

# Open System Specification Framework

**A Framework for Specifying Open Control  
Systems with LONWORKS<sup>®</sup> Technology.**

**Version 4.0**

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**\*\*\*PLEASE REVIEW THE DOCUMENTS ‘*INTRODUCTION TO LONWORKS TECHNOLOGY*’ AND ‘*OPEN SYSTEM DESIGN GUIDE*’, PRIOR TO DEVELOPING A SPECIFICATION BASED ON THIS FRAMEWORK.**

## ARTICLE 1. USING THE SPECIFICATION FRAMEWORK

This document provides the framework of a comprehensive specification for a building automation system. It has been prepared to assist the Building Construction Industry in designing and implementing open Building Automation Systems using ANSI/EIA standard 709.1, also known as the LonTalk protocol. 'LONWORKS technology' refers to the hardware and software components that use or support this protocol.

This system specification framework leverages the product interoperability standards defined by the LonMark® Association as well as the industry standard LonWorks Network Services (LNS) technologies. For additional information concerning the LonMark association reference the LonMark website at [www.LonMark.org](http://www.LonMark.org).

### FRAMEWORK USAGE

The Institute of Electrical and Electronics Engineers (IEEE) has defined an 'open system' in the following way:

*"An open system provides capabilities that enable properly implemented applications to run on a variety of platforms from multiple vendors, interoperate with other applications, and present a consistent style of interaction with the user"*

Within this document, the term 'open system' refers to a control system that meets this definition. An open system based on LonWorks technology exhibits the following specific characteristics:

- 1) Uses de facto industry standard Network Services for design, installation, and commissioning.
- 2) Contains LonMark compliant products from multiple manufacturers.
- 3) Uses gateways only for interaction with legacy systems or as required by codes
- 4) Stresses horizontal functionality over proprietary vertical subsystem implementation

Systems that have the characteristics enumerated above provide the following benefits:

- 1) Empowers the end user to select best in class products.
- 2) Ensures competitive bidding of multiple phases or additions to a system.
- 3) Maximizes use of media infrastructure and minimize wiring needs.
- 4) Leverages multi-service networking of control, data, and telecommunication information

Thus, the combination of open products and standard services defined within this document enables multiple integrators to easily construct a complete open system solution with products from multiple manufacturers. An open LonWorks system is one in which products may be competitively bid as can add, move, and change to the system itself. In order to meet these goals, this specification framework calls for the incorporation of products manufactured to meet LonMark guidelines wherever possible and network tools based upon LonWorks Networks Services(LNS) for design, installation, and commissioning. True interoperability and an open, holistic building control system can be obtained by following the recommendations within this framework.

The scope of this specification framework addresses control products in every aspect of building control. The specification assumes a Network Integrator will be charged with providing a comprehensive BAS system. This includes products and control systems furnished and installed by mechanical and electrical trade contractors, as well as products provided by general system integrators. The intent is to ensure the trade contractor that traditionally furnishes and installs the customary equipment can utilize conventional, competitive purchasing practices to secure these components.

This specification framework is not meant to be a complete or comprehensive specification. Several of the sections are meant to serve as a 'menu' of items that may or may not be used on any given project. The owner, specifier, or consultant should freely edit the materials within this framework in order to

tailor it to meet project needs. The core of the framework is intended to define the minimal technical requirements for implementing a truly open system based upon LONWORKS technology. Sequences of Operation, controller quantity and type, and physical hardware input/outputs are not provided in this document. It is preferable that these items as well as temperature control diagrams, wiring schematics and logical diagrams be developed for each individual project. It is recommended that sequences of operation should reside with the corresponding system diagrams to clearly identify the performance and installation requirements.

This specification framework encompasses those integration services required to install a complete system. The numbering scheme used is intentionally generic to allow ease of integration into standard specifications anywhere in the world. It should be noted, however, that the terms, units of measure, and codes mentioned herein are based upon North American standards. If AIA standards are used, the network integration content provided within this framework is applicable for use in Division 17. Portions of this material can also be used for the mechanical control system content normally found in Division 15, and the electrical control system content (Lighting, Access, Fire) normally found in Division 16.

The generic architectures described in this document provide the infrastructure on which a BAS installation with multiple sub-systems (HVAC controls, lighting, access, fire alarm, power monitoring, etc.) may be installed. The installation may be by a single integrator or by separate trade contractors who provide open systems that are integrated into a common building-wide open system by the Network Integrator. The physical installation of the communication media and control product power supplies can be provided by the Network Integrator or by an independent electrical contractor. The contractor designated to perform this work should be clearly defined in the plans and specifications, particularly in Section 2.

Portions of this specification framework that must be completed by the consulting control engineer/consultant in order to properly specify a given system are in bold and preceded by the symbol ‘\*\*\*’. This allows the items to be easily found and addressed in both print and electronic versions of this document by searching for this symbol. Once the proper changes or additions are made to the document for a project, these comments should be deleted. This section of the document, Section 0, should also be removed prior to distribution of the specification for bidding purposes.

### ***Introduction to LONWORKS Technology and the Open System Design Guide***

‘*Introduction to LONWORKS Technology*’ and ‘*The Open System Design Guide*’ are provided as a sister documents to this specification framework. They are intended to provide a broad context of information for engineers/consultants prior to using the specification framework for an actual project. It is highly recommended that the user review this information prior to producing a complete specification from the framework.

## 1.01 ABBREVIATIONS, DEFINITIONS, AND CODES

### 1.1 DESCRIPTION

This Section outlines the various technical terms and abbreviations used throughout this specification. In addition, the appropriate local and national codes for the project BAS installation are indicated.

### 1.2 ABBREVIATIONS

AGC	Application Generic Controller
ASC	Application Specific Controller
BAS	Building Automation System
CAC	Custom Application Controller
COS	Change of State
CPU	Central Processing Unit
DDC	Direct Digital Controller
Dpr.	Damper
DRF	Device Resource File
Dwgs.	Drawings
EP	Electric-pneumatic
FPB	Fan powered VAV box
FPM	Feet per minute.
FACP	Fire Alarm Control Panel
FCC	Fire Command Center
FMS	Fire Management System
GPM	Gallons per minute
GUI	Graphical User Interface
HVAC	Heating, Ventilating and Air Conditioning
I/O	Input/Output
LNS	LONWORKS Network Services
NSS	Network Services Server
NSI	Network Services Interface
NI	NETWORK INTEGRATOR
NFPA	National Fire Protection Association
OI	Operator interface
OS	Operating System
PE	Pneumatic-electric
PRV	Pressure Reducing Valve
PSI (g)	Pounds per square inch (gauge)
RAM	Random Access Memory
SCADA	Supervisory Control and Data Acquisition System
SCP	System Control Panel
UL	Underwriters' Laboratory
VAV	Variable Air Volume
VCS	Voice Communication System
WC	Water Column
XIF	External Interface File

