

1 PART 1 GENERAL**2 WORK INCLUDED**

3 Modifications to the existing Trane Summit control system.

4
5 Furnish and install conduit, wire, branch circuit protection, etc. as required to bring 120 VAC power to control
6 panel locations and equipment (actuators, sensors, control devices, etc.) as required by the Drawings and
7 described in the specifications.

8
9 Prepare individual hardware layouts, interconnection Drawings, and software configuration from project
10 design data.

11
12 Implement the detailed design for all analog and binary objects added to the system, system database
13 changes, additional graphic displays, logs, and management reports as required based on control
14 descriptions, logic Drawings, and bid documents.

15
16 Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and
17 all associated hardware.

18
19 Furnish all interconnecting cables between supplied cabinets, application controllers, and input/output
20 devices.

21
22 Furnish all interconnecting cables between all operator's terminals and peripheral devices supplied under this
23 section.

24
25 Provide complete manufacturer's specifications for all new items that are supplied. Include vendor name of
26 every item supplied.

27
28 Provide supervisory specialists and technicians at the job site to assist in all phases of system installation,
29 startup, and commissioning.

30
31 Provide a comprehensive operator and technician training program related to new or modified systems or
32 sequences as described herein.

33
34 Provide as-built documentation, operator's terminal software, diagrams, and all other associated project
35 operational documentation (such as technical manuals) on approved media, the sum of which accurately
36 represents the final system. Use the original O&M information as the base for this document. The
37 requirement is to provide a single record drawing with any revisions to the existing systems and new systems
38 noted. A separate control drawing showing just the new work will not be accepted. Revisions noted on
39 Owners hard copies in PDF form to be inserted into their current O&M manual will be acceptable.

40
41 Furnish and install a complete sensor, actuator, wiring and piping system for all air handling and related
42 equipment as shown on the plans and specified in this section. Install all necessary sensors and actuators as
43 required by the plans and specifications and equipment schedules.

44
45 Commissioning according to commissioning specification, if required by Owner.

46
47 All line drivers, signal boosters, and signal conditioners etc. shall be provided as necessary for proper data
48 communication. It shall be assumed that all communication to systems in the school work currently.

49
50 Coordination as required with other sections of the specification for the proper and complete installation of the
51 wiring and tubing system, control devices, dampers, valve, actuators, etc.

52
53 Furnish and install Direct Digital Control Equipment (DDC) as required by the point list, plans, and
54 specifications including, control units, software, database development, check-out, and debugging. Provide
55 points necessary for a complete and operable system.

56
57 Install the sequence of operations specified in the Drawings and in this section.

- 1
- 2 Software testing requirements shall include testing in the field of all logic sequences including actual
- 3 simulation of different processes and events and observing program response to the process or event. All
- 4 deviations from the requirements of the sequence as specified on the Drawings or this specification shall be
- 5 corrected immediately at no additional cost to the Owner.
- 6
- 7 Provide documentation of software system testing before acceptance testing.
- 8
- 9 Provide staff for acceptance testing procedures. Modify hardware and software errors/problems at no
- 10 additional cost to the Owner.
- 11
- 12 Setup trending data before and after system acceptance.
- 13
- 14 Provide detailed documentation of system configuration including control units and all control devices.

15
16 SYSTEM DESCRIPTION

- 17
- 18 Re-use and modify existing Trane Summit DDC system. Retain existing building and primary control devices.
- 19 Provide new application specific controllers for new HVAC components as required.
- 20
- 21 Application controllers shall be mounted next to controlled equipment and communicate with building
- 22 controller via existing building network.

23
24 APPROVED MANUFACTURER OF BUILDING AUTOMATION SYSTEM COMPONENTS AND SOFTWARE
25 Trane Summit

26
27 QUALITY ASSURANCE
28 Responsibility: The supplier of the BAS shall be responsible for inspection and Quality Assurance (QA) for all
29 new materials and workmanship furnished.

30
31 Component Testing: Maximum reliability shall be achieved through extensive use of high- quality, pre-tested
32 components. Every controller, sensor, and all other DDC components shall be individually tested by the
33 manufacturer prior to shipment or in the field if factory testing is not available.

34
35 Tools, Testing, and Calibration Equipment: The BAS supplier shall provide all tools, testing, and calibration
36 equipment necessary to ensure reliability and accuracy of the system.

37
38 The systems control contractor shall have been in business of minimum of five years and be authorized
39 installing contractor for the manufacturer of the Trane Summit components.

40
41 Control system shall be engineered, programmed and supported completely by representative's local office
42 that must be within 75 miles of project site.

