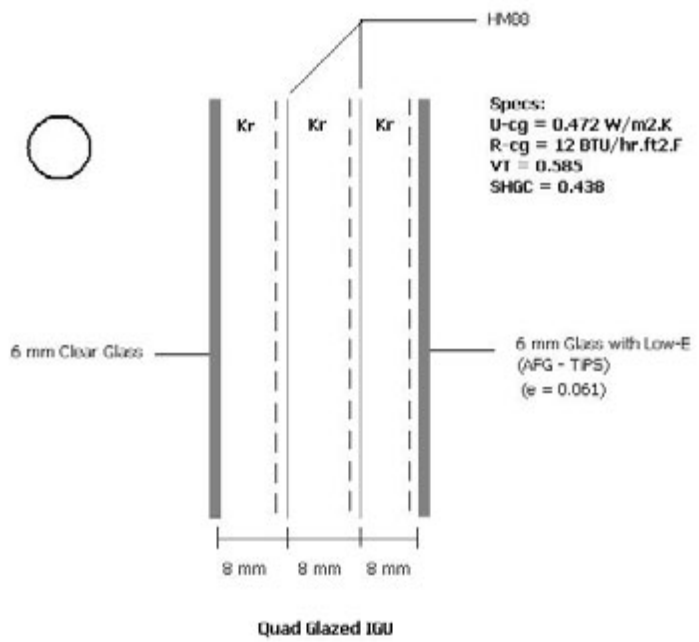

Figure 12.4.2: Quad-Layered Insulated Glazing Unit (IGU)

One of the challenges with buildings that have large window areas is the increased cooling load required to offset unwanted solar heat gains. To overcome this challenge, North House uses retractable exterior venetian blinds to block the incoming sun. By deploying the exterior shades when cooling is desired, the cooling load can be reduced to as little as one third as without the PCM's. Through the use of these exterior blinds, the building can finely adjust the amount of solar heat passing through the windows and can go into both solar heat collection and solar heat rejection modes depending on the interior temperature of the house and amount of incoming solar radiation. This offers a high degree of control to make the most of the available energy flows around the house.

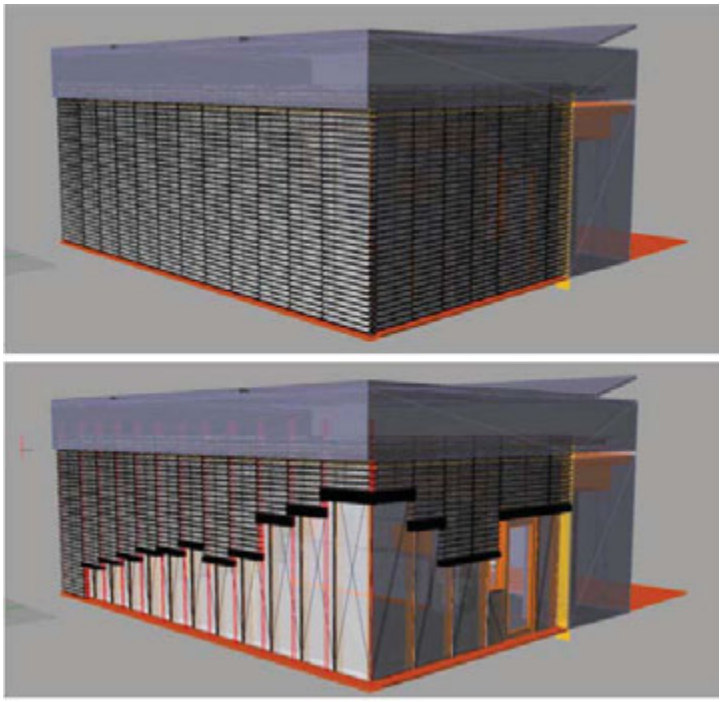

Figure 12.4.3: Exterior Shading Arrangements

With a highly insulated and controllable building envelope, North House is able to minimize overall heating, cooling and peak demand loads by adjusting itself to optimize the available energy in the external environment. This offers significant savings in operational energy as well as capital costs, since the majority of the HVAC equipment can be significantly downsized or in some cases completely eliminated. For example, by using highly insulated windows, perimeter heaters can be eliminated even with a large window area since the occupant will still be thermally comfortable due to relatively warmer interior glass temperatures.

Domestic Hot Water and HVAC System

The mechanical system in North House has been designed with the goal of collecting enough solar energy to cover the majority of the domestic hot water and space heating demands throughout the year, while conserving every last watt of electrical power. Because of the unique way in which the system has been implemented, simulations have shown that North House can achieve an impressive solar fraction of over 70% for the competition week, with an average of 65% yearly.

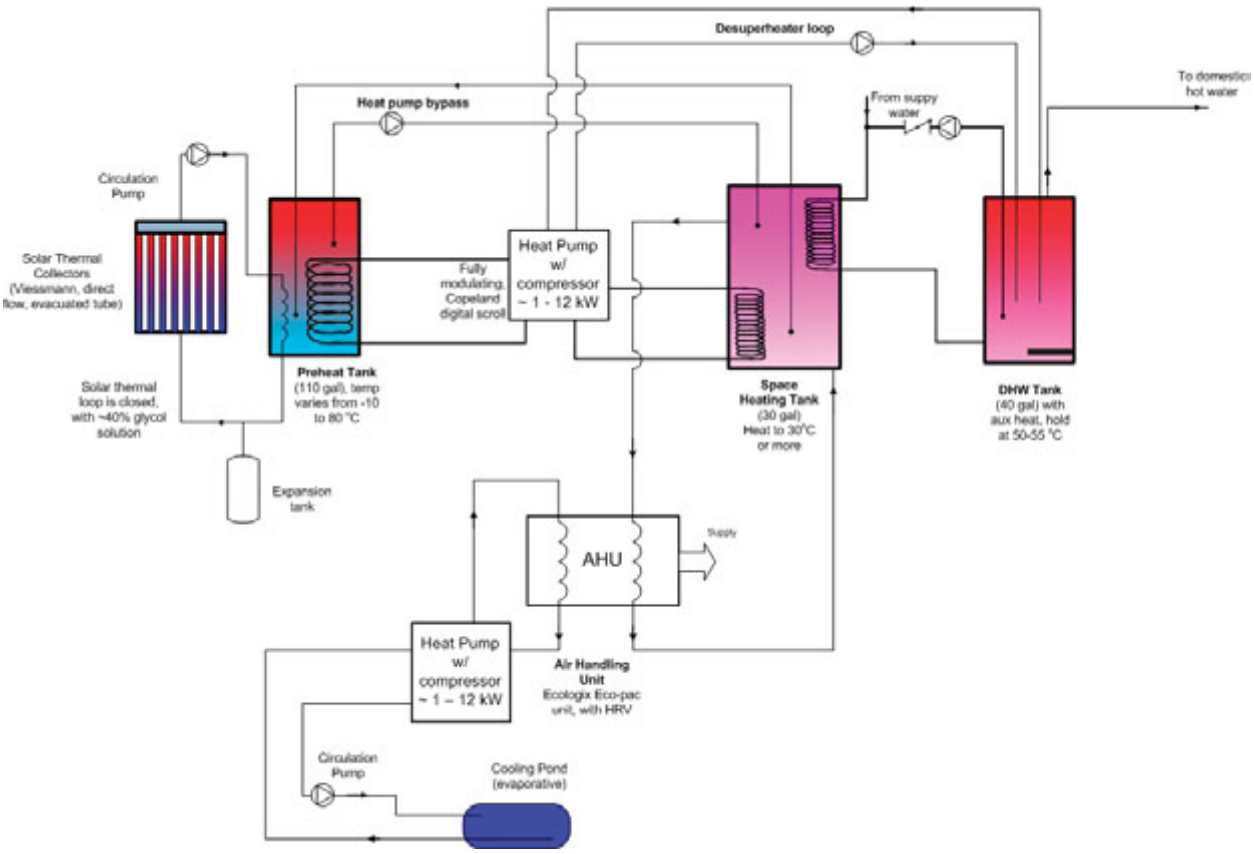

Figure 12.4.4: HVAC Schematic Diagram

Solar thermal energy is captured through the use of two arrays of evacuated tube solar-thermal collectors installed on the roof. Evacuated tube collectors are known to outperform flat plate collectors in the colder climates found in many Canadian cities. In order to maintain the aesthetic profile of the house, state-of-the-art "direct flow" collectors are used, which do not rely on the heat pipe effect and thus have the unique ability to be installed horizontally. By orienting the evacuated tubes in the east-west direction, however, it is still possible to rotate each individual tube to an angle of up to 20° to the south without self-shading, further increasing their collection efficiency. A heat dissipator system is integrated into the solar thermal loop in order to prevent overheated fluid from entering the pre-heat tank and to prevent the collectors from getting dangerously hot. Fluid leaving the collectors is directed to the heat dissipators via a three-way solenoid valve whenever its temperature exceeds 80°C (176°F).

In order to make the most of the collected solar energy, North House is outfitted with a customized and highly-efficient three-tank system, incorporating two advanced variable-capacity heat pumps. Each tank is designed to serve a certain purpose: a large preheat tank whose temperature floats between -10 and 80°C (14 and 176°F) stores collected solar thermal energy, a space heating tank kept at a minimum of 30°C (86°F) supplies hydronic space heating, and a domestic hot water tank kept at about 50-55°C (122-131°F) provides hot water for the occupants' daily activities. The tank temperatures and sizes have been chosen in order to ensure that all space heating and domestic hot water demands can be met with ease.

Collected solar energy is delivered to the preheat tank and distributed to the rest of the system as efficiently as possible given the current tank temperatures and heat demands. If there is sufficient solar energy to bring the preheat tank to the required domestic hot water temperature, heat is simply distributed to the other tanks via heat exchanger coils immersed in the tanks and small, high-efficiency circulator pumps. When this is not the condition, heat is delivered as required via a custom heat pump.

North House's heating system strives to outperform a typical gas-fired or electrical resistance system through the use of an advanced heat pump unit. In order to overcome the unique challenge of efficiently pumping heat from widely-varying low-side temperatures, the heat pump consists of a digital scroll compressor and an accurate controller. This allows the heat pump capacity to modulate down to 10% with negligible loss in efficiency in order to achieve the best possible performance under a wide range of conditions. Heat is transferred to and from the heat pump evaporator and condenser via heat exchanger loops with fluid circulated by precisely-controlled variable speed pumps, which constantly adjust to deliver only the necessary amount of heat, and minimize required pumping energy. A desuperheater loop delivers the higher-temperature latent heat from the superheated refrigerant directly to the domestic hot water tank, minimizing heat transfer efficiency losses. To further guarantee that heating demands will be constantly met, two auxiliary electric heaters are located in the domestic hot water tank to add heat as necessary.

Space heat is distributed throughout the living space via a hydronic coil located in the air handler. Space cooling demands are met through a second custom modulating heat pump which adjusts to draw the appropriate amount of heat from the air via an evaporator coil in the air handler. This heat is dumped to a cooling pond located in the shaded area under the deck, which naturally loses its heat through a combination of evaporative cooling, convective losses to the surrounding air, and conductive losses to the earth. The pond will be set up during competition in order to simulate a geothermal ground loop or borehole storage system. Combining the near-ambient temperature heat dump with the gain in heat transfer effectiveness achieved when using such a water-based system, the heat pump is expected to greatly outperform a typical air-source heat pump, achieving a cooling COP of between 4 and 5.

In order to reduce the additional heating and cooling loads introduced while required ventilation takes place, incoming fresh air passes through a heat recovery ventilator. The air handler and heat recovery ventilator are controlled via a Central Home Automation Server (CHAS), which adjusts operation based on frequently measured temperature, relative humidity, and carbon dioxide content. The CHAS operates the HVAC system based on an algorithm which takes into account previous operation states in what is known as a hysteresis. The hysteresis eliminates any frequent cycling of the mechanical system due to minor changes in internal air temperature and relative humidity over predefined set points. This

allows the system to have multiple states within the same temperature or humidity range depending on that status of the previous state. Based on the temperature and relative humidity set points defined by the occupant, the CHAS automatically adjusts the mechanical system to deliver the desired conditions for thermal comfort. The CHAS also provides optional occupant overrides for fine adjustment of temperature and ventilation rates.

Distributed Photovoltaic System

Design evolution

Many different PV array configurations were studied at the beginning of the project. Figure 12.4.5 is an initial comparison of yearly energy output for four different layouts. For all cases, the blue part of the columns is the roof output. For the first column, the red is the output from the south facade, and the green and purple are the outputs from the east and west. The green part of the second and fourth columns represent the energy output of the east- and west-facing photovoltaics.

The first column consists of a horizontal roof covered in photovoltaics and a 5-foot high band at the top of the east, west and south facades. The second column represents a roof covered in photovoltaics but tilted 12 degrees towards the south (maximum tilt to stay within solar envelope) with PV installed on the east and west facades where possible. The third column represents an area which is the size of the roof, tracking the sun in two axes (zero angle of incidence at all time). This scenario would be difficult to produce due to the size of the roof, and would not fit within the solar envelope. Also, if the two-axis tracking was constrained within the solar envelope, it was found that there would be no gain in electricity generation compared to a static roof with vertical sides. The last column is the same as the second, but for a greater slope of the roof. Columns three and four could not be used during competition but are good for comparison purposes.

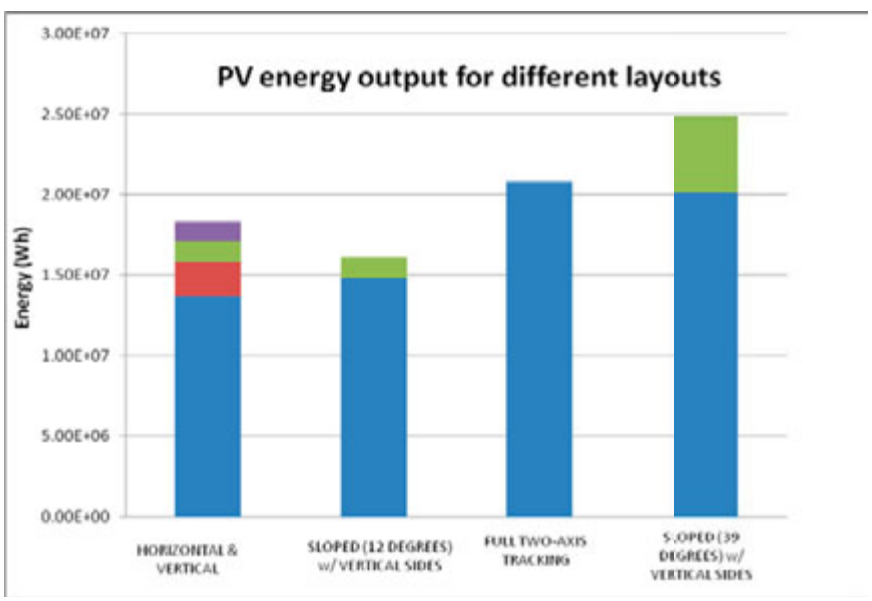

Figure 12.4.5: Initial Comparison of Power Production for Various PV Orientations

The concept of a "partial tracking" (repositioning) system as seen in Figure 12.4.6 was evaluated. The array in this concept is split in four sections and would stay within the solar envelope at all time. In the morning, the two sections on the west side of the house would tilt towards the east. At around midday, the two sections on the north side would tilt towards the south. Finally, in the evening, the two sections on the east side of the house would tilt west. This is an interesting concept but it was proven to result in almost the exact same power production as a fixed tilted roof at 11.5 degrees .

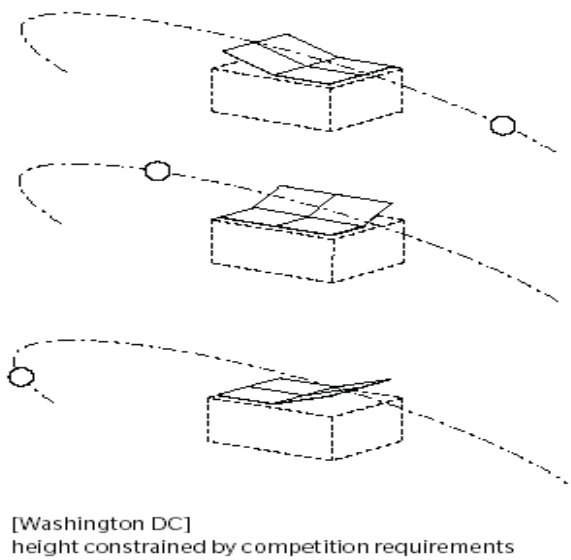

Figure 12.4.6: Repositioning system

From these analyses, it was found that the single most important variable for PV energy production is the total PV area. Based on these findings, the following PV layout was chosen.

Final Design

In order to achieve North House's goal of maximizing power production throughout the year, in a variety of climatic conditions, energy production systems are integrated into virtually every surface of the building envelope. This makes use of the surface area on the building by making it into an active energy producer, as well as avoiding some of the complexities of solar tracking which have plagued many large PV installations in the past, particularly in cold climates. In addition, the precise orientation of the house and its solar exposure become less of a problem since PV panels are mounted on a large area on the building at different orientations.

A large array of typical photovoltaic (PV) panels is located on the roof, which acts as the primary electrical producer and produces approximately 74% of the house's electrical production. The rest of North House's electrical power production comes from building integrated photovoltaic (BIPV) panels located on the south, east, and west façades, which operate when the sun is at a low angle. The combination of both horizontally- and vertically-mounted PV allows North House to make use of its surface area collect solar energy without re-orientating itself. The entire PV array and BIPV is expected

to produce approximately 10,450 kWh annually, and a peak production of 10 kW. All of the power produced by this array is converted into grid quality power by inverters and fed directly into the electrical grid. [Sébastien1]This combination of arrays is estimated to produce more than double the estimated electrical consumption of the house. The location of the BIPV is shown in Figure 12.4.7.

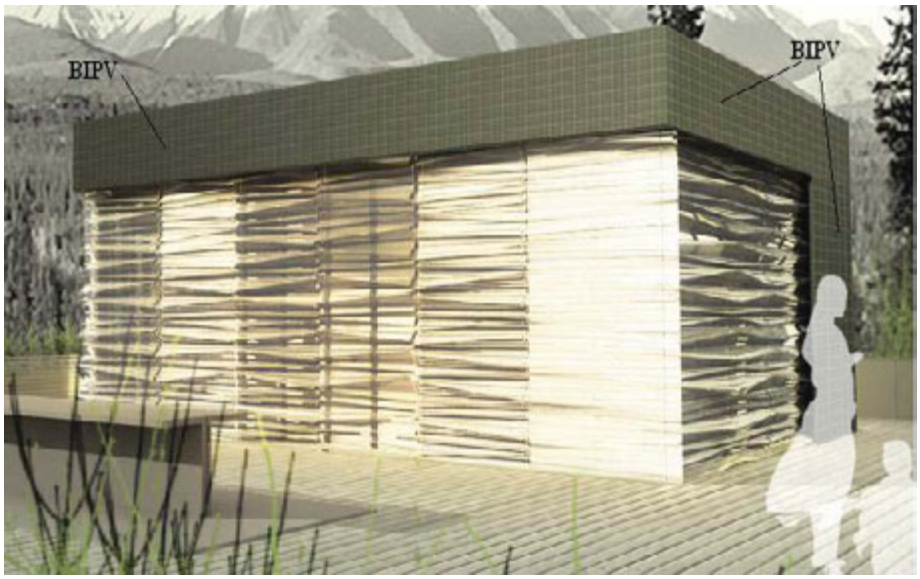

Figure 12.4.7: North House BIPV Arrangment

Integrated Smart Control System

The integrated controls system for North House offers many opportunities for technical innovation. Because the building's integrated controls system has to efficiently manage the operation of multiple subsystems and provide feedback to the user regarding the performance of the house, the control system is being custom designed and built.

At the heart of the integrated control system is the Central Home Automation Server (CHAS), which manages both the Graphic User Interface (GUI) as well as all of subsystems of the house. Depending on internal and external conditions, the CHAS is able to make high-level decisions to enhance the energy performance of the house. For example, the CHAS will determine the operation of the external shading system depending on the internal air temperature of the home, the amount of incoming solar radiation, the exterior wind speeds, and the expected position of the sun. Based on these conditions the CHAS will determine if the house should go into solar heat harvest mode to save on heating energy or solar heat rejection mode to save on cooling energy. Similarly, the CHAS also controls the HVAC system in conjunction with the operation of the exterior shades to maintain thermal comfort while ensuring energy efficiency. For systems such as the internal temperature and relative humidity and exterior shading controls, where the systems will operate differently over a range of conditions, a hysteresis control algorithm is developed which allows the CHAS to make intelligent decisions based on real-time inputs and the previous state of the system. This ensures smooth transitions between states and avoids frequent chattering between different settings. For example, the exterior shade is operated based on

incoming solar radiation and interior air temperature. If the exterior shades were deployed and in solar blocking mode and a cloud rolls by to reduce the amount of incoming solar radiation, the exterior shades will not readjust itself until the internal temperature of the house has changed enough that it requires solar heat gain to raise the interior air temperature. This ensures that frequent and short-term events such as rolling clouds will not frequently cause the exterior blinds to change state and use excess energy.

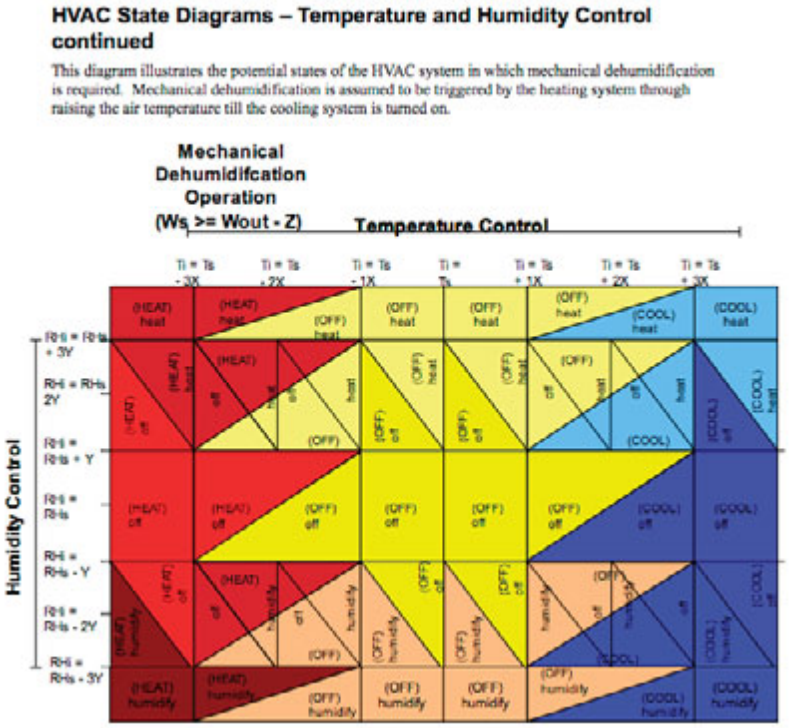

Figure 12.4.8: HVAC States Diagram and Hysteresis

In total, the CHAS will interface with and manage six systems, including the exterior shading, interior shading, HVAC, lighting, communications, and security systems. Many of the subsystems have their own sub-controllers, which intelligently manage the operation of the specific system. For example, the HVAC sub-controller will be able to intelligently operate heat pumps and fans to deliver the required conditions for thermal comfort as set by the CHAS.

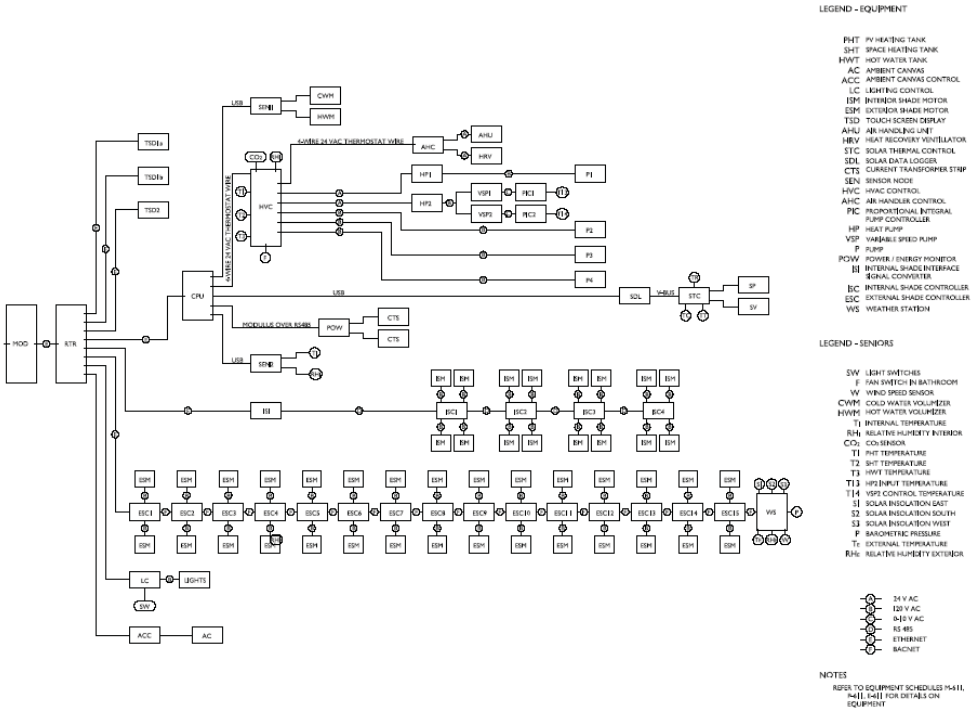

Figure 12.4.9: Integrated Smart Controls Schematic Diagram (See T-601 in Drawing set)

The CHAS is also able to provide real-time and historical feedback regarding the performance of the house though the GUI. The GUI can be accessed either locally in the house or through the internet via a web application. This is where the occupant can inquire about the status of the house as well as configure system preferences. The GUI essentially serves as both the control interface as well as the primary status/feedback display system. The feedback includes, but is not limited to, detailed energy production and consumption information, which allows the occupant to make informed decisions in their daily operations that can lead to further increases in energy efficiency. Although the house is automated through the CHAS, the automated coordination will not interfere with the occupants' ability to temporarily override the system and operate the home as they see fit. The aim of the overall integrated control system is to educate the user about energy efficient practices rather than to limit their lifestyle choices.

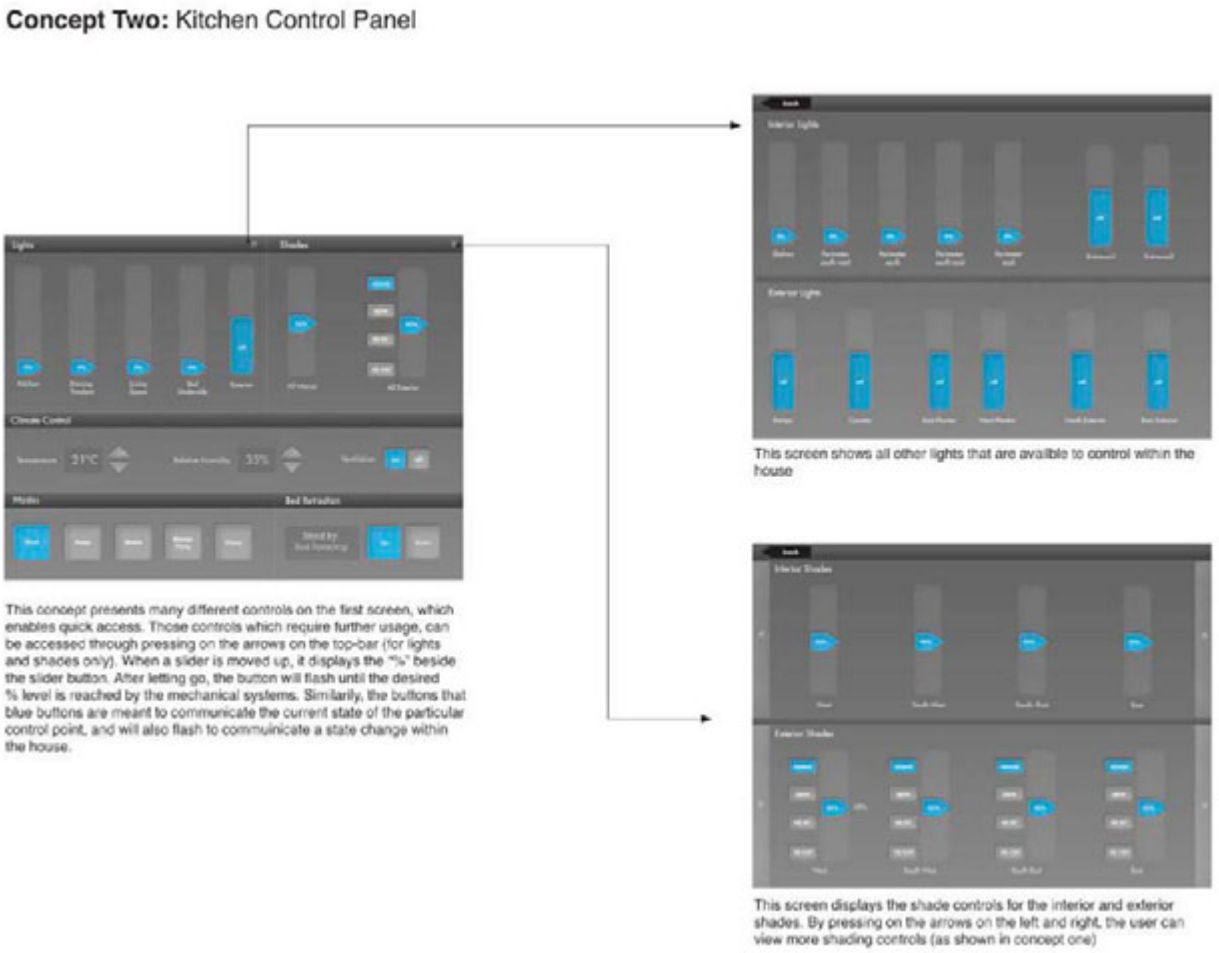

Figure 12.4.10: North House Graphical User Interface

Numerous technological innovations have been developed in the design of North House including advances in the building envelope, solar hot water and HVAC systems, BIPV installation, and integrated controls system. Many of these systems are found in a select few high-performance buildings in the world, with the majority of these technologies foreign to the North American building industry, let alone residential buildings. Although many of these innovative systems are relatively new, they have been proven to work in many buildings in Europe, although, many of have not be used in concert in the same manner as in North House. For example, innovative design features in the building envelope such as exterior venetian blinds and PCMs have been applied to high-performance buildings before, but, they have rarely been used together to manage the space heating and cooling of a building. North House strives to apply and demonstrate new and innovative building systems. Efficient hydronic and heat-pump systems are typically found in large scale buildings, however, these systems are only now starting to gain ground in residential buildings as many building designers are beginning to see the significant energy savings. However, perhaps the most significant innovated feature of North House is the integrated control system, which is programmed to find the most energy-efficient way to operate the house and automatically adjust the house to changing exterior and interior environmental conditions. All of these features help to make North House a demonstration of a highly energy efficient net positive building capable of adapting to the extreme climates of Canada.

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13.0 Adaptive Living Interface System

13.1 Control Panel GUI | Interaction Design Flow and Screens

Team North
University of Waterloo
Ryerson University and
Simon Fraser University
NORTH HOUSE

Control Panel GUI | Interaction Design Flow and Screens

Version 2 | Date: May 28, 2009

Wireframes provide a quick and cost effective method to illustrate a system's functionality and flow. They are not meant to convey visual design, rather they allow work groups to comment on and agree to the functionality before design and programming is done.

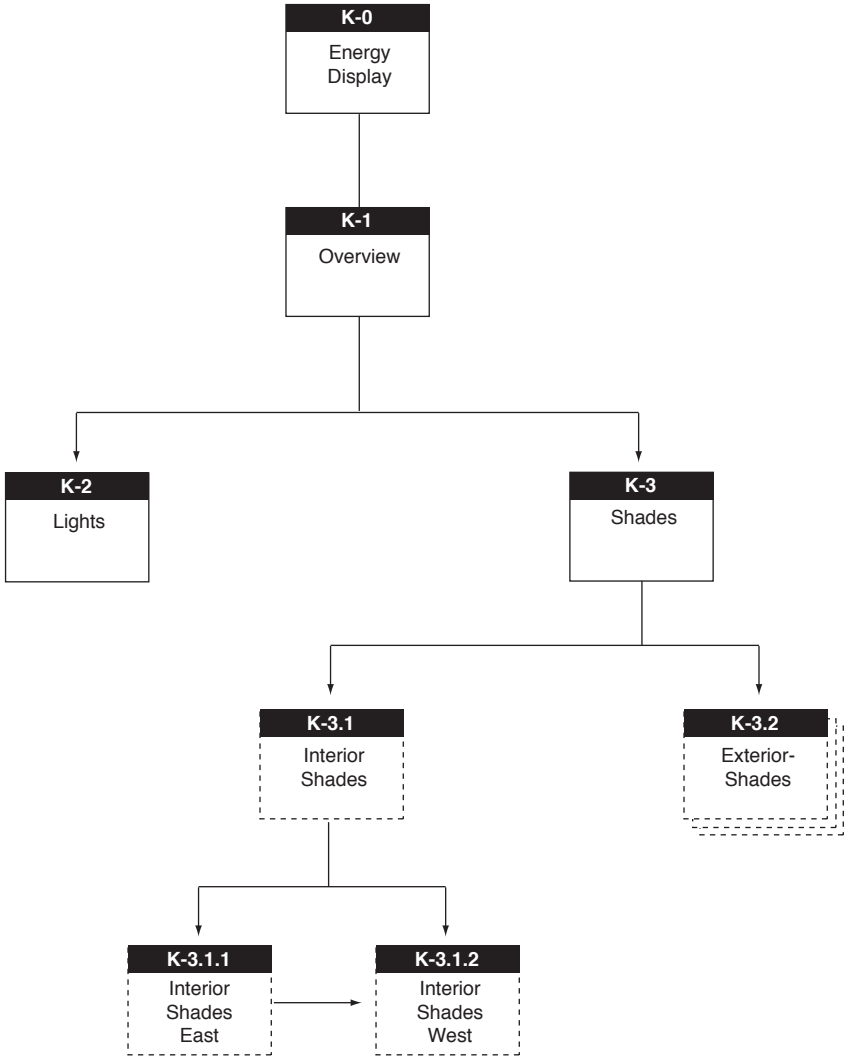
Revision History:

(V.1) From the various concepts developed, this plan has been drawn out, specifics of the lighting and shading elements is required to finalize this document.

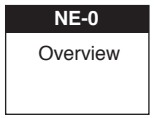
(V.2) Redesign of the kitchen Panel based on recommendations from user evaluations. Added Icons to kitchen display, changes to sliders to provide feedback on current state. Minimal graphical chages to all buttons.