### 1.3 DEFINITIONS

- A. Alarm: Notification of an abnormal condition.
- B. Algorithm: A logical procedure for solving a recurring problem.
- C. Analog: Handling or display of continuously variable parameters signal value such as temperature, current, velocity, etc..
- D. Application Generic Controller (AGC): A networked device or node that contains a complete, configurable application that is generic in nature and suited for various control tasks. The device manufacturer produces this application. The manufacturer exposes a high number of network variables and configuration properties on the device to allow the specific use of the device to be configured with network tools.
- E. Application Specific Controller (ASC): A networked device or node that contains a complete, configurable application that is specific to a particular task. This application is normally produced by the device manufacturer and contains a number of configuration parameters that may be adjusted by network tools.
- F. Binary: Two-position I/O data such as open or closed contacts or operating status of on or off.
- G. Bridge: A device that routes messages or isolates message traffic to a particular segment, sub-net or domain of the same physical communication media.
- H. Building Automation System (BAS). The complete facility control system comprised of mechanical system automation, security control, lighting control, automatic temperature control, etc., as defined in the contract documents. The BAS is built upon a single network infrastructure based upon LONWORKS Network Services. This infrastructure may include field wiring, LAN wiring, routers, bridges, raceways, and gateways as required connecting non-interoperable subsystems and devices.
- I. Channel: A physical media serving a number of nodes. All nodes on any given channel 'hear' messages produced by other nodes on the channel. The network configuration and node application program determines whether or not a device responds to the messages.
- J. Contractor: Where referenced in Sections 15905 through 15935 "contractor" is control contractor.
- K. Custom Application Controller (CAC): Programmable control product that incorporates solid-state components based upon the Neuron<sup>®</sup> chip to perform control loops or functions. The application in the controller is custom software produced by the integrator specifically for the project. These applications shall conform to the LONMARK<sup>®</sup> functional profiles and interoperability standards. Complete documentation including object diagrams and external interface files must be submitted to owner when such devices are used.
- L. Control Wiring: Includes conduit, wire and wiring devices to install complete control systems including motor control circuits, interlocks, thermostats, EP and IP switches and like devices. Includes all wiring from Intelligent Devices and Controllers to all sensors and points defined in the input/output summary shown on the drawings or specified herein and required to execute the sequence of operation.
- M. Deadband: A temperature range over which no heating or cooling energy is supplied, such as 72-78 ° F, i.e. as opposed to single point changeover or overlap.
- N. Device Resource File:
- O. Distributed Control: A system whereby control processing is decentralized and independent of a central computer.
- P. Diagnostic Program: Machine-executable instructions used to detect and isolate system and component malfunctions.
- Q. Domain: A domain is logical collection of nodes on one or more channels. Communications can only take place among nodes configured in a common domain; therefore, a domain forms a virtual network. Multiple domains can occupy the same channels, so domains may be used
- R. Gateway: A device that contains an I/O software driver to translate data from a particular format to that conforming to another format. In this specification, the

- standard protocol is LonTalk<sup>®</sup>. All gateways will translate to/from other formats to the LonTalk protocol.
- S. GUI: Graphical User Interface is a graphical subset of operator interfaces.
  - T. Intelligent Devices (ID's): Control products that incorporate solid-state components based around the Neuron chip to perform a dedicated functions (ex: actuators, sensors, switches). Each such device should be submitted with functional profiles based on LONMARK Interoperability Association Standards.
  - U. LONWORKS Technology: The generic technology that supports products that communicate using LonTalk Communication protocol. The technology employs routers, gateways, bridges and multimedia transceivers permitting topology and media independent control solutions.
  - V. Man-Machine Interface (MMI) or Graphical User Interface (GUI): A graphical, object-oriented method by which an operator is capable of communicating with the BAS. Man-machine interfacing allows the operator to manage, command, monitor, and program the system.
  - W. Network: A system of distributed control units that are linked together on a communication bus. A network allows sharing of point information between all control units. Additionally, a network provides central monitoring and control of the entire system from any distributed control unit location.
  - X. Node: An intelligent device attached to the network. Usually falls into one of the following categories; sensor, actuator, ASC, AGC, CAC.
  - Y. Operator Interface: A device combination of hardware and software, (PC, laptop or display terminal) which incorporates the LONWORKS Network Services Interface (NSI), Application Program Interface (API) for remote network client services. The operator interface workstation may connect either to a LonTalk or IP network.
  - Z. Operating System (OS): Software, which controls the execution of computer programs and which provides scheduling, debugging, input/output controls, accounting, compilation, storage assignment, data management, and related services.
  - AA. Peripheral: Input/Output equipment used to communicate to and from the computer and make hard copies of system outputs and magnetic files. Peripherals include CRT, printer, hard drives, disk drives, modems, etc.,
  - BB. Point: Group of data, which corresponds to a hardware input, output, or calculated value.
  - CC. Portable Operator's Terminal (POT): Hand-held or laptop device which allows local and remote access to any SCP.
  - DD. Router: A device that routes or forwards messages destined for a node on another subnet or domain of the control network. The device controls message traffic based on node address and priority. Routers may also serve as communication interfaces between different channel media. (i.e., powerline, twisted pair, Ethernet/TCP/IP, and RF)
  - EE. Segment: A set of channels connected by bridges or repeaters. A node sees every packet from every other node on its segment.
  - FF. Sensor: Device capable of measuring the condition or value of a variable.
  - GG. SCP: A system control panel containing multiple AGC's, ASC's CAC's and Routers for the purpose of controlling a particular system.
  - HH. Software: Programs and routines used to extend the capabilities of computers hardware.
  - II. Subnet: A subnet is a logical collection of up to 127 nodes within a domain. Up to 255 subnets can be defined within a single domain. All nodes in a subnet must be on the same segment. Subnets cannot cross intelligent routers.

## 1.4 CODES AND REGULATIONS

**\*\*\*INSERT APPROPRIATE INFORMATION REGARDING NATIONAL AND LOCAL CODES AND REGULATIONS HERE.**

**END OF SECTION**





## **ARTICLE II. SUMMARY OF WORK**

### **2.1 DESCRIPTION**

- A. This section describes the scope of work for the NETWORK INTEGRATOR on the project. This section also coordinates the responsibilities of the Mechanical (Div. 15) and Electrical trade (Div. 16) contractors pertaining to control products or systems, furnished by each trade, that will be integrated by the NETWORK INTEGRATOR.
- B. The low voltage and communication raceway systems, wiring and termination responsibilities for control products and systems are also identified in this section.

### **2.2 PROJECT SUMMARY**

- A. The BAS will consist of a flat, open architecture that utilizes ANSI/EIA standard 709.1, the LonTalk protocol, as the common communication protocol between all controlled and controlling devices. Where necessary or desired, LonTalk packets may be encapsulated into TCP/IP messages to take advantage of existing infrastructure or to increase network bandwidth. Any such encapsulation of the LonTalk protocol into IP datagrams shall conform to existing LonMark guidelines for such encapsulation.
- B. The BAS is intended to seamlessly connect devices throughout the building regardless of subsystem type, i.e. HVAC, lighting, and security devices should easily coexist on the same network channel. Gateways shall not be used unless specifically authorized by the project engineer. Use of a gateway requires submittal of the documentation detailed in Section 6. It is the intent of this specification that gateways be limited to integrating legacy systems. Gateways used to separate channels of open devices will not be allowed.
- C. The products used in constructing the BAS shall be LONMARK compliant. In those instances in which LONMARK devices are not available, the NETWORK INTEGRATOR shall provide LONWORKS devices with application source code, device resource files, and external interface definitions as described in Section 6. The software tools required to install and commission the device shall be provided for non-LONMARK devices.
- D. The Network Integrator Contractor shall furnish and install a Windows-based, LonWorks-protocol, networked Direct Digital Control (DDC) system for control and monitoring of the building heating, ventilating and air conditioning systems as described in this specification and attached points list
- E. System shall consist of stand-alone Custom Application Controllers (CAC), sensors, automatic valves, actuators, dampers, operating software, approved submittal, operation and maintenance manuals, start-test-check documentation, as-built documents, operator training, installation labor, warranty and all other necessary material and labor to provide a complete and workable system.
- F. Network services for the BAS shall be provided by LONWORKS Network Services (LNS). Proposed network service alternatives must demonstrate industry standardization by documenting an ability to support tools, applications, and products manufactured by no fewer than ten (10) distinct companies in the building control industry. Proposed alternatives will then be field tested with network management tools from at least five (5) distinct manufacturers.
- G. System Monitoring and Supervisory Control shall be provided through the installation of GUI software applications that support either a direct driver to the LNS database or a fast DDE interface. GUI workstations shall provide complete access to any point in the system at any time. Remote Operator interfaces and configuration tools shall be supported by the LNS database in a client-server fashion.