43
44 REFERENCE STANDARDS
45 The latest edition of the following standards and codes in effect and amended as of supplier's proposal date,
46 and any applicable subsections thereof, shall govern design and selection of equipment and material
47 supplied:

- 48 Uniform Building Code (UBC), including local amendments.
- 49 UL 91d Underwriters Laboratories Standard for Energy Management Equipment. Canada and the
- 50 US.
- 51 National Electrical Code (NEC).
- 52 FCC Part 15, Subpart J, Class A
- 53 EMC Directive 89/336/EEC (European CE Mark)

54
55 City, County, State, and Federal regulations and codes in effect as of contract date.

56

1 Except as otherwise indicated the system supplier shall secure and pay for all permits, inspections, and
2 certifications required for his work and arrange for necessary approvals by the governing authorities.

3
4 **SUBMITTALS**
5 Drawings

6 The system supplier shall submit engineering Drawings, control sequence, and bill of materials for
7 approval.
8 Drawings shall be submitted in PDF form.

9
10 System Documentation. Including the following in submittal package:
11 System configuration diagrams in simplified block format.
12 All input/output object listings and an alarm point summary listing.
13 Electrical Drawings that show all system internal and external connection points, terminal block
14 layouts, and terminal identification.
15 Complete bill of materials and valve schedule.
16 Manufacturer's instructions and Drawings for installation, maintenance, and operation of all new
17 items.
18 Overall system operation and maintenance instructions- including preventive maintenance and
19 troubleshooting instructions.
20 A list of all functions available and a sample of function block programming that shall be part of
21 delivered system.

22
23 Project Management
24 The vendor shall provide a detailed project design and installation schedule integrated with the
25 general contractor's schedule. Provide coordination as required for all construction phases.

26
27 **WARRANTY**
28 Warranty shall cover all costs for new parts, labor associated travel, and expenses for a period of one year
29 from completion of system acceptance.

30
31 Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service
32 in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide
33 this service at the site shall be 24 hours Monday-Friday, 48 hours on Saturday and Sunday.

34
35 This warranty shall apply equally to both new hardware and software.

36
37 **RELATED WORK IN OTHER SECTION**
38 Refer to Division 0 and Division 1 for related contractual requirements.

39
40 Refer to Section 23 05 00 for General Mechanical Provisions

41
42 Refer to Section 26 05 00 for General Electrical Provisions

43 **PART 2 PRODUCTS**

44 **TERMINAL UNIT APPLICATION CONTROLLERS (HEAT PUMPS, AS UNITS, FAN COILS)**
45 Provide one application controller for each piece of unitary mechanical equipment that adequately
46 covers all objects listed in object list for unit. All controllers shall interface to building controller via
47 existing Trane Summit protocol. Controllers shall include input, output and self-contained logic
48 program as needed for complete control of unit.

49
50 Universal Inputs

1 Application controllers shall include universal inputs with 10-bit resolution that accept 3K and 10K
2 thermistors, 0-10 VDC, 0-5 VDC, 4-20 mA and dry contact signals. Any input on a controller may be
3 either analog or digital with a minimum of 3 inputs that accept pulses. Controller shall also include
4 support and modifiable programming for interface to intelligent room sensor with digital display.
5 Controller shall include binary and analog outputs on board. Analog outputs shall be switch
6 selectable as either 0-10 VDC or 0-20 mA. Software shall include scaling features for analog outputs.
7 Application controller shall include 24 VDC voltage supply for use as power supply to external
8 sensors.

9

10 SENSORS

11 All sensing inputs shall be provided industry standard signals.

12

13 Temperatures, humidities, differential pressure signals, and all other signal inputs shall be industry standard
14 variable voltage or amperage.

15

16 All signal inputs shall be compatible with controllers used and with requirement for readout of variables as
17 specified.

18

19 If sensors are not linear, then software will linearize sensor output.

20

21 Controls and sensor for NAV boxes to be provided to VAV manufacturer for installation at the factory.

22

23 TEMPERATURE SENSORS/THERMOSTATS

24 All sensors shall be completely electronic.

25

26 Duct / Air Handling Unit Type Temperature Sensor (mixed, discharge / supply, and return air).

27 The probe of the duct sensor shall be 12" in length and be made of stainless steel. Applications
28 where the smallest dimension of the duct is less than 24", the probe shall be sized to reach the center
29 of the duct.

30 Large systems above 9 square feet may require an averaging probe if sufficient mixing of the air
31 stream is not possible.

32 Mount the sensor far enough downstream to allow mixing of the air stream, this is most important on
33 Hot and Cold Deck applications where the coil is placed after the fan.