Contributors: Kevin Muise, John Rodgers,

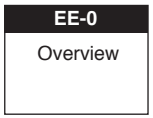
Kitchen Control Panel



North Entrance Control Panel



East Entrance Control Panel



Legend

a new view that changes part of the active page

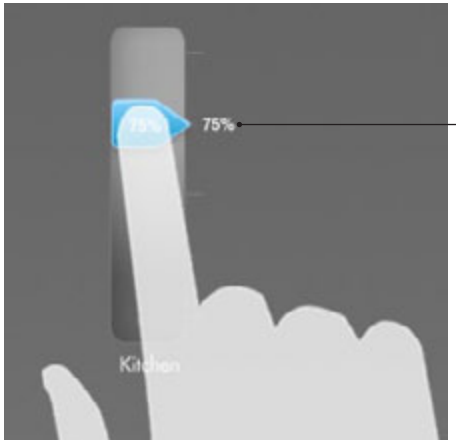
a page

Control Elements & States

Light Dimmers and Shades

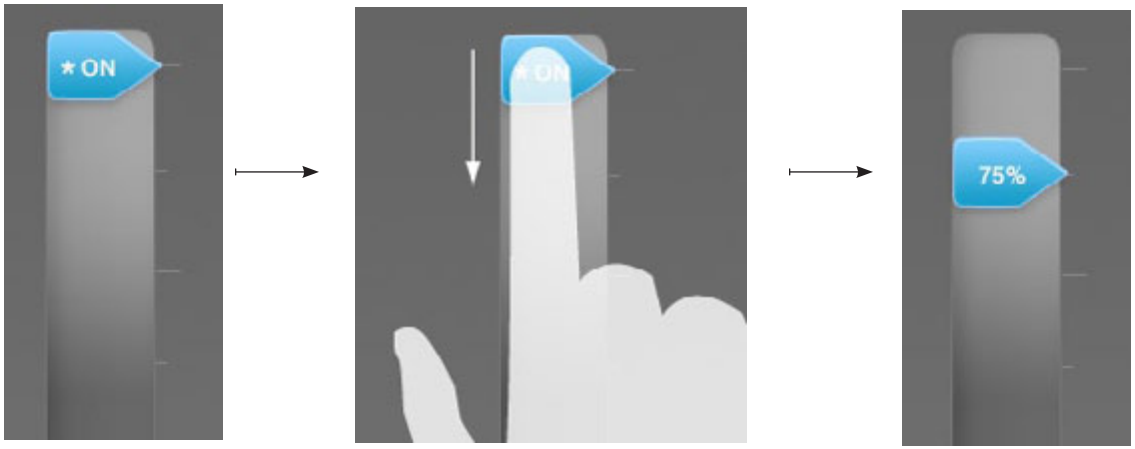
The interactions below pertain to both the light dimmers and the shade sliders.

Control point (draggable)



When dragging the control point, the “%” appears to the right in order to allow the resident to see what level it is at (as the number on the slider is hidden by finger)

After dragging the control point, it will fade in and out (from blue to grey) until the actual light reaches the level specified (at which point, the contol point will remain blue)
This matters less for lights, however it is necessary for other elements, such as shades and tempeprature.



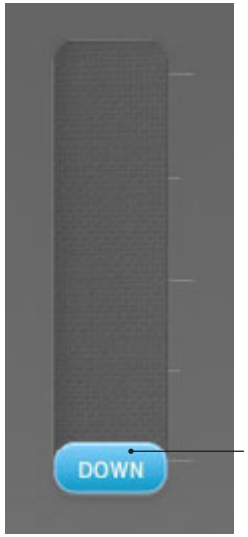
The asterix beside the “ON” label on the control point only appears on Masters (dimmers that control multiple sub controls) when the sub-levels under it are in various postions. (eg. One sub-level is at 25% and the other is at full 100% / ON – in this case the slider would look like the image above-left).

When the Master control point is moved to a new position, all sub-controlls under it are then changed to the level selected on the master. Because all the sub-levels are the same as the Master, the asterix is no longer needed and is removed.

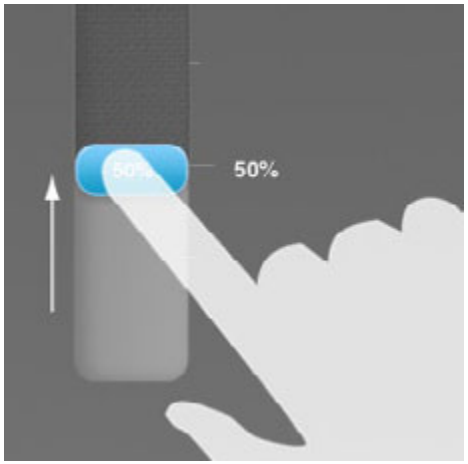
Control Elements & States

All Shades

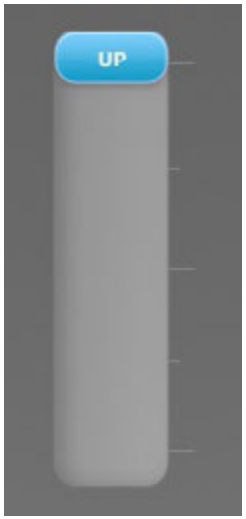
The interactions below pertain to both the interior and exterior shades



Control point
(draggable)



When draggng the control point up, the % level appears to the right. The dark portion above the control point recedes, much like an actual shade would recede when raised.

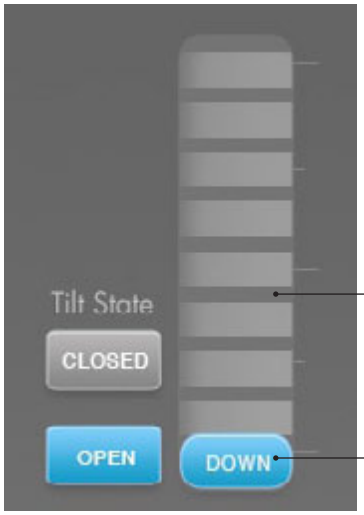


After letting go of the control point, the “%” label changes to “UP” and the control point fades in and out as shown in the image sequence above. It continues to fade in and out until the actual blinds reach the level specified on the control GUI.

Control Elements & States

Exterior Shades

The interactions below pertain only to the exterior shades.



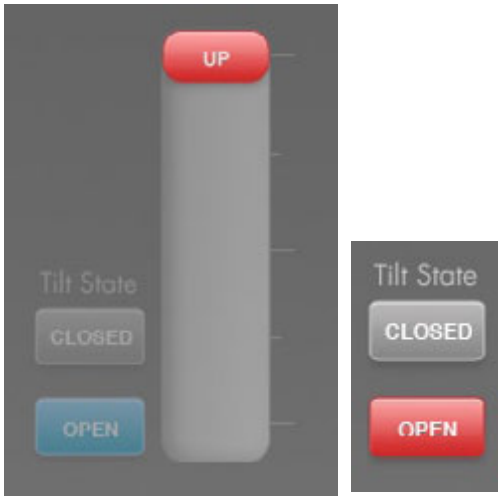
Tilt state (open)

Control point (draggable)

Once pressing on the “closed” button, the button begins to fade in and out until the actual blinds reach the “closed” position.

The tilt state on the slider changes as soon as the “closed” button is pressed, however the “closed” button continues to fade in-and-out until the actual blinds reach the closed state.

In order to restrict the resident’s control of the blinds (in states of emergency or when contol for the element is not avail.), the controls will be faded and the user will not be able to interact with them.

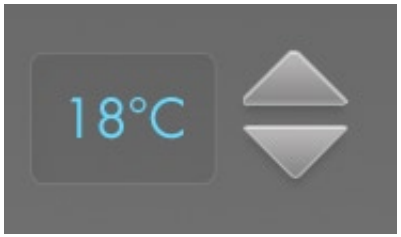


When the house system considers a resident’s actions to be counter to the production of electricity, the contol point will change to the colour red. Once the resident changes the state of the blind, the colour is restored to blue (to signify the active state).

Control Elements & States

Climate

The interactions below pertain to the temperature and Humidity controls



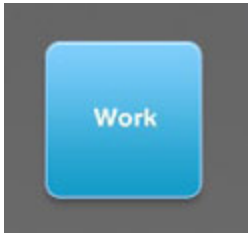
When pressing on the down button, it lowers temperature on the GUI. It also provides feedback; if temperature goes down the system writes “now cooling”, if the temperature goes up, the system writes “now warming”

For humidity, the values would be “now increasing humidity” or “now decreasing humidity”

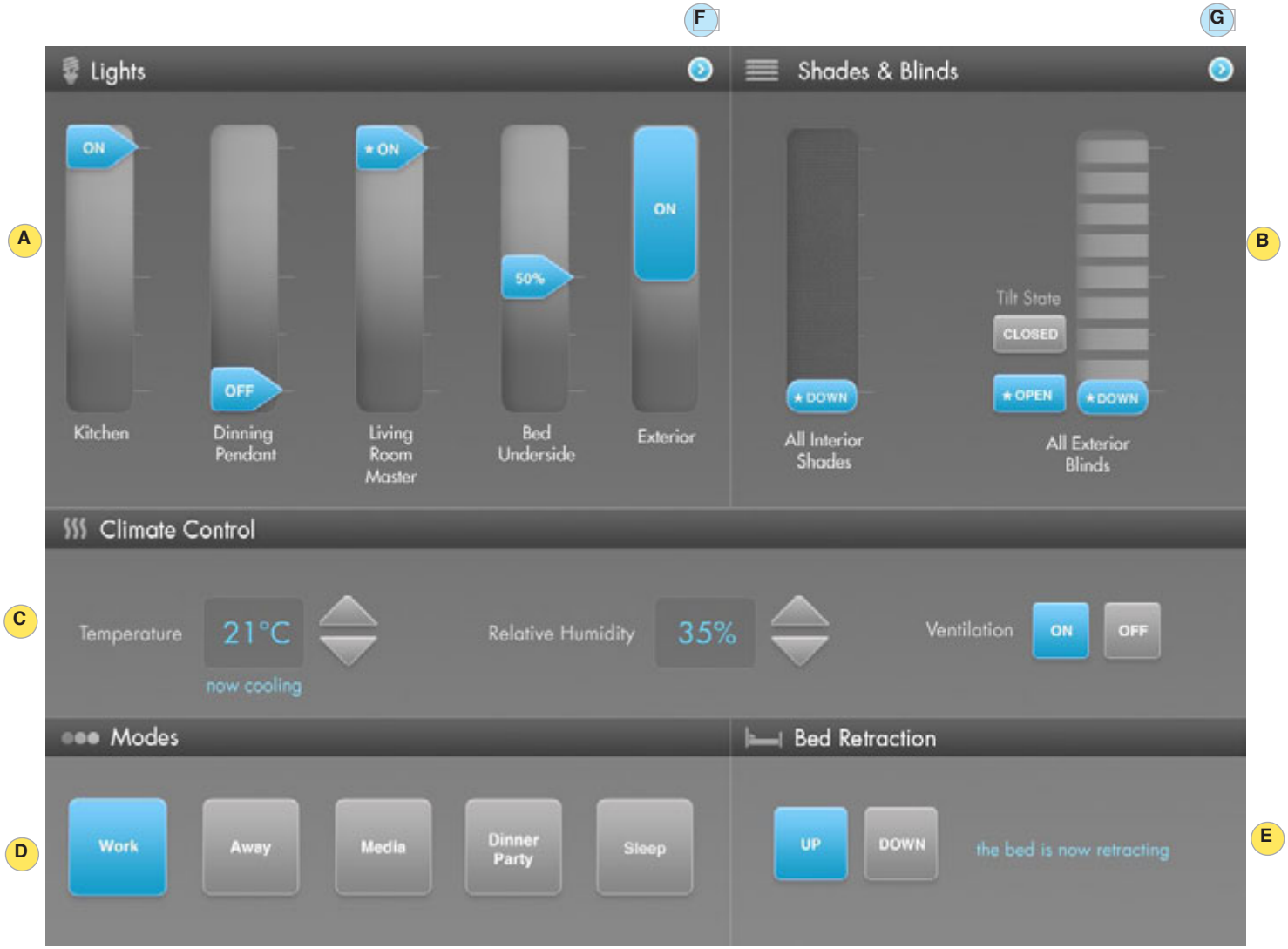
The numerical value fades in-and-out until the actual temperature in the house reaches the temperature selected on the GUI, at which point the numerical value stops fading, and remains blue.

Buttons

The interactions below pertain to the interactions with the buttons



Similar to the control points discussed earlier, all of the buttons also provide feedback based on the actual state of the utilities in the home. Within modes, the non-active mode (in grey) is pressed. Once pressed, the button fades into blue (and back to grey), until all of the presets for that mode are reached within the house.



Page ID: K-1

Page Title: Overview

Page Details

A: Controls for the lights. There are two types of controls i) sliders that allow the light to dim and ii) toggle switches which turns lights on or off (ex. Exterior). The current state of the light is displayed on the blue control point. As one moves the dimmer control point up or down, text appears beside the arrow-point that displays the current state (this improves usability as a user's finger hides the % on the control point when controlling a dimmer).
B: Controls for the shades. These function similarly to the light dimmers. The buttons "closed" and "open" control the tilt of the blind. When one changes the state, of the blinds, the control points and the buttons flash (from blue to white) until the blinds reach the desired set-point (at which point they remain blue).
C: We have grouped these controls together under house climate. The arrows beside humidity and temperature can raise it up or down to change the set point. When one does so, the text flashes (from blue to white) until the desired set-point is reached, at which point the text remains blue. Additinally, text appears under the value to communicate wheather the temp. is rising or falling. The ventilation controls function as a toggle – in this view, the ventilation is currently on.
D: Controls for the modes. The blue represents the mode that is currently active. The button will flash (blue to white) until all the set-points for that mode have been reached, at which point, it will remain blue.
E: Controls for the bed. The blue represents the current state. The button will flash (blue to white) until all the set-points for that mode have been reached, at which point, it will remain blue. Additionally, the text beside the buttons also communicates whether the bed is going up or down. When there is no activity, there is no text.

F: Go to K-2

G: Go to K-3

Page ID: K-2

Page Title: Lights

Page Details

A: The interior lighting controls function in the same manner as on the first page. They are seperateed from the exterior light to improve usability.

B: Returns to K-1

Page ID: K-3 / K-3.1

Page Title: Shades

Page Details

A: Go to K-1

B: The interior shades function in the same manner as on “K-1”. These act as master controllers for each of the four zones.

C: The star signifies that the shades that make up this master control are in different positions. (this only is employed for master controls).

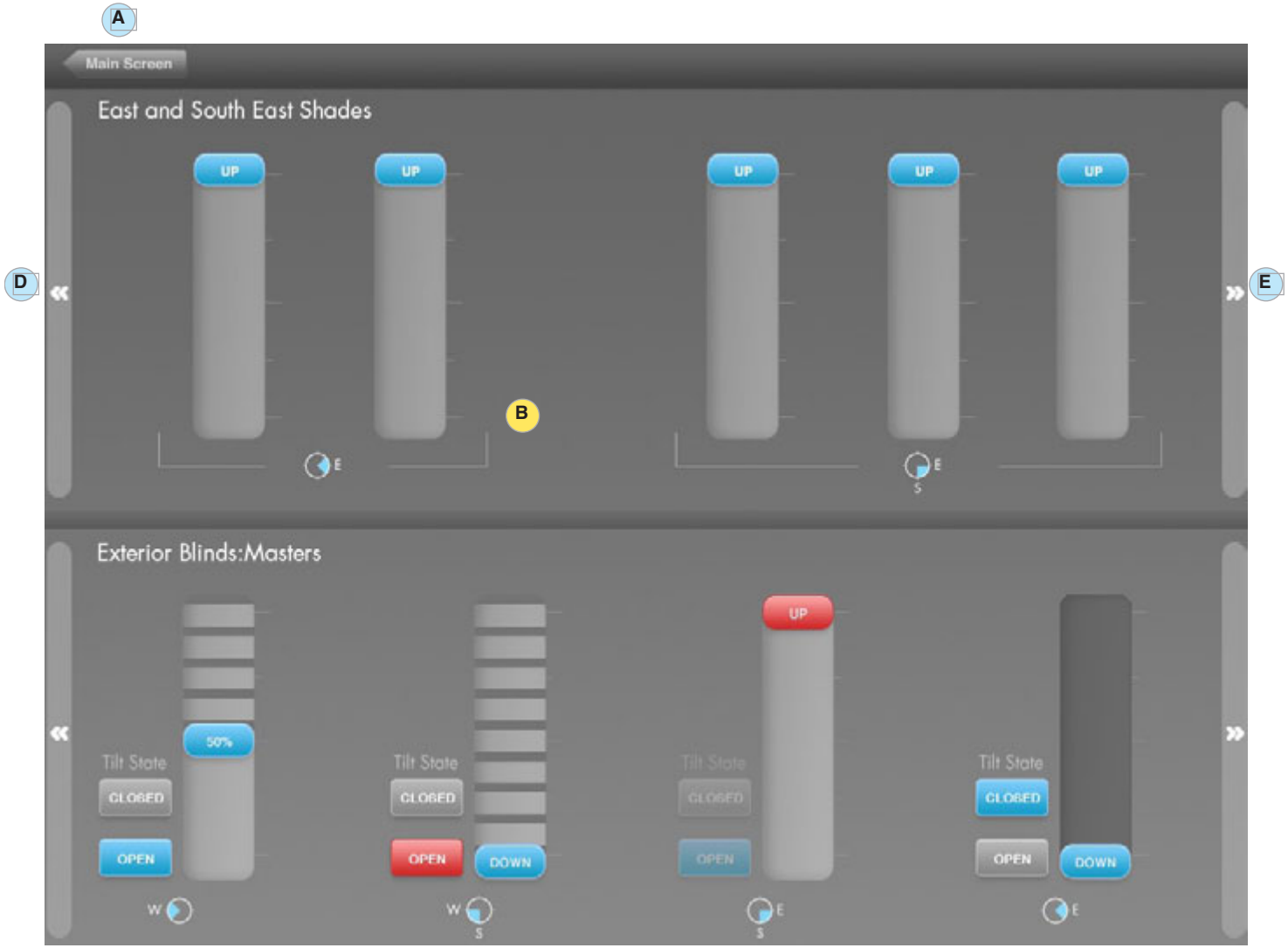
D: Go to K-3.1.2

E: Go to K-3.1.1

F: The exterior shades function in the same manner as on K-1. They too are seperated into zones, and those displayed here are master conrtrols for each zone in the house.

G: The control is faded-out to and cannot be interacted with at the current moment. This will occur only when the blinds are up (and thus the tilt state cannot be operated, or when the house takes control of the system based on high priority/ emergency states)

H: The red button indicates that the current state of the blinds is not in the optimal state (based on the house’s computation model).



Page ID: K-3.1.1

Page Title: Interior Shades East

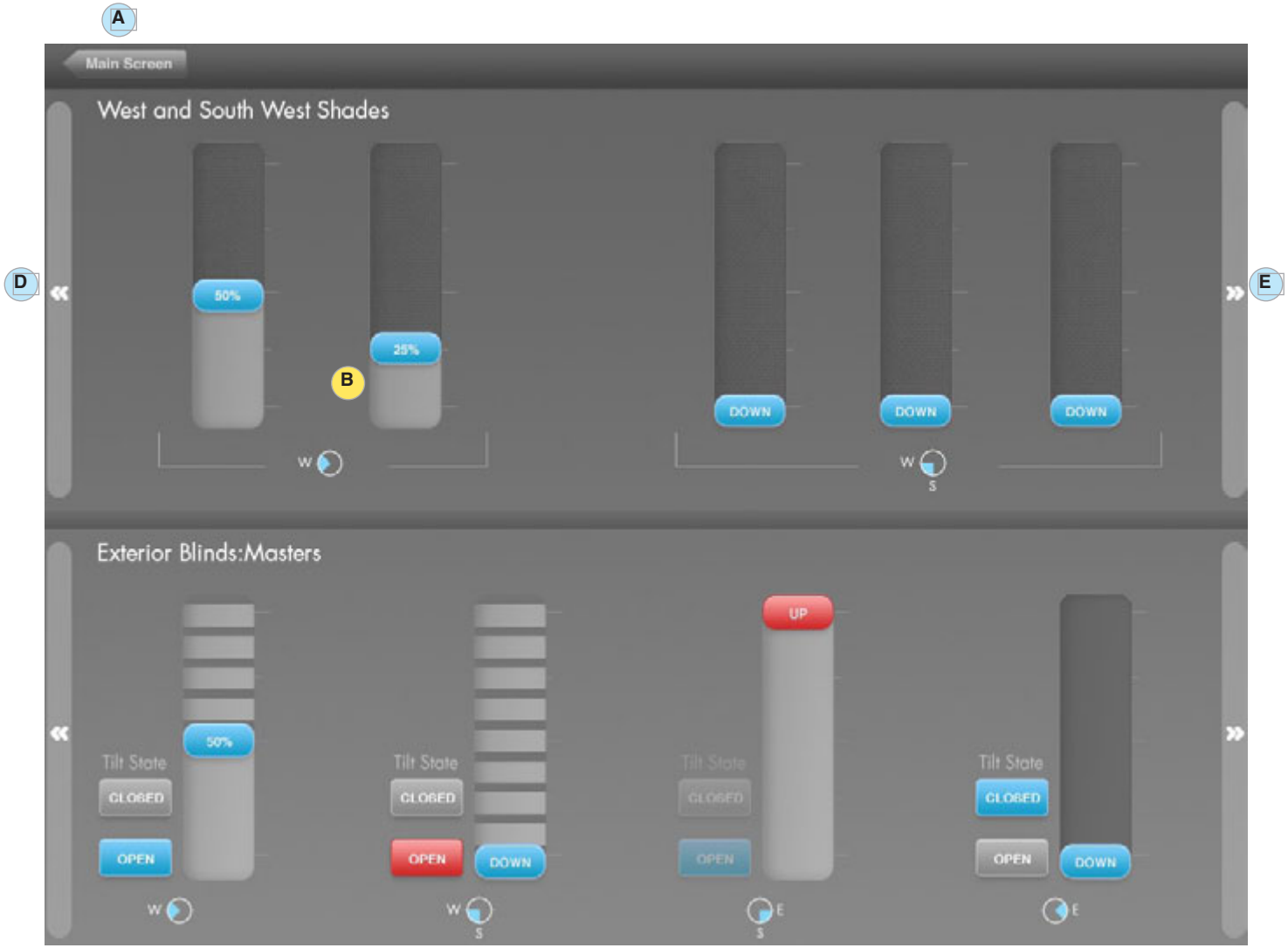
Page Details

A: Go to K-1

B: The shades are grouped into zones, the lines help to communicate the groupings.

D: Go to K-3.1.2

E: Go to K-3.1



Page ID: K-3.1.2

Page Title: Interior Shades West

Page Details

A: Go to K-1

B: The different states in these shades effects the master level of this zone, see K-3 “C”

D: Go to K-3.1.2

E: Go to K-3.1

Page ID: NE-0

Page Title: Overview

Page Details

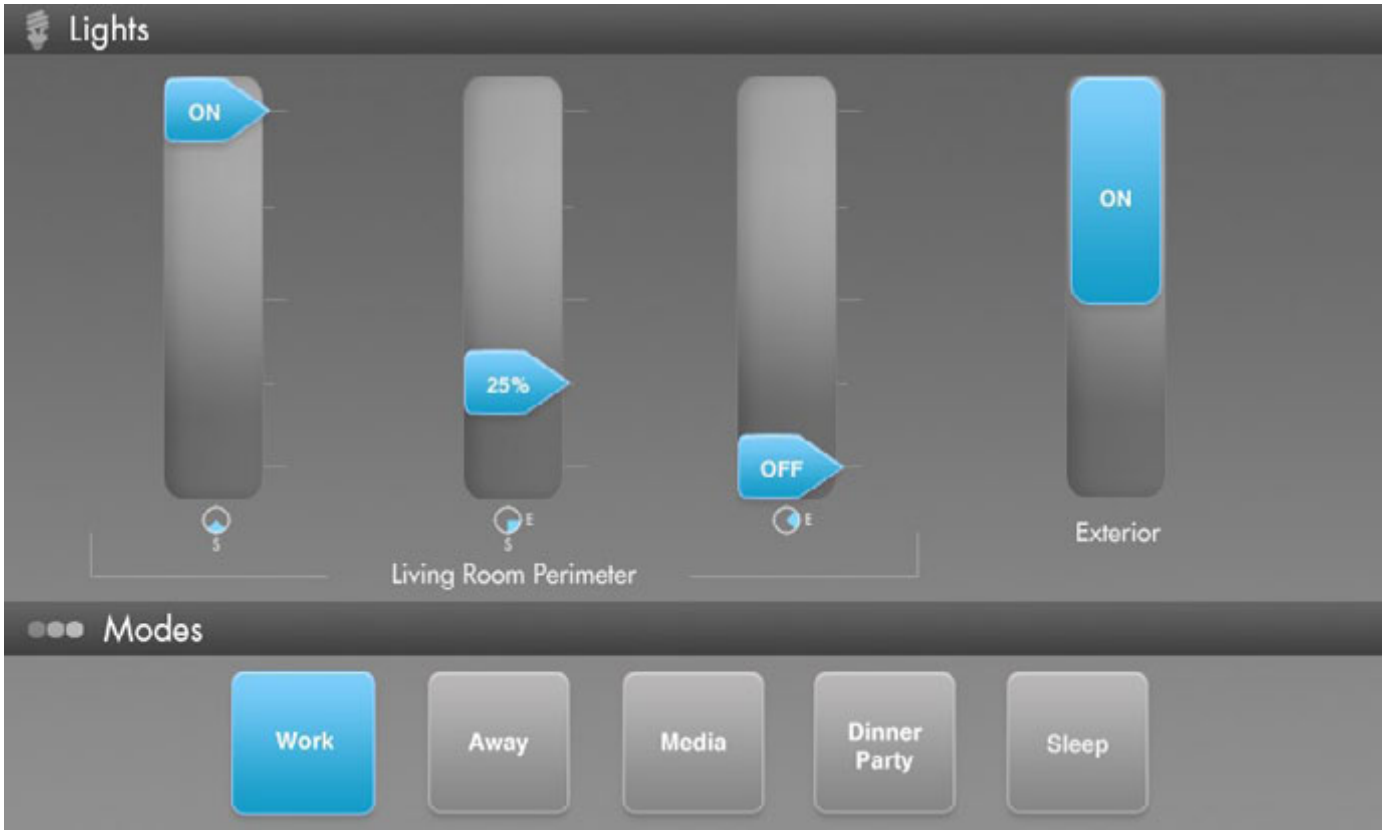
This panel would be located by the north-entrance, and would provide contextual-based controls that would relate to lights located close to that area.

A: These are controls for the lighting, and function in the same manner as on the kitchen display.

B: These are the modes that have been created, and they function in the same manner as on the kitchen display.

A

B



Page ID: EE-0

Page Title: Overview

Page Details

This panel would be located by the east-entrance, and would provide contextual-based controls that would relate to lights located close to that area.

A: These are controls for the lighting, and function in the same manner as on the kitchen display.

B: These are the modes that have been created, and they function in the same manner as on the kitchen display.

13.2 Desktop GUI | Information Architecture & Wireframes

Desktop Graphical User Interface | Information Architecture & Wireframes

Version 2.4 | Date: April 23, 2009

Wireframes provide a quick and cost effective method to illustrate a system's functionality and flow. They are not meant to convey visual design, rather they allow work groups to comment on and agree to the functionality before design and programming is done.

Revision History:

(V.2) A revised and simplified system is presented. Completely changed overview page, new navigation structure, and reduced community section

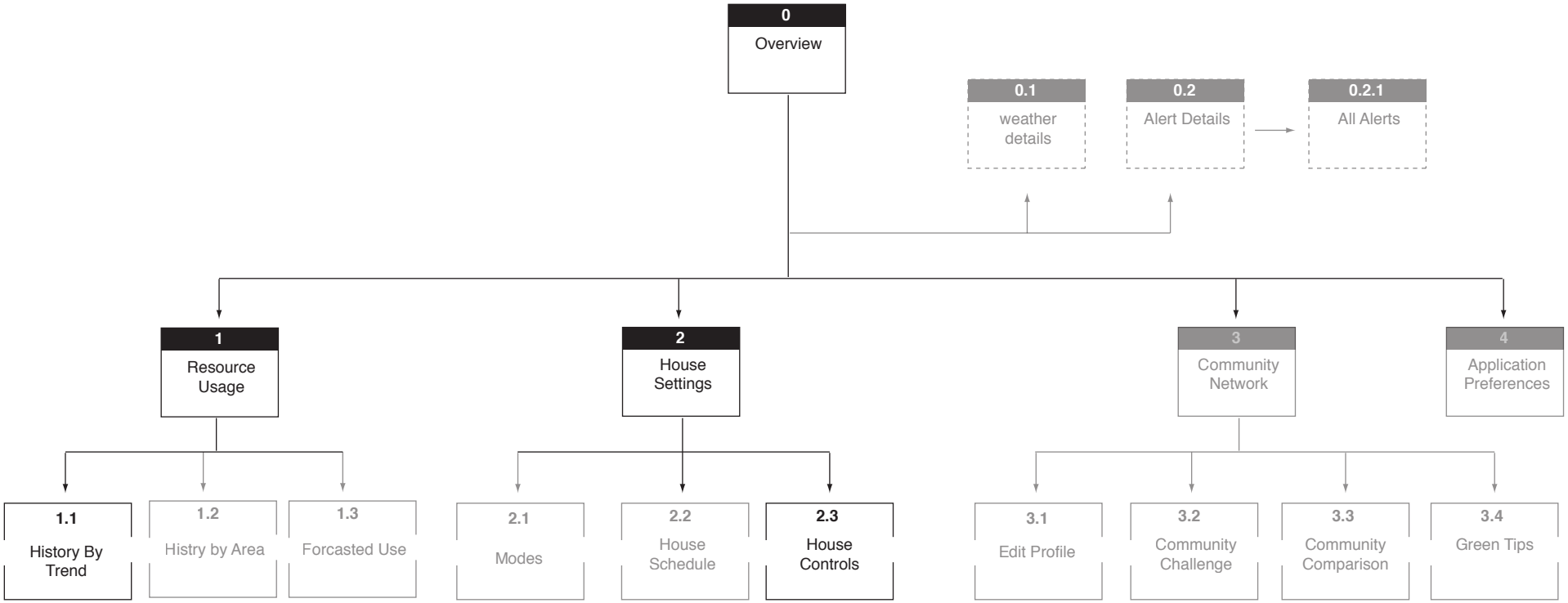
(V.2.1) Added history, trends and modes sections. Also added links to allow for interactive navigation within the PDF document

(V.2.2) Added scheduling, controls, and complete community section. Adjusted site-maps to reflect additions. (There remains only the System configurations section, forecasting section, and "history-by-area" , along with "adding a note functionality" to be completed).

(V.2.3) Small refinements to the community challenge and mode settings

(V.2.4) Updated house controls to be consistent with mobile application (sliders, buttions, toggles). Other small updates