### **2.3 SUBMITTALS**

- A. Comply with submittal section of architectural specification.
- B. Shop Drawings: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, including specific requirements indicated.

1. Control diagrams: Use at least one individual sheet for each major HVAC system.
  - (a) HVAC system flow diagram with sensing, control and interlock devices.
  - (b) Internal control panel layouts, control panel cover layouts, pneumatic connections inside control panels.
  - (c) Internal control panel layouts, control panel cover layouts, electrical connections inside control panels.
  - (d) Ladder-type wiring diagrams showing interlock, monitoring and control wiring to and from equipment provided by Division 15 and Division 16, including control systems equipment.
  - (e) Communications wiring schematic drawings indicating interconnections between ASC's, CAC's, AGC's, OWS's, and other peripherals.
  - (f) Provide a summary points list and software points (regardless of whether or not they appear in Section 15\*\*\*).
  - (g) Flow-chart control sequences.
2. Descriptive data and sequence of operations for operating user and application software, including complete operator's manual and programmer's manual.
3. Point to point and basic function commissioning forms to be used on site for the start, test and check of control components and systems.
  - (a) List of specific personnel who will be involved in the system installation and commissioning.
  - (b) Instrumentation to be used for testing and calibrating during point-to-point and basic function testing.
4. Functional performance test documentation and procedures to be used in commissioning control sequences.
5. Valve, damper actuator, pressure tap and temperature well schedules.
  - (a) List component sizes, mounting orientations, capacities and locations.
  - (b) Provide installation details and specific instructions for three-way valves, mixed air damper actuators, flow sensors, temperature wells and pressure taps.
6. Compressor sizing calculations.
7. Specific locations for 110 VAC power required for control panels
- C. Contract Closeout Submittals: In compliance with Section \*\*\*\*\*.
  1. Operating and Maintenance Manuals, including:
    - (a) Backup software copies including system graphics.
    - (b) Actual control sequence programming with comment line for each programming statement.
    - (c) Shop drawings and product data in Project Record format.
    - (d) One laminated, non-fading, appropriate size, not to exceed 11 inch by 17 inch copy of each air handling system and each major control system (e.g., heating water, chilled water, etc.).
  2. Special warranty conditions, special servicing conditions, and expanded warranty or service contract proposals.
  3. List of recommended spare parts and calibration tools for owner's maintenance staff.

## 2.4 FACTORY CALIBRATIONS AND PRE-INSTALLATION SOFTWARE TESTING

- A. Factory calibration and bench testing are required by the manufacturer and contractor. Contractor to provide certification from the manufacturer that controller, sensor, and

actuator component testing has been completed. Copies of reports shall be made available within one week of request of copy. Contractor to test project specific database software routines and provide a written test report before downloading at the site for start-up – point to point and basic function testing.

## 2.5 START-UP - POINT TO POINT AND BASIC FUNCTION TESTING

- A. Upon completion of component or system installation, the contractor shall initiate comprehensive point-to-point and basic function testing. Factory calibration and bench testing will not be considered acceptable alternates to onsite field-testing.
- B. Start-up/Point to Point Scope
  - 1. Testing all end field devices through proper input/output to graphic and operator interface.
  - 2. Testing must be complete, detailed and documented on approved point-to-point verification forms.
  - 3. All field calibration must be done with high quality instrumentation. Test instrumentation selected for calibrating field devices shall be suitable for application. Instruments shall display current (12-month) NIST traceable calibration sticker. Associated instrument calibration certificates shall be made available within 24 hours of request for copy.
  - 4. Testing and documentation criteria
    - (a) Field device and functionality
      - i. Verify all field devices installed are properly sized or ranged for anticipated operating range. Devices are adjusted for correct position, orientation and full range.
    - (b) Conductor Integrity
      - i. Test all wiring continuity from field devices to correct input/output.
    - (c) Conductor Termination
      - i. Verify all device wire terminations are per submittal package.
      - ii. Verify all input/output wire terminations are correct.
      - iii. Verify field devices communicate to operator interface.
    - (d) Conductor to Output
      - i. Test linear-scaling calibration of every analog output point
    - (e) Alarm Graphics Interlocking
      - i. Verify all alarm signals from device initiation through all required notification components. (Workstation, pager, e-mail, local annunciation, etc.)
    - (f) Device Calibration
      - i. All field devices are to be field calibrated. All thermistor sensors shall be tested for accuracy.
      - ii. Calibration must be done at or close to normal operating conditions.
    - (g) Calibration Criteria
      - i. Space Temperature  $\pm 1^{\circ}\text{F}$
      - ii. Air Temperature – Unitary  $\pm 1^{\circ}\text{F}$
      - iii. Fluid Temperature  $\pm 1^{\circ}\text{F}$
      - iv. Air Flow Rate  $\pm 5\%$
      - v. Liquid Flow Rate  $\pm 5\%$
      - vi. Differential Pressure  $\pm 3\%$
      - vii. Gage Pressure  $\pm 5\%$

viii.	Relative Humidity	± 2%
ix.	CO Monitor	± 5% mid range
x.	CO2 Monitor	± 5% mid range
xi.	Refrigerant Monitor	± 5% at 50 PPM

## 2.6 FUNCTIONAL PERFORMANCE TESTING

- A. A comprehensive functional performance testing shall be performed on every installation or modification to the control system. Contractor shall test and document all logic and control sequence statements for accomplishing each specific control function as detailed in the approved sequence of operation. Contractor shall record each process and corresponding results. Documentation will include names of test personnel and final test dates.

## 2.7 PUNCH LIST AND DEFICIENCY RESOLUTION

- A. Within one business day of deficiency notification, contractor shall resolve or provide written response indicating the earliest possible time and date the deficiency can and will be resolved.
- B. Control deficiencies discovered during commissioning process that result in the need for retest are subject to cost impacts.

## 2.8 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Not less than 5 years experience in the actual production of specified products or functionally equivalent products.
- B. Installer's Qualifications: Firm experienced in installation or application of systems similar in complexity to those required for this Project, plus the following.
  1. Acceptable to or licensed directly by manufacturer.
  2. Not less than 3 years experience with specified systems or functionally equivalent systems for contractor and electrical installations subcontractor, if applicable.
  3. Successfully completed not less than 5 comparable scale projects using specified system or functionally equivalent system for contractor and electrical installations subcontractor, if applicable.

## SCHEDULE

- A. All work shall be in conjunction with applicable construction schedules.

## 2.10 MANPOWER AND SUPPORT

- A. Contractor shall provide adequate, qualified manpower for the purpose of providing a complete control installation.
- B. Contractor shall support all peripheral functions, including equipment start-up, test and balance, commissioning, owner training.