34 Sensors for mounting on insulated ducts or casings are to be equipped with brackets for mounting
35 clear of the isolation.

36 Do not locate sensors in dead air spaces or in positions with obstructed air flow.

37 Provide separate duct flange for each sensing element.

38 Temperature sensing elements shall be thermally isolated from brackets and supports.

39 Securely seal ducts where elements or connections penetrate duct.

40 Mount sensor enclosures to allow for easy removal and servicing without disturbance or removal of
41 duct insulation.

42

43 TRANSFORMERS

44 Transformers selected and sized for appropriate VA capacity and installed and fused according to applicable
45 codes.

46

47 CURRENT SWITCHES

48 The status of all non-VFD fan and pump motors and all VFD fan and pump motors less than 20 HP shall
49 ONLY be detected using current switches.

50

51 The current switch shall be provided for electrical equipment status applications only.

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53 Switch should attach directly to the conductor and have a mounting bracket for installation flexibility.

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55 The current switch shall be 100% solid state electronics.

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57 The current switch shall be induce powered from the monitored load.

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RELAYS

Coil voltage draw shall not exceed secondary controller output current generation. 24V coil with contacts rated for up to 277V. controls shall be rated for 20 amps.

CURRENT SENSORS / TRANSFORMERS

The status and amperage of all VFD motors for fan and pumps greater than 20 HP shall be detected using current sensors ONLY.

The amp signal shall be provided on operator screen.

The scale used must be selected in order to obtain normal operating readings at the mid-point of the scale.

The scale used must be selected in order to detect changes in current flow resulting from motor belt or coupling loss. Belt slippage, and other mechanical failures and should be able to distinguish low load conditions.

ELECTRONIC ACTUATORS AND VALVES

Quality Assurance for Actuators and Valves

UL Listed Standard 873 and C.S.A. Class 4813 02 certified.

NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.

Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.

Execution Details for Actuators and Valves

Spring actuators are not acceptable by Owner.

Only as specifically required by Owner shall each DDC analog output point shall have an actuator feedback signal, independent of control signal, wired and terminated in the control panel for true position information and troubleshooting. Or the actuator feedback signal may be wired to the DDC as an analog input for true actuator position status. This may apply to chilled heating water plants.

VAV box damper actuation shall be Floating Type or Analog (2-10 VDC, 4-20mA).

Booster-heat valve actuation shall be Floating type or Analog (2-10 VDC, 4-20mA).

Primary valve control shall be analog (2-10 VDC, 4-20mA).

Actuators for Damper and Control Valves 1/2" to 6" shall be Electric unless otherwise specified, Provide actuators as follows:

UL Listed standard 873 and Canadian Standards association Class 481302 shall certify actuators.

NEMA 2 rated actuator enclosures. Use additional weather shield to protect actuator when mounted outside.

5-year Manufacturer's Warranty. Two-year unconditional, plus three-year product defect from date of installation.

No spring return actuators, unless approved by the Owner.

Position indicator device shall be installed and made visible to the exposed side of the Actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the actuator.

Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for Butterfly Valve actuators.

A push button gearbox release shall be provided for all non-spring actuators.

Modulating actuators shall be 24VAC and consume 10 VA power or less.

Conduit connectors are required when specified and when code requires it.

Damper Actuators

No spring return actuators, unless approved by the Owner.

Economizer Actuators shall utilize Analog control 2-10 VDC, Floating control is not acceptable.

1 Electric damper actuators (including VAV box actuators) shall be direct shaft mounted and use a V-
2 bolt and toothed V-Clamp causing a cold weld effect for positive gripping. Single bolt or setscrew
3 type fasteners are not acceptable.
4 Once electronic actuator shall be direct shaft mounted per damper section. No connecting rods or
5 jackshafts shall be needed. Small outside air and return air economizer dampers may be
6 mechanically linked together if one actuator has enough torque to drive both and damper drive shafts
7 are both horizontal installed.
8 Multi-section dampers with electric actuators shall be arranged so that each damper section operates
9 individually. Once electronic actuator shall be direct shaft mounted per damper section (see below
10 execution section for more installation details).

11
12 Valve Actuators: 1/2" to 6"

13 No spring return actuators, unless approved by the Owner.
14 The valve actuator shall be capable of providing the minimum torque required for proper valve close
15 off for the required application.
16 All control valves actuators shall have an attached 3-foot cable for easy installation to a junction box.
17 Override handle and gearbox release shall be provided for all non-spring return valve actuators.