Contributors: Kevin Muise, Jin Fan, Jenny Thai, John Rodgers,

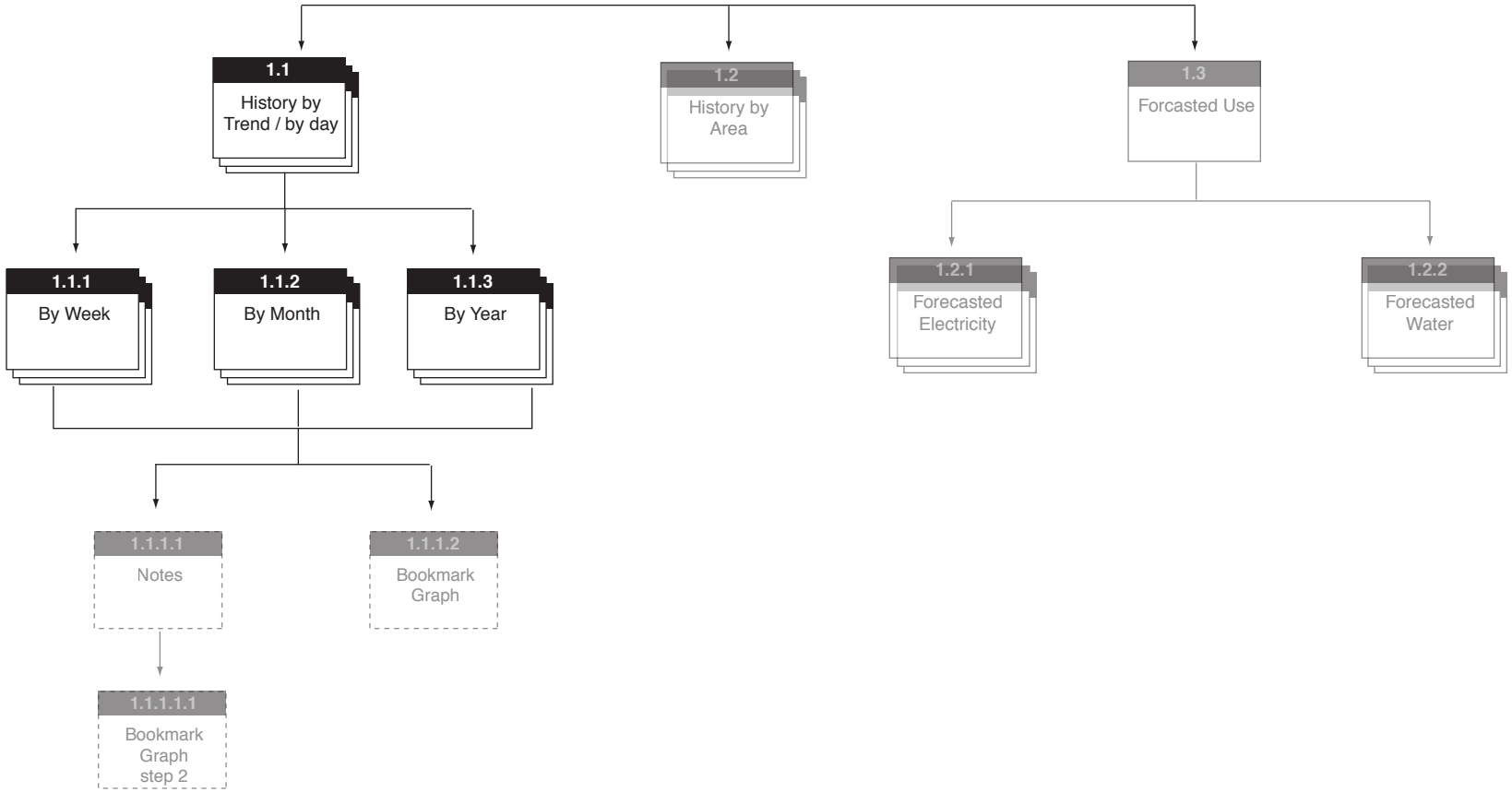


Legend

a new view that changes part of the active page

a page

the page is displayed elsewhere

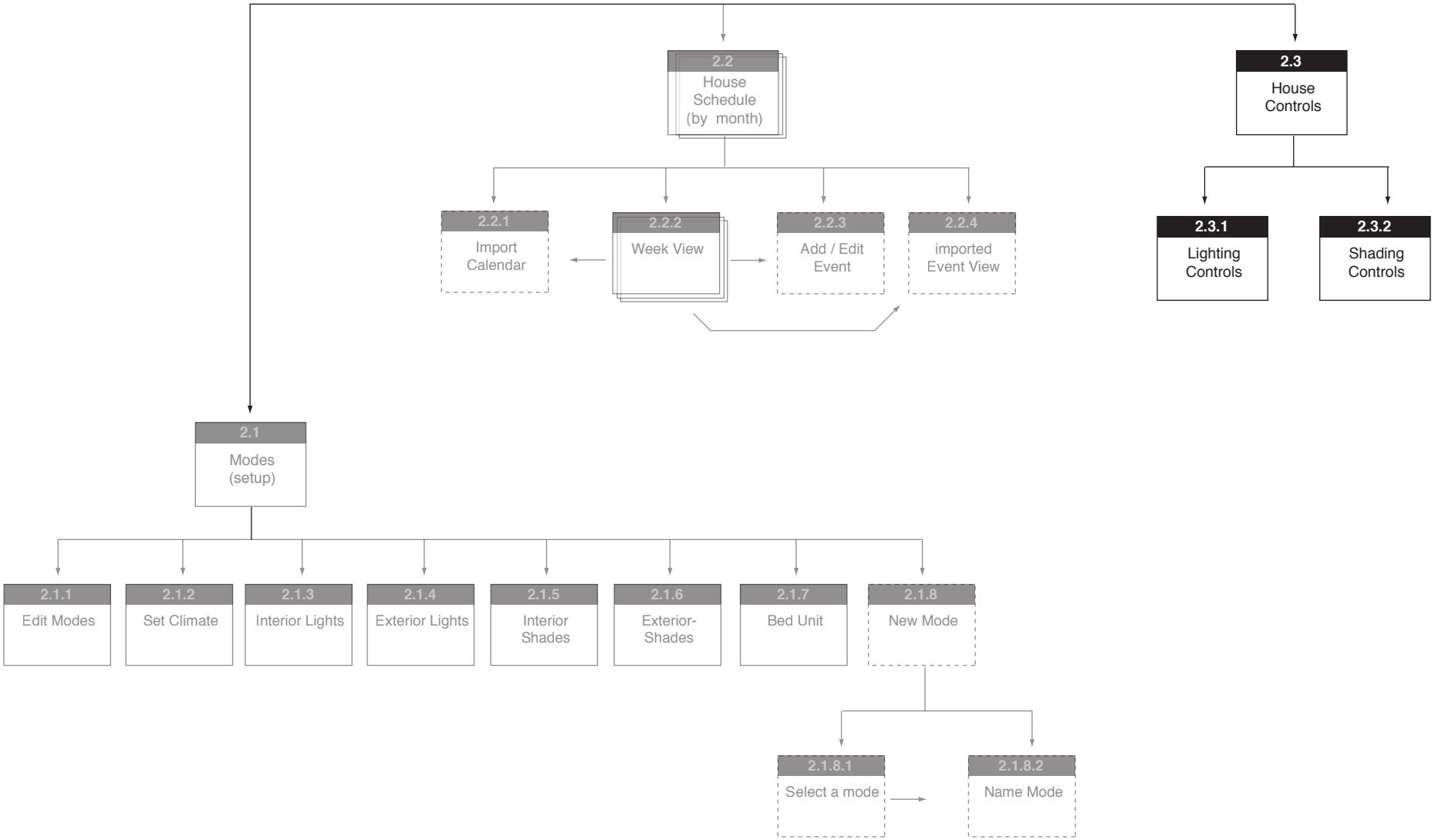


Legend

a new view that changes part of the active page

a page

the page is displayed elsewhere

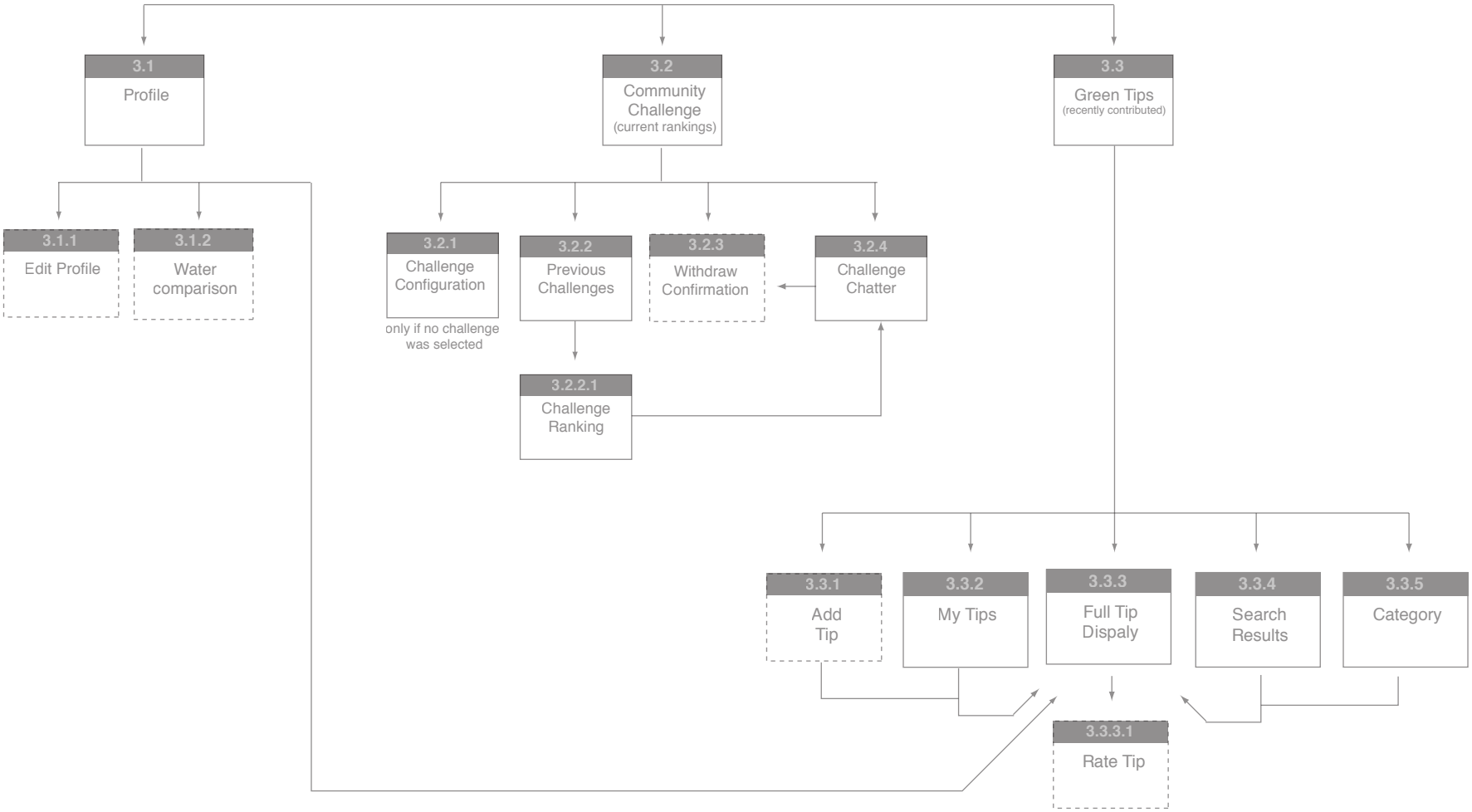


Legend

a new view that changes part of the active page

a page

the page is displayed elsewhere

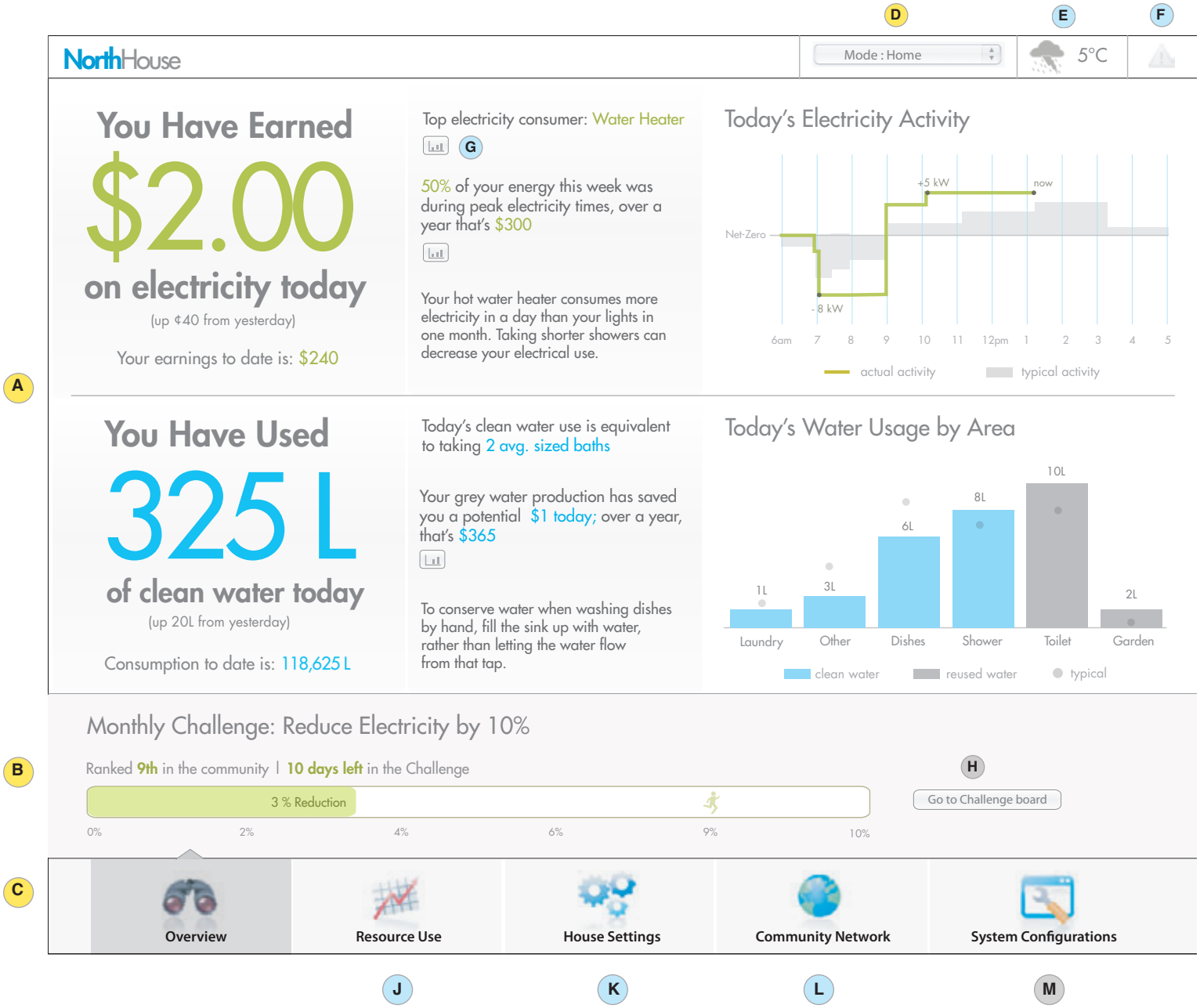


Legend

a new view that changes part of the active page

a page

the page is displayed elsewhere



Page ID: 0

Page Title: Overview

Page Details

A: The two top elements provide overview information for both electricity (top) and water (bottom).

B: This element is propagated through the community challenge element. It allows the resident to know how much she has reduced and they can compare their targets to the challenge leader.

C: The navigation that highlights to denote the section that is currently displayed.

D: Mode selector allows user to pull down the menu and select a mode that were previously created.

.

E: Displays the current weather, when user can press on it to receive further details (page ID 0.1)

F: Alerts / notifications appear as icons and colour combination to alert the resident of any issues with the house, or community updates. The user can press on the icon to get further information (page ID 0.2)

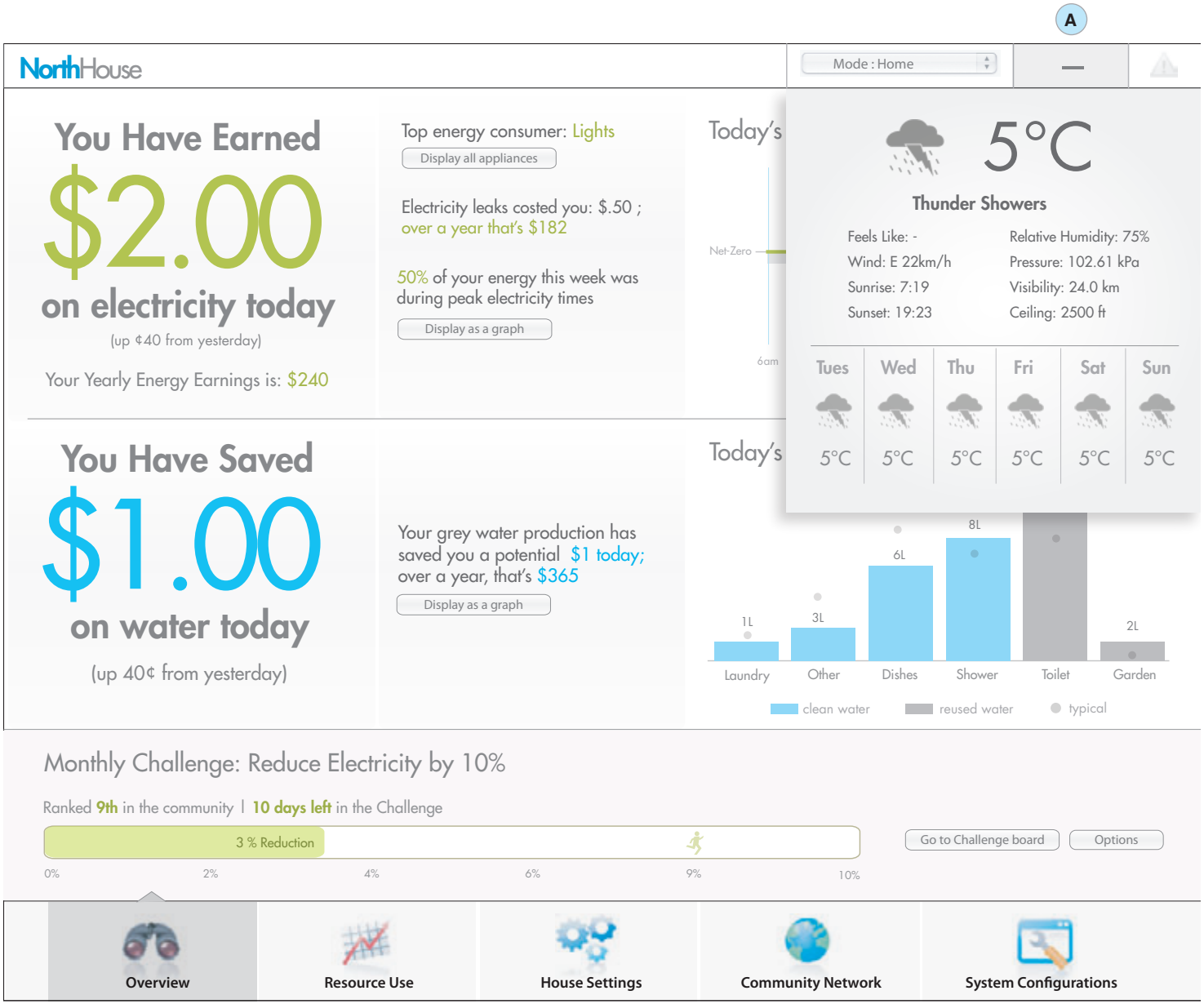
G: Allows the user to see more information on the topic. Pressing on the button forwards the user to the appropriate graph view (that relates to the text). Links to 1.1.1 or 1.2.1

H: This buton sends the user to the appropriate section in the community area.

J: This sends the user to the resource area (Links to 1.1)

Page ID: 0.1

Page Title: weather details



Page Details

A: After depressing the button, the temperature icon changes to a collapse icon. If the user presses on this button, it returns the user to page 01 (causing the weather pop-up to dissapear)

Page ID: 0.2

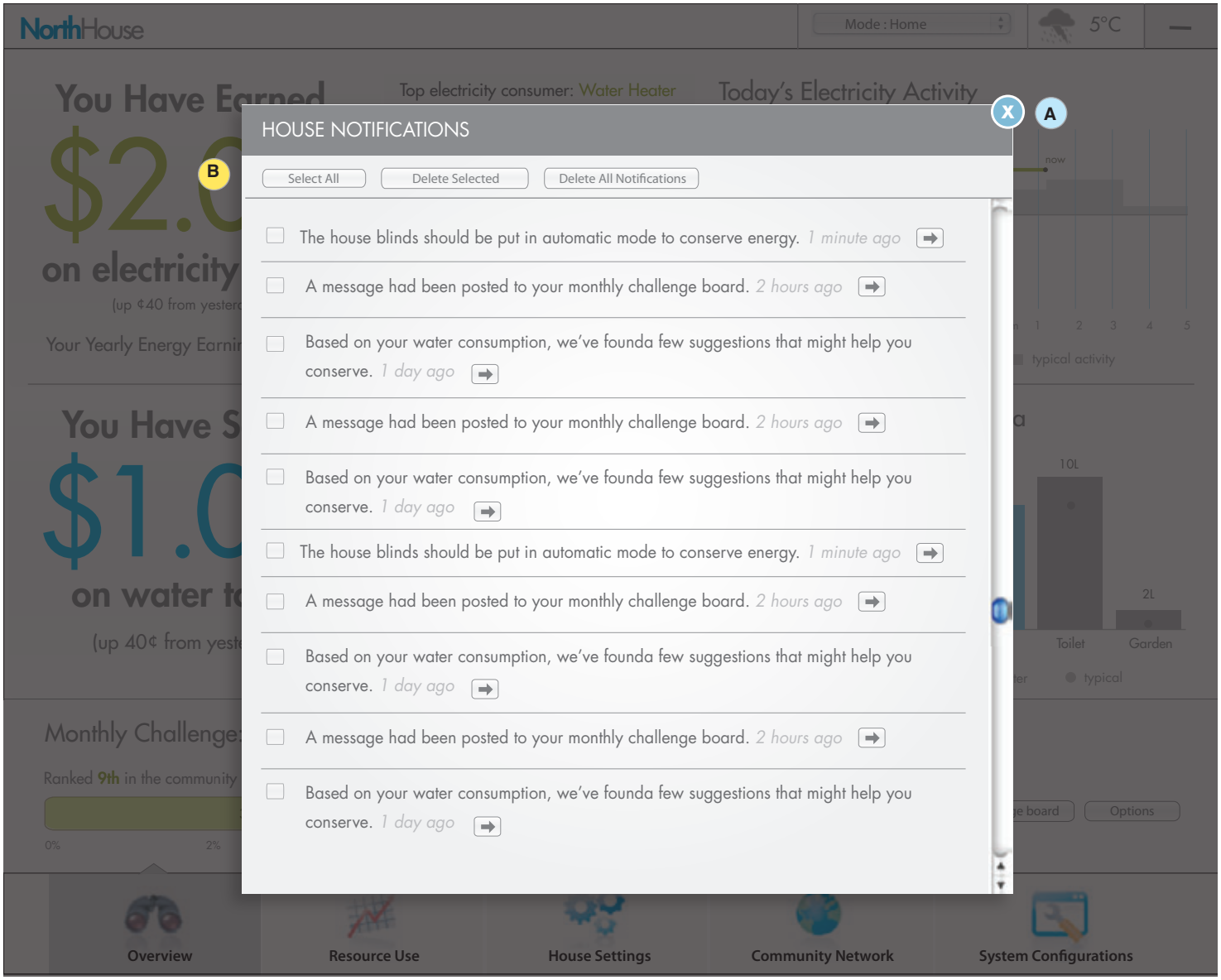
Page Title: Alert details

Page Details

A: After depressing the button, the alert icon changes to a collapse icon. If the user presses on this button, it returns the user to page 01 (causing the alert pop-up to dissapear)

B: Once a user mouses over a notice/alert, an "X" appears which (if clicked on) will delete the notice

C: The notice list will only keep 5 recent notices. The user can see more by clicking on the "see all" link



Page ID: 0.2.1

Page Title: All Alert details

Page Details

A: This closes the pop-up window, and brings the user back to the overview page

B: The user can select/deslect notices, and delete them. A delete confirmation window will appear, asking for confirmation.

Page ID: 1.1

Page Title: History by Trend & day

Page Details

A: This section provides a quick overview for to the user in human-terms, based on the data they are looking at on the graph
B: These are draggable variables that the user can select and place on one of three positions on the graph. (based on the current selection, some variables will be greyed-out / not -available).
C: This is the title of the graph, which changes dynamically, based on the variables that were selected.
D: The user can change units using (Kwh,$, ecological)
E: Toggle switch for last year's consumption. go to: page 20 (ID 1.1)
F: The user can click here to make annotate parts of the graph.
G: This toggles on/off the notes on the graph.
H: The user can click here to bookmark the graph (save the graph)/ page 17 (ID 1.1)

I: The user can click here to export the graph (not active in this version)

J: Here the user can select a previously saved graph

K: The link to the history by area section

L: The link to the forecasting section

N: Go to 1.1.1
O: Go to 1.1.2
P: Go to 1.1.3

Page ID: 1.1

Page Title: History by Trend & day (showing roll-overs)

Page Details

A: When rolling-over the weather icons at the top, it provides the user with the avg. weather for that day.

B: When rolling over points on each line, the graph displays the exact amount of electricity and amount of money earned.

C: When rolling over the lengend items, a pop-up appears to display the cost.

Page ID: 1.1

Page Title: History by Trend & day (showing interaction)

Page Details

This page displays usage in a yearly view

A: In order to add a new variable, the user is required to delete the current one. The user can click on the “x” to delete it from the graph. (go to next page)

Page ID: 1.1

Page Title: History by Trend & day (showing interaction)

Page Details

A: this shows what an empty cell looks like, the dotted line is used to communicate that a variable from the list can be dragged into this position.

Page ID: 1.1

Page Title: History by Trend & day (showing interaction)

Page Details

A: When rolling over a variable in the list, a pop-up appears which presents further information about the variable.

Page ID: 1.1

Page Title: History by Trend & day (showing interaction)

Page Details

A: This illustrates how a variable can be dragged into position on the graph.

Page ID: 1.1

Page Title: History by Trend & day (showing interaction)

Page Details

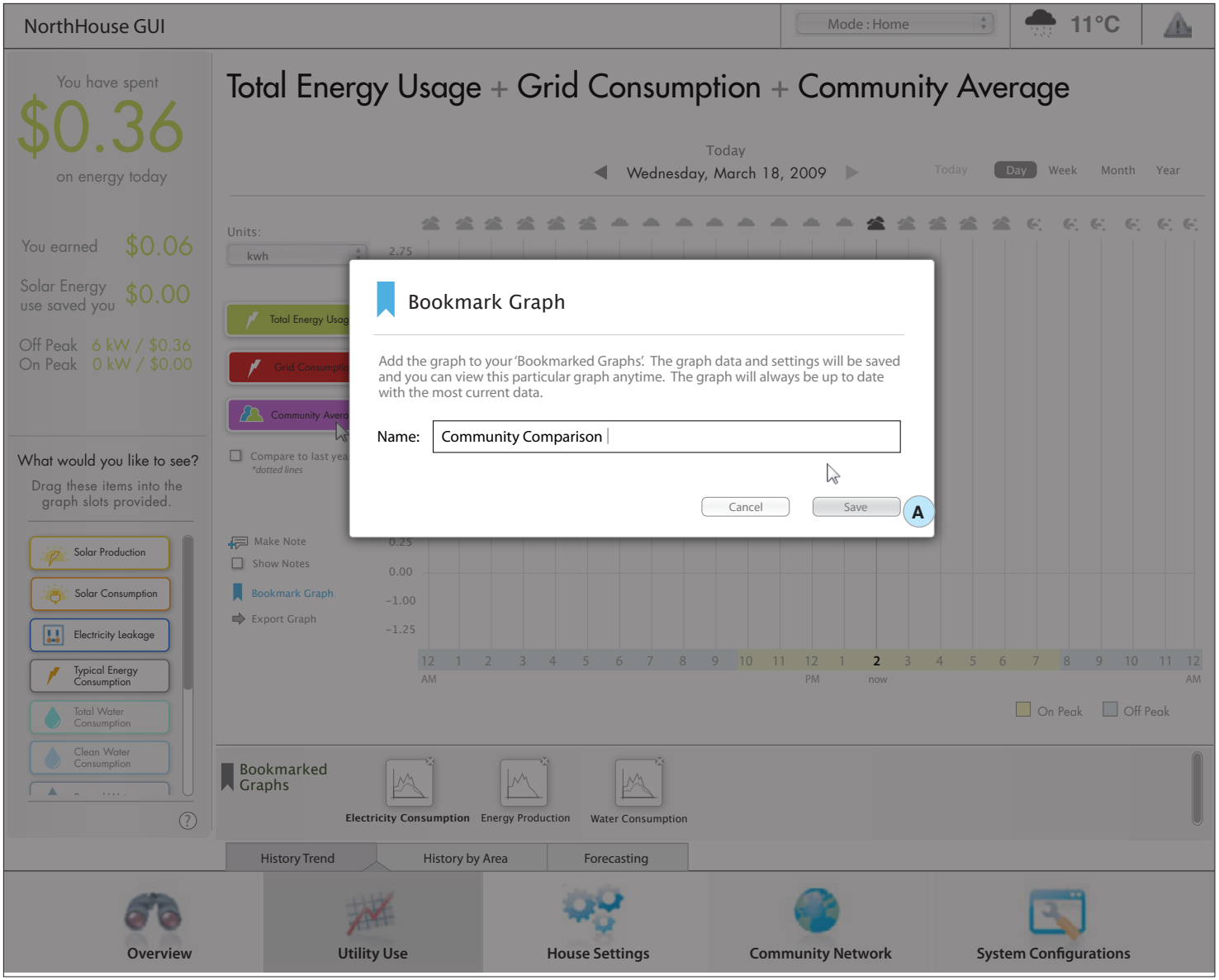
A: Once a variable is in place, a new line appears that uses the same colour as the varible-draggable.

Page ID: 1.1

Page Title: History by Trend & day (bookmark roll-over)

Page Details

A: When rolling-over the icon, it is high-lighted in blue, and it when clicked on, will bring the user to a pop-up where they can save the graph. (go to ID 1.1.1.2)



Page ID: 1.1.1.2

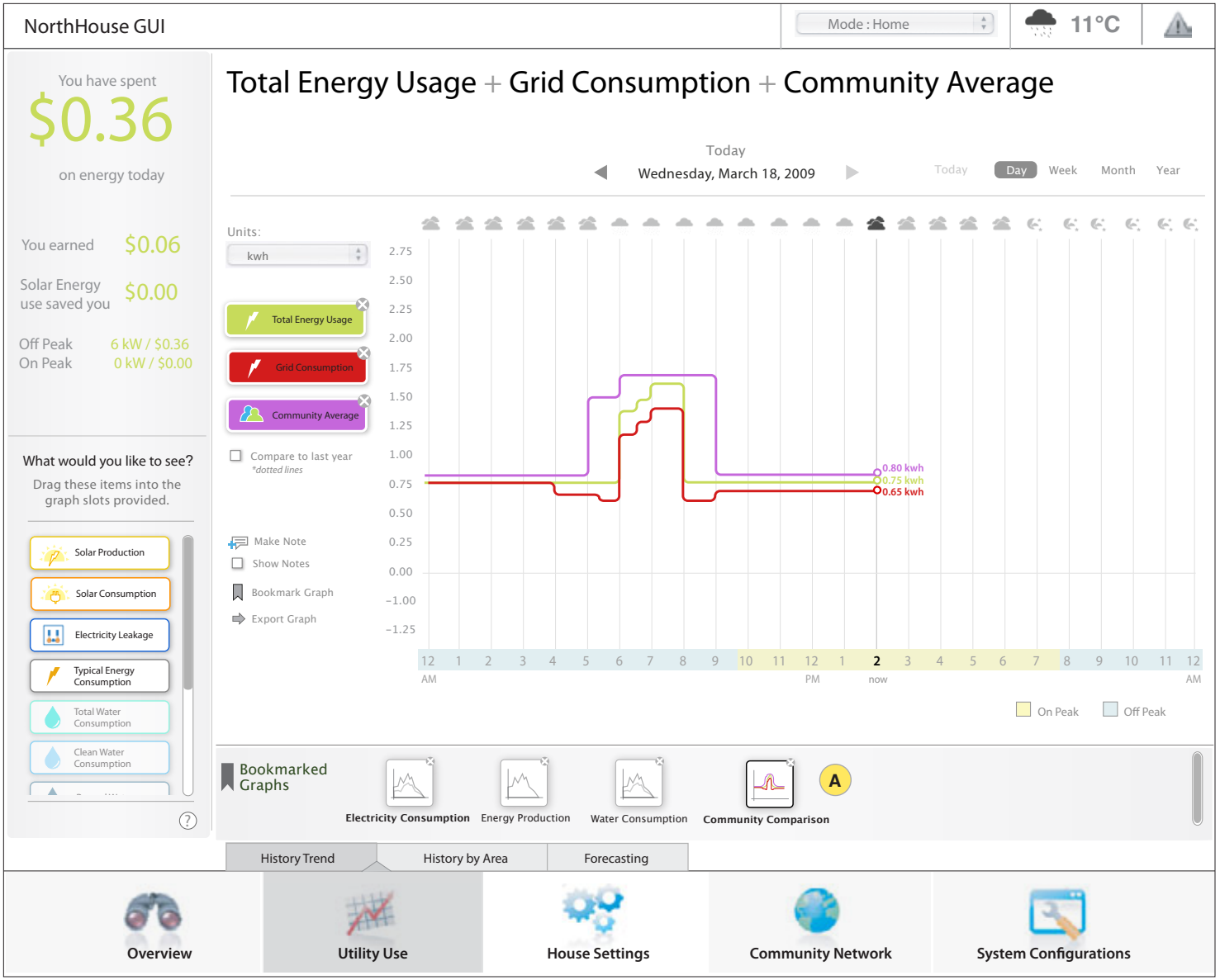
Page Title: Bookmarking Graph

Page Details

A: The user can enter the name of the graph, and can choose to save it or press cancel. (go to next page)

Page ID: 1.1

Page Title: History by Trend & day (saved bookmark)



Page Details

A: A new bookmark link appears in the list.

Page ID: 1.1

Page Title: History by Trend & day (showing last year's)

Page Details

A: If the toggle is checked for the "compare last year", a dotted line appears for each line to denote the previous year's use for each variable.

Page ID: 1.1.1

Page Title: By Week

Page Details

A: In the week view, the graph is displayed which is an aggregate of the daily variables. The same interaction model applies as was discussed in the “day” view.

B: In pressing on the arrow, the user can view the previous week’s data. (go to next page)

Page ID: 1.1.1

Page Title: By Week

Page Details

A: The user can see the previous week's usage.

Page ID: 1.1.1

Page Title: By Week
(displaying roll-overs)

Page Details

A: When the user rolls-over a line, a node appears and a pop-up displays the consumption for that point on the line.

Page ID: 1.1.1

Page Title: By Week
(displaying roll-overs)

Page Details

This page shows some other roll-over states.

Page ID: 1.1.2

Page Title: By Month
(displaying roll-overs)

Page Details

This page displays usage in a month view

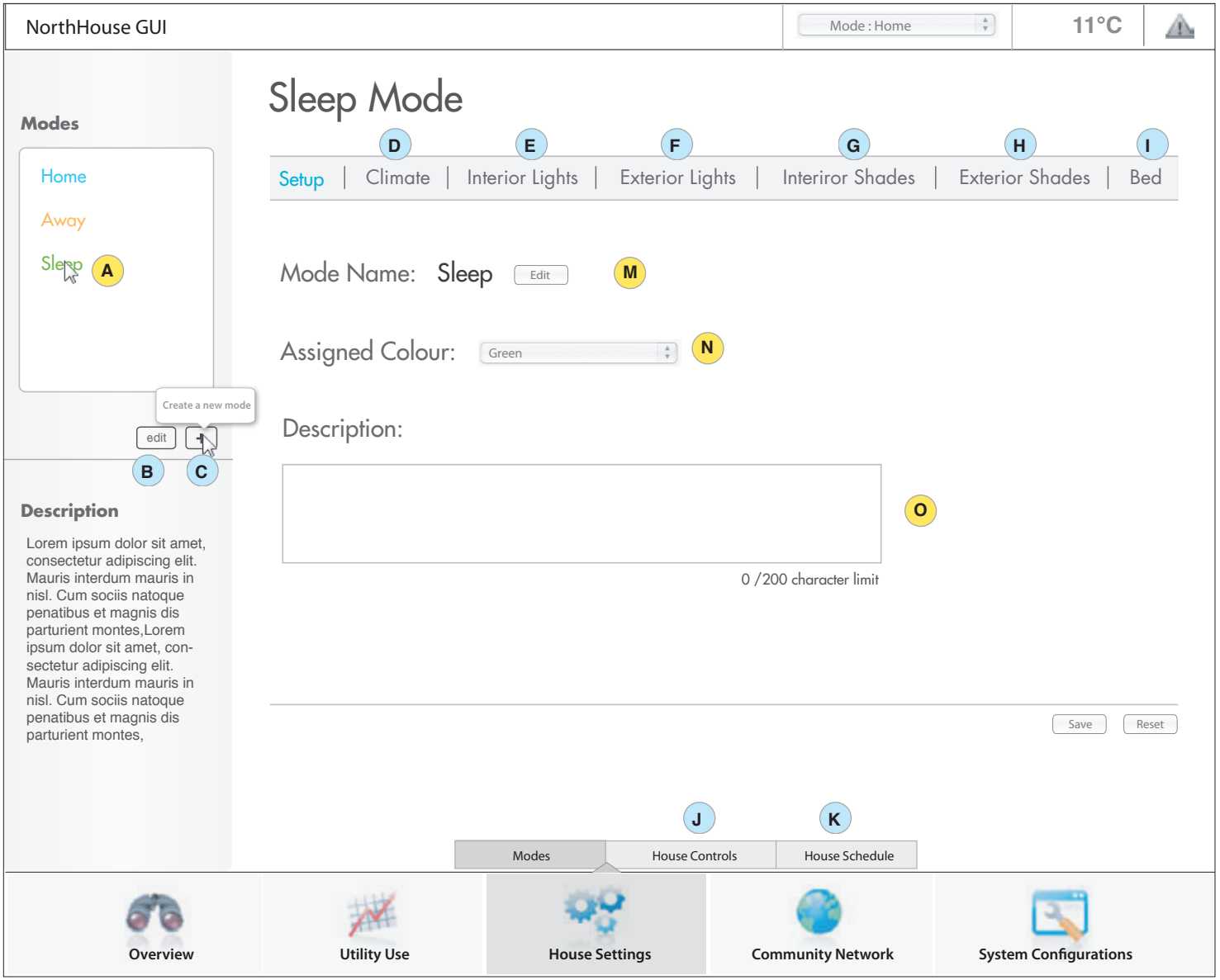
Page ID: 1.1.3

Page Title: By Year

Page Details

This page displays usage in a yearly view

A: The stars display the high and low points of consumption (blue low, orange - high).



Page ID: 2.1

Page Title: Modes (setup)

Page Details

A: The existing modes are displayed as a list. Hovering over each mode provides a description below.

B: The user can press on the “edit” button to delete the modes (go to page 28)

C: The user can click on this button to add new modes. Hovering over the button provides an info bubble. (Page ID 2.1.8).

D: go to 2.1.2
E: go to 2.1.3
F: go to 2.1.4
G: go to 2.1.5
H: go to 2.1.6
I: go to 2.1.7

M: The user can edit the current name of the mode by pressing on the edit button.

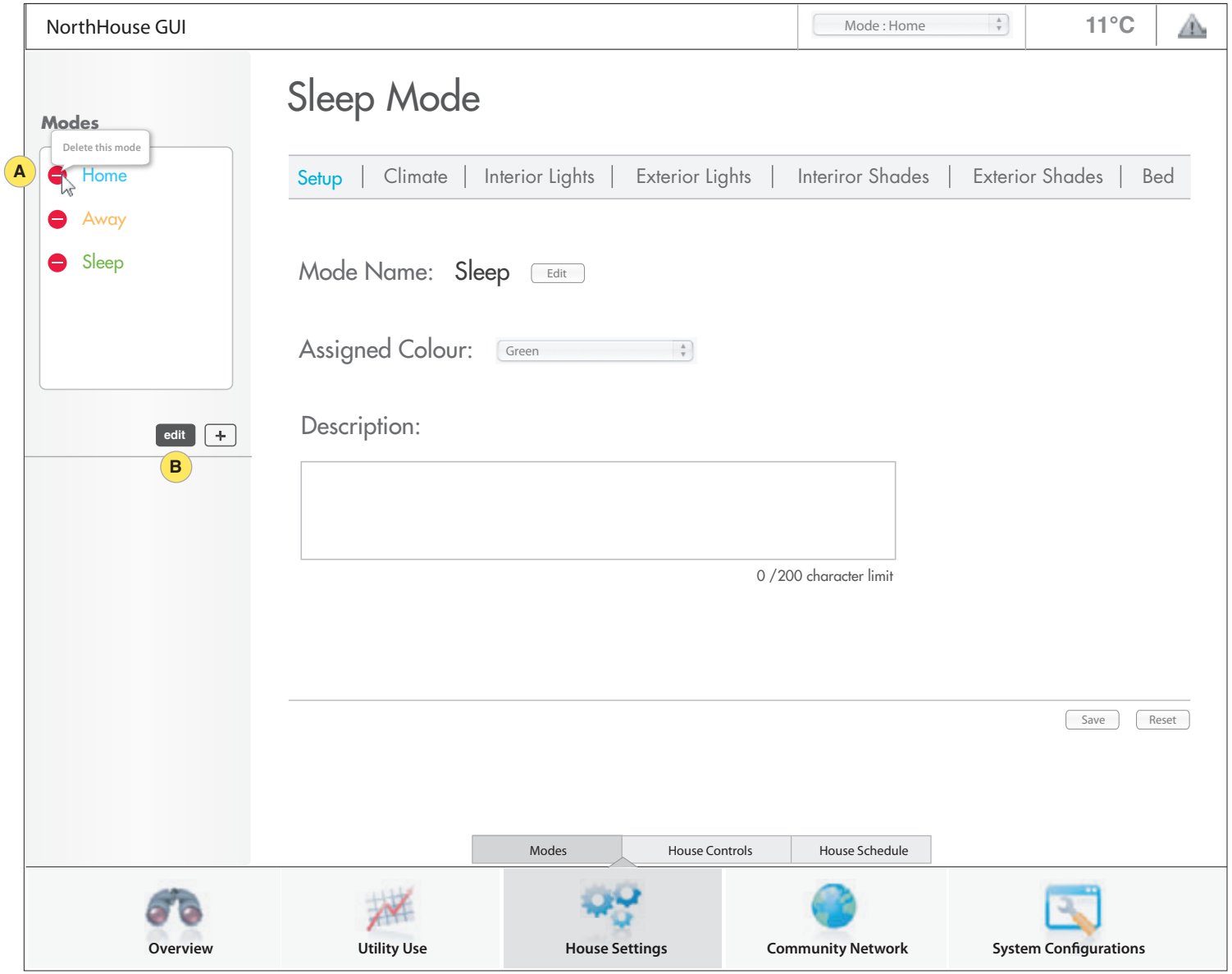
N: The user can select the colour that the mode will be assigned. This is used for the “house schedule” section.