## 2.11 DEMONSTRATIONS

- A. Following completion of entire system commissioning, demonstrate to Architect's and or Mechanical Engineer's satisfaction that control systems function as designed.
- B. Following completion of Owner's training, demonstrate entire system operation to Owner's and Architect's satisfaction.
  1. Demonstrate each menuing function and graphic screen path.
  2. Display each graphic screen at the OWS.
  3. Demonstrate each manual override command at OWS and POT.

4. Demonstrate the ability of the system to communicate remotely. Provide any and all software or system specific hardware (modems, keys, I/O cards) to Service Contractor for the remote monitoring of the control system.

## 2.12 TRAINING

- A. Provide on-site instruction for up to 8 people.

- |   |   |         |
|---|---|---------|
| 1 | Entire system operating fundamentals                | 8 Hours |
| 2 | Entire system operating and maintenance instruction | 2 Hours |
| 3 | Each unique air handling system type                | 8 Hours |

- B. Provide a minimum of (2) additional 2-hour training sessions at owner's request in warranty period (within 1 year).

## 2.13 SCOPE OF WORK

**\*\*\*THE SCOPE OF WORK SHOULD INCLUDE ANY NECESSARY INFORMATION REGARDING SPECIAL CONSIDERATIONS FOR THE FOLLOWING:**

1. **Renovation requirements (if applicable).**
2. **Integration of the BAS with Energy Management, Demand Limiting, Facility Management, or ERP functions.**
3. **Integration requirements with legacy systems or control products.**
4. **Special commissioning requirements.**
5. **Schedule or sequencing provisions based on project construction schedule (particularly important with renovation work).**

- A. The NETWORK INTEGRATOR shall provide network management, start-up, and commissioning for the following products and/or systems specified in this specification as indicated in the Schedule of Responsibilities.

1. Electrical Division:

- (a) Lighting Control Intelligent Devices and Control Units.
- (b) Security System Intelligent Devices and Control Units.
- (c) Fire Management System (Gateway or 'blocking Router' allowed).
- (d) Power Monitoring System Intelligent Devices and Control Units.

- B. Mechanical Division:

1. Air Terminal Device Control Units.
2. Intelligent Valve and Damper Operators.
3. Packaged Air Conditioning Equipment.

- (a) Rooftop Units.
- (b) Heat Pumps.
- (c) Unitary Air Conditioners.
- (d) Fan Coil Units.
- (e) Air Handling Unit.

- C. Packaged Heating and Refrigeration Equipment

1. Boilers, Hot Water Generators, etc.
2. Chillers
3. Packaged Pumping Systems.

- D. Automatic Plumbing Flush Valves.
- E. Domestic Booster Pump Controller.
- F. Variable speed drives

## **2.14 RELATED WORK SPECIFIED OR PROVIDED ELSEWHERE**

### **\*\*\*COORDINATION THIS SECTION WITH OTHER DIVISIONS TO AVOID WORK OMISSIONS AND/OR DUPLICATIONS.**

- A. General Trades Contract provides:
  - 1. Concrete work, including equipment housekeeping pads, inertia blocks, curbs, etc.
  - 2. Base and counter flashing for materials penetrating walls or roofs.

- B. Electrical Division provides:

### **\*\*\*COORDINATE WHICH DIVISION PROVIDES CONTROL POWER WIRING AND CONTROL COMMUNICATION WIRING HERE AND IN SCHEDULE OF RESPONSIBILITIES.**

- 1. Motor controllers and starters other than those included with factory-pre-assembled equipment as specified hereinafter such as air compressors.
- 2. Power wiring for motors and motor controllers.
- 3. Line Voltage Control wiring (120 VAC and greater) for the following:
- 4. Control and electrical wiring for condenser water treatment system.
- 5. Final 120-VAC power connection from a local junction box.
- 6. Control wiring for solenoid valves, water meters and remote conductivity sensors.
- 7. Lighting control units and intelligent devices.
- 8. Security control units and intelligent devices.
- 9. Fire management system.
- 10. Power monitoring system control units and intelligent devices.

- C. Mechanical Division provides:

### **\*\*\*VALVES AND DAMPERS MUST BE SCHEDULED AND SIZED FOR MECHANICAL CONTRACTOR TO FURNISH AND INSTALL. CHOOSE DIVISION M SCOPE FROM FOLLOWING SUGGESTIONS.**

- 1. Air terminal units
- 2. Installation of automatic control valves and dampers
- 3. Packaged air conditioning equipment with Control Units.
  - (a) Heat pumps.
  - (b) Rooftop units.
  - (c) Unitary air conditioners.
  - (d) Fan coil units.
  - (e) Air Handling Units.
- 4. Packaged Refrigeration and Heating equipment with Control Units.
  - (a) Boilers, Hot Water Generators, etc.
  - (b) Chillers.
  - (c) Packaged Pumping Systems.
  - (d) Variable Frequency Drives

## **ELECTRICAL WORK PROVIDED BY THIS DIVISION**

**\*\*\*THIS SECTION MUST BE CLOSELY COORDINATED WITH ELECTRICAL CONTRACT TO ENSURE THAT THE ELECTRICAL INSTALLATION WORK IS COVERED BY EITHER DIVISION E OR NI.**

- A. Provide terminations for twisted pair communication media between all nodes, routers, gateways, and bridges.
- B. Provide raceway systems and wiring for inputs and outputs from control units to the I/O devices, including:
  - 1. EMT conduit.
  - 2. I/O wiring.
  - 3. E/P transducers.
  - 4. Pneumatic solenoids and relays.
  - 5. Local control panels (for installation of transducers, solenoids and relays).

#### **SCHEDULE OF RESPONSIBILITIES**

- A. The following schedule identifies the responsible Division for the installation of the building automation system. This schedule should be used as a general guide. The General Contractor is the central authority governing the total responsibility of all trade contractors. Therefore, deviations and clarifications of this schedule are permitted provided the General Contractor assumes responsibility to coordinate the trade contractors different than as indicated herein. If deviations or clarifications to this schedule are implemented, submit a record copy to the Architect.

**\*\*\*CONSULTANT/SPECIFIER MUST EDIT FOLLOWING SCHEDULE TO INDICATE CONTRACTOR RESPONSIBLE FOR GIVEN SCOPE OF WORK.**

Item		Furnish By	Install By	Power By	Control Wiring By
1.	Equipment Motors	M	M	E	□
2.	Magnetic Motor Starters:				
	a. Automatically controlled, with or without HOA switches.	E	E	E	NI
	b. Manually controlled.	E	E	E	□
	c. Manually controlled, and which are furnished as part of factory wired equipment	M	M	E	E
	d. Special duty type (part winding, multi-speed, etc.)	M	See Note 1.	E	See Note 1.
	e. Adjustable frequency drives with manual bypass.	NI	NI	E	NI See Note 2.
	f. Domestic booster pump. Motor Controls	M	M	E	NI
5.	General equipment disconnect switches, thermal overload switches, manual operating switches.	E	E	E	□
6.	Sprinkler system water flow and tamper switches.	M	M	E	□
7.	Outside fire alarm horn and light (at Siamese connection).	M	M	E	□
8.	Line voltage contactors.	E	E	E	NI
9.	Control relay transformers (other than starters).	NI	NI	E	NI
10.	Main fuel oil tank alarms (high and low level) and remote indicating lights.	M	M	NI	NI
11.	Day tank fuel oil alarms (high and low level) and remote indicating lights.	E	E	E	NI
12.	Line voltage control items such as line voltage thermostats not connected to control panel systems.	M	E	E	E
13.	Loose controls and instruments furnished as part of the packaged mechanical equipment or required for operation such as valves, float controls, relays, sensors, etc.	M	M	M	M