18
19 Control Valves 1/2" to 6"

20 The BAS contractor shall furnish all specified motorized control valves and actuators. BAS contractor
21 shall furnish all control wiring to actuators. The plumbing contractor shall install all valves. Equal
22 Percentage control characteristic shall be provided for all water coil control valves. Linear valve
23 characteristic is acceptable for 3-way valves 2 1/2" inch and above.
24 Characterized Control Valves shall be used for hydronic heating or cooling applications and small to
25 medium AHU water coil applications to 100 GPM.

26 Leakage is Zero Percent, Close-off is 200 psi, Maximum Differential is 30 psi. Rangeability is
27 500:1.

28 Valves 1/2 inch through 2 inches shall be nickel-plated forged brass body, NPT screw type
29 connections.

30 Valves 1/2 inch through 1 1/4 inches shall be rated for ANSI Class 600 working pressure.

31 Valves 1 1/2 inch and 2 inches shall be rated for ANSI Class 400 working pressure.

32 The operating temperature range shall be 0° to 250° F.

33 Stainless steel ball & stem shall be furnished on all modulating valves.

34 Seats shall be fiberglass reinforced Teflon.

35 Two-way and three-way valves shall have an equal percentage control port. Full stem
36 rotation is required for maximum flow to insure stable BTU control of the coil.

37 Three-way valve shall be applicable for both mixing and diverting.

38 The characterizing disc is made of TEFZEL and shall be keyed and held secure by a
39 retaining ring.

40 The valves shall have a blowout proof stem design.

41 The stem packing shall consist of 2 lubricated O-rings designed for on-off or modulating
42 service and require no maintenance.

43 The valves shall have an ISO type, 4-bolt flange, for mounting actuator in any orientation
44 parallel or perpendicular to the pipe.

45 A non-metallic thermal isolation adapter shall separate valve flange from actuator.

46 One fastening screw shall secure the direct coupling of the thermal isolation adapter between
47 the actuator and the valve. This will prevent all lateral or rotational forces from affecting the
48 stem and its packing O-rings.

49 Globe valves 1/2" to 2" shall be used for steam control or water flow applications.

50 Valves shall be bronze body, NPT screw type, and shall be rated for ANSI Class 250 working
51 pressure.

52 Valves 1/2 inch (DC 15) through 2 inches (DNSO) shall close off against 50 psi pressure
53 differential with Class III leakage (0.1%).

54 The operating temperature range shall be 20° to 280°F.

55 Spring loaded TFE packing shall protect against leakage at the stem.

56 Two-way valves shall have an equal percentage control port.

57 Three-way valves shall have a linear control and bypass port.

58 Mixing and diverting valves must be installed specific to the valve design.

- 1 Valve Sizing for Water Coil.
2 On/Off Control Valves shall be line size.
3 Modulating Control Valve Body Size may be reduced at most two pipe sizes from the line size
4 or not less than half the pipe size. The BAS contractor shall size all water coil control valves
5 for the application as follows.
6 Booster-heat valves shall be sized not to exceed 4-9 psi differential pressure. Size
7 valve for 50% Valve Authority. Valve design pressure drop is equal to the sum of coil
8 drop plus the balance valve drop.
9 Primary valves shall be sized not to exceed 5-15 psi differential pressure. Size valve
10 for 50% Valve Authority. Valve design pressure drop is equal to the sum of coil drop
11 plus the balance valve drop.
12 Butterfly valves shall be sized for modulating service at 60-70-degree rotation.
13 Design velocity shall be 12 feet per second or less when used with standard EPDM
14 seats.
15 Valve Mounting Arrangements Shall Comply to the following:
16 Unions shall be provided on all ports of two-way and three-way valves.
17 Install three-way equal percentage Characterized Control Valves in a mixing
18 configuration with the "A" port piped to the coil.
19 Install 2 1/2" inch and above, Three-way Globe Valves, as manufactured for mixing
20 or diverting service to the coil.
21 Two-way Valve shall be piped in the return side of the coil in order to minimize
22 ambient heat at the coil.
23 All valves and actuators to be Belimo unless directed otherwise by Owner.

24

25 ENCLOSURES

26

26 All controllers, power supplies and relays shall be mounted in enclosures.

27

28

28 Enclosures may be NEMA I when located in a clean, dry indoor environment. Indoor enclosures shall be
29 NEMA 12 when installed in other than a clean environment.

30

31

31 Enclosures shall have hinged, locking doors.

32

33

33 Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include
34 location and unit served on nameplate. Laminated plastic shall be 1/8" thick sized appropriately to make label
35 easy to read.