O: The user can add a description, which has a 200 characther limit.

J: go to:
K: go to page ID 2.2

Page ID: 2.1.1

Page Title: Modes (setup)



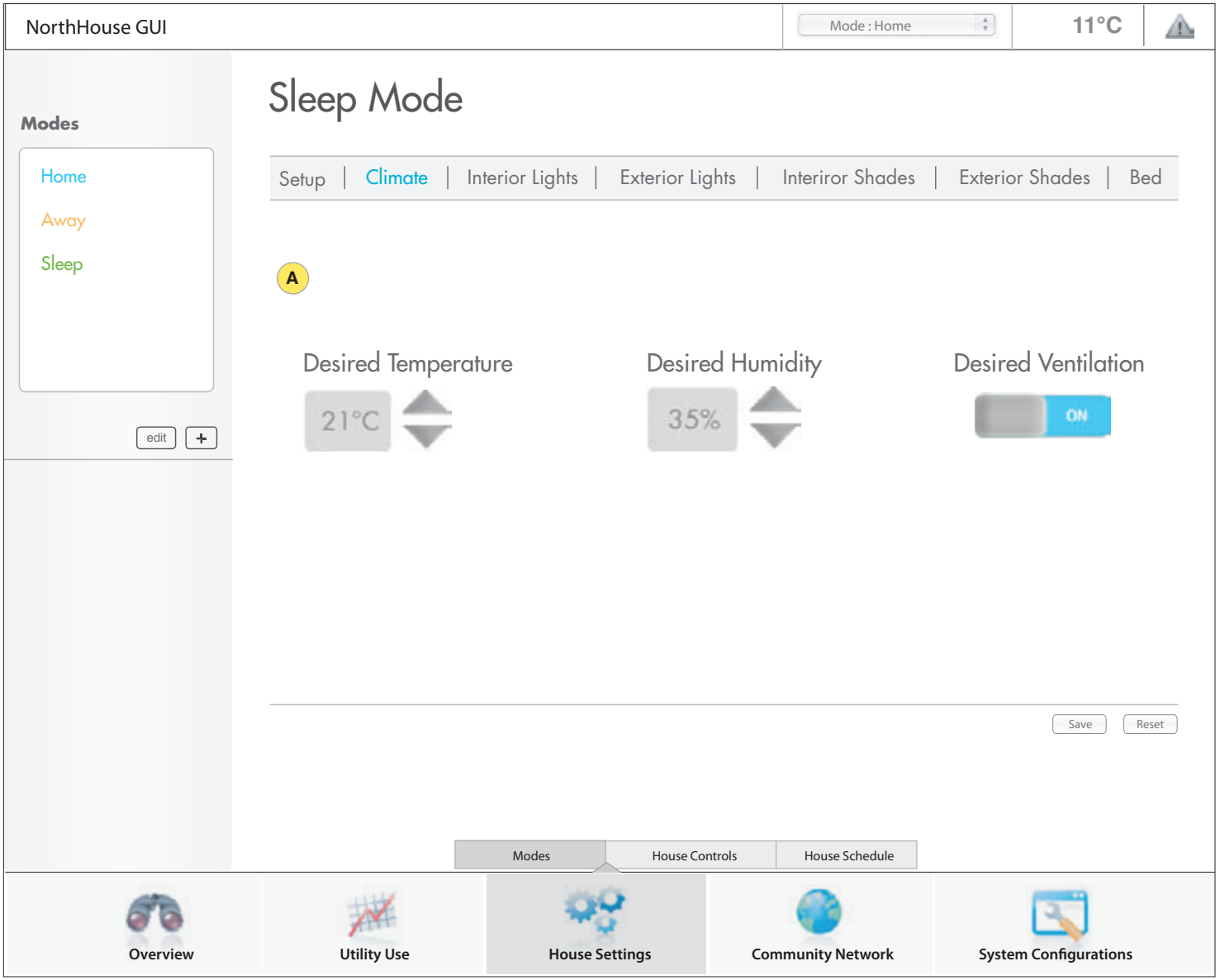
Page Details

A: After pressing on the edit button, these “delete” buttons appear, which allow the user to delete the modes.

B: The edit button is dark when in the “edit mode”

Page ID: 2.1.2

Page Title: Set Climate

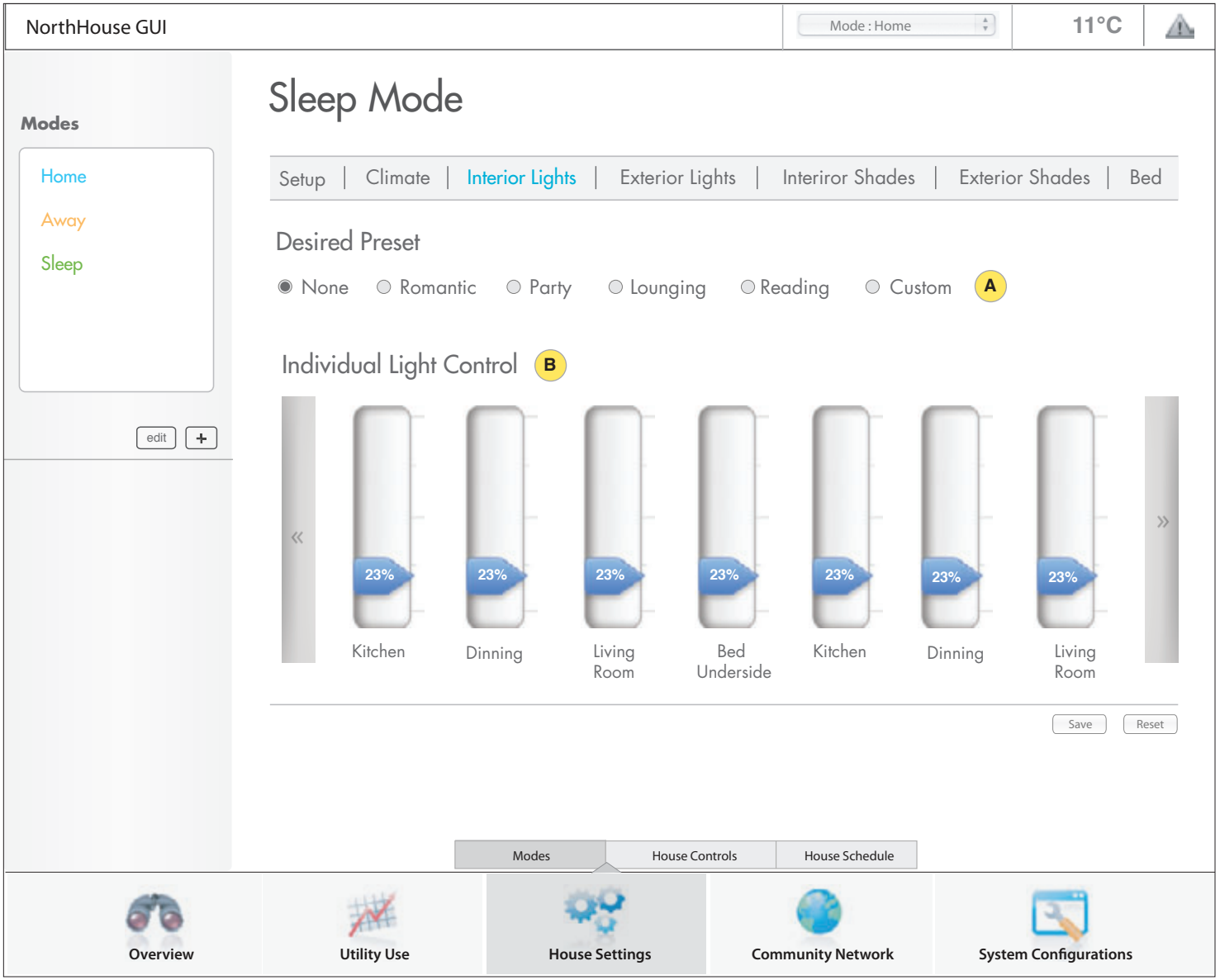


Page Details

A: The user can use the various controls to set the desired temperature, humidity and ventilation. This will not alter the current house state.

Page ID: 2.1.3

Page Title: Interior Lights



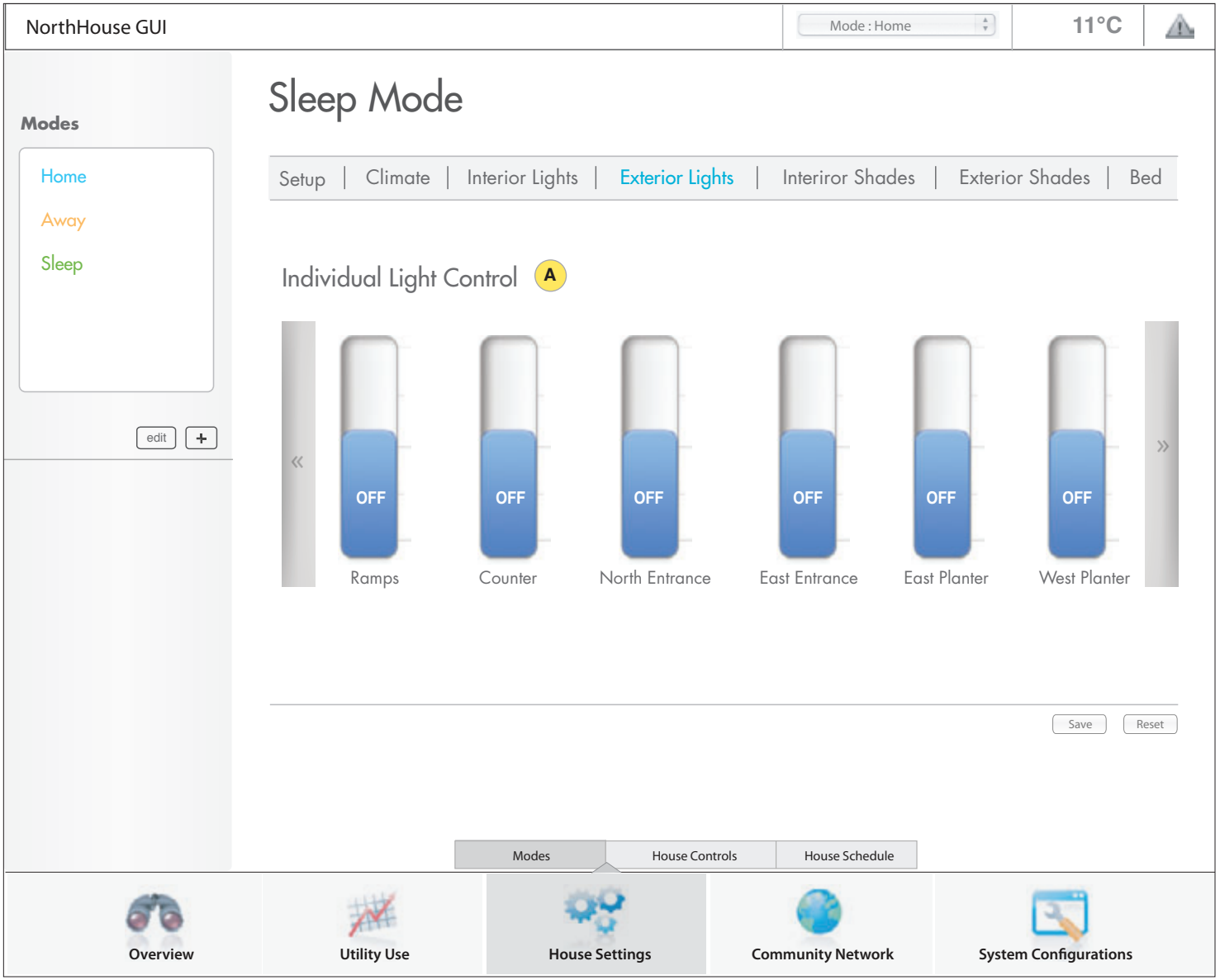
Page Details

A: The user can choose from a number of lighting presets, or can start from scratch. If the user chooses a preset, all of the interior lighting controls will be altered to match the preset levels. If the user makes any changes to the individual light controls, the radio button will automatically switch to the "custom" option.

B: Here the user can raise and lower the individual light controls through the slide-bars. Through clicking on the arrows on the side, the user cycle through all of the available interior lighting controls

Page ID: 2.1.4

Page Title: Exterior Lights

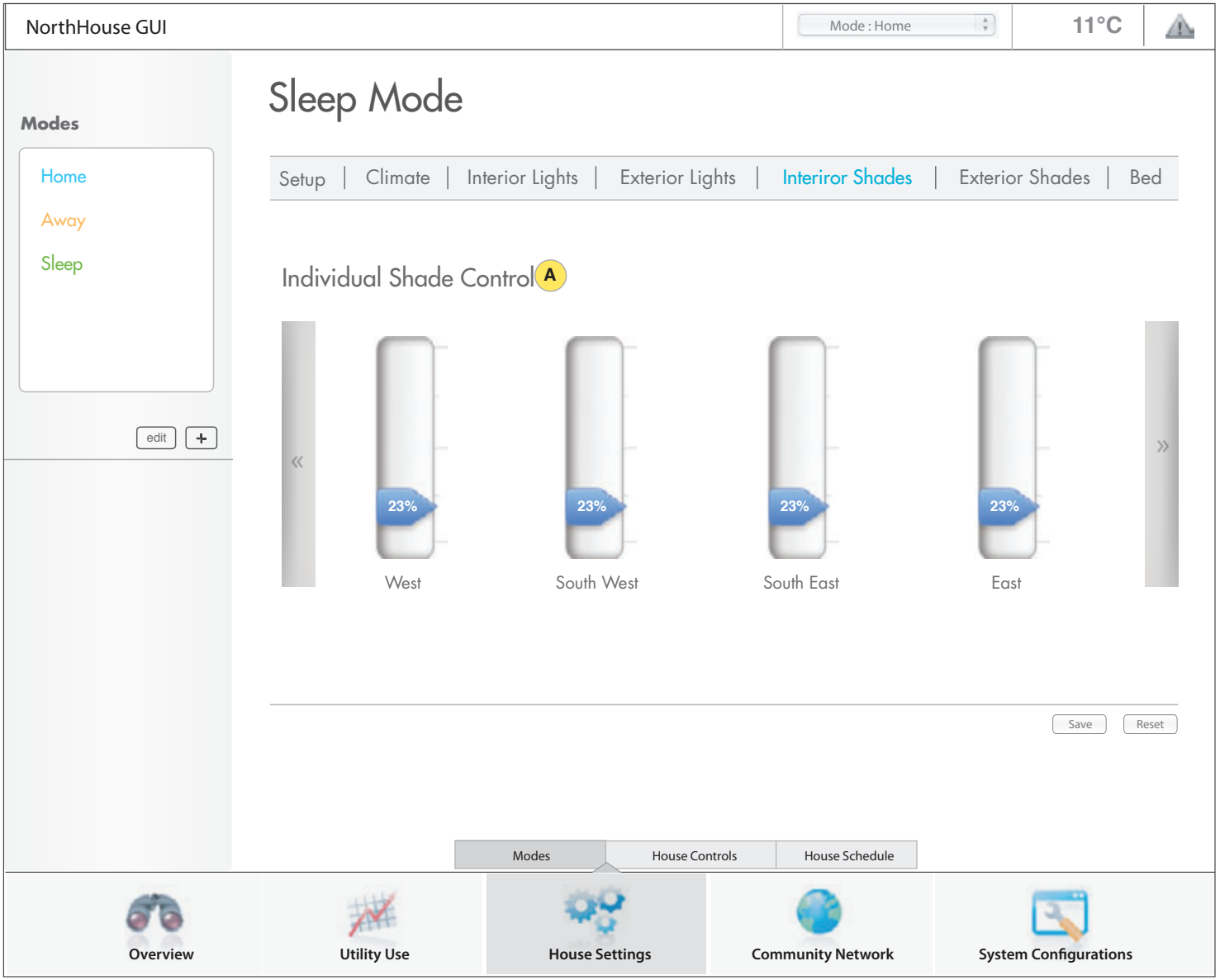


Page Details

A: Here the user can raise and lower the individual light controls through the toggle controls. Through clicking on the arrows on the side, the user cycle through all of the available exterior lighting controls

Page ID: 2.1.5

Page Title: Interior Shades

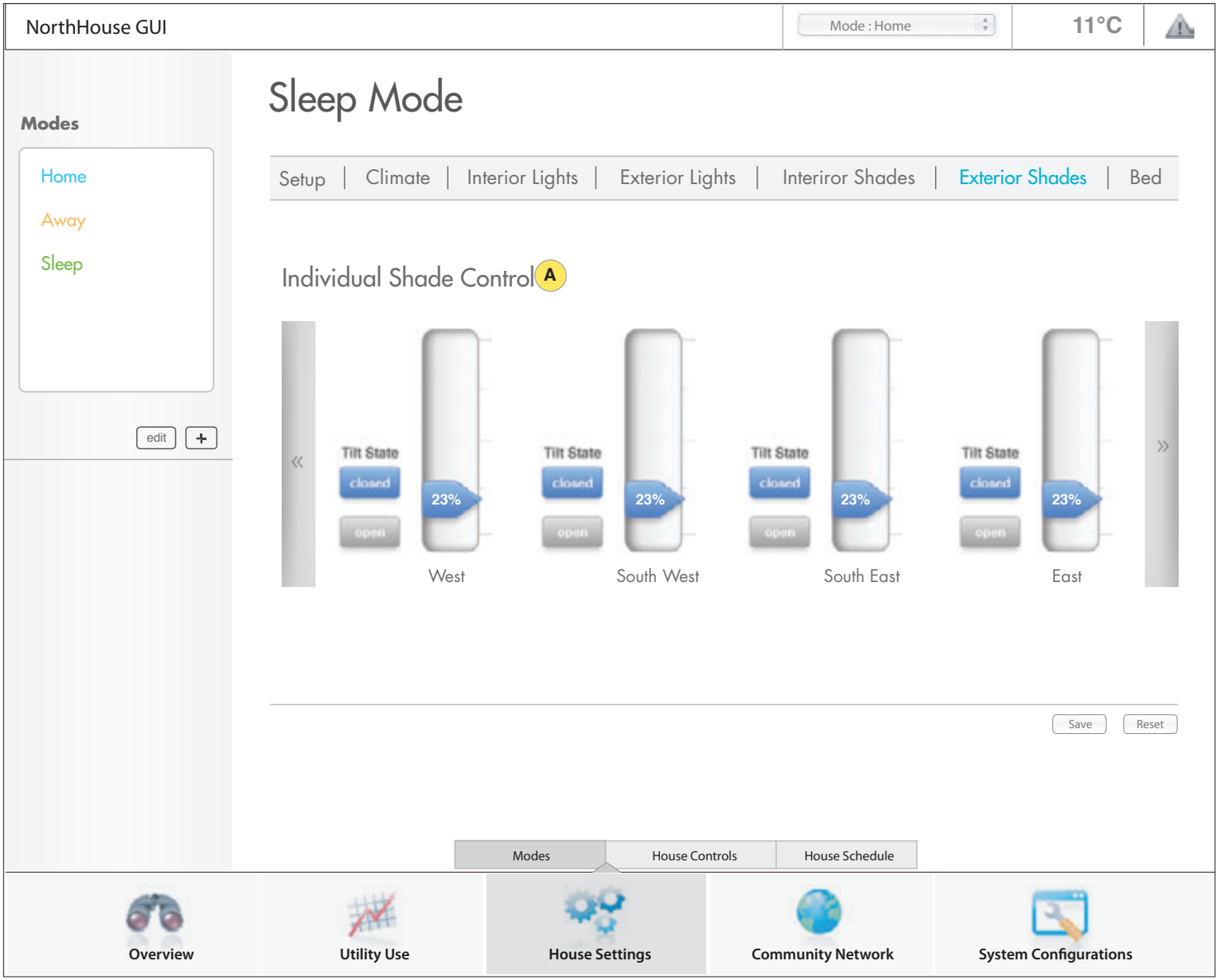


Page Details

A: Here the user can raise and lower the individual shades through the slidebars. Through clicking on the arrows on the side, the user cycle through all of the available interior shade controls

Page ID: 2.1.6

Page Title: Exterior Shades

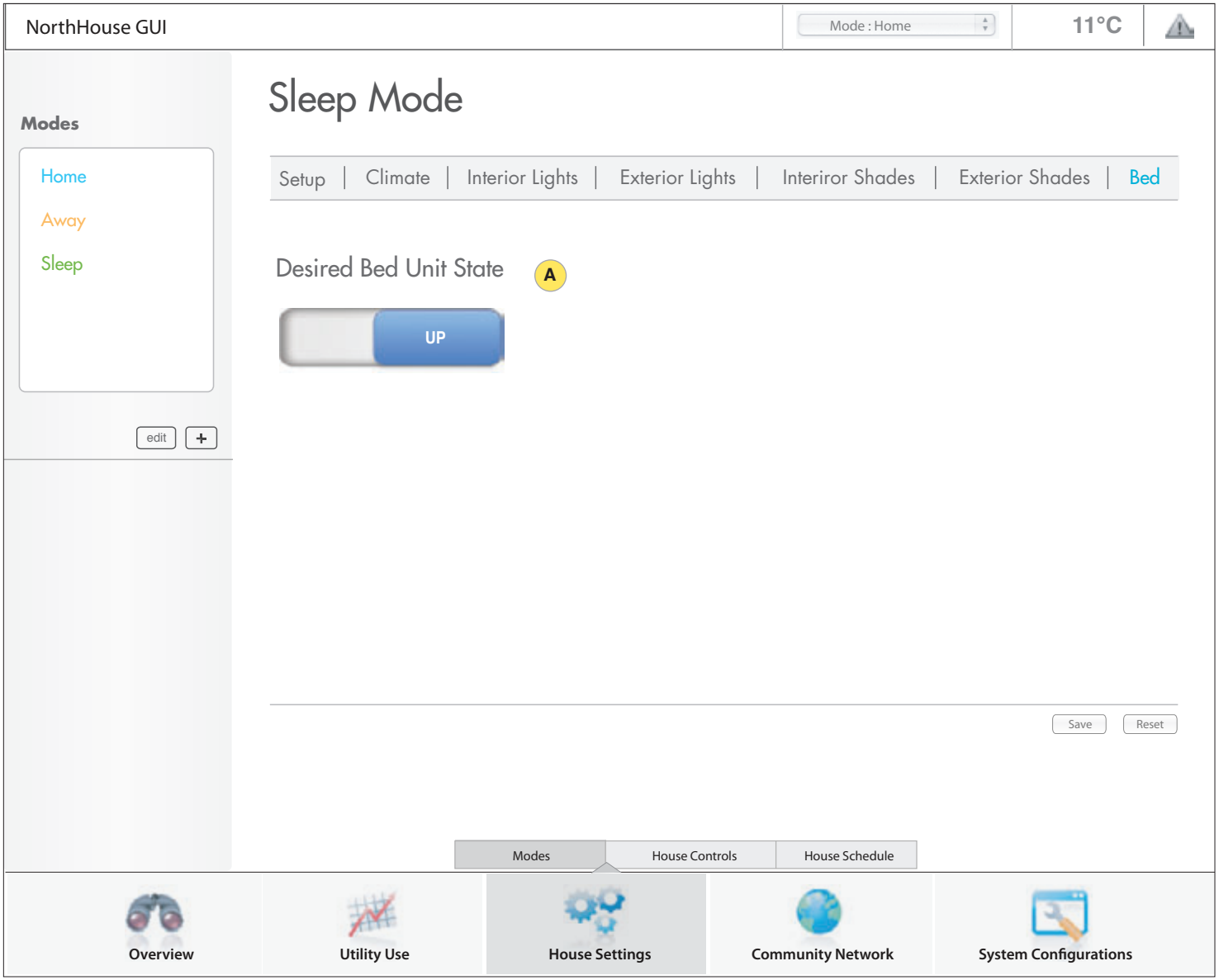


Page Details

A: Here the user can raise and lower the individual shade controls through the slidebars and change the tilt of the blinds through the different buttons. Through clicking on the arrows on the side, the user cycle through all of the available exterior shade controls

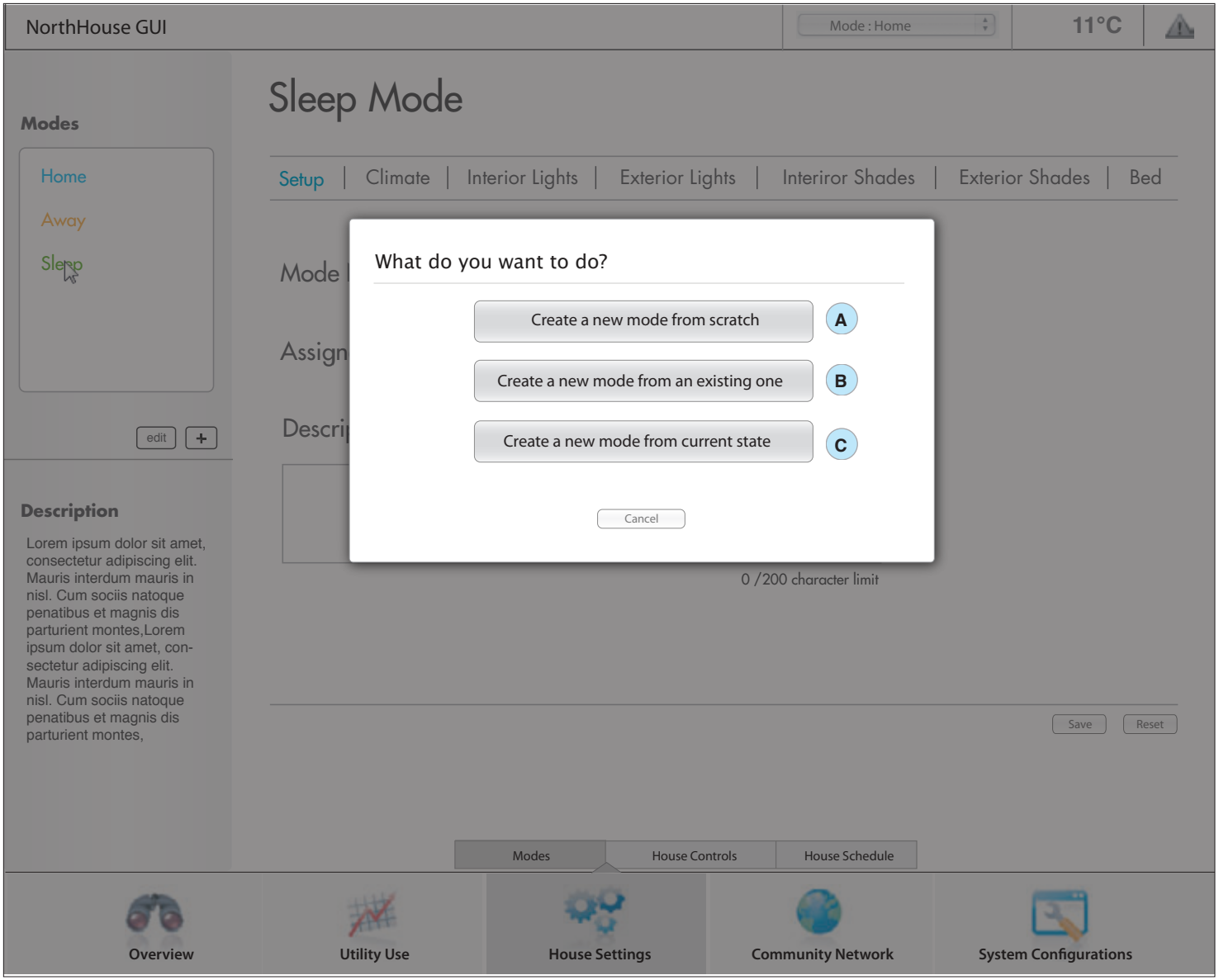
Page ID: 2.1.7

Page Title: Bed Unit



Page Details

A: The user can set the desired bed state for the mode by using the toggle switch.



Page ID: 2.1.8

Page Title: New Mode

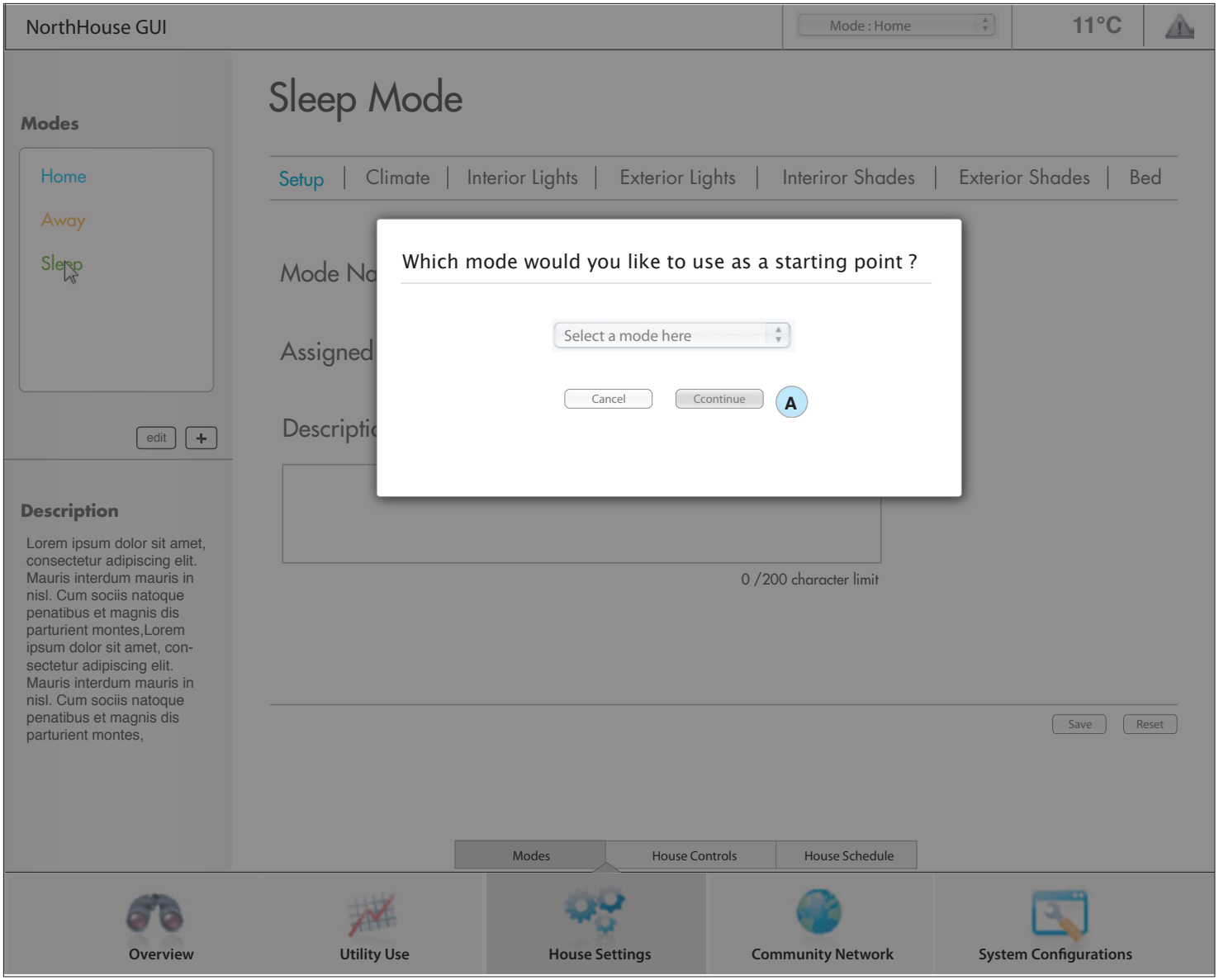
Page Details

A: The user can create a new mode, that will have all the controls start from zero. pressing the btn takes the user to: 2.1.8.2

B: The user can create a new mode from an existing one. Go to: 2.1.8.1

C: The user can create a new mode from the current house settings. pressing the btn takes the user to: 2.1.8.2

The user can choose to also cancel, which will get rid of the pop-up and light-box funciton.