Item	Furnish By	Install By	Power By	Control Wiring By
14. Control and Instrumentation panels	NI	NI	E	NI
15. Automatic control valves, automatic dampers and damper operators, solenoid valves, insertion temperature and pressure sensors.	NI	M	E	NI
17. Duct type fire and smoke detectors, including relays for fan shut down.	NI	NI	E	NI
18. Contactors for cooling tower basin heaters.	M	M	E	M
19. Mechanical piping heat tracing (including relays, contactors, thermostats, etc.)	M	M	E	M
20. Emergency power off (EPO) shut down pushbutton(s) (break glass station) and controls.	M	M	M	M
21. Control interlock wiring or software bindings between chillers, pumps and cooling towers, fans and air handling units and other miscellaneous mechanical equipment.	NI	NI	E	NI
22. Electric radiant heating panels unducted electric unit heaters and cabinet heaters, and electric baseboard radiation.	E	E	E	E
23. Airflow control devices with transmitter.	NI	M	E	NI
24. Air terminal devices (i.e., VAV and fan powered boxes).	M	M	E	NI
25. Intelligent Devices and Control Units provided with packaged mechanical equipment such as:	M	M	E	NI
Valve and damper operators. Heat pumps, AC units. Fan Coil Units. Air Terminal Units. Boilers, chillers.				
26. Intelligent Devices and Control Units provided with electrical systems such as:	E	E	E	NI
Occupancy/motion sensors. Lighting Control Panels. Switches and Dimmers. Switch Multiplexing Control Units. Door Entry Control Units.				

Item		Furnish By	Install By	Power By	Control Wiring By
27.	Gateways for protocol conversion with a non-LONWORKS based system	NI	NI	NI	NI
28.	Routers, Bridges and Repeaters.	NI	NI	NI	NI
<u>Abbreviations</u>					
Furnish.		Furnished by			
Install.		Installed by			
Power		Power Wiring Connection, Low and Medium Voltage			
NI		NETWORK INTEGRATOR			
M		Mechanical Contractor			
E		Electrical Contractor			

Notes to Schedule of Responsibilities:

1. Magnetic motor starters (special duty type) shall be set in place under electrical division except when part of factory wired equipment, in which case set in place under mechanical division.
2. Where a remote motor disconnect is required in addition to the one provided integral to an Variable Frequency Drive (VFD), the NI Contractor shall provide the necessary control interlock between the disconnects.
3. The NETWORK INTEGRATOR shall inform the Mechanical Contractor and the Electrical Contractor of the additional capacity required of control power transformers.
4. The Mechanical Contractor shall refer to the electrical specifications and plans for all power and control wiring and shall advise the Architect of any discrepancies prior to bidding. The NETWORK INTEGRATOR shall be responsible for all control wiring as outlined, whether called for by the mechanical or electrical drawings and specifications.

**END OF SECTION**

## ARTICLE III. INTEGRATION REQUIREMENTS

### 3.1 INTEGRATOR QUALIFICATIONS

- A. The NETWORK INTEGRATOR shall have an office that is staffed with engineers trained in Integrating Interoperable Systems and technicians fully capable of providing LONWORKS instruction and routine emergency maintenance service on all system components.
- B. NETWORK INTEGRATOR shall have in house capabilities to provide control strategies for whole building control. This includes HVAC, lighting, access, and security applications.
- C. NETWORK INTEGRATOR shall be a company willing and able to supply product from a variety of manufacturers. Companies owned by product manufacturers will be considered only if they submit a letter of intent with their bid stating their intention to provide an open system as defined herein that is comprised of products from multiple vendors.
- D. NETWORK INTEGRATOR must possess a LonManager<sup>®</sup> Protocol Analyzer or equivalent product and be familiar with the capabilities and use of this equipment.
- E. NETWORK INTEGRATOR shall have a service facility, staffed with qualified service personnel, capable of providing instructions and routine emergency maintenance service for networked control systems.

### 3.2 DOCUMENTATION OF INTEGRATOR QUALIFICATIONS

- A. Submit resumes with the bid proposal indicating passing certificates for Echelon Corporation's INTEGRATING INTEROPERABLE SYSTEMS COURSE, or proof of equivalent training. Such proof must include summary of coursework and indicate both written and laboratory requirements of alternate training.
- B. Submit a list of similar projects, which have Building Automation Systems installed by the NETWORK INTEGRATOR. These projects must be on-line and functional such that the Owners/Users representative can observe the BAS in full operation.
- C. Submit an organizational diagram indicating the key technical staff proposed for the project including, Project Manager, Superintendent, Electrical Foreman, etc.
- D. Submit qualification checklist with bid proposal indicating certified network Integrators, network architecture, network management tools, LonMark products, and LonMark profiles to be used on this project.

### 3.3 ACCEPTABLE INTEGRATORS

\*\*\*LIST ACCEPTABLE CONTRACTORS HERE.

- A. Acceptable Integrators qualified to furnish and install the BAS work as specified herein are as follows:
  - 1. \_\_\_\_\_  
-----
  - 2. \_\_\_\_\_  
-----
  - 3. \_\_\_\_\_  
-----

### 3.4 ACCEPTABLE PRODUCTS

- A. NETWORK INTEGRATOR shall furnish and install LONWORKS products manufactured by multiple manufacturers as required. Materials and equipment shall be catalogued products and shall be manufacturer's latest standard design that complies with the specification requirements.
- B. All microprocessor based control products(excluding workstations) used shall include a Neuron chip or other processor with complete implementation of the LonTalk protocol

stack. Devices that use the Neuron Chip as a communications co-processor shall be distinctly identified in submittals with the heading 'MIP Device' and are subject to additional submittal requirements and testing to ensure interoperability.

- C. Individual products shall conform whenever possible to the LONMARK Interoperability Standards. If products are not certified by the LONMARK organization, product submittals must include the application source code, external interface file, resource files and complete documentation regarding all network variables and configuration properties supported by the device.
- D. Control devices connected to the LONWORKS control network should be readily replaceable with devices from multiple manufacturers.

### **3.5 EXECUTION OF THE WORK**

- A. Provide related items and work indicated on the Mechanical, Electrical and Building Automation System Drawings and items and work called for in this Section of the Specifications. This includes all incidentals, equipment, services, hoisting, scaffolding, supports, tools, supervision, labor, consumable items, fees, licenses, etc., necessary to provide complete systems. Perform start up and commissioning on each control product, subsystem, and system to provide fully operable systems in accordance with the specified functional performance.
- B. Provide and install devices, relays, switches, thermostats, sensors, dampers, conduit, wiring, and tubing to provide a complete temperature regulation and control operation system. All wiring shall be run according to building lines (no angles) and concealed where possible. All wiring shall be installed in a workmanlike manner as outlined in the National Electrical Code. Electrical inspection sign off does not remove Owner's right to refuse acceptance of the electrical installation for incorrect or noncompliance with NEC. Installation must comply with all local control system electrical codes.
- C. Comply with applicable codes and ordinances. If any conflict arises between these Specification and Drawings or codes and ordinances, immediately notify the Architect. Do not deviate from the Drawings and Specifications nor install any work, which may be in conflict with codes and ordinances until the conflict is resolved and the solution accepted by the Architect.
- D. Contractor is responsible for providing a complete and operational system as called out in the description of operation and/or in the points list summary and/or the mechanical/electrical drawings for this project. Any item referenced in one part of the system documentation but not listed elsewhere shall be covered under contractors pricing (i.e. damper called out in sequence but not indicated on drawings).
- E. In addition to the requirements for submittals stated in the General Conditions of the project specifications provide additional submittals as specified in this Division of Work.
- F. The Mechanical, Electrical and Building Automation System Drawings show the general arrangement of the respective systems. Follow these drawings, as closely as actual building construction and the work of other trades will permit. Provide devices, fittings, and accessories, which may be required but not shown on the Drawings or specified herein. Investigate conditions affecting the work and arrange the work accordingly. Provide modifications and accessories as may be required to meet such conditions.