36 PART 3 EXECUTION

37 EXAMINATION

38 Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to
39 the point where work of this section may properly commence.

40

41

41 Notify the Owners representative in writing of conditions detrimental to the proper and timely completion of the
42 work.

43

44

44 Do not begin work until all unsatisfactory conditions are resolved.

45

46

46 INSTALLATION (GENERAL)

47

47 Install in accordance with manufacturer's instructions.

48

49

49 Provide all miscellaneous devices, hardware, software, interconnections installation and programming
50 required to ensure a complete operating system in accordance with the sequences of operation and point
51 schedules.

52

53

53 LOCATION AND INSTALLATION OF COMPONENTS

54

54 Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum
55 3'-0" clear access space in front of units. Obtain approval on locations from Owner's representative prior to
56 installation.

1
2 All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from
3 vibration, moisture and high or low temperatures.

4
5 Identify all equipment and panels. Provide permanently mounted tags for all panels.

6
7 Provide stainless steel or brass thermowells suitable for respective application and for installation under other
8 sections sized to suit pipe diameter without restricting flow.

9 10 INTERLOCKING AND CONTROL WIRING

11 Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance
12 with Specification Division 26 and all national, state, and local electrical codes.

13
14 Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to
15 serve specified control functions. Provide shielded low capacitance wire for all communications trunks.

16
17 Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches
18 shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and
19 arrangement of all control equipment with the Owner's representative prior to rough-in.

20
21 Provide auxiliary pilot duty relays on motor starters as required for control function.

22
23 Provide power for all control components from nearest electrical control panel or as indicated on the electrical
24 Drawings. Coordinate with electrical contractor.

25
26 All control wiring to be installed neatly and consistently per local code requirements. If local code allows,
27 control wiring above accessible ceiling spaces may be run with plenum rated cable (without conduit).

28 29 WIRING, CONDUIT, AND HANGERS

30 All wiring and fiber optic cable in the central plant, tunnels, and plenums to be supported by B-line Bridle rings
31 or equal. All wiring and fiber optic cable in the hallways, rooms and other public areas shall be in conduit.

32
33 All wires in Bridle Rings or conduit shall follow building lines and shall run within several inches of the wall as
34 much as possible.

35
36 Wire and cable of the sizes and types shown on the plans and/or hereinafter specified shall be furnished and
37 installed by the Control Contractor. All wire and cable shall be new soft drawn copper and shall conform to all
38 the latest requirements of the National Electrical Code, IPCEA, and shall meet the specifications of the ASTM.

39
40 Input/output wiring: Wiring serving inputs and outputs from the BAS shall be cables consisting of single or
41 multiple twisted individually shielded pairs. Each pair shall have an independent shield with drain wire.
42 Cables installed without Condit shall be plenum rated and comply with NEC article 725. Where automation
43 input/output wiring is run in cable tray furnish and install conductors or multiconductor cable rated for use in
44 cable trays per NEC article 340 and/or 725.

45
46 Power Conductors shall provide power to controls furnished under this section, unless power to controllers is
47 noted on the electrical Drawings. Contractor shall coordinate with electrical contractor to identify dedicated
48 controls circuits. All feeder and branch circuit wire shall be 600 V insulated of THHN type unless shown or
49 specified to be otherwise. No wire less than No. 12 gauge shall be used except for control
50 circuits or low voltage wiring. Wire sizes No. 14 to No. 10 shall be solid except where otherwise indicated.
51 Wire sizes No. 8 and larger shall be stranded. All wire sizes shown are American Wire Gauge sizes. Where
52 power conductors are run in cable tray, furnish and install conductors or multiconductor cable rated for use in
53 cable trays per NEC articles 340 and/or 725.

54
55 All the conductors used for signals from the controllers and field sensors must be shielded two wire, 18 AWG,
56 with a drain wire.

57

- 1 All power wiring to be copper stranded RW 90 type, with appropriate gauge in accordance with the codes.
2 The following color code must be applied:
3 Line voltage to be black and/or white
4 Ground to be green

5
6 **Wiring Installation**

- 7 All wires shall be continuous from outlet to outlet and there shall be no unnecessary slack in the
8 conductors.
9 All drain wires must be grounded at the source end. The other end must be protected with a
10 dielectric material (tape).