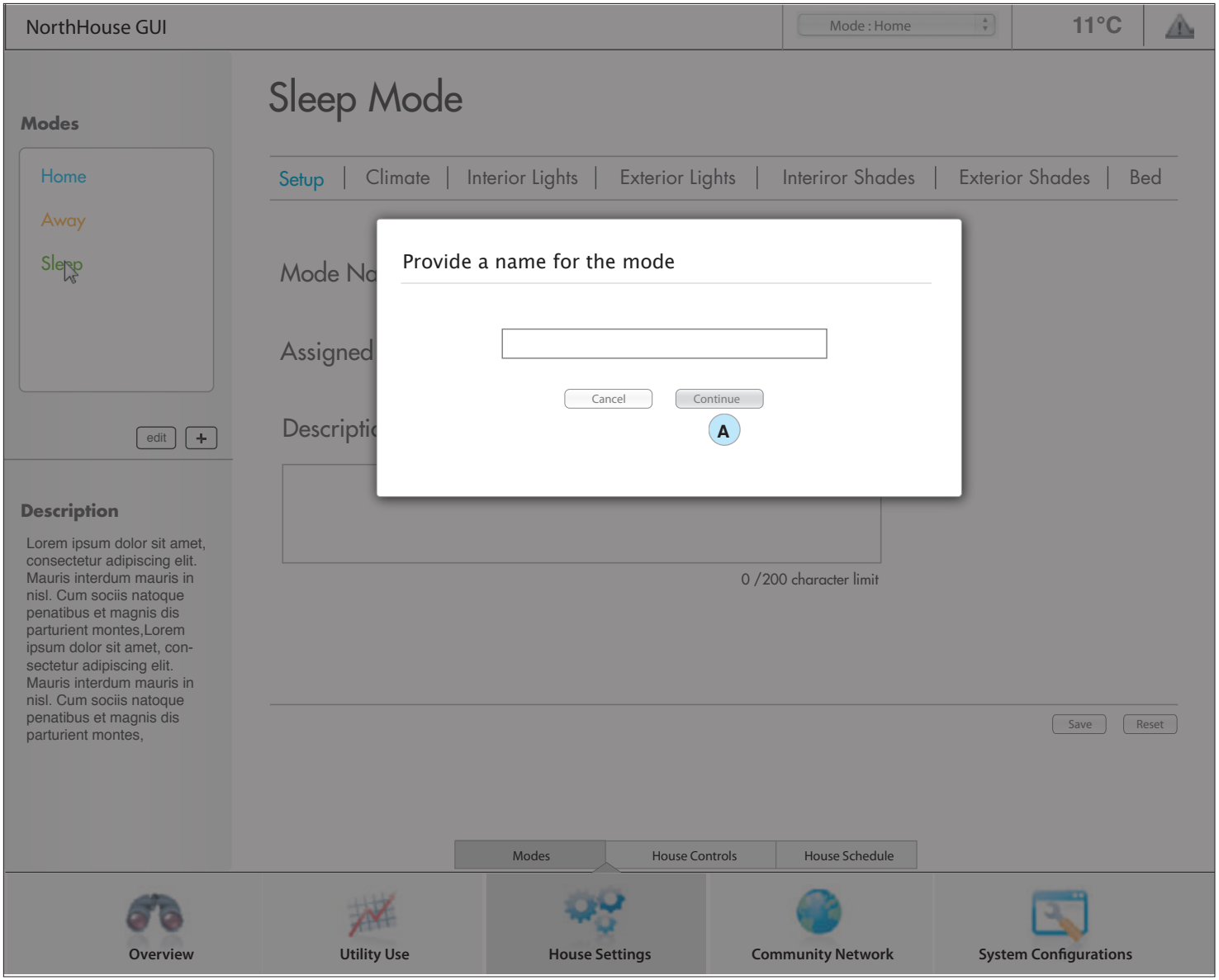


Page ID: 2.1.8.1

Page Title: Select a mode

Page Details

A: The user can select from a list of existing modes. pressing continue takes the user to: 2.1.8.2



Page ID: 2.1.8.2

Page Title: Name Mode

Page Details

A: The user is asked to provide a name for the mode. After the user does so, he can press on continue which will bring the user to the “edit mode” page (Page ID 2.1)

Page ID: 2.2

Page Title: Schedule Schedule (by month - interaction)

NorthHouse GUI | Mode : Home | 11°C

Imported Calendars
- Google Cal – Work
- Google Cal – Play

Modes
- A I'm Home
- Away
- Sleep

March 2009 — Week | Month

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
30	1	2 8:30 Work 11p Sleep	3 8:30 Wrok 11p Sleep	4 8:30 Work 11p Sleep	5 8:30 Work 11p Sleep	6 8:30 Work 11p Sleep
7 10 Dragon Boad 10 Away 11p Sleep	8 8:30 Work 10 Meet John 4:30p Go to bank 11p Sleep	9 2p Client Meeting 11p Sleep	10 8:30 Day Care 10 Conference Call 7p Mom's Bday 11p Sleep	11 8:30 Work 11p Sleep	12 8:30 Day Care 11p Sleep	13 10 Away 7p Music Concert 11:59p Sleep
14 10 Dragon Boad 10 Away 11p Sleep	15 8:30 Work 10 Meet John 4:30p Go to bank 11p Sleep	16 2p Client Meeting 11p Sleep	17 8:30 Day Care 10 Conference Call 7p Mom's Bday 11p Sleep	18 8:30 Work 11p Sleep	19 8:30 Day Care 11p Sleep	20 10 Away 7p Music Concert 11:59p Sleep
21 10 Dragon Boad 10 Away 11p Sleep	22 8:30 Work 10 Meet John 4:30p Go to bank 11p Sleep	23 2p Client Meeting 11p Sleep	24 8:30 Day Care 10 Conference Call 7p Mom's Bday 11p Sleep	25 8:30 Work 11p Sleep	26 8:30 Day Care 11p Sleep	28 10 Away 7p Music Concert 11:59p Sleep
29 10 Dragon Boad 10 Away 11p Sleep	30 8:30 Work 10 Meet John 4:30p Go to bank 11p Sleep	31 2p Client Meeting 11p Sleep	1 8:30 Day Care 10 Conference Call 7p Mom's Bday 11p Sleep	8:30 Work 11p Sleep	2 3 8:30 Day Care 11p Sleep	4 10 Away 7p Music Concert 11:59p Sleep

Modes | House Controls | House Schedule

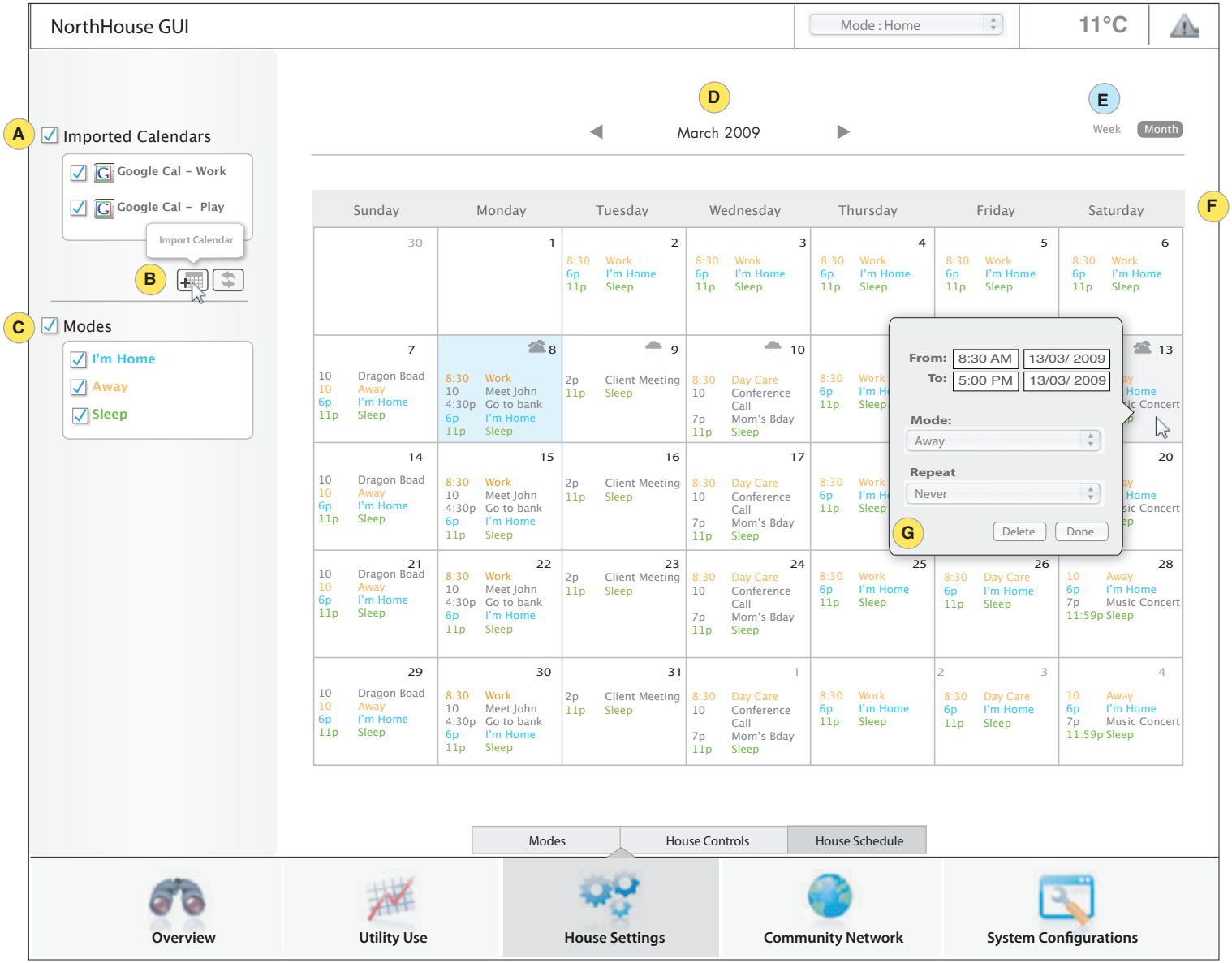
Overview | Utility Use | House Settings | Community Network | System Configurations

Page Details

A: This demonstrates how a mode calendar's visibility can be toggled on and off through the use of the checkboxes

Page ID: 2.2.3

Page Title: Add/ Edit Event

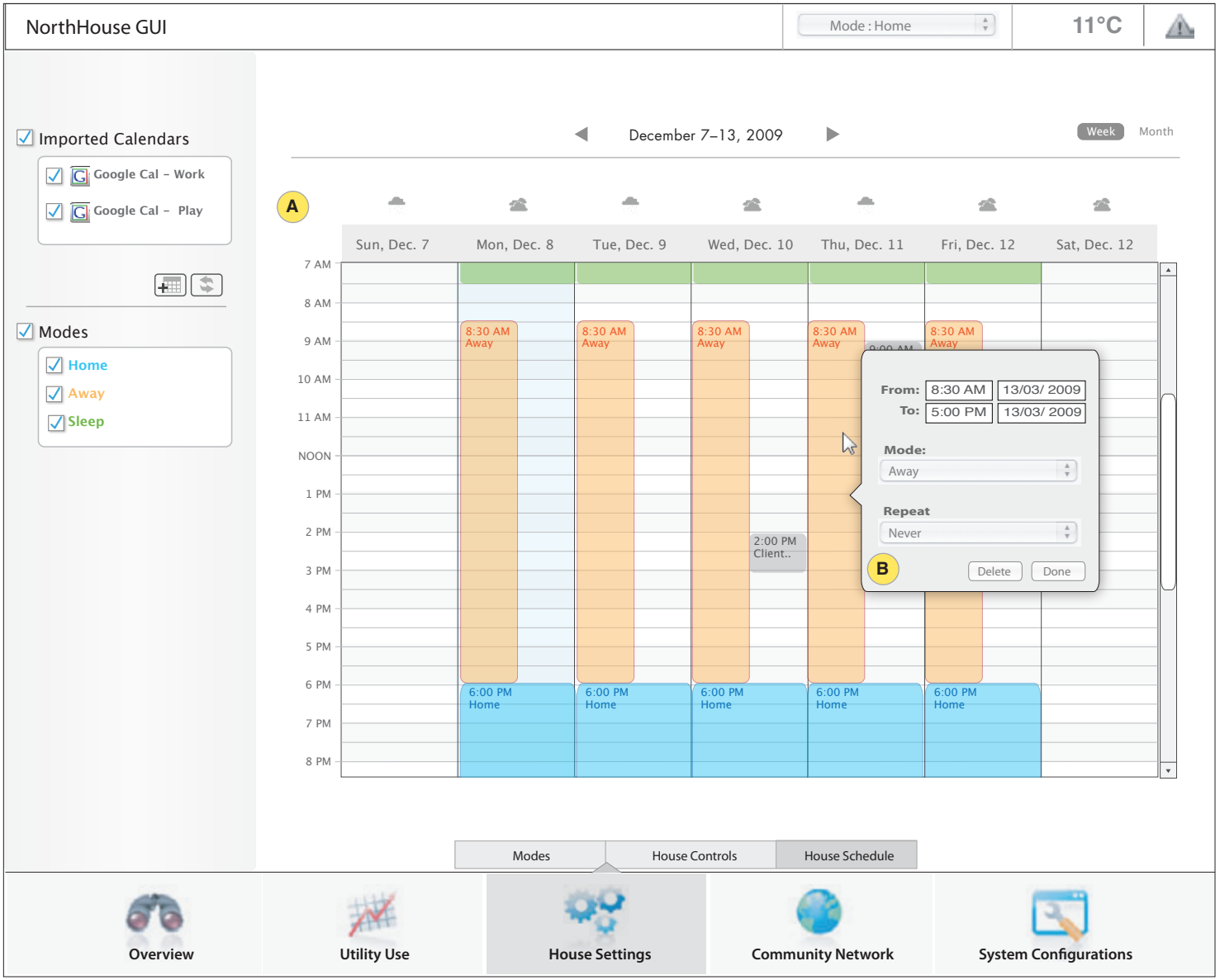


Page Details

A: The user can see the imported calandars (from either Google, I-cal, ect). Using the checkboxes, the user can make them visible/ non-visible in the large calendar display (F). These calendars are read-only, meaning that the user cannot add new events to these calendars.
B: The user can import calendars from google or i-cal. When hovering over the button, an info pop-up appears. The button on the right is refreshes/updates the imported calendars (these functions will not be fully functional in the prototype).
C: The user can see the imported calandars (from either Google, I-cal, ect). Using the checkboxes, the user can make them visible/ non-visible in the large calendar display (F). These calendars are read-only, meaning that the user cannot add new events to these calendars.
D: This displays the current month. The user can click on the left & right arrows to move the month back and forth.
E: The user can change the view to a week view.
F: The calendar displays events in the colour associated with the mode or imported calendar. The user can click on a cell in order to create a new event, or click on an existing event to view or edit it.
G: A pop-up appears after clicking on a cell, which allows the user to add a new event. The user can set the starting, ending time, the desired mode, and can choose to repeat the event (on a daily, weekly on that day, montly on that day) interval. This can only be done for modes-events.

Page ID: 2.2.2

Page Title: Schedule Schedule (by Week - interaction)



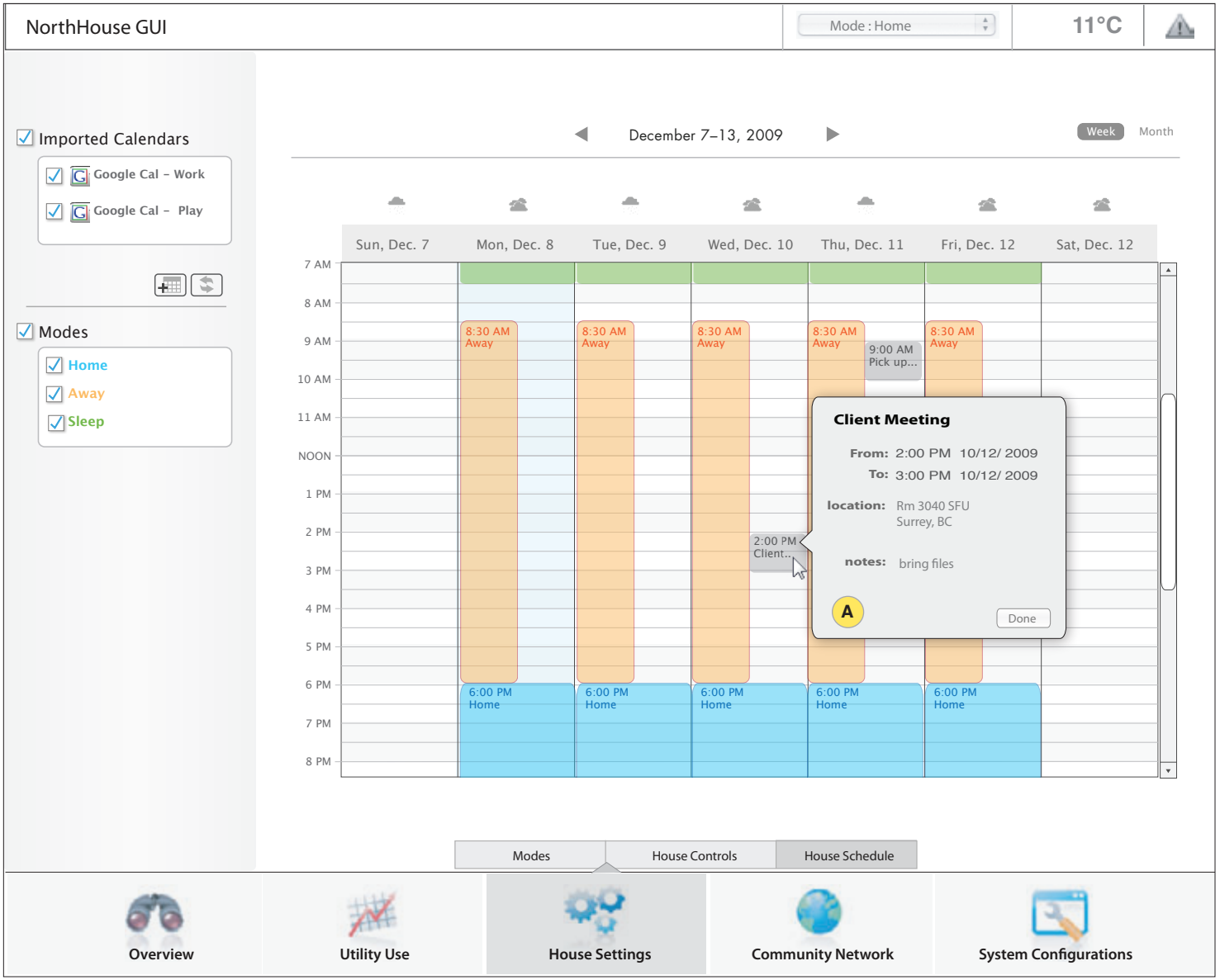
Page Details

A: This is the week view of the calendar, it functions in the same way as the month calendar with regards to the adding/editing of events. For the current week, the user can see the weekly forecast (future and past weeks will not be display the weather icons).

B: From clicking on an exisitng mode-event the user can view and edit it, which is the same display as the add-event pop-up.

Page ID: 2.2.3

Page Title: Imported Event View

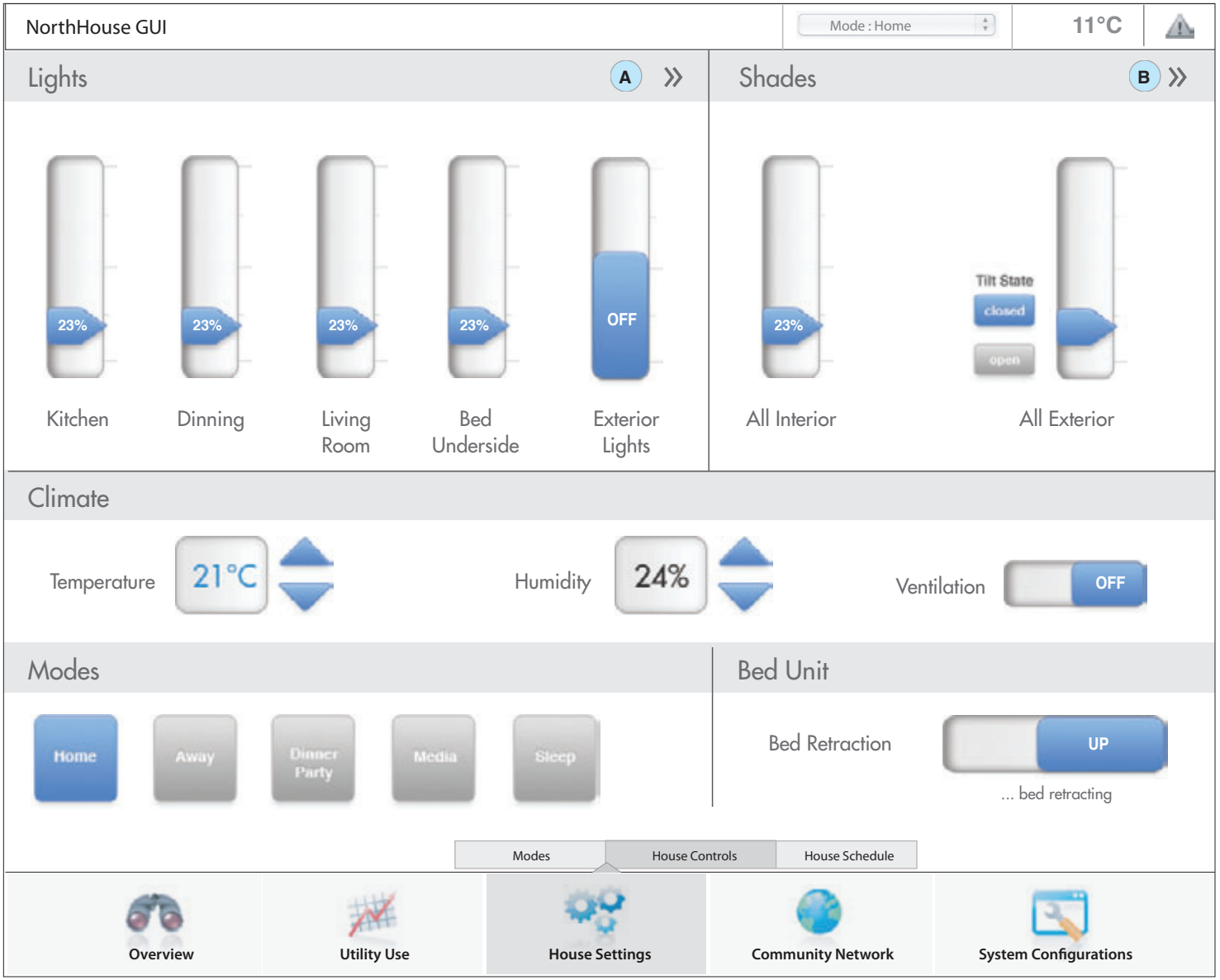


Page Details

A: After clicking on an imported-calendar based event, the user can only view the information, but cannot edit or delete it.

Page ID: 2.3

Page Title: House Controls



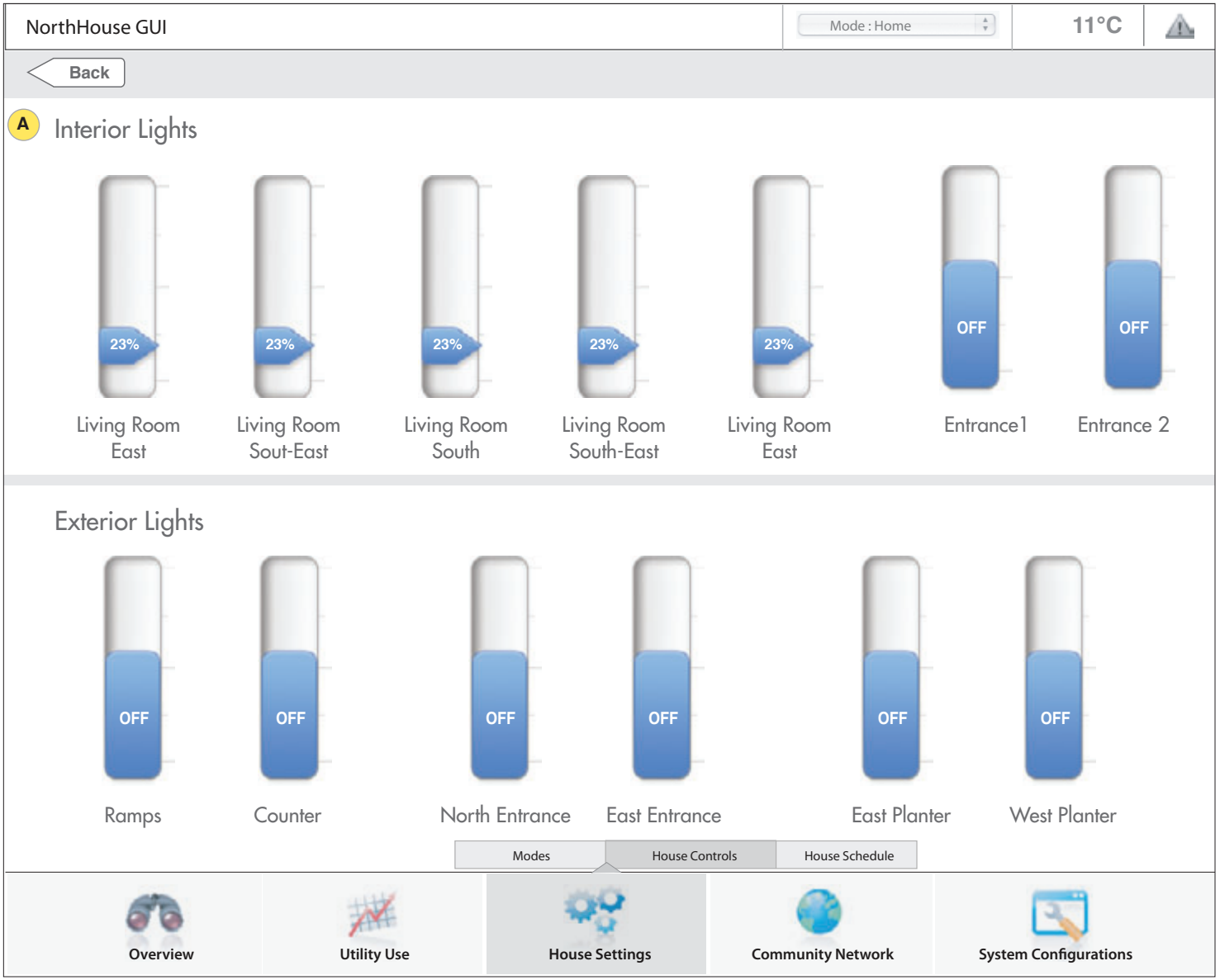
Page Details

A: The arrow link brings the user to all the lighting controls

B: The arrow link brings the user to all the shade controls

Page ID: 2.3.1

Page Title: Light Controls

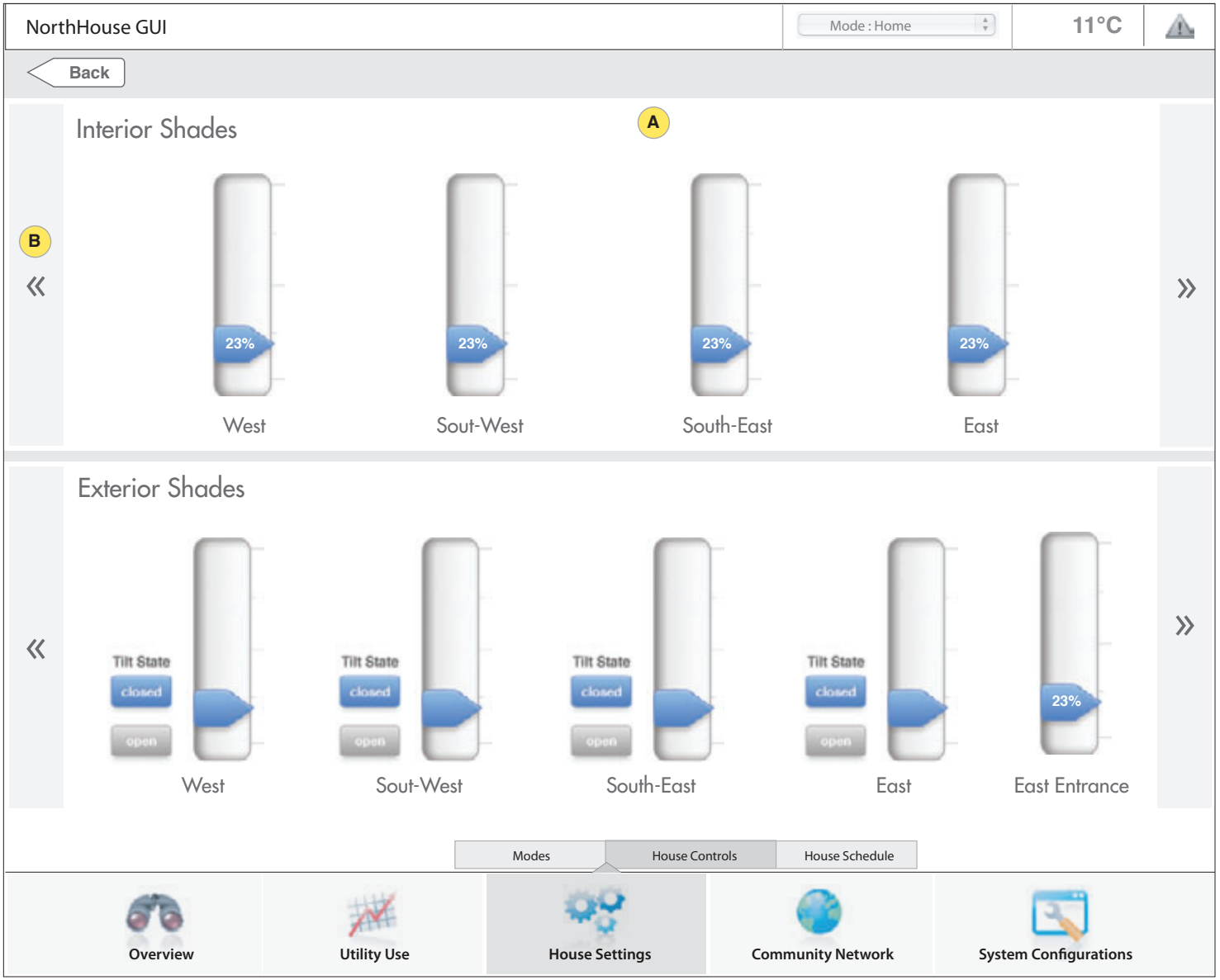


Page Details

A: The user can raise and lower lights using the slider bars and toggle switches.

Page ID: 2.3.2

Page Title: Shade Controls



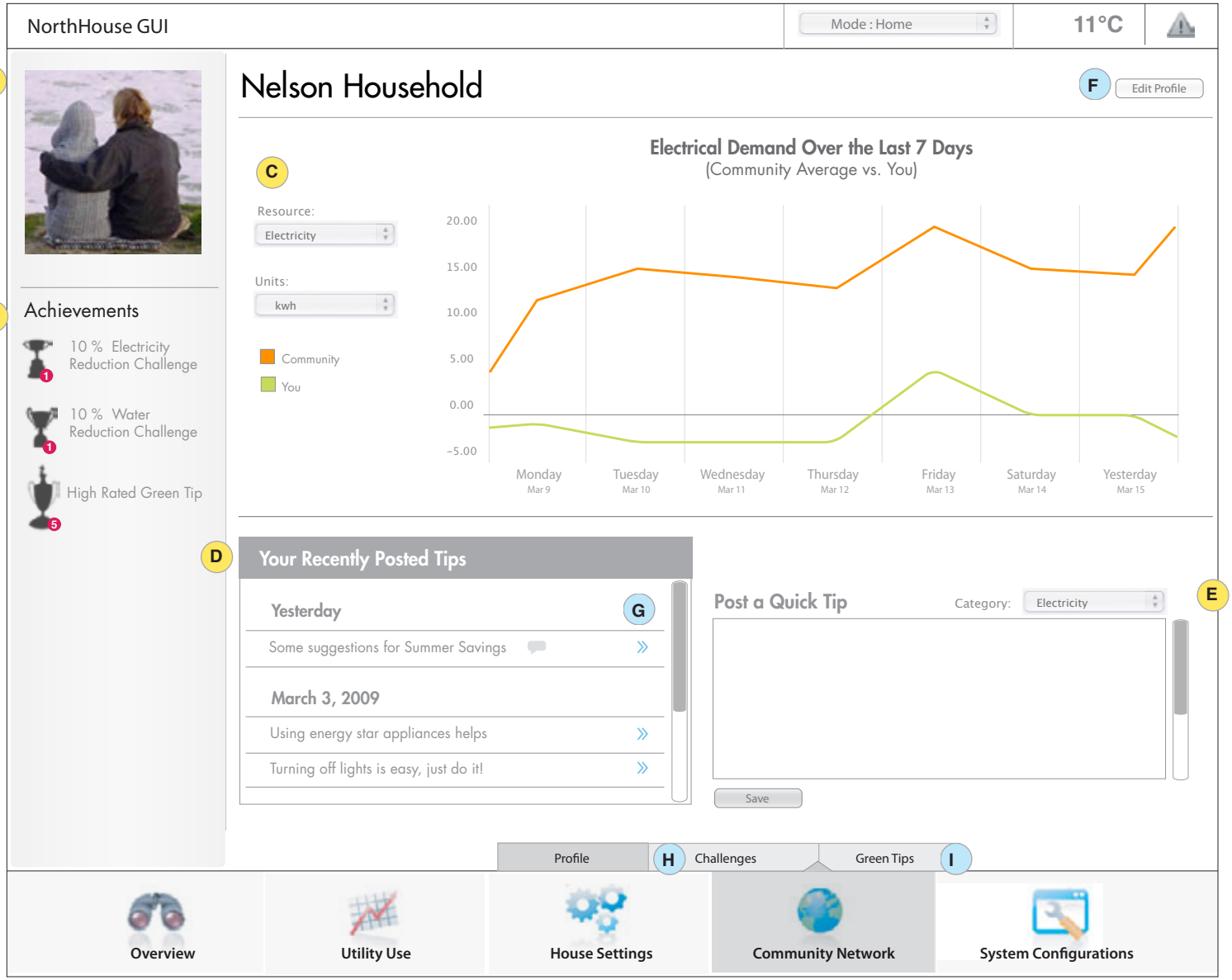
Page Details

A: The user can raise and lower shades using the slider bars and toggle switches.

B: The user see more shade controls by clicking on these buttons.

Page ID: 3.1

Page Title: Profile



Page Details

A: This is an uploaded image that the user can add. It will serve as your "community face"

B: This is a list of achievements that the user has earned through competing in challenges and through contributing to the community through adding green tips

C: This is a graph that provides the user with a quick overview of their resource use compared to the community average. The user can choose to view either water or electrical consumption. They can also switch between different kinds of units.

D: This is a list of recently contributed tips that are displayed in reverse-chronological order. Each listed item displays the title of the tip and if a comment is posted, a grey "talk bubble" will be present

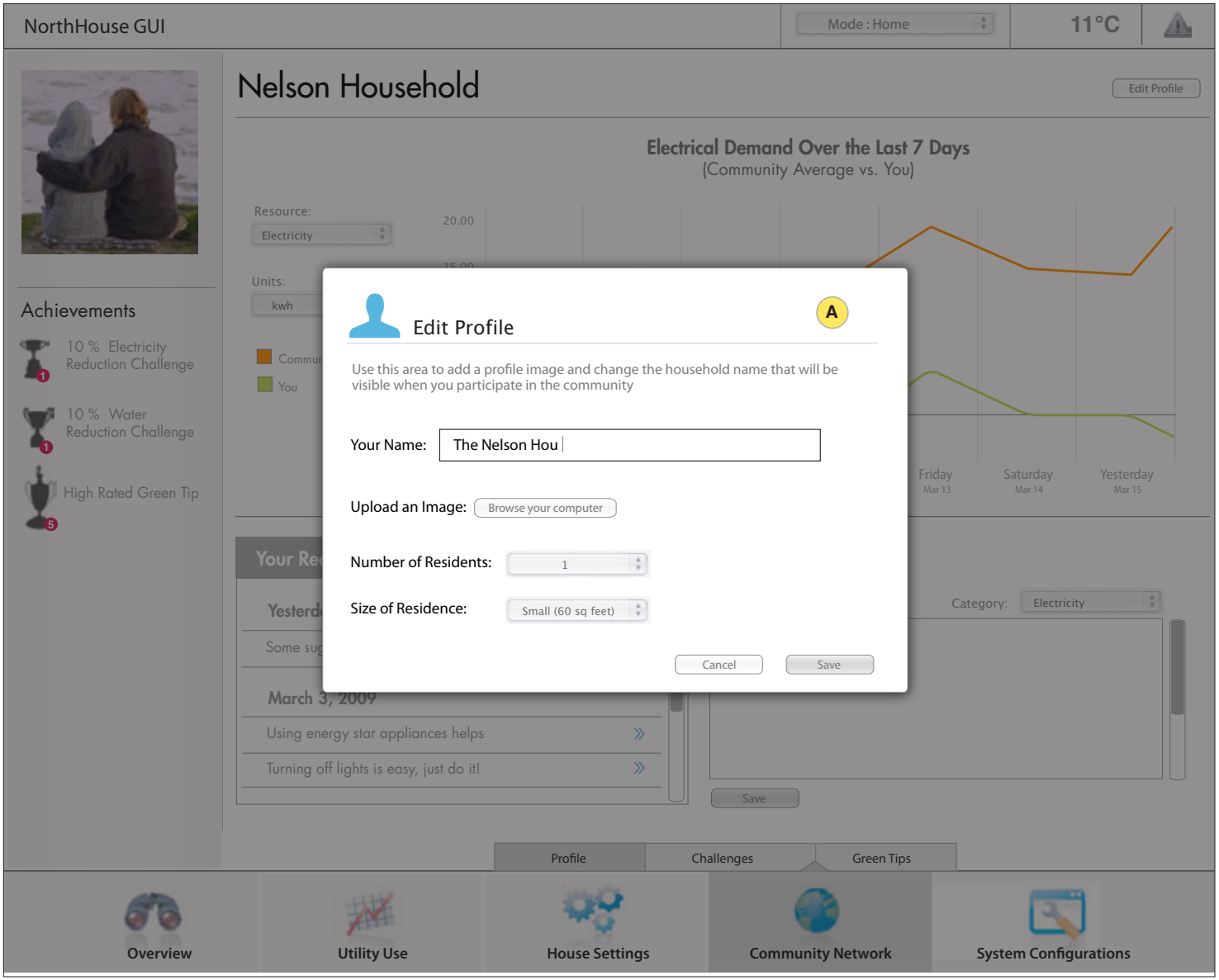
E: The user can use this area to post a tip to the community. The pull-down menu allows the user to catagorize the tip.