### **3.6 COORDINATION OF WORK**

- A. Examine and compare the Building Automation System (BAS) Specifications and Drawings with the Specifications and Drawings of the other trades and report any discrepancies between them to the Architect. Obtain the Architect's written instructions for changes necessary in the BAS work. Install and coordinate the BAS work in cooperation with the other trades installing interrelated work. All changes required in the work of the Contractor, caused by noncompliance with the specifications, shall be made at contractor's expense.
- B. Other trades will provide certain LONMARK compliant products and systems. Examine the Contract Documents to ascertain these requirements.

- C. Carefully check space requirements with other trades to insure that all material can be installed in the allotted spaces, including above finished suspended ceilings.
- D. Wherever work interconnects with work of other trades, coordinate with other trades to insure that all trades have the information necessary so that they may properly install all the necessary connections and equipment.
- E. Coordinate, protect and schedule work with other trades in accordance with the construction sequence.
- F. Install the BAS work to permit removal (without damage to other parts) of other parts requiring periodic replacement or maintenance.
- G. Make certain that all materials selected directly or selected by suppliers conform to the requirements of the Specifications. Transmittal of such Specification information to persons manufacturing and supplying materials to the project, and rigid adherence thereto, is the Contractor's responsibility.

### **3.7 INSTALLATION**

#### **A. Wiring classifications:**

- 1. Wiring greater than 30 volts: Conductors and cable enclosed in raceway.
- 2. Exposed, unfinished locations, such as mechanical rooms and below accessible raised flooring: Conductors and cable plenum rated (where local code or officials allow).
- 3. Concealed, unfinished locations, such as ceiling plenums, ceiling spaces, shafts, crawl spaces, tunnels: Conductors enclosed in raceway and cable enclosed in raceway or plenum-rated cable (where local code or officials allow).
- 4. Control panels: route all wiring and cabling via cable trough and wrap with flexible connection at the door hinge.
- 4. For industrial/manufacturing space provide, at a minimum, conduit protection of all control system wiring up to 20 feet from floor. All control wiring overhead must be routed with other conduit, duct, or structural beams.

#### **B. Control Power source provided by Division 16:**

- 1. 120 VAC emergency power or UPS power circuits where required.
- 2. Power wiring to Division 15 equipment is by Division 16.
- 3. Control contractor to provide list/location of all control panels requiring 120 VAC power. 120 VAC dedicated circuits shall be requested for all SCP's associated with emergency generator system or UPS power backup control sequences or monitoring.
- 5. Request 120 VAC UPS dedicated circuits from Division 16 where required for emergency operation or when available.

- C. Provide necessary miscellaneous transformers, relays, enclosures, terminal strips, switches, pilot lights, etc.
- D. Where raceway is required for wiring carrying direct current, that raceway shall not contain wiring carrying alternating current unless 30 volts or less and all wires are shielded.
- E. Coordinate equipment control and power connections with Division 15 and Division 16.

### **3.8 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A. Products shall be provided with complete documentation. This shall include diagrams of all LONMARK objects supported by the product as well as relevant technical specifications. Undocumented products must be tagged and accepted by Architect or Engineer prior to installation. Do not install undocumented products without such acceptance.
- B. All products and materials shall be new, clean, and free of defects, damage and corrosion.

- C. Ship and store products and materials in a manner that will protect them from damage, weather, and entry of debris. Do not install damaged items, but take immediate steps to obtain replacement or repair.

### **3.9 PRELIMINARY START UP**

- A. Should the Owner request that any portion of the systems or equipment be operated prior to the final completion and acceptance of the work, the NETWORK INTEGRATOR shall consent. Such operation shall be under the direct supervision of the NI, but the expense thereof shall be borne by the Owner. The cost for the temporary operation (Utilities, Operating, Labor, etc.) shall be separate from any money paid towards the Contract sum. Such preliminary operation, or payment thereof, shall not be construed as an acceptance of any of the work.
- B. If final completion of the work is not completed in accordance with the approved construction schedule, and operation of the equipment is required to meet Owner's lease commitments as defined in the construction schedule, the cost of temporary operation of the equipment shall be the NETWORK INTEGRATOR'S.
- C. The warrantee period for work and systems of this project shall commence after the Owner's final acceptance.

### **3.10 EQUIPMENT PROTECTION AND CLEANING**

- A. The NETWORK INTEGRATOR shall provide adequate means for and shall fully protect all finish parts of the materials and equipment against damage during the progress of the work until final acceptance.
- B. Equipment and accessories shall be thoroughly cleaned of cement, plaster, and other materials; grease and oil spots shall be removed with cleaning solvent and surfaces carefully wiped.

### **3.11 WARRANTY**

**\*\*\*EDIT WARRANTY TO SUIT JOB CONDITIONS AND PRODUCTS.**

- A. The BAS shall be free from defects in workmanship and material under normal use and service. If within 12 months from the date of substantial completion the installed equipment is found to be defective in operation, workmanship or materials, replace, repair or adjust the defect at no cost to the Owner, provided that the defect is reported within seven (7) days of failure occurrence. Service shall be provided within 48 hours upon notice from the Owner.
- B. The warrantee shall extend to material that is furnished and installed by the NETWORK INTEGRATOR. Materials furnished by, but not installed by, the NETWORK INTEGRATOR shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation. NETWORK INTEGRATOR shall assume cost to trouble shoot and diagnose network communication problems resulting from products provided by other trades.
- C. Corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks.

### **3.12 SPARE PARTS:**

**\*\*\*EDIT SPARE PARTS LISTS TO SUIT JOB CONDITIONS AND PRODUCTS. INCLUDE REQUIREMENTS FOR PRODUCTS FURNISHED IN DIVISIONS M AND E.**

- A. Spare Parts: Provide the following products used on this project as spare parts. Deliver the spare parts to the Owner's representative prior to final completion.