11
12 **Pull-Box and Junction Box**

- 13 Pull boxes and junction boxes shall be installed where indicated on the Drawings or where required to
14 facilitate wire installation. Locate in conjunction with other trades to install without conflict with other
15 materials or equipment.
16 A pull-box will be located at every 50'.
17 All switch, pull, junction boxes etc., shall be hot dipped galvanized or sherardized, concrete tight, with
18 interlocking ring or multiple point locking devices. Connectors shall be three pieces. Indentation
19 fittings are not acceptable.
20 In suspended ceilings, all boxes must be installed on the structure.
21 Boxes shall be attached by fasteners designed for the purpose and shall provide adequate
22 mechanical strength for future maintenance.
23 Junction and pull boxes not dimensioned shall be minimum 4-inches square.

- 24
25 Care shall be used to avoid proximity to heat ducts and/or steam lines. Where crossings are unavoidable,
26 conduit shall clear cover of line by at least six inches.

- 27
28 All splices, taps, and terminations shall be made at outlet, junction, or pull boxes. Wire to No. 6 gauge shall
29 be spliced using Scotch Lok wire nuts. No Bakelite wire nuts shall be used. Wire No. 6 and larger shall be
30 spliced using soldemess connectors as manufactured by Penn Union Company. Splices No. 6 and larger
31 shall be insulated by taping with plastic vinyl tape as manufactured by Minnesota Mining and Manufacturing
32 Company. Splices shall not be permitted in automation input and output wiring without specific written
33 authorization from the Engineer. If such splice is approved, the location of the splice shall be clearly
34 documented on the "As Built" Drawings. Splices in automation wiring, if necessary shall be made using
35 Thomas & Betts STA-KON connectors installed per the manufacturer's directions to maintain NEMA specified
36 voltage drops and wire retention forces.

37
38 **Grounding**

- 39 The contractor shall extend existing equipment grounding systems. The contractor shall use only
40 approved grounding clamps and connectors as manufactured by Penn Union, Bumdy or O-Z Mfg.
41 Company.
42 The conduit system of the 480/277 and 208Y/120-volt systems shall be continuous and shall be used
43 as the static grounding conductor, except for circuits installed in flexible conduit. Install a green
44 grounding conductor inside all flexible conduits and extend to the nearest outlet or junction box.
45 Install a green grounding conductor inside all non-metallic conduits or raceways.

46
47 **Conduit Material**

- 48 All wiring to be E.M.T. type conduits unless in plenum or above the 8' level in mechanical rooms and
49 attics.
50 All conduits to be a minimum of 1/2 ".
51 All flexible conduits will not exceed 6' in length and are to be used only in areas where vibrations
52 and/or expansion joints are present.
53 Flexible conduit to be used for connecting any element to its conduit. The length of this flexible
54 conduit will not exceed 24".
55 Flexible steel conduit shall be used where flexible conduit connections are required and at
56 connections to all motorized equipment and motors. If located outside seal-tight shall be used.
57 In damp areas, the conduit and related equipment must be suitable for the application.

1 Electrometallic tubing shall be installed for all exposed work and for all concealed work in applications
2 where conduit is required.
3 Conduit shall be by Allied, Triangle, Republic, Youngstown, Canon, Rob Roy, or approved equal.
4 For exposed finished area where the conduit cannot be run in ceiling spaces, wall cavities or attics,
5 surface-mounted powdered coated conduit is acceptable. Provide samples for size and color
6 selection. Wiremold may be used only with Owner's approval.

7 8 Conduit Installation

9 All wiring in mechanical rooms at heights below 8 feet must be run in conduit. Otherwise, wiring in all
10 other open areas (areas with no ceiling or cloud ceiling) must be routed in conduit. Wiring above
11 accessible ceilings or drops in walls to single control devices need not be in conduit.
12 All conduits to be installed in a concealed manner where possible and shall be installed parallel to the
13 lines of the building.
14 All exposed conduits in finished areas shall be white powder coated and installed parallel or at right
15 angles to be the building walls or floors. Wiremold is to be used only as directed by Owner.
16 Conduit bends shall be made with standard hickies of proper size. Radius of bends to be at least 6
17 times the diameter of the conduit. Runs between outlets shall not contain more than the equivalent of
18 three-quarter bends. Conduit runs shall be continuous from outlet to outlet, outlet to cabinet, etc.
19 Conduits shall be installed with pitch toward outlet box wherever possible. All heavy wall conduits
20 shall have two locknuts and a bushing at each termination outlet box, junction box, etc., except where
21 terminated in a threaded hub.
22 A bushing shall be used where conduit enters a panel box. Bushing for No. 4 AWG or larger shall be
23 insulated type with provisions for grounding as type "BL" made by O-Z Electric Company or approved
24 equal.
25 Expansion fittings shall be provided at all conduits across the building expansion joints. Fittings shall
26 be Type "AX" or "TX" as made by O-Z Electric Company or approved equal. Provide copper bonding
27 jumper at each expansion fitting.
28 All 1" conduit to be supported every 6', the supports will be located at the connector end of the
29 conduit.
30 Exposed conduit shall be securely fastened in place on maximum 5 ft. intervals for 3/4 " through 2 1/2
31 " nominal sizes. Supports may be one-hole malleable straps or other approved devices. No
32 perforated metal straps will be permitted.
33 In mechanical attics, conduit to be run vertically up to the 8' level and run in plenum rated cable after
34 that.