F: This allows the user to edit their profile go to : ID 3.1.1

G: By clicking on the arrow, the user can view the full display post within the Green Tip section. go to : ID 3.3.3

H: go to : ID 3.2

I: go to : ID 3.3



Page ID: 3.1.1

Page Title: Edit Profile

Page Details

A: This pop-up will allow the user to input their desired name (to be used in the community), upload a profile image, along with adding some information that is pertanent to allow the user to compare their use versus others.

Page ID: 3.2

Page Title: Community Challenge (current)

Page Details

A: This displays the page header, along with the challenge name underneath it.

B: This area communicates the previous interaction within the challenge section, and the level of success in their endeavors.

C: These are the achievements that are specific to the challenges.

D: These are the different rankings of each community member who is participating in this challenge. It displays the rank number, the name of the participant, and their progress. If there are a lot of users, a scrollbar will appear allowing the user to scroll up and down

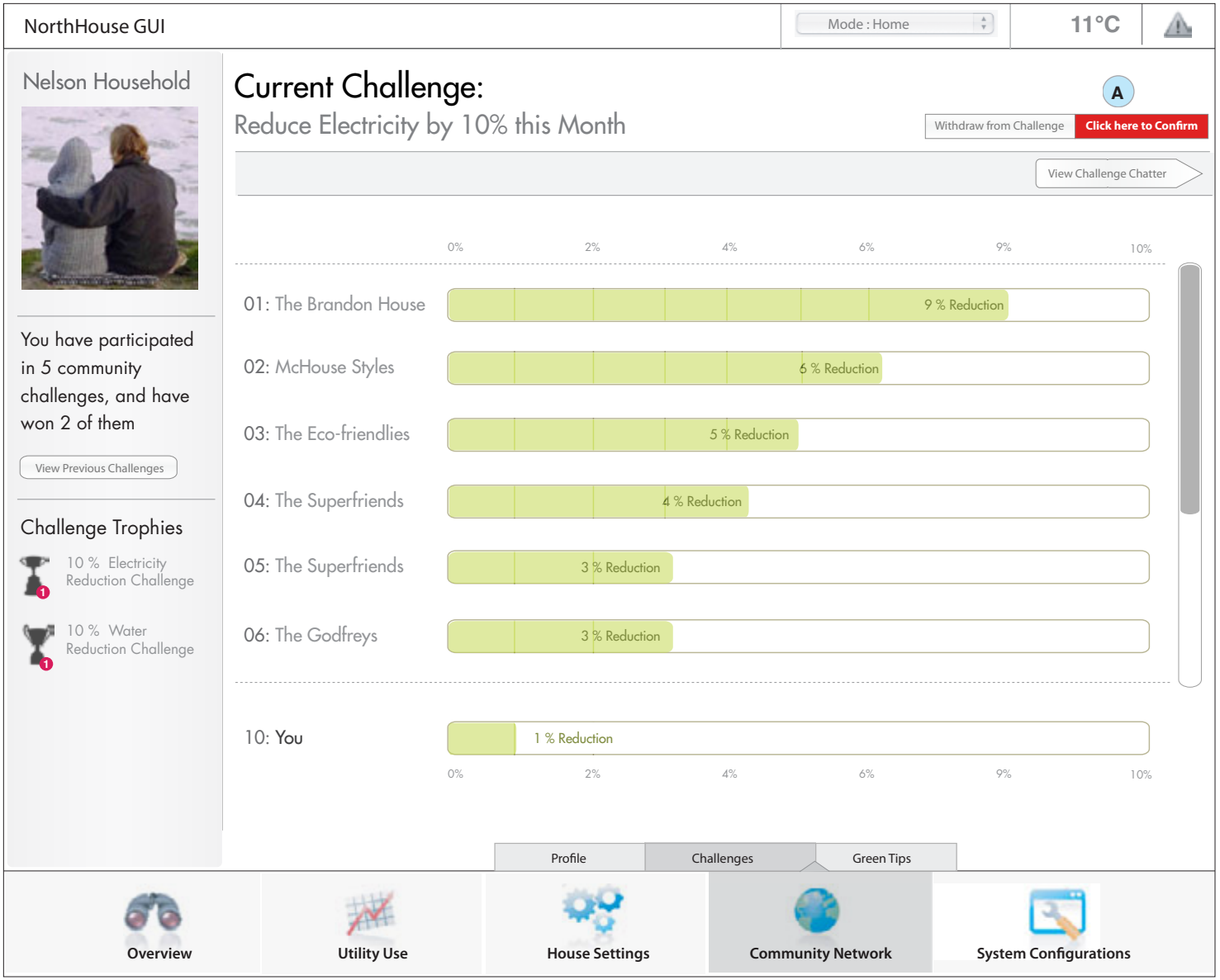
E: This is the user's progress to date. It will always appear there, regardless of how high or low they are are ranked.

F: This button allows the user to withdraw from the competition. Go to: ID 3.2.3

G: The user can press here to view any conversations that are occuring within the challenge go to: ID 3.2.4

Page ID: 3.2.3

Page Title: Withdraw Confirmation

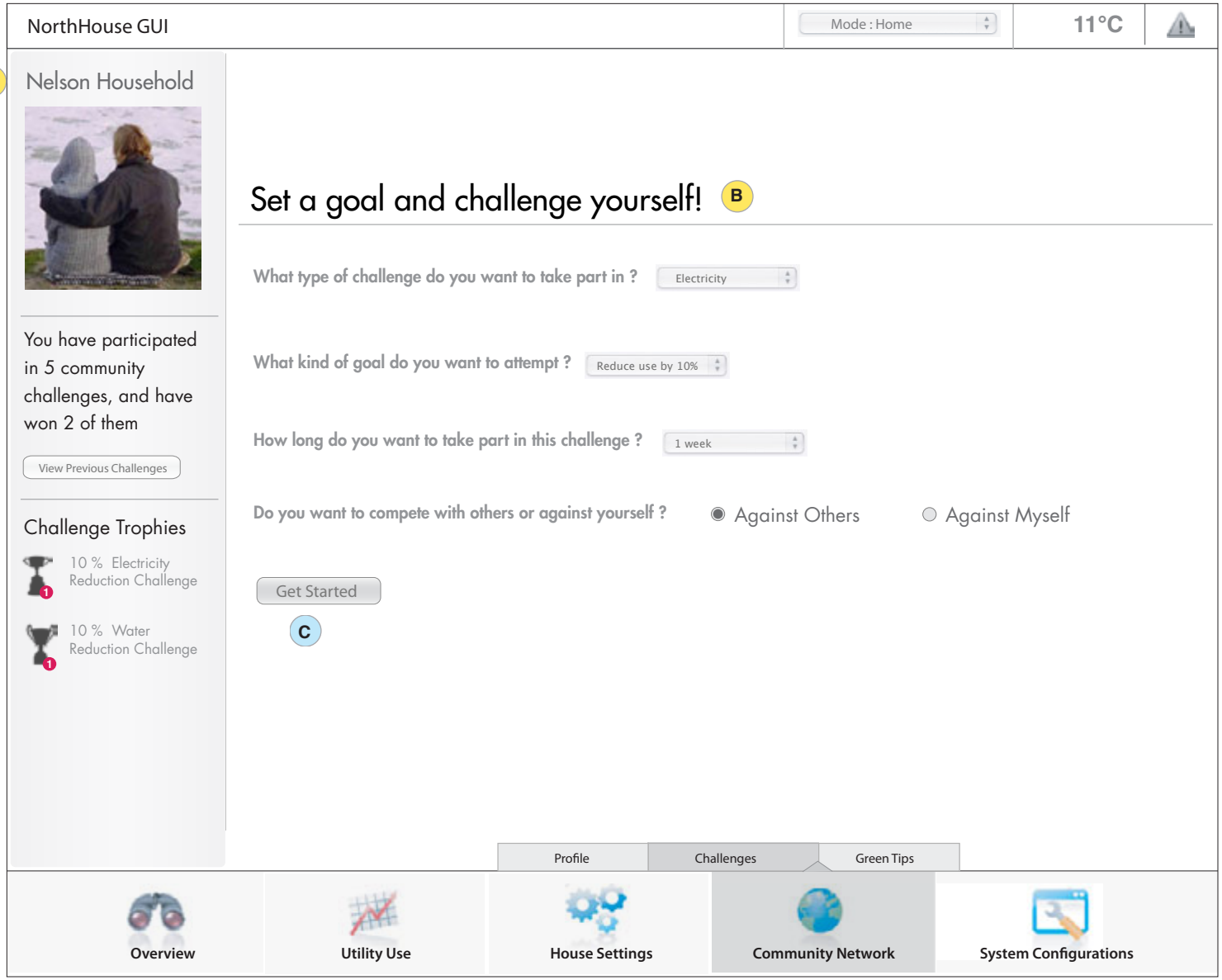


Page Details

A: After initially pressing the button, the button slides to the left to reveal the red "confirmation" button. Once the user presses this button the user will be withdrawn from the challenge. if so, go to : ID 3.2.1

Page ID: 3.2.1

Page Title: Challenge Config.



Page Details

If the user is not currently in a challenge, this page will appear.

A: The user's profile pic and name appears here.

B: These are the different options the user has to choose from when decididng on what challenge to join.

C: go to: 3.2

Page ID: 3.2.4

Page Title: Challenge Chatter

NorthHouse GUI | Mode : Home | 11°C

Nelson Household

You have participated in 5 community challenges, and have won 2 of them

View Previous Challenges

Challenge Trophies

10 % Electricity Reduction Challenge

10 % Water Reduction Challenge

Current Challenge:

Reduce Electricity by 10% this Month

Withdraw from Challenge

Back to Rankings (A)

(B) Add to the Chatter

Post

0/300 Characters

The Eco-friendlies said: Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sed ultricies justo id dui. Fusce vulputate, erat vel tristique ullamcorper, nisi leo pharetra justo, id sagittis purus justo sed purus nullam.

– 5 minutes ago

You said: Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sed ultricies justo id dui. Fusce vulputate, erat vel tristique ullamcorper, nisi leo pharetra justo, id sagittis purus justo sed purus nullam. (X) (C)

– 2 hours ago

The Fullers said: Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sed ultricies justo id dui. Fusce vulputate, erat vel tristique ullamcorper, nisi leo pharetra justo, id sagittis purus justo sed purus nullam.

– 3 hours ago

The Hamptons said: Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sed ultricies justo id dui. Fusce vulputate, erat vel tristique ullamcorper, nisi leo pharetra justo, id sagittis purus justo sed purus nullam.

– 4 hours ago

The Eco-friendlies said: Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sed ultricies justo id dui. Fusce vulputate, erat vel tristique ullamcorper, nisi leo pharetra justo, id sagittis purus justo sed purus nullam.

– A day ago

Profile | Challenges | Green Tips

Overview | Utility Use | House Settings | Community Network | System Configurations

Page Details

A: go to: ID 3.2

B: This text box allows the user to add comments to the chatter. There is a limited character limit, which encourages quick comments – meant to encourage other competitors. The user's comments are highlighted in yellow.

C: If the comment was posted by the user, there will be a delete button, that allows the user to re-tract their post.

Page ID: 3.2.2

Page Title: Previous Challenges

NorthHouse GUI | Mode : Home | 11°C

Nelson Household

You have participated in 5 community challenges, and have won 2 of them

View Previous Challenges

Challenge Trophies

10 % Electricity Reduction Challenge

10 % Water Reduction Challenge

Back to Current Challenge (A)

Previous Challenges (B)

February 2008: 5% Reduction in overall electricity demand
Outcome: Success (C)

January 2008: 1% Reduction in overall electricity demand
Outcome: Success

February 2008: 5% Reduction in overall electricity demand
Outcome: Incomplete

January 2008: 1% Reduction in overall electricity demand
Outcome: Incomplete

February 2008: 5% Reduction in overall electricity demand
Outcome: Incomplete

Profile | Challenges | Green Tips

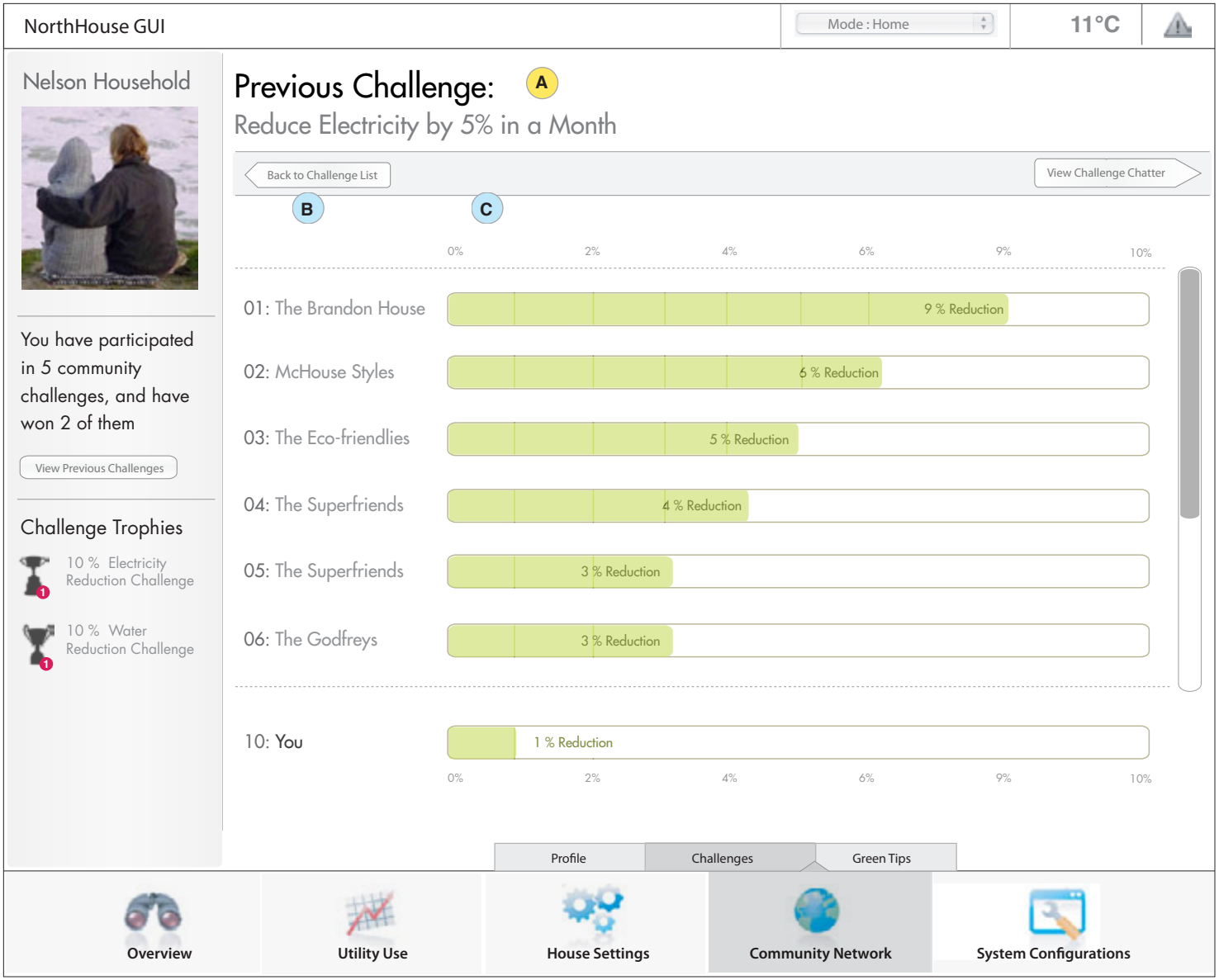
Overview | Utility Use | House Settings | Community Network | System Configurations

Page Details

A: go to: ID 3.2

B: The header changes to reflect the new section. Here the user can see all previous challenges, and their level of success.

C: Clicking on the arrow allows the user to view the previous challenge rankings. Go to: ID 3.2.2.1



Page ID: 3.2.2.1

Page Title: Previous Challenge Rankings

Page Details

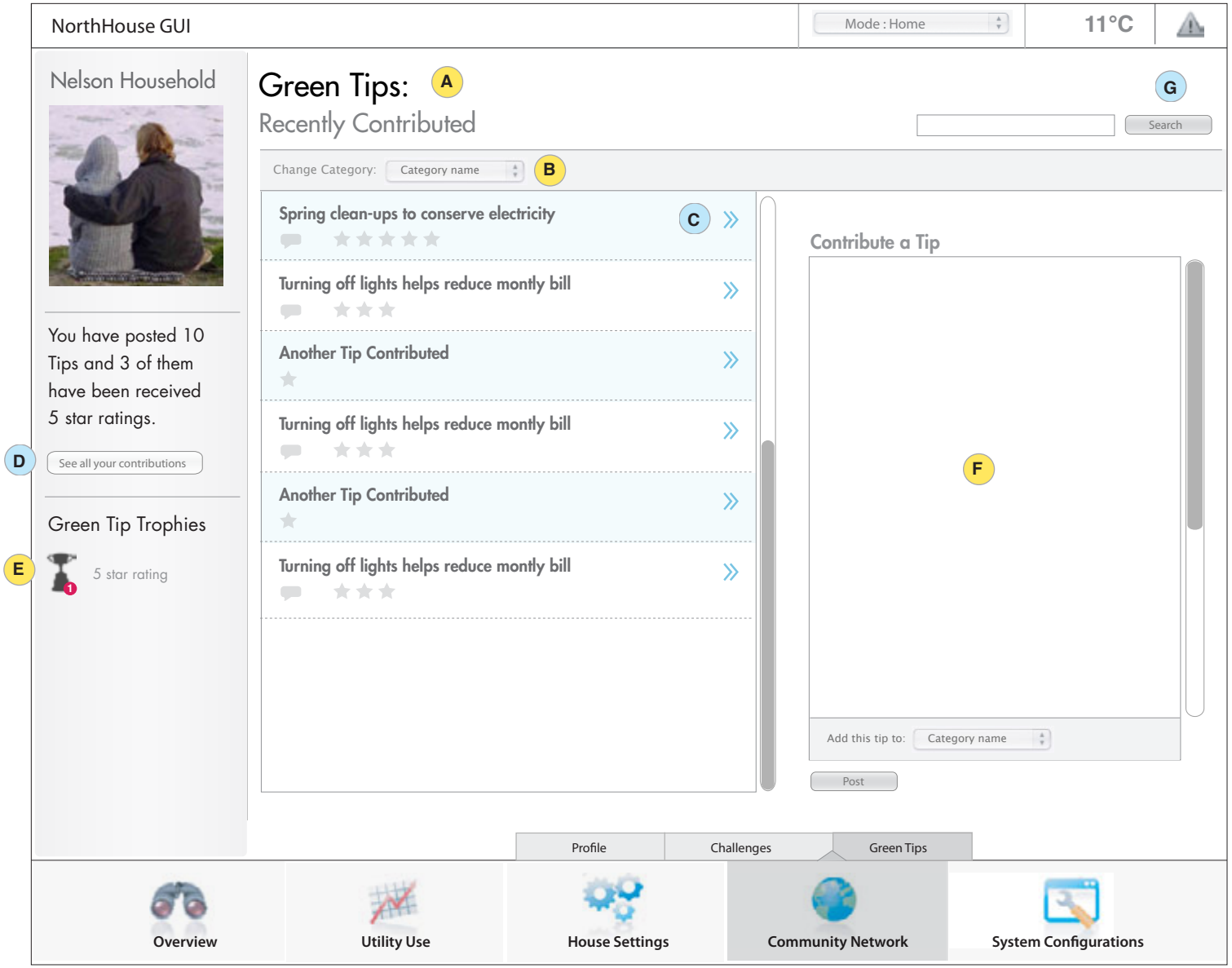
A: Notice the header change to reflect the current section, and the abscence of the withdraw button.

B: This allows the user to go back to the “previous challenge list” go to: 3.2.2

C: The user can also view the chatter for this challenge. Go to: 3.2.4

Page ID: 3.3

Page Title: Green Tips



Page Details

A: The header displays the section title, along with the subheading (the current category name).

B: THis pull-down menu allows the user to change the category.

C: This link allows the user to view the full post. Go to : ID 3.3.3

D: This allows the user to see all of the user's contributed tips.

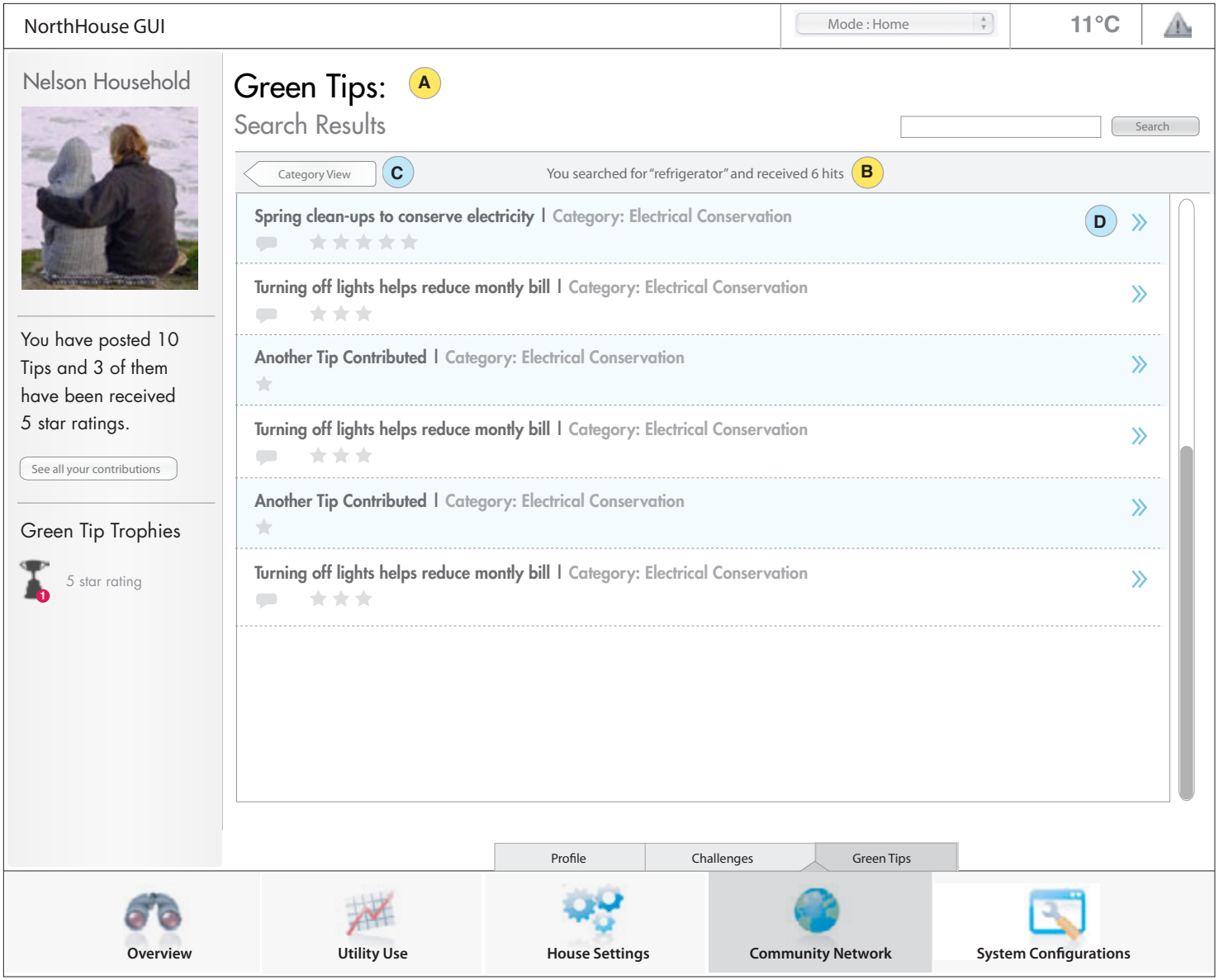
E: This displays all the achievement that are related to the "tips" section.

F: This area allows the user to post a tip to the board. It involves a pull down menu to categorize the post, and a submit button. After submitting the post, it will appear in the list on the left.

G: The user can use this field to search for specific tips. go to: ID 3.3.4

Page ID: 3.3.4

Page Title: Search Results



Page Details

A: The header changes to reflect the new section.

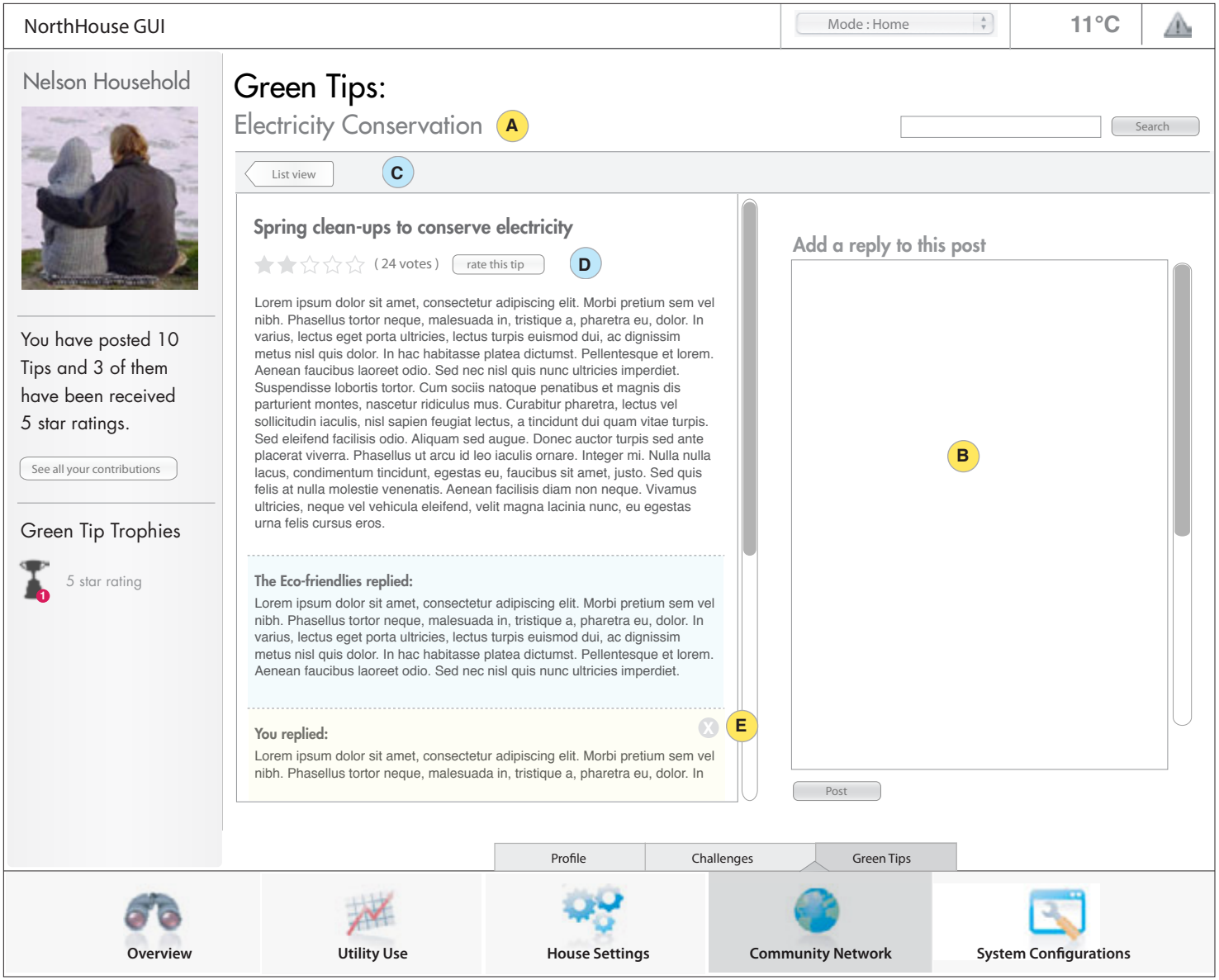
B: The search word and number of hits are displayed here.

C: This button brings the user back to the previous page that they were on (go to: ID 3.3)

D: This arrow brings the user to the full tip display page. Go to ID 3.3.3

Page ID: 3.3.3

Page Title: Full display tip



Page Details

A: The section changes based on the category that the post belongs to.

B: This section now becomes a reply box, in order to allow the user to reply to the tip.

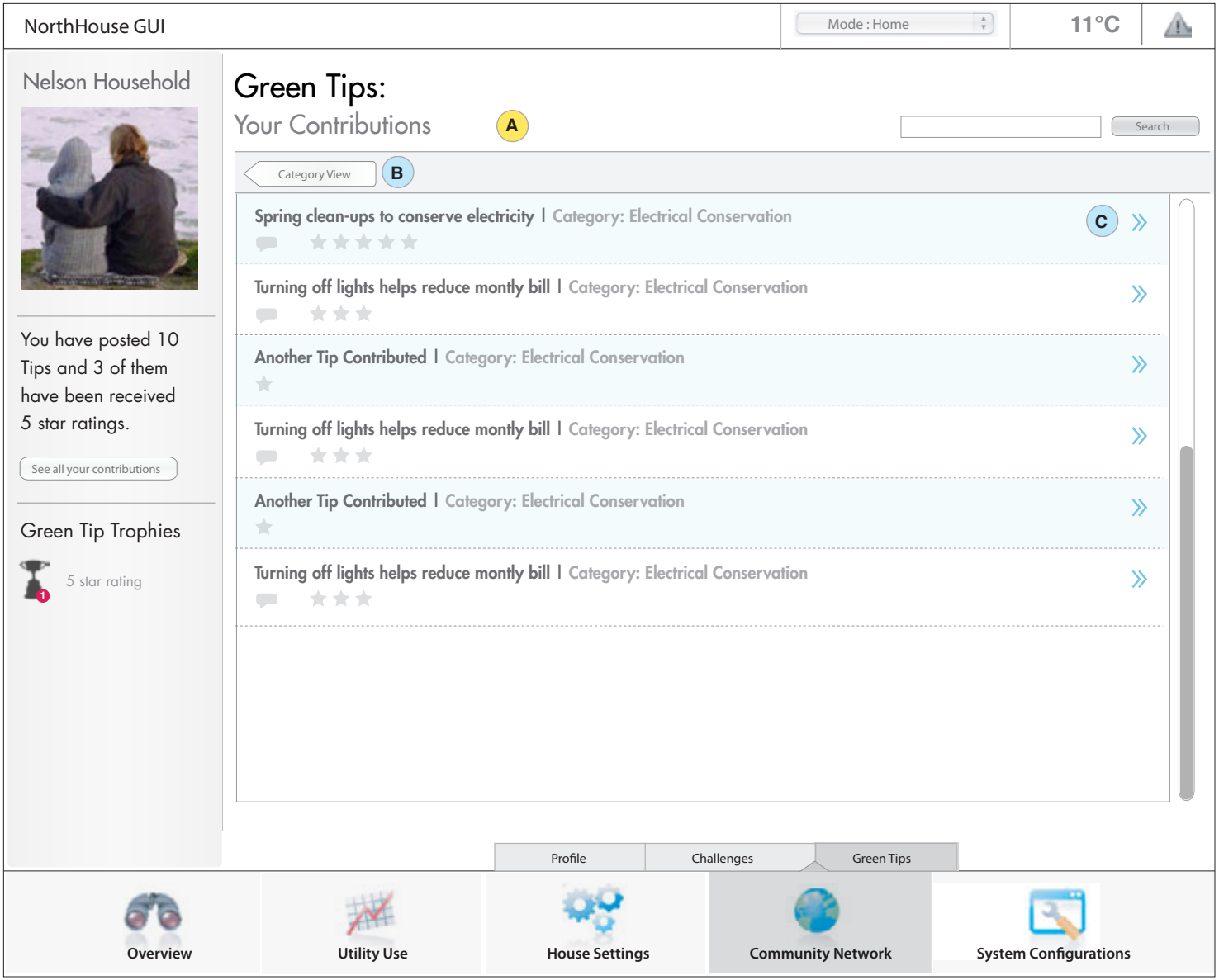
C: This link brings the user back to the previous page that they were on. Go to ID: 3.3

D: This allows the user to rate the tip.

E: This will allow the user to delete his/her post.

Page ID: 3.3.2

Page Title: My Tips

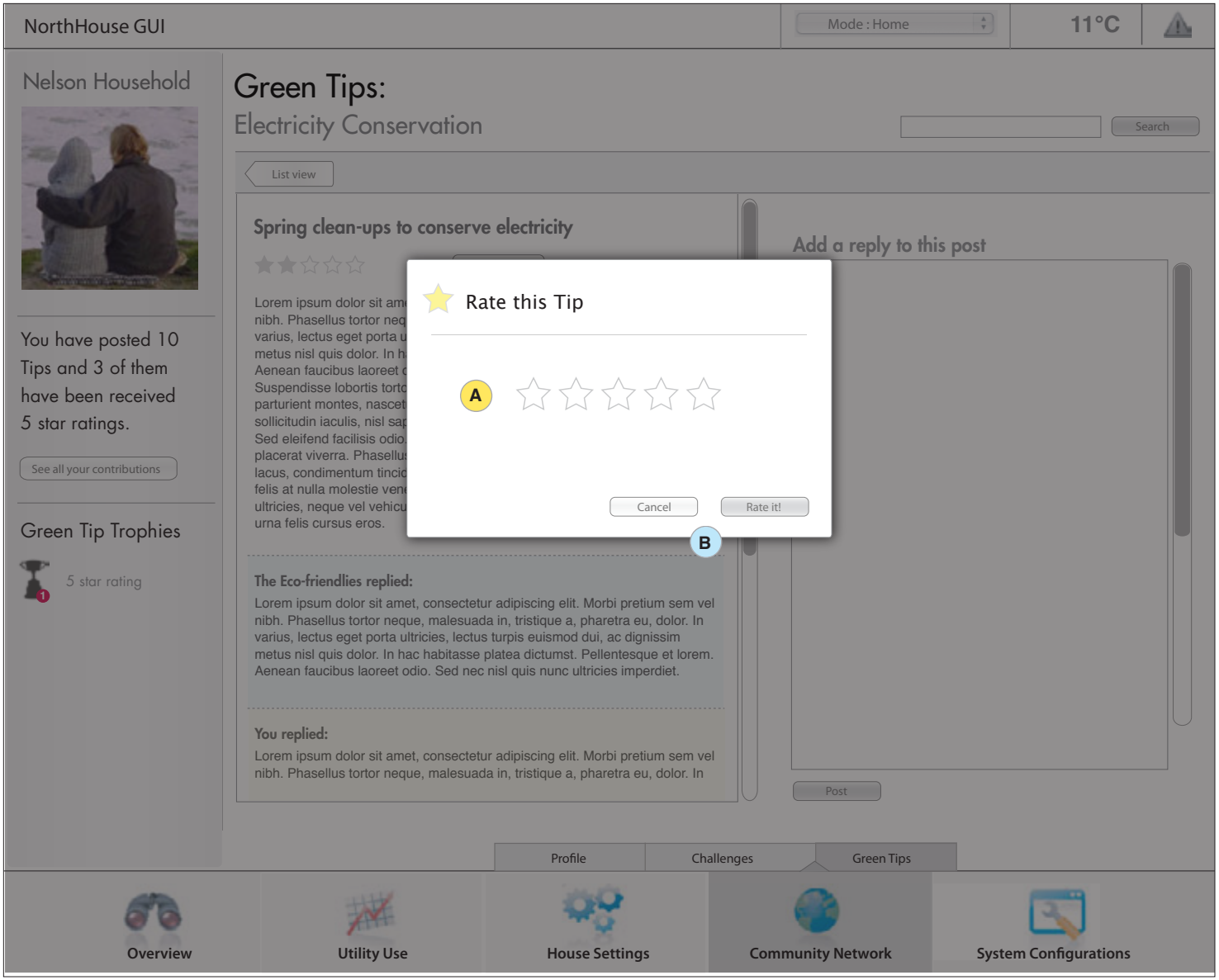


Page Details

A: The header name changes to reflect the new section

B: The user can use this button to go back to the previous page they were on (ID 3.3)

C: The user can use this link to go to the full post. Go to ID 3.3.3



Page ID: 3.3.2

Page Title: My Tips

Page Details

A: By pressing on the stars, they get filled in with a colour.