**END OF SECTION**







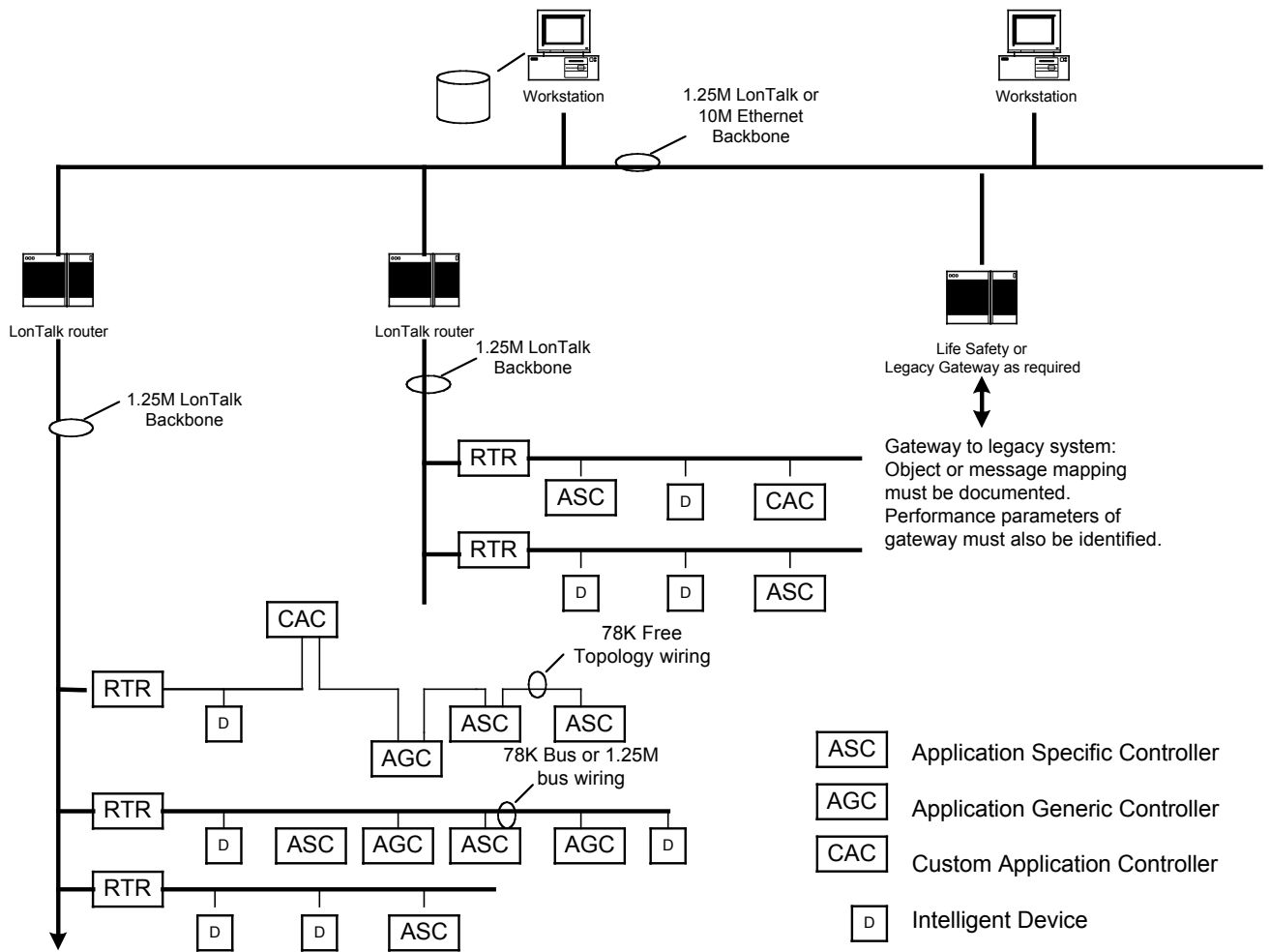
## **ARTICLE IV. NETWORK DESIGN AND MANAGEMENT**

### **4.1 DESCRIPTION**

- A. This section describes the features and requirements of the hardware and software necessary to manage OPEN SYSTEM Networks.
- B. Responsibilities of the NETWORK INTEGRATOR relative to Network Management are also defined herein.

**\*\*\*THIS SECTION DESCRIBES A MEDIUM TO LARGE BAS INSTALLATION WHERE THE NETWORK MANAGEMENT DATABASE IS LOCATED IN A DEDICATED SERVER ON THE BAS LOCAL AREA NETWORK. FOR SMALL TO MEDIUM PROJECTS, THE DATABASE MAY BE REMOVED FROM THE JOBSITE ACCORDING TO YOUR PROJECT DESIGN AND OPERATIONAL REQUIREMENTS.**

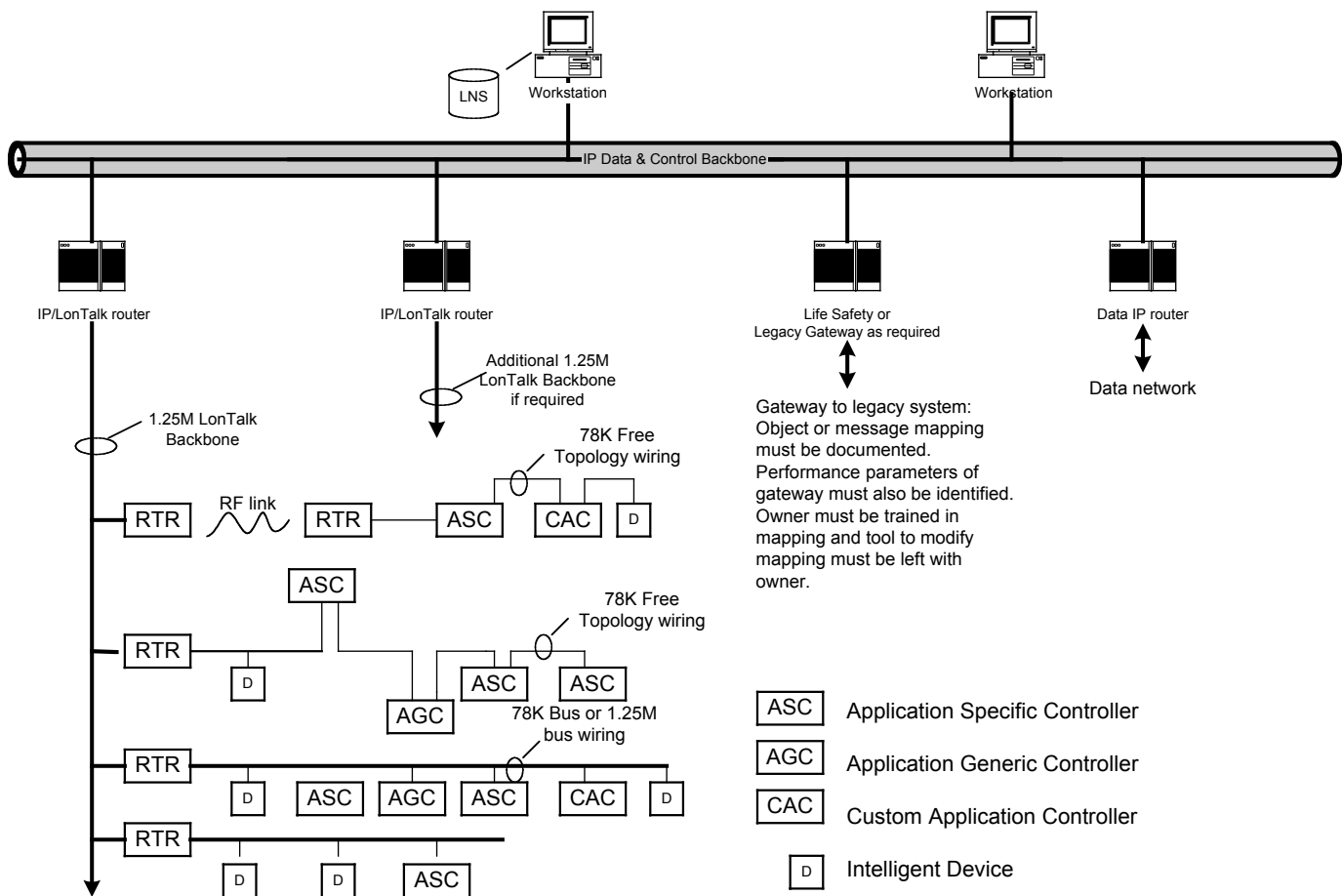
**\*\*\*THE BAS ARCHITECTURES DEPICTED IN THE FIGURES IN THIS SECTION ARE FOR EXAMPLE ONLY AND REPRESENT A BAS USED FOR CONTROL OF MULTIPLE SYSTEMS WITHIN A BUILDING. SELECT EITHER FIGURE 1,2, OR 3 AS APPROPRIATE FOR DESIGN. EDIT DIAGRAMS AS REQUIRED TO REFLECT THE PROJECT SPECIFIC REQUIREMENTS.**