35 36 Wireway

37 Furnish and install at all control panel locations a NEMA 1 lay-in wireway system to bring cable into
38 and out of the panel as detailed on the Drawings and specified in this section. Furnish 3-way
39 wireways at each panel location; one for Class 1 wiring, 1 for Class 2, and Class 3 wiring. Panels at
40 units to be NEMA 3R or better.
41 Wireway systems at locations where cables are to be run without conduit or in a cable tray shall
42 consist of a connection to the control panel with a vertical extension to 8'-0" or the pipe rack or cable
43 tray level, whichever is higher. The vertical section shall terminate in a 90° fitting with a closure plate.
44 The closure plate shall be provided with a conduit nipple with locknuts and bushings as a wire entry
45 point into the square duct. The conduit nipple shall be one size smaller than the wireway it is
46 associated with.
47 Wireway systems at locations where cables are to be run in conduit shall consist of a horizontal
48 section of wireway with a length equal to the control panel width and located above the control panel
49 and connected to the control panel with three conduit nipples, locknuts, and bushings; ne for tubing,
50 one for Class 1 wiring and one for Class 2 and 3 wiring. Conduits for cable runs shall terminate on
51 the wireway.
52 The intent of the wireway configurations outlined above is to provide a method for adding input and
53 output wiring to the control panel without having to drill directly into the electronics enclosure after the
54 system is on line and running and to provide sufficient area to land field conduits while maintaining
55 appropriate circuit segregation for wire entry into the controller enclosure. The installation of wireway
56 shall be made with this consideration in mind.

57 58 Hangers and Anchors

1 Where control system tubing is run on trapezes and/or hangers used by and or installed by other
2 trades, supports for trapezes shall be coordinated by all trades using the trapeze to assure that the
3 anchor system is not overloaded and is sufficient for the load imposed including a margin of safety
4 and seismic considerations. Under no circumstances shall a trapeze or hanger system installed by
5 the electrical trades be used to support work by any other trade, nor shall the electrical trades use the
6 trapezes installed by any of the other trades for the support of electrical equipment, all as required by
7 the National Electric Code. Similarly, under no circumstances shall a trapeze or hanger system
8 installed by the sprinkler trades be used to support work by any other trade, nor shall the sprinkler
9 trades use the trapezes installed by any of the other trades for the support of sprinkler systems or
10 equipment, all as required by NFPA 13, standard for The Installation of sprinkler Systems.
11 Anchors to be loaded in tension for use in existing concrete structure and anchors loaded in tension
12 and not cast in place shall be epoxy resin set anchors installed per the manufacturer's
13 recommendations for technique, size, loading, embedment, etc. Where anchors are loaded in shear
14 at these locations, suitably sized and installed wedge type anchors may be used.
15 In all cases anchor loading shall be based on hanger spacing, weight of the pipe to be supported
16 when full and insulated, weight of any additional loads imposed upon the anchor, wind loading,
17 seismic loading, quality of the material that the anchor is being installed in, etc. The control
18 contractor shall verify in the field that the anchors used and the materials that they are being installed
19 in are suitable for the load imposed and shall bring any problems to the attention of the Engineer in
20 writing immediately and not proceed without direction from the Engineer.
21 Wedge type anchors shall be Hilti Kwik Bolt II. Adhesive anchors shall be Hilti HVA.

22 23 UNIT CONTROL PANELS INSTALLATION AND FABRICATION

24 Enclosed cabinet type with hinged door for mounting all relays, switches, thermometers, and miscellaneous
25 controls not requiring direct mounting on equipment such as sensing elements, valves, and damper motors.
26 Provide cabinet for each control unit adjacent to each system.

27
28 Control panels shall be fabricated to match the approved shop Drawings submitted by the control contractor.
29 Fabrication shall be in a neat and workmanlike manner and shall facilitate repair, maintenance, and
30 adjustment of the equipment contained therein.