B: After rating the tip, the user will return to the page that they were previously on. go to ID: 3.3.3

13.3 Mobile GUI | Information Architecture & Interface

Desktop Graphical User Interface | Information Architecture & Interface Draft

Version 1.1 | Date: May 1, 2009

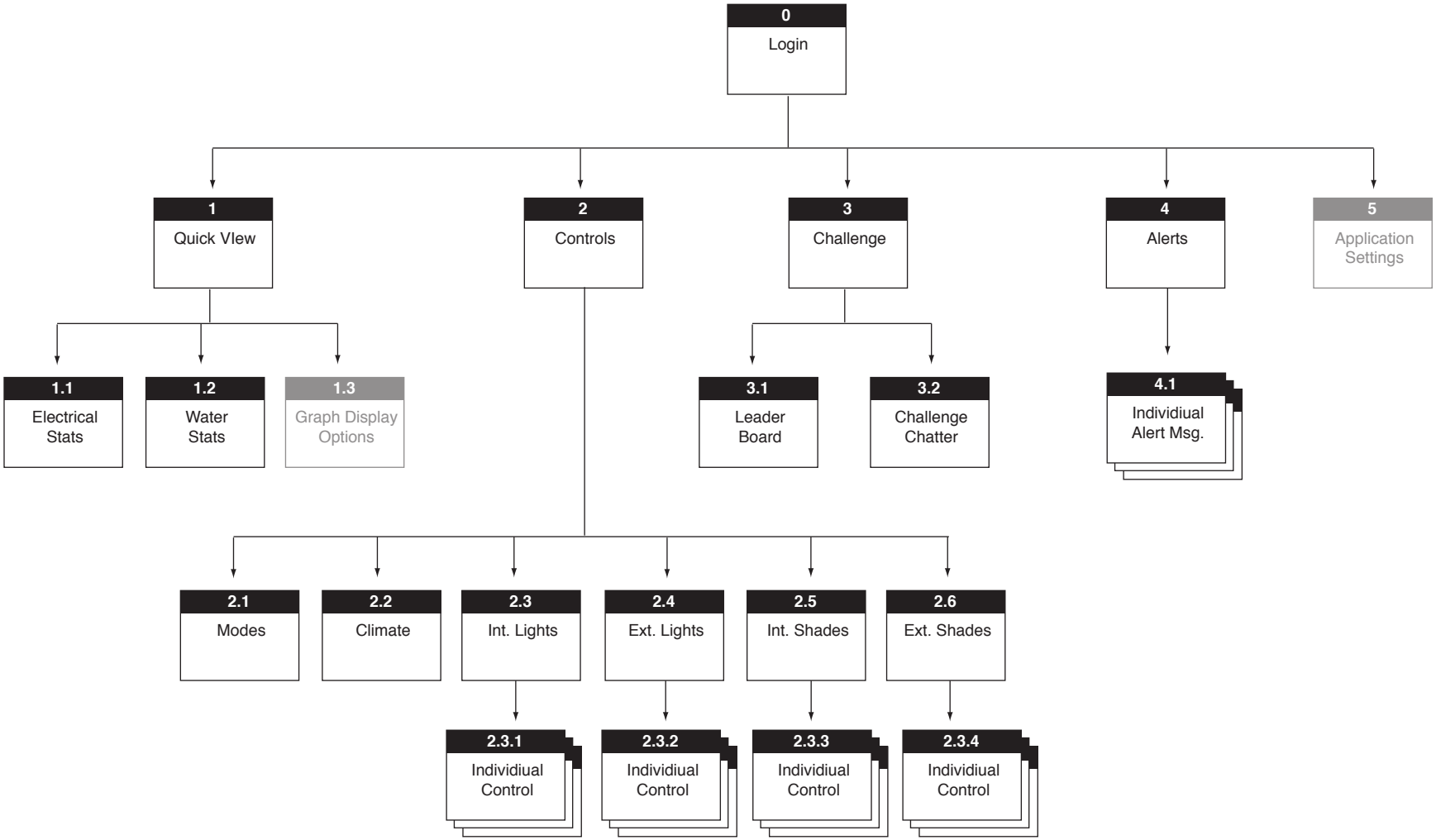
Revision History:

V.1 Developed the system with four main sections (quick-view, controls, challenges, and alerts). These sections were drawn from the larger, desktop, GUI system based and interactions were simplified according to i-phone interaction guidelines / conventions. The “application settings” section is yet to be designed, but will consist of username / password, privacy settings, and other settings that deal with the overall application’s use.

V.1.1 Alterations made to the community page and small adjustments to the con trols interfaces

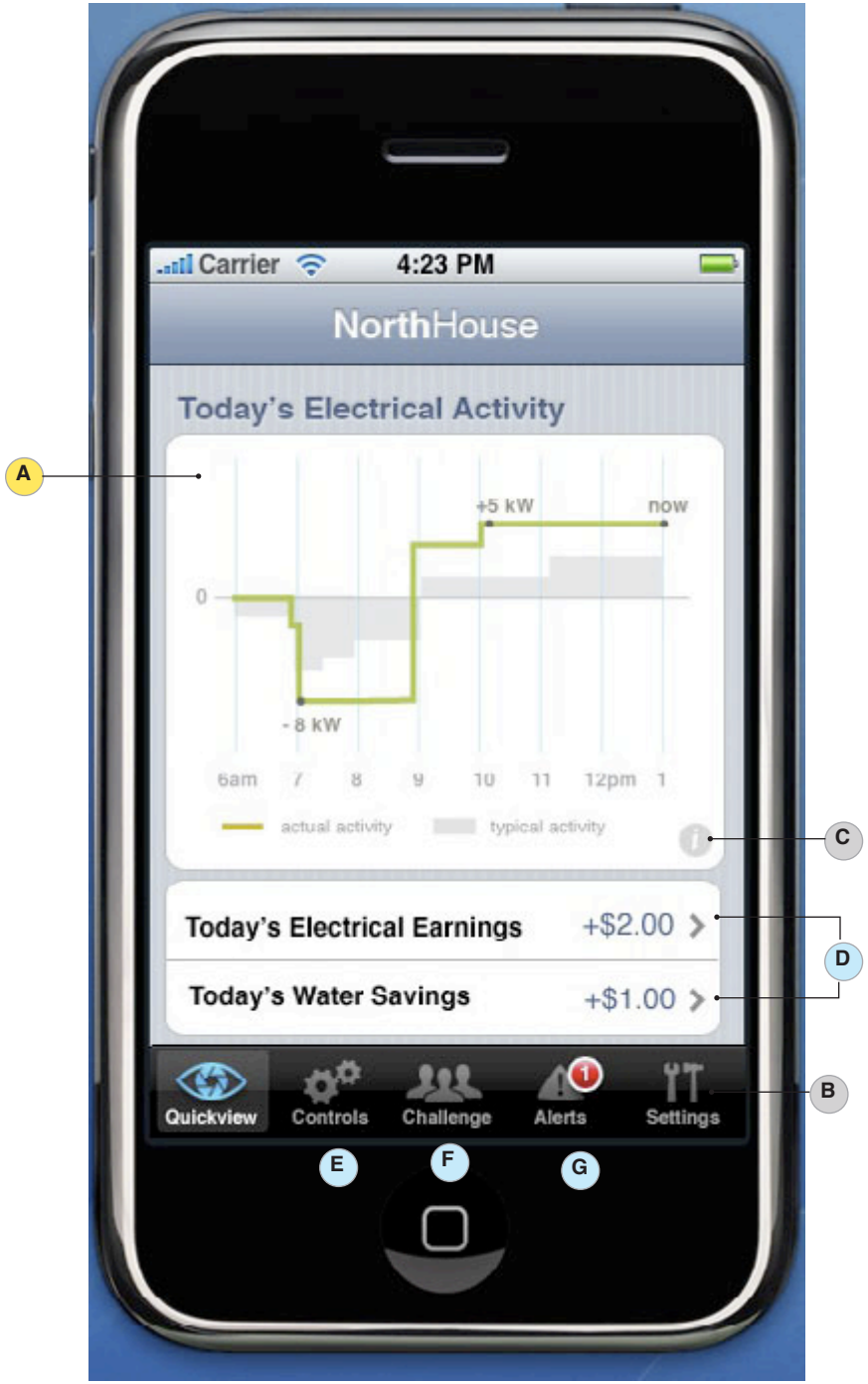
V.1.2 Moved the “application settings” icon from the top nav bar to the bottom tool bar. Added progress bar to challenge page list.

Contributors: Kevin Muise, John Rodgers,


0
Login
1
Quick VIew
2
Controls
3
Challenge
4
Alerts
5
Application Settings
1.1
Electrical Stats
1.2
Water Stats
1.3
Graph Display Options
3.1
Leader Board
3.2
Challenge Chatter
4.1
Individiual Alert Msg.
2.1
Modes
2.2
Climate
2.3
Int. Lights
2.4
Ext. Lights
2.5
Int. Shades
2.6
Ext. Shades
2.3.1
Individiual Control
2.3.2
Individiual Control
2.3.3
Individiual Control
2.3.4
Individiual Control

Legend

a page



Page ID: 1

Page Title: Quick View

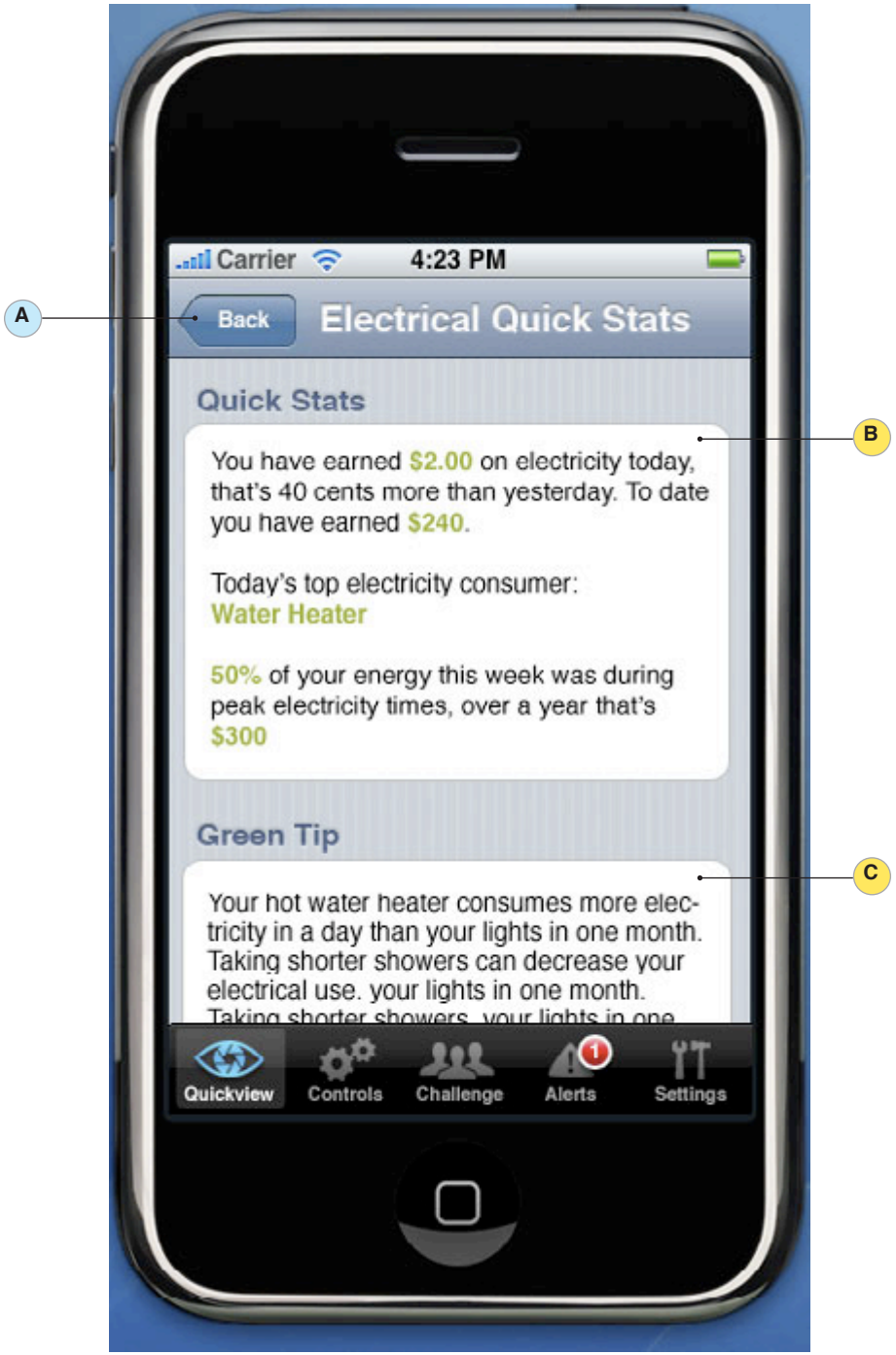
Page Details

A: The graph is a derivative of the overview net-zero graph from the desktop GUI. The graph displays the house's net-zero activity. The type of graph and type of visualizaion can be changed, but for the purposes of this prototype, this graph is used. The user would be able to change the represenations by clicking on "C" (the info button).
B: This button allows the user to view the application's preferences, such as login information, connectivity configurations, and privacy information. (not shown in this version)
C: By clicking on this button, the white box would then animate in a "flip" fashion to reveal options to change the type of graph and the representation. (other ideas would include a tree representation, a globe re-prentation, ect.) – not shown in this version.
D: This provides the resident with more information regarding their house's activity, this is also taken from the GUI overview section. The monetary figures relate to net-zero and water reuse. (the titles for this may vary - ex. Earnings, or Savings) By clicking on the arrow, the user can view more information regarding these resources.
(Go to page ID 1.1)

E: The house controls section
(Go to page ID 2)

F: The community challenge section
(Go to page ID 3)

G: The house alerts/notifications section. The red bubble only appears when a new alert exists. The number signififes the number of new alerts.
(Go to page ID 4)



Page ID: 1.1

Page Title: Electrical Stats

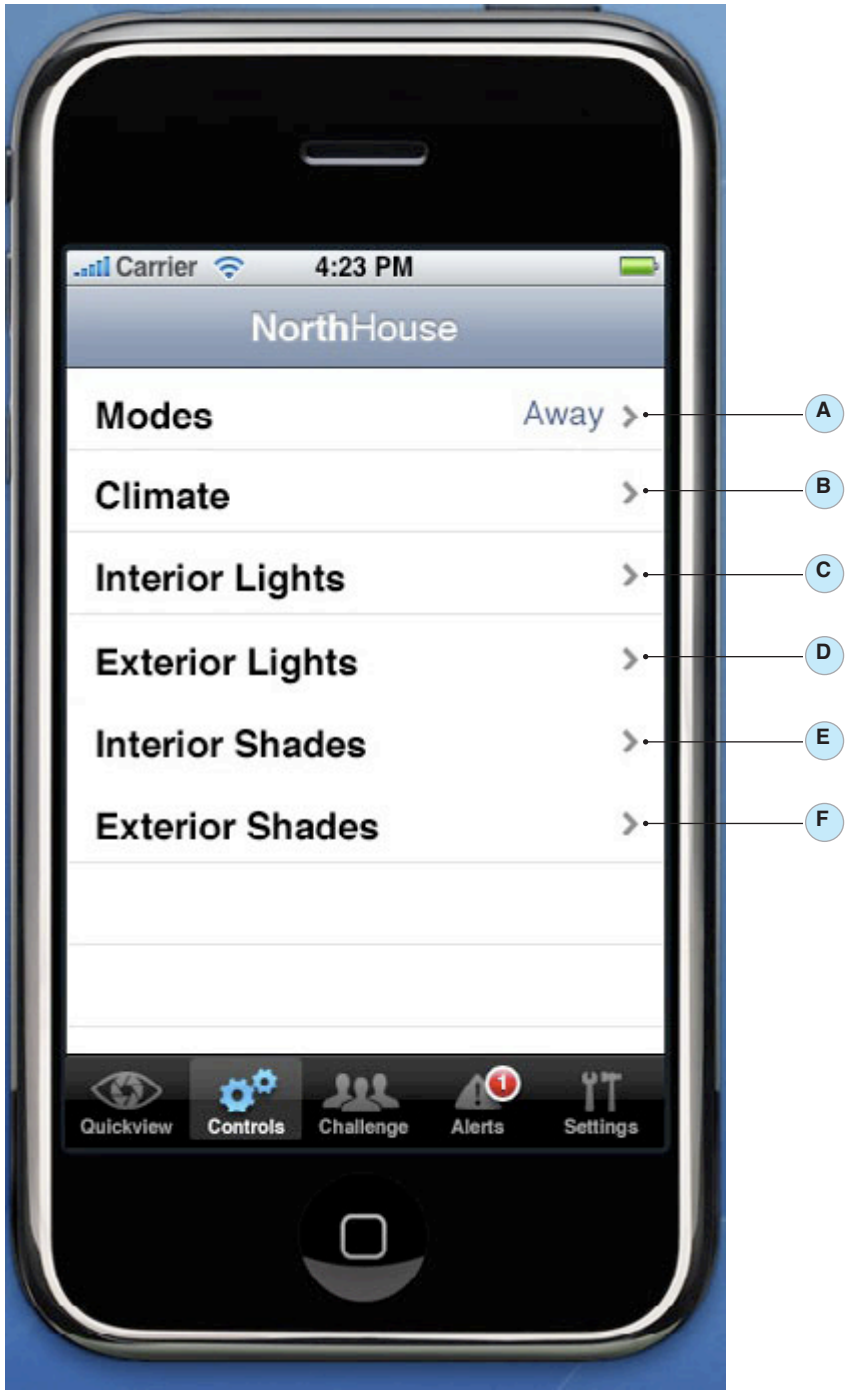
Page Details

A: Brings the user back to the quick view page (page ID 1)

B: This area provides the user with tidbits of information on their house's activity. Similar to the information on the desktop GUI, the information is communicated in a human manner, and expresses figures in a short-term period, and a long term format. Doing so allows the user to understand the impact of their choices over a period of time.

C: The Green Tip section is also from the desktop GUI, and displays a relevant tip based on the house's activity.

** the information on this screen extends beyond the page. The user can use the iphone scroll function to see information that lays outside of the page limit.



Page ID: 2

Page Title: Controls

Page Details

A: This brings the user to the modes control screen. the “Away” text in blue displays the current mode that is active.
(go to page ID 2.1)

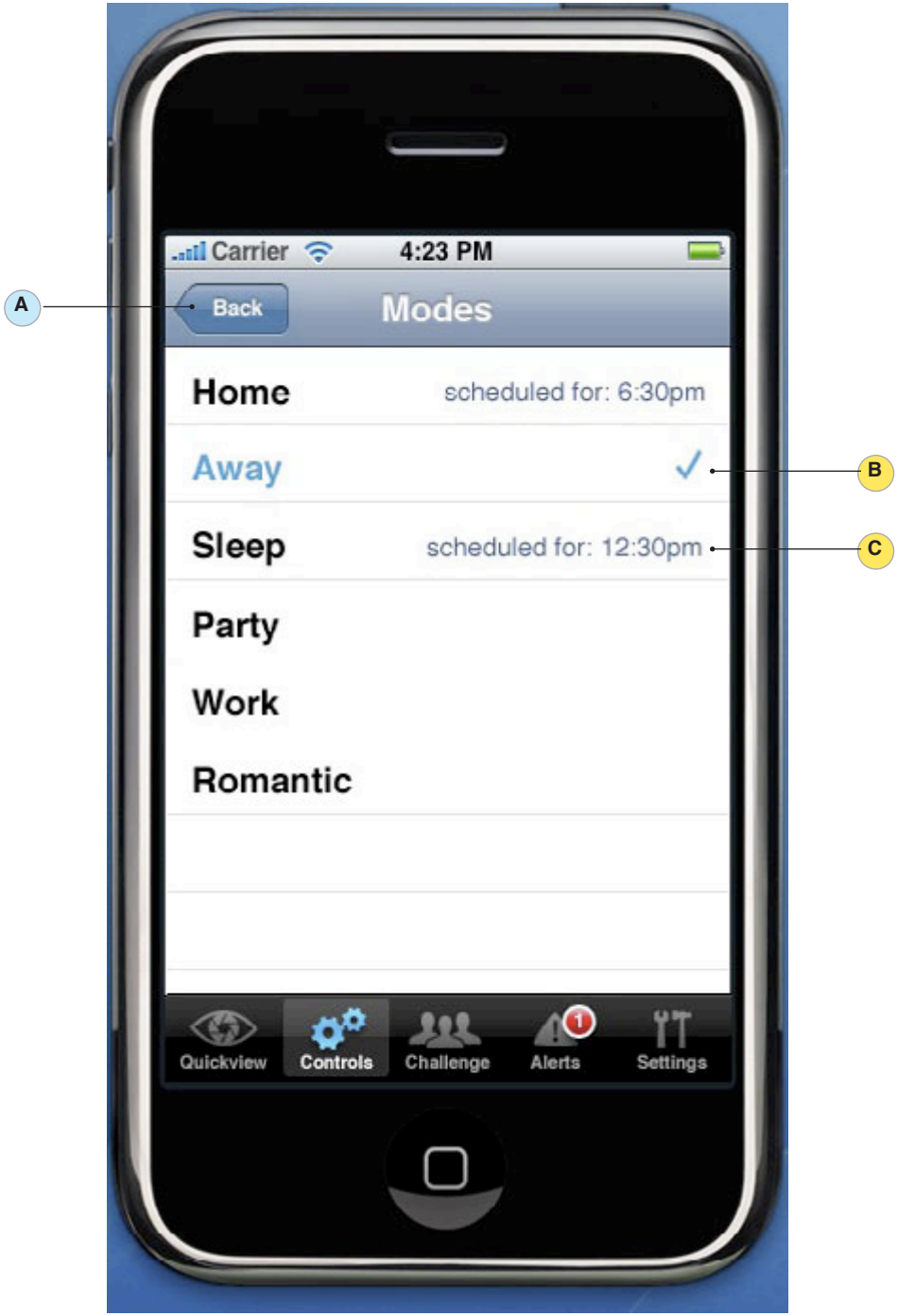
B: This brings the user to the Climate control screen (go to page ID 2.2)

C: This brings the user to the Interior light control screen
(go to page ID 2.3)

D: This brings the user to the Exterior light control screen
(go to page ID 2.4)

E: This brings the user to the Interior shades control screen
(go to page ID 2.5)

F: This brings the user to the Exterior shades control screen
(go to page ID 2.6)



Page ID: 2.1

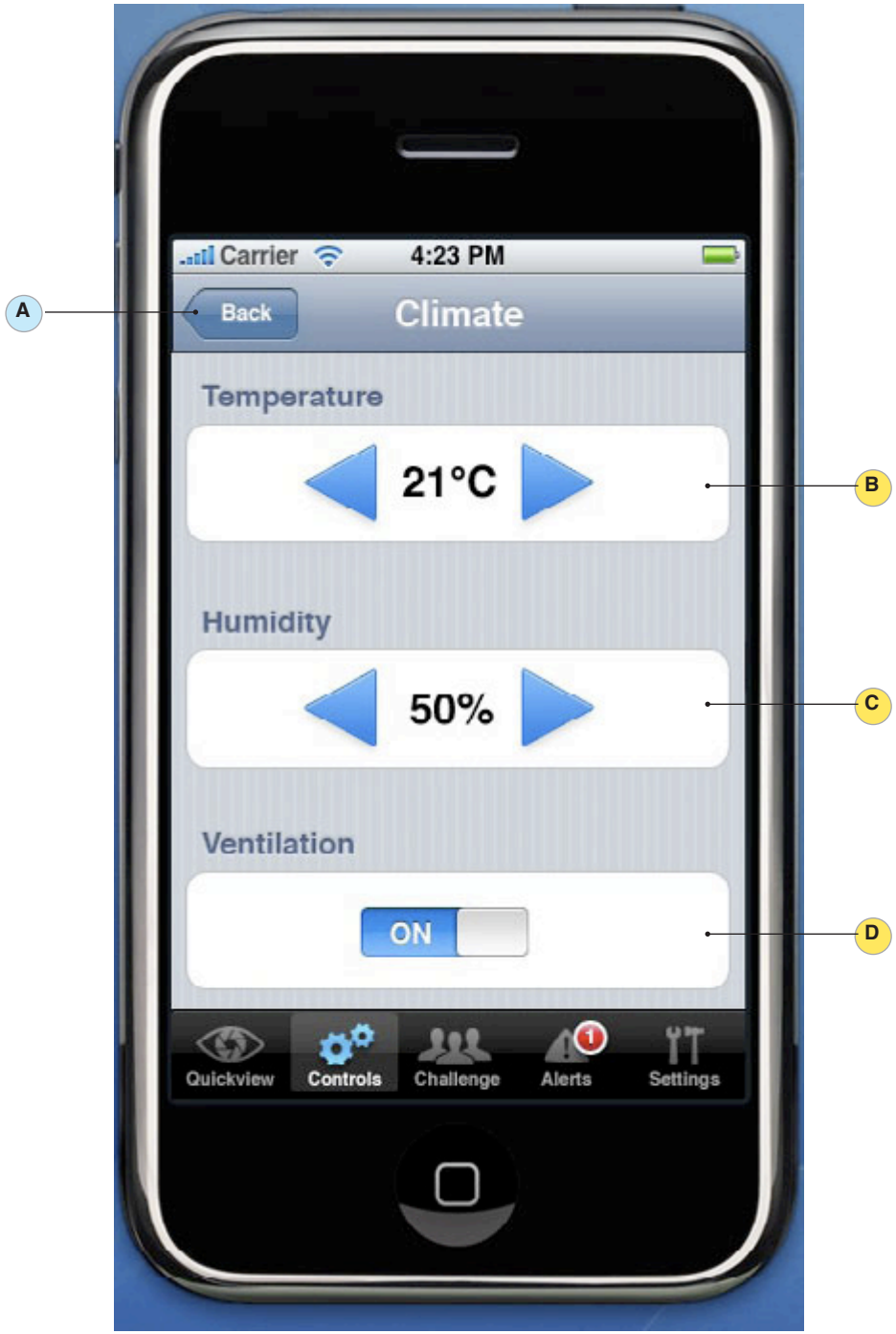
Page Title: Modes

Page Details

A: Takes the user back to the main controls page

B: The blue highlight and checkmark denotes the active mode. The user can click on the other mode text to activate the mode. Whe clicked upon the mode text flashes blue-to-black until all the setpoints for the mode are reached. Only one mode can be active at a time.

C: This provides the user with an understanding of when the mode is next scheduled to tun on. The user cannot change this time through the mobile device, however this provides some extra information that may be helpful to them. (it only appears if the mode is scheduled for that day)



Page ID: 2.2

Page Title: Climate

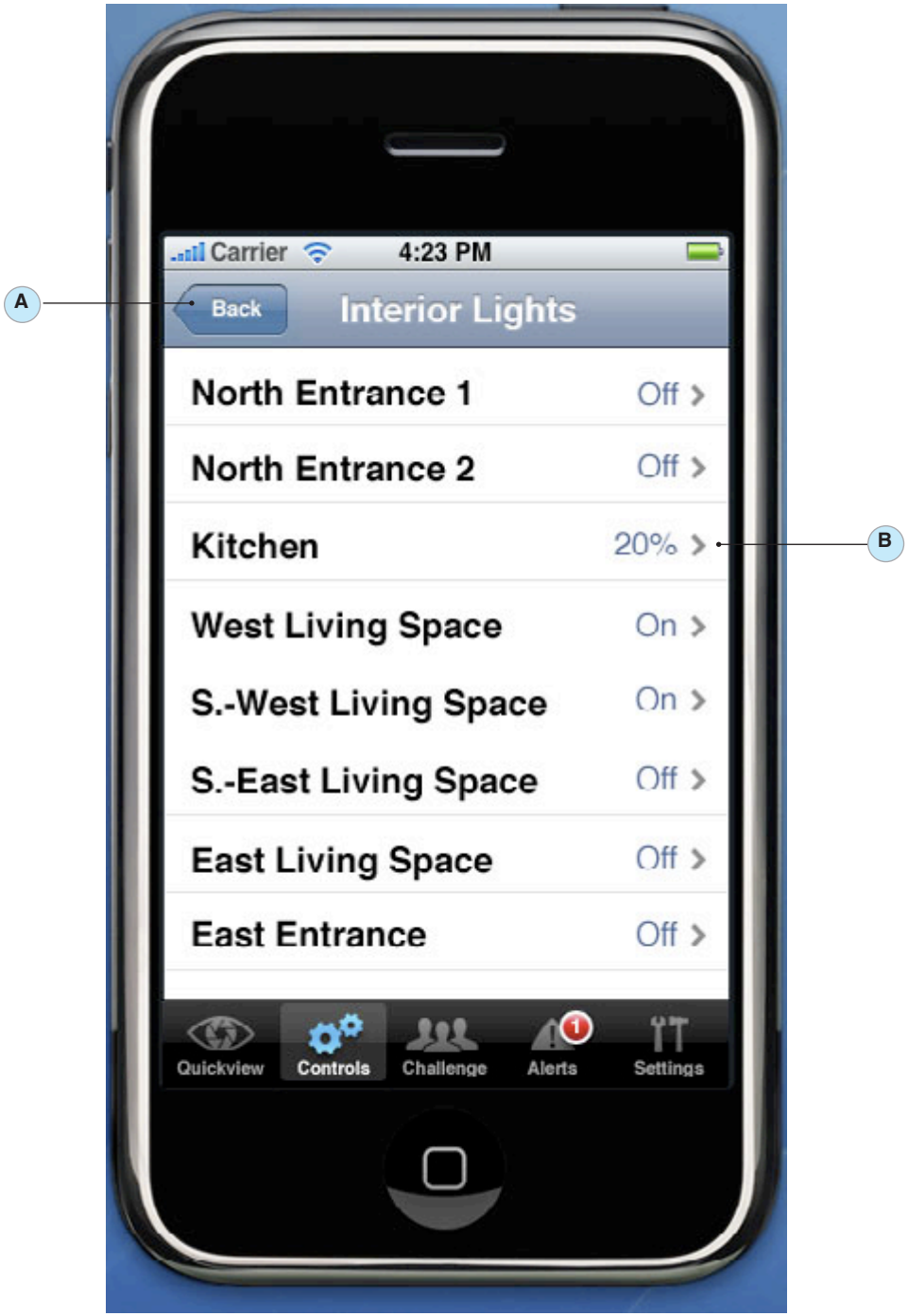
Page Details

A: Takes the user back to the main controls page

B: This changes the temperature up or down through pressing on the arrow buttons.

C: This changes the humidity up or down through pressing on the arrow buttons.

D: The user can use the toggle switch (native to the iphone) to turn the ventilation on or off.



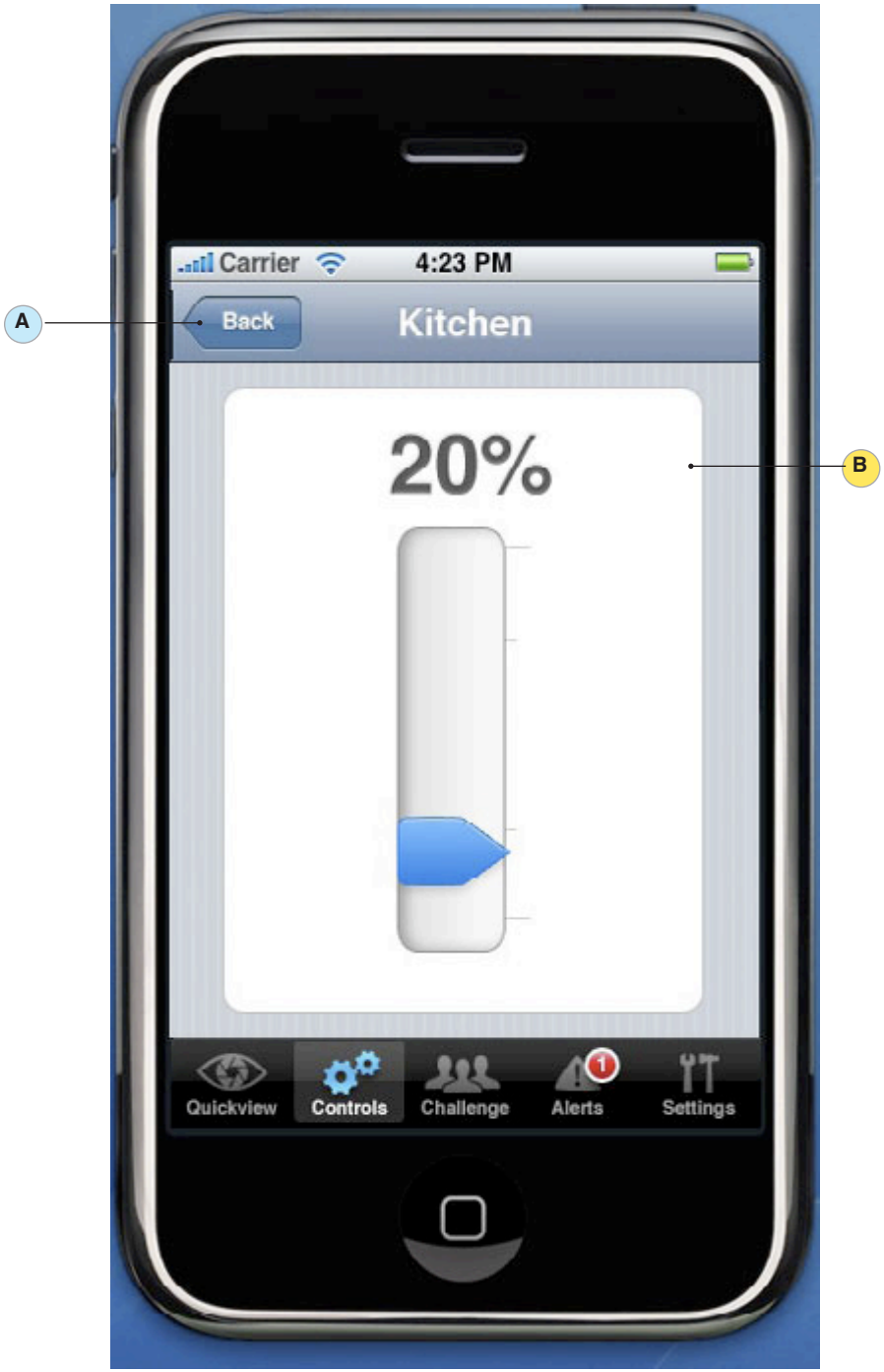
Page ID: 2.3

Page Title: Interior Lights

Page Details

A: Takes the user back to the main controls page

B: Each of these sections allows the user to access the respective light. The name represents the name of the light, the “off/on, %” represents the state of that light and the arrow is the action button to control the light. To see an example of the a dimmer controller go to page ID 2.3.1



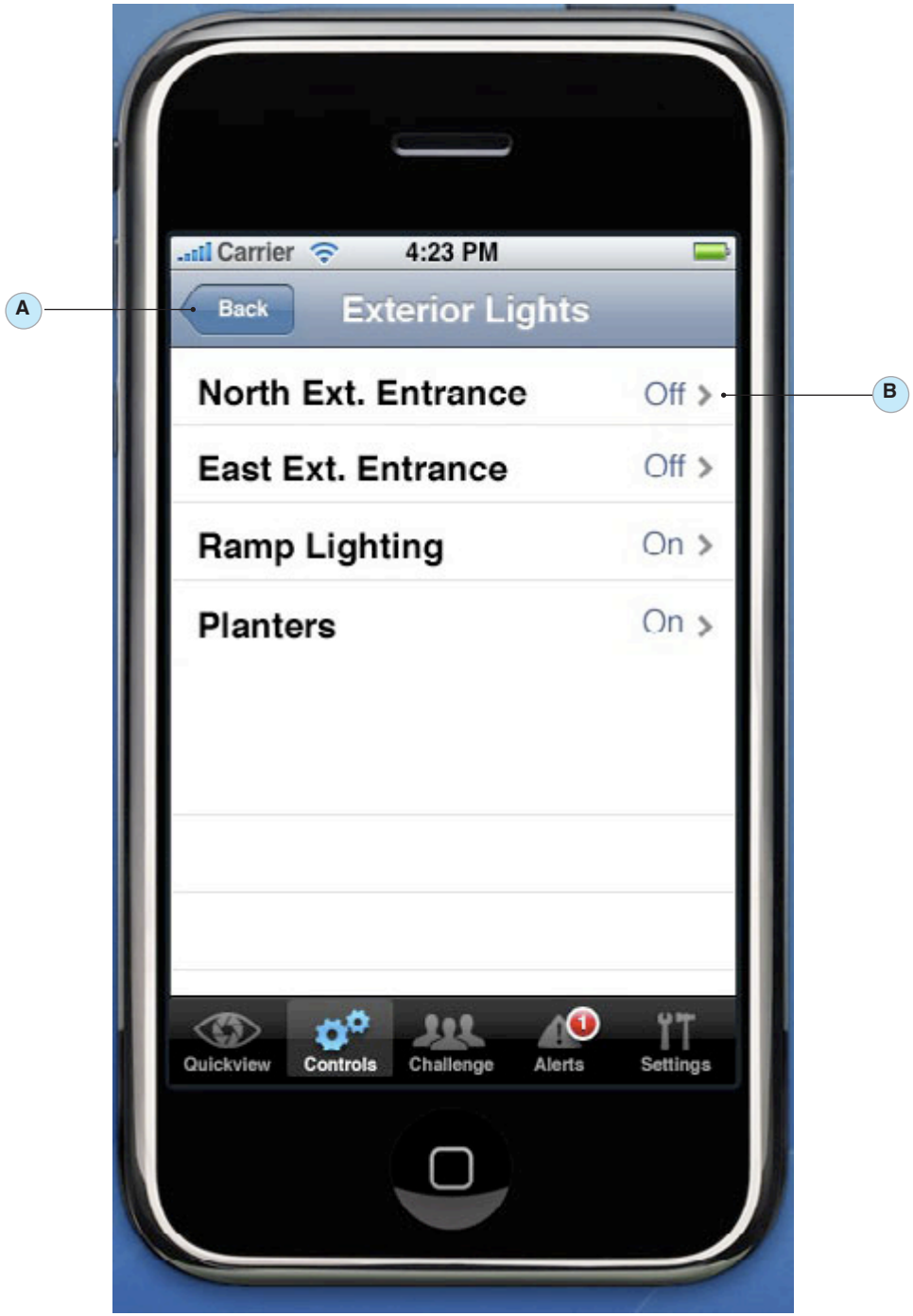
Page ID: 2.3.1

Page Title: Ind. Light Control

Page Details

A: Takes the user back to the interior lights controls list

B: This is an example of a dimmer control. The user can raise and lower the blue control point. Raising it up or down changes the "%" displayed above the controller.