31
32 Control panels shall be fabricated and laid out to incorporate the following features:

33 Identification of all internally and cover mounted devices. Cover mounted labels shall be engraved
34 labels as specified in page 7 line 33. Labels shall be mounted adjacent to the device they are
35 associated with so that replacement of the device does not eliminate the label. Provide laminated
36 control diagram at each panel.

37 Electrical wiring shall enter the panel from the top, bottom, and/or side of the left side of the panel or
38 as required by the panel supplier to meet NEC requirements.

39 All wires entering or leaving the panel shall pass through a rail terminal trip. Where the wires are part
40 of a current loop transmission circuit, the terminals shall be the disconnecting link type. Terminals
41 shall be identified with a number that corresponds to the terminal number on the job wiring diagram.

42 Rail terminal trip specifications include:

43 Terminal rail assemblies shall be fabricated from components selected from the product line
44 of one manufacturer.

45 Sizes (heights, widths, and profiles) of each terminal shall be selected to be compatible with
46 the other terminals on the rail.

47 Terminal units located at the end of a rail or adjacent to terminals with a different profile (for
48 example, where disconnecting terminals are located next to resistor terminals) shall be
49 provided with end caps to completely close off the terminal unit interior components from the
50 local environment.

51 End stops shall be provided for on all rails to secure the terminals located on the rail in place.

52 All internal wiring and tubing shall be run inside plastic wiring/tubing duct as manufactured by Tyton.
53 Wire duct shall be sized to hold the required number of wires and tubes without crimping the tubes
54 and with enough space to allow wiring and tubing to be traced during troubleshooting operation.

55 Wires that pass from the panel interior to cover mounted devices shall be provided with a flex loop
56 that is anchored on both sides of the hinge. Wiring running to cover mounted devices shall be
57 bundled using cable ties.

58 Provide strain relief type cord and cable connectors for all cables that leave the panel as individual
59 cables not in conduit.

1 All control panels shall be provided with removeable sub panels to allow the panel enclosures to be
2 installed at the job site during rough in while the panels are fabricated off-site for later installation.
3 In areas of low light, provide one under cabinet type fluorescent light with switch mounted internally in
4 the control panel. Panels with external light hoods will also be acceptable if the light will illuminate the
5 panel interior with the door open.
6 Provide one duplex outlet mounted inside the global controller panel only and separately fuse it with a
7 non-time delay fuse at 15 A at any panel location containing electronic or electrical control
8 components. This receptacle may be served from the control panel 120 VAC power source.
9 Each control panel shall be provided with a control power disconnect switch located and wired to
10 disconnect all control power in the panel. The leaving side of this switch shall be wired to the panel
11 and field components through a fuse or fuses sized and applied to protect both the components of the
12 system as well as the wire and as required for code compliance.
13 Power to the following equipment will have a fuse rated for applicable current and voltage. Fuses will
14 be on rail terminal strips. Equipment includes:
15 Each control unit
16 Control devices
17 Panel light
18 Receptacle loads (i.e. modems, laptops)
19 All control panels containing electrical equipment shall be NEMA rated for the location in which they
20 are installed. Cover mounted components, tubing penetration, and conduit penetrations shall be
21 made in a manner consistent with the NEMA rating.
22 All wiring leaving the panel shall be separated by classification; i.e., Class 1 circuits shall not be run
23 with Class 2 circuits, etc. Segregation shall be maintained inside the panel to the fullest extent
24 possible. Where low voltage wires carrying low level ac and dc signals cross wires containing power
25 and high-level ac signals, the wires shall cross at a 90° angle.
26 Control panels shall be shop fabricated and tested prior to installation in the field. The Engineer shall
27 be given the opportunity to witness the testing of the panels.
28 Panel Location
29 Each control panel is to be located for convenient servicing.

30
31 **FIELD SERVICES**
32 Prepare and start logic control system under provisions of this section.
33
34 Start-up and functional test of control systems. Allow enough time for start-up and functional test prior to
35 placing control systems in permanent operation.
36
37 Provide the capability for off-site monitoring at control contractor's local or main office. At a minimum, off site
38 facility shall be capable of system diagnostics and software download.
39
40 Provide Owner's representative with spare parts list. Identify equipment critical to maintaining the integrity of
41 the operating system.
42
43 **TRAINING**
44 Provide Application Engineer to instruct Owner in operation of systems and equipment.
45
46 Provide system operator's training to include, but not limited to, such items as the following:
47 Modification of data displays
48 Alarm and status descriptors
49 Requesting data
50 Execution of commands
51 Request of logs
52
53 Provide on-site training above as required for up to 12 hours in 2 to 4 hour sessions (travel hours are included
54 as part of the 12 hours) as part of this contract.
55 **END OF SECTION**