Page ID: 2.4

Page Title: Exterior Lights

Page Details

A: Takes the user back to the main controls page

B: Each of these sections allows the user to access the respective light. The name represents the name of the light, the “off/on” represents the state of that light and the arrow is the action button to control the light. To see an example of the a dimmer controller go to page ID 2.4.1

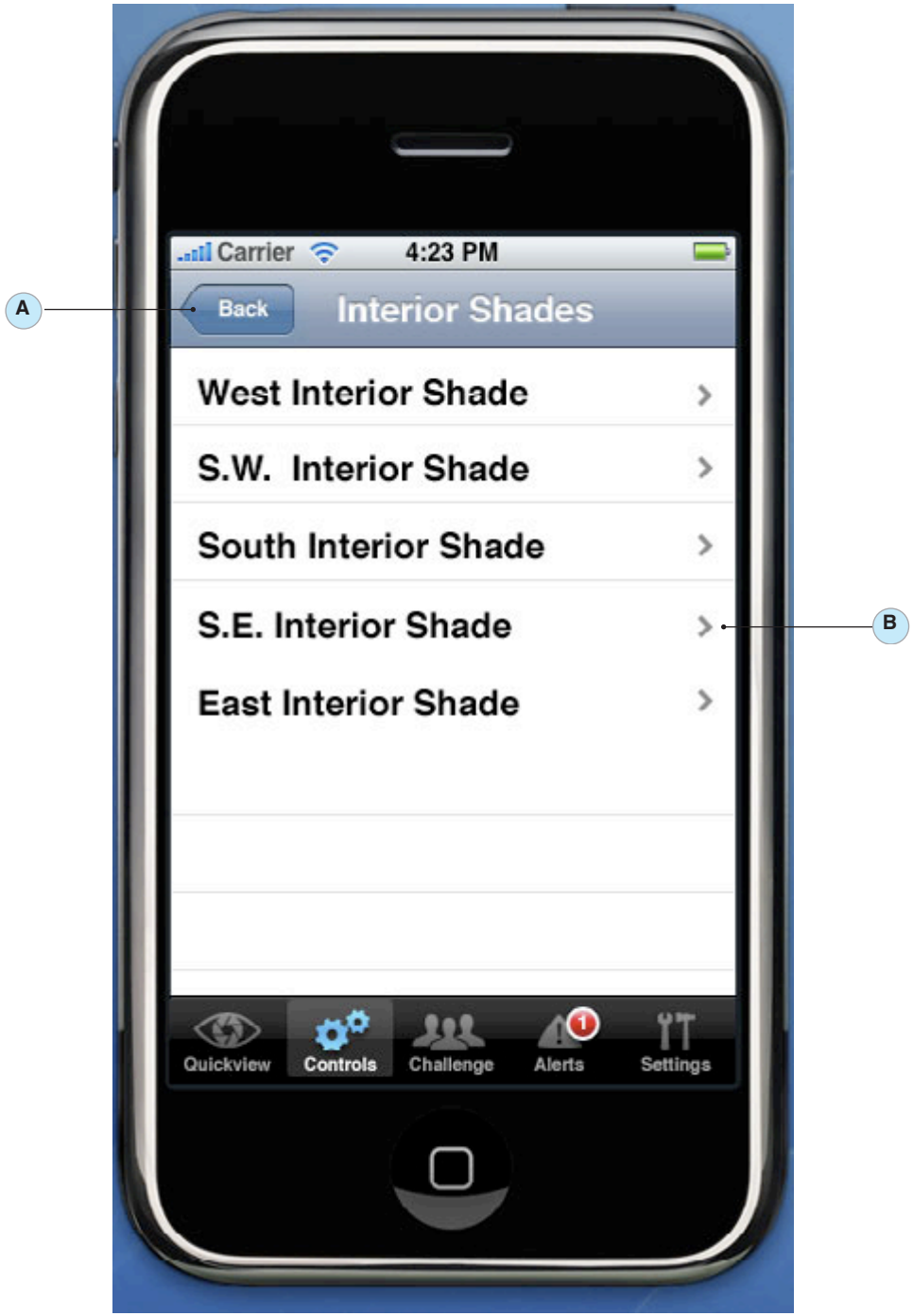
Page ID: 2.4.1

Page Title: Ind. Light Control

Page Details

A: Takes the user back to the exterior lights controls list

B: This is an example of a toggle switch control. The user can raise and lower the blue control point. Raising it up or down changes the “on/off” displayed above the controller.



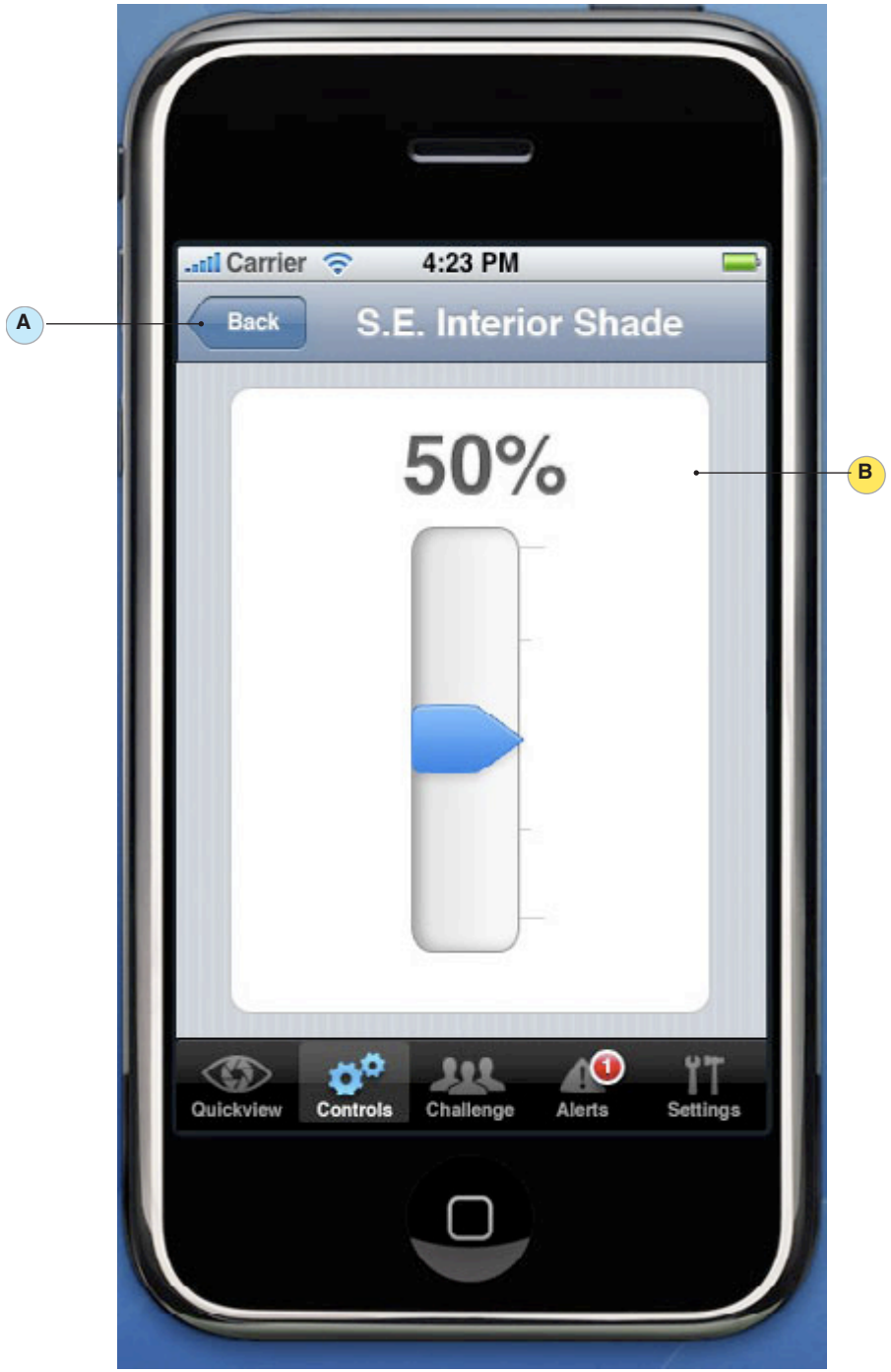
Page ID: 2.5

Page Title: Interior Shades

Page Details

A: Takes the user back to the main controls page

B: Each of these sections allows the user to access the respective shade. The name represents the name of the shade, and the arrow is the action button to control the light. To see an example of the a dimmer controller go to page ID 2.5 .1



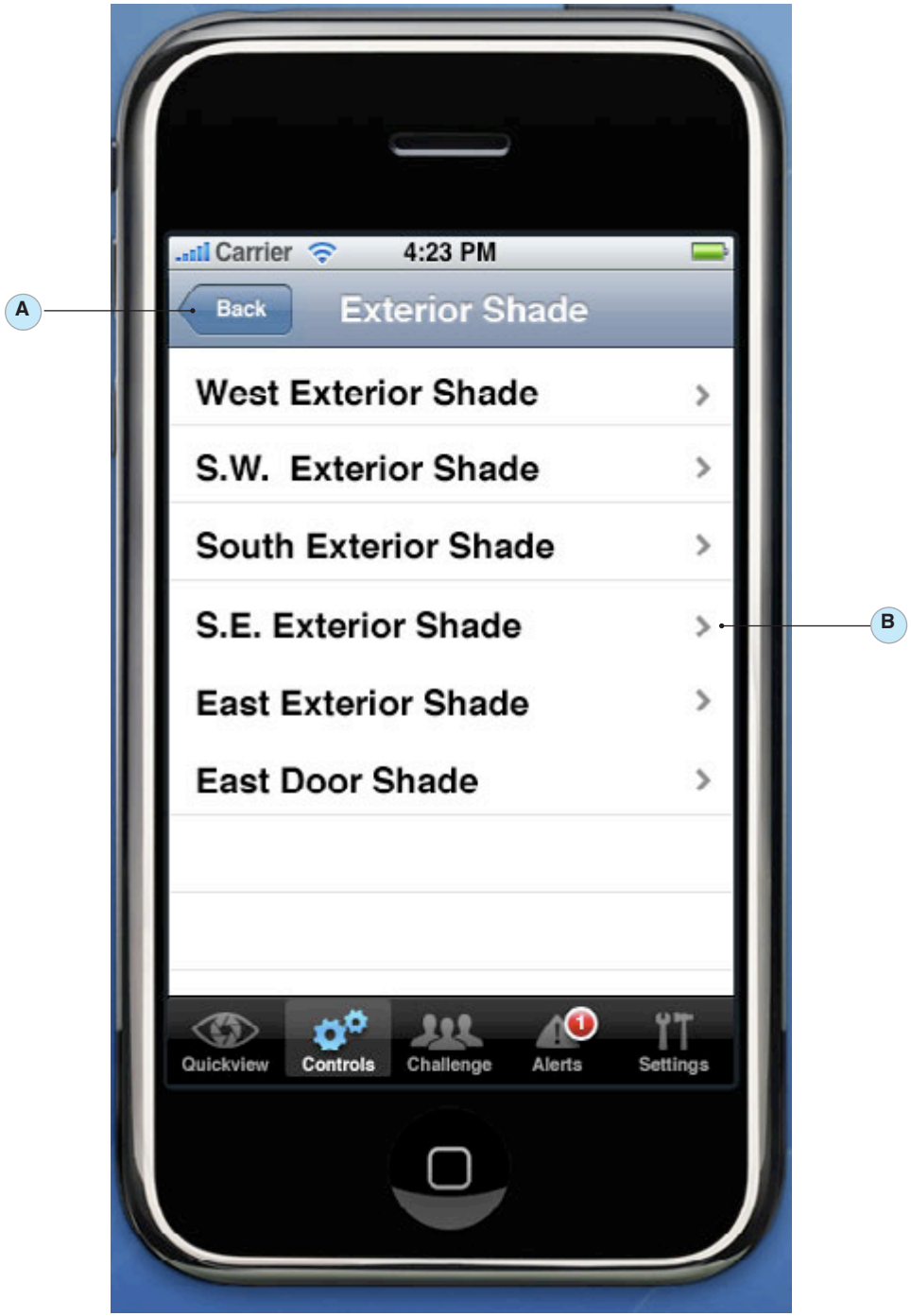
Page ID: 2.5.1

Page Title: Ind. Int. Shade control

Page Details

A: Takes the user back to the interior shades controls list

B: This is an example of a dimmer control. The user can raise and lower the blue control point. Raising it up or down changes the "%" displayed above the controller.



Page ID: 2.6

Page Title: Exterior Shades

Page Details

A: Takes the user back to the main controls page

B: Each of these sections allows the user to access the respective shade. The name represents the name of the shade, and the arrow is the action button to control the light. To see an example of the a dimmer controller go to page ID 2.6.1

Page ID: 2.6.1

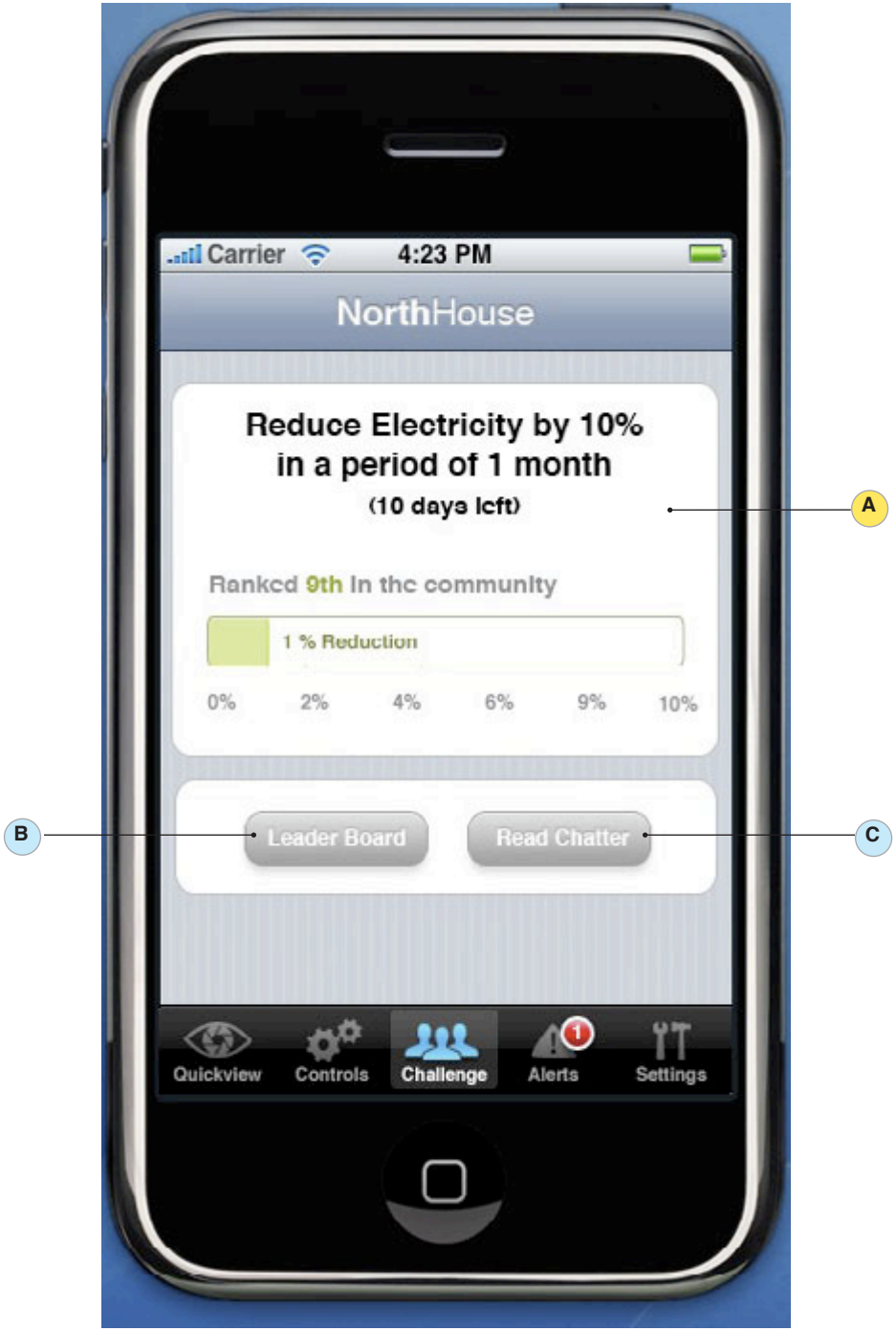
Page Title: Ind. Ext. Shade control

Page Details

A: Takes the user back to the exterior shades controls list

B: This is an example of a dimmer control. The user can raise and lower the blue control point. Raising it up or down changes the "%" displayed above the controller.

C: These buttons tilt the shades open or closed. The blue indicates the present state of the shade. (ie. the tilt orientation of the shade is currently open / 90 degrees).



Page ID: 3

Page Title: Challenge

Page Details

A: This displays your current challenge, how much time is left, and your current state & rank in the challenge.

B: This brings the user to the leader board for the challenge. (go to page ID 3.1)

C: This brings the user to the chatter / discussions that surround the challenge. (go to page ID 3.2)

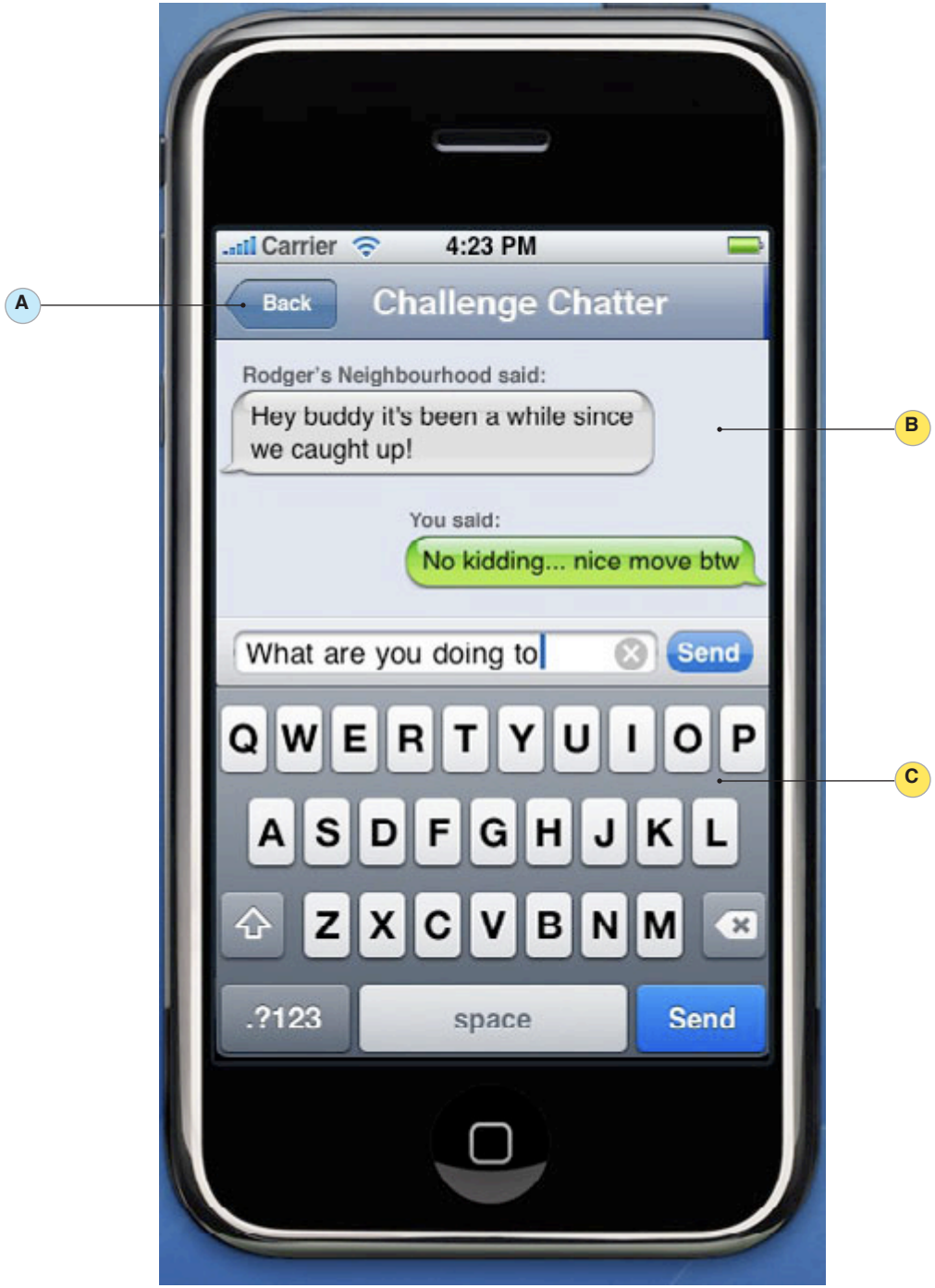
Page ID: 3.1

Page Title: Leader Board

Page Details

A: Brings the user back to the main challenge page (page ID 3)

B: This is a running list of those competing in teh challenge. The user can scroll down the page to view the entire list.



Page ID: 3.2

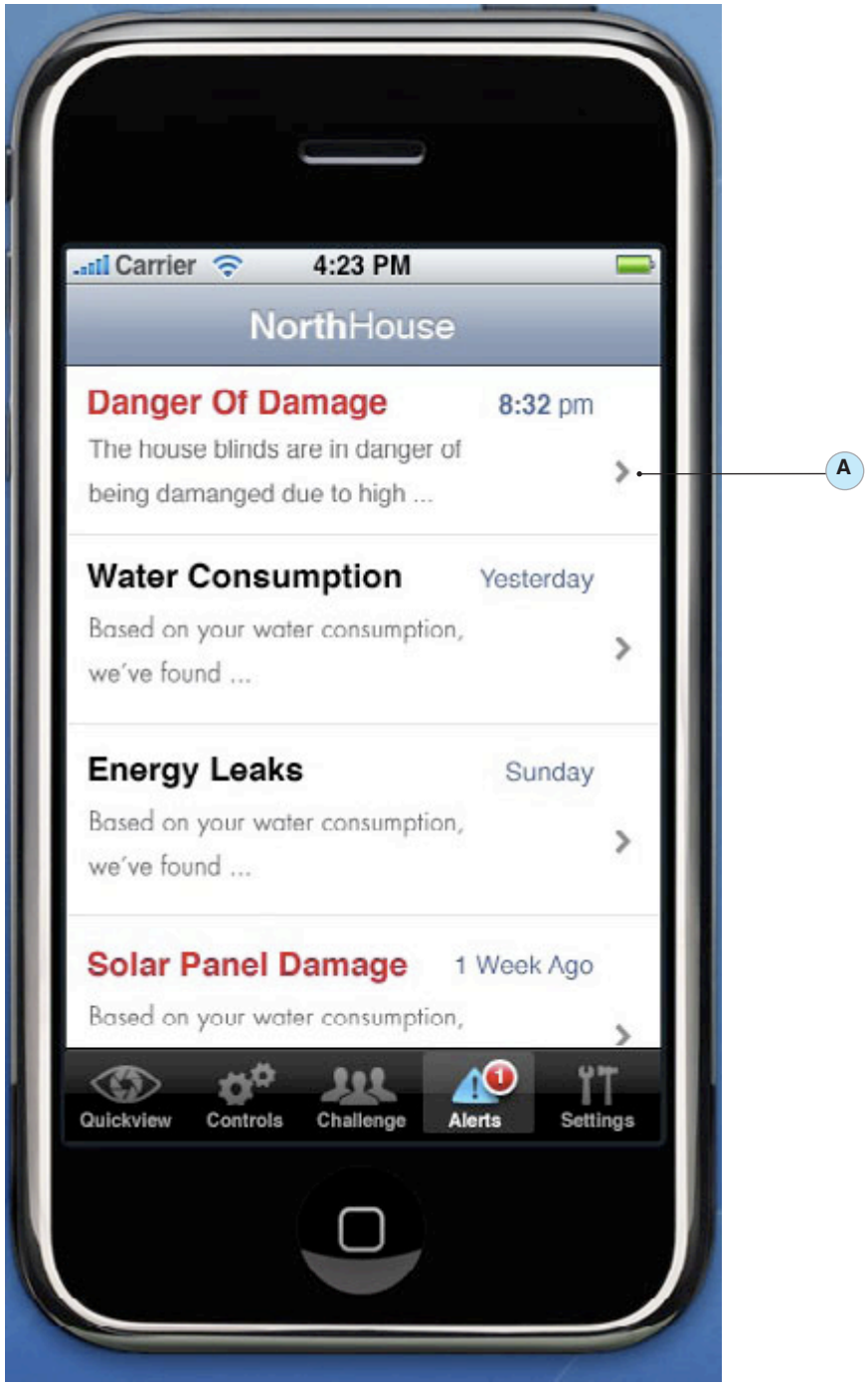
Page Title: Challenge Chatter

Page Details

A: Brings the user back to the main challenge page (page ID 3)

B: This displays the conversation as bubbles between different competitors. The name of the competitor appears above the posted comment.

C: The user can enter a comment through the standard i-phone keyboard. The keyboard slides up and down to make more visible space, depending upon it's use



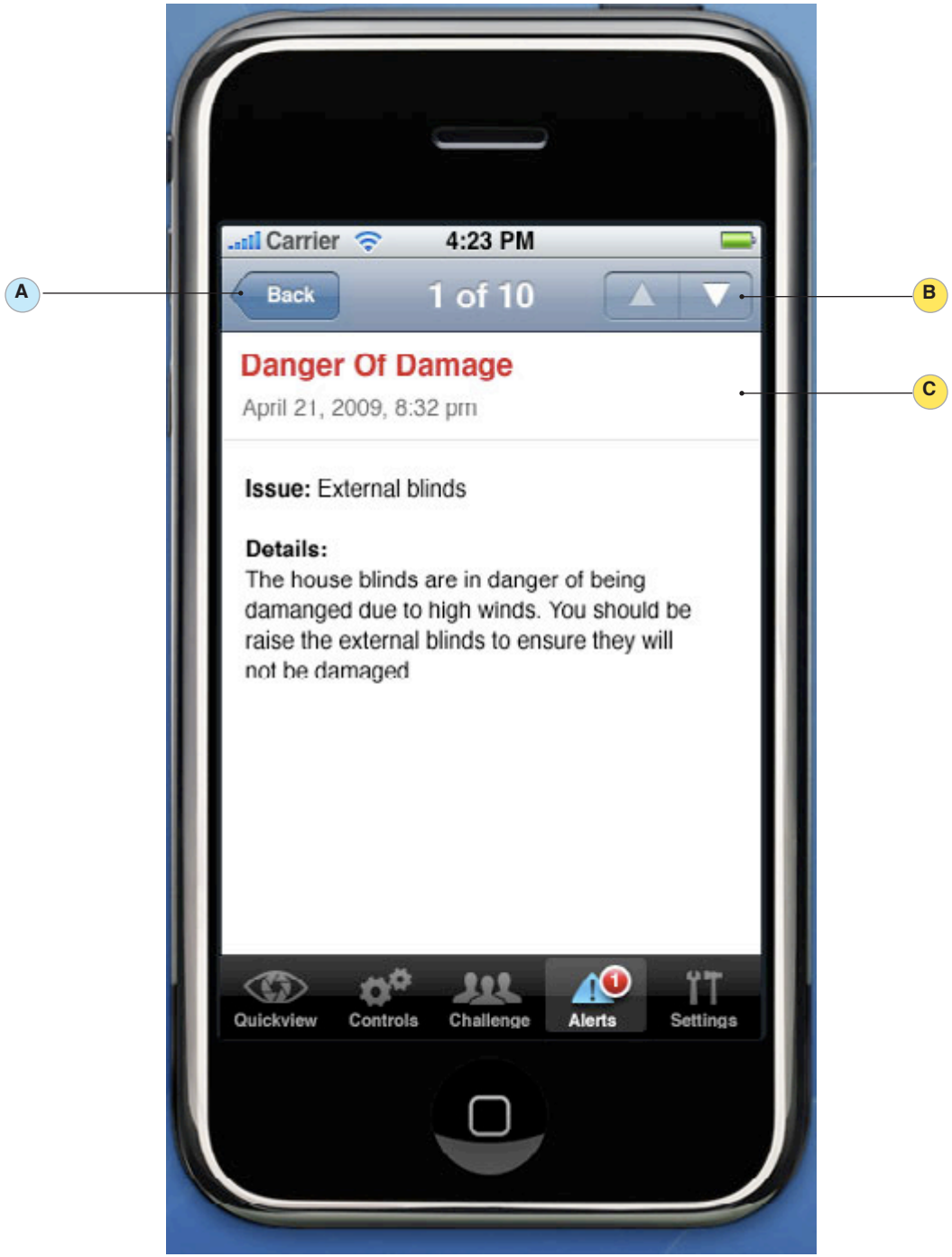
Page ID: 4

Page Title: Alerts

Page Details

A: This is a list of previous alerts. The list is scrollable and displays the last 25 alerts. Each alert has a title (based on the appliance in question). The red text denotes a higher alert priority. Underneath the title is teaser text. The time represents when the alert was sent. As the alert gets older, the time becomes less specific.

Clicking on the arrow allows the user to see more detailed information (go to page ID 4.1).



Page ID: 4

Page Title: Ind. Alert Msg.

Page Details

A: Brings the user back to the alerts list (page ID 4).

B: The up and down arrow allow the user to scroll through the list of alerts without having to go back to the main alerts list.

C: This displays the full alert message.

13.4 Ambient Canvas

Created by: Yin He, Jenny Thai, Alex Skibicki

The Ambient Canvas explores light as a means of conveying information in a smart home setting:

- net zero energy: what is my energy production and consumption?
- water consumption: how much water am I using?
- reach goals: how am I doing with respect to my goals that I have set out?

Though the information conveyed by the lights may be ambiguous at first, it is our hope, that through prolonged living in this home, the occupants will come to understand the meanings behind the qualities of light and it will serve as a central information hub. This will give a chance for the occupants to grow with their house.

We use the properties of refraction and reflection of light to cast interesting designs. Refraction can cause light to travel along surfaces so they are not limited to the straight line form.

Materials: LED lighting and Corian for the kitchen backsplash

The Ambient Canvas will be incorporated into the kitchen backsplash, at the centre of the house.

When light rays shine on a curved surface, rays will disperse along the curves.

Inspiration

Taken from an amalgamation of The Corian Lighted Bed and ideas of curved lighting.

+

Control 1: Intensity of Lights

- Each of the three lights can be controlled separately, to represent the three types of information.
- As the intensity of the lights increases, more lights travel along the curves to display the perimeter of the shape.

Progression of lighting:

*only the progression of the left light is shown, the others will follow suit

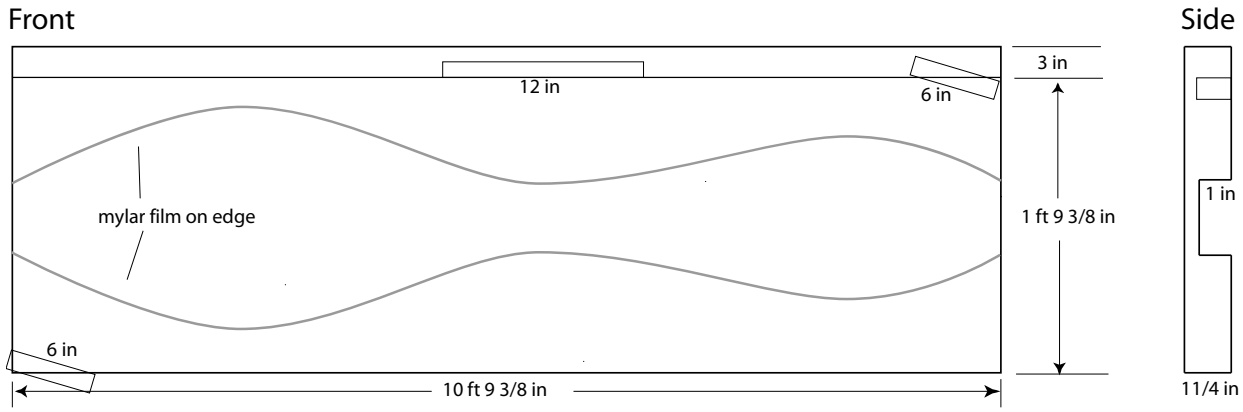
Min

Med

Max

How it Works:

3 high intensity LEDs are positioned at fixed locations along the perimeter of the Ambient Canvas, as shown below. The curved shape in gray is thinner than the other parts to allow light to travel. The depth to which the Corian will be milled will need to be determined through testing.



Early Prototypes

Lights are actually white, picture makes it look blue. This picture was taken under normal lighting conditions in an office setting, on high voltage.

The prototype is made from 4 layers: (from left to right in middle picture) ¼ in. Corian illumination series, ¼ in. translucent acrylic (big piece), ½ in. clear acrylic, ½ in. clear acrylic. The translucent acrylic is used to disperse the quality of the light but each light can still be seen.

Lights shown is a string of bendable LED lights where each light is 3 LEDs. LEDs can be controlled in parallel. The lights take 12V and come in 1m length, which can be cut and reused.