**Figure No. 1: OPEN SYSTEM Architecture – all LON TALK communication**

**\*\*\* IMPLEMENTATION NOTES:**

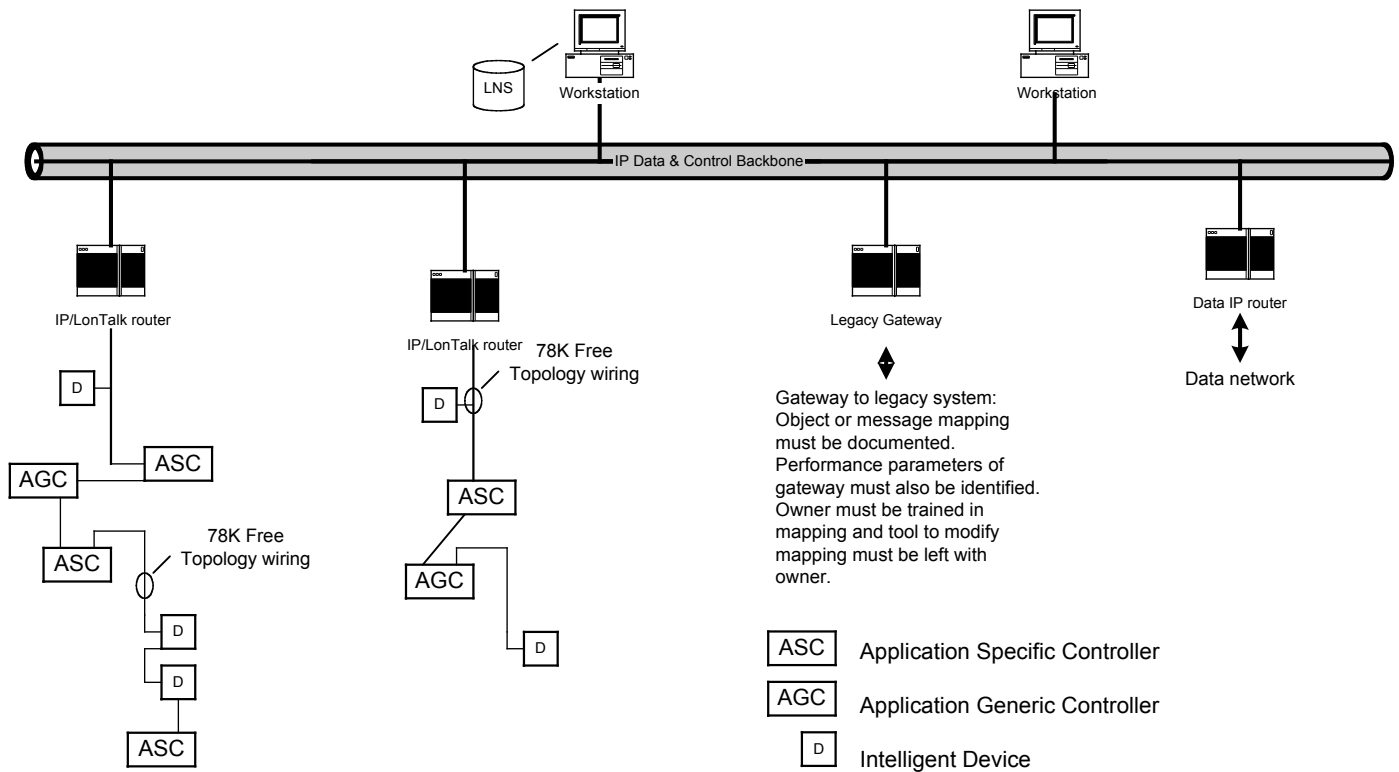
**IN THIS APPROACH, A 1.25M LON TALK BACKBONE IS USED TO CONNECT 78K CONTROL CHANNELS TO EACH OTHER. EACH CHANNEL MAY REPRESENT A ROOM, A FLOOR, OR A WING DEPENDING ON THE NUMBER OF DEVICES AND DISTANCES INVOLVED. THIS APPROACH IS USED WHEN THE CONTROL SYSTEM IS TO REMAIN INDEPENDENT OF THE STANDARD DATA NETWORK. NOTE THAT THE WORKSTATIONS MIGHT ALSO CONTAIN ETHERNET CARDS AND INTERFACE TO A COMMON IP DATA NETWORK.**



**Figure No. 2: OPEN SYSTEM Architecture – LONTALK using IP**

**\*\*\* IMPLEMENTATION NOTES:**

**IN THIS APPROACH, A 1.25M LONTALK BACKBONE IS USED TO CONNECT 78K FREE TOPOLOGY CONTROL CHANNELS TO EACH OTHER. AN IP NETWORK THEN CONNECTS THE 1.25M LONTALK CHANNELS. EACH 1.25M CHANNEL MAY REPRESENT A ROOM, A FLOOR, OR A WING DEPENDING ON THE NUMBER OF DEVICES AND DISTANCES INVOLVED. THIS APPROACH IS USED TO TAKE ADVANTAGE OF IP INFRASTRUCTURE. IN THIS APPROACH, A LIMITED NUMBER OF LONTALK TO IP ROUTERS CONNECTED TO THE IP BACKBONE IN THE BUILDING. NOTE THAT IT IS STILL POSSIBLE TO INSTALL INDEPENDENT NETWORK INTERFACE CARDS (NIC) INTO EACH WORKSTATION AND PROVIDE THE WIRING FOR A SEPARATE IP DATA NETWORK.**



**Figure No. 3: OPEN SYSTEM Architecture – LONTALK integrated over IP**

**\*\*\*IMPLEMENTATION NOTES:**

**IN THIS ARCHITECTURE, IP CHANNELS RUN THROUGHOUT THE BUILDING AND ARE AVAILABLE IN OR NEAR THE MECHANICAL ROOMS AND/OR THE CENTRAL PLANT. THE CONTROL AND DATA NETWORKS ARE COMPLETELY INTEGRATED. IP TO LONTALK ROUTERS ARE USED TO SEAMLESSLY CONNECT MULTIPLE 78K FREE TOPOLOGY CHANNELS.**

## 4.2 SYSTEM COMPONENTS

- A. The NETWORK INTEGRATOR shall furnish network management hardware and applications and logically install BAS Control Devices. Network management shall include the following services: device installation, device configuration, device diagnostics, field programming, device maintenance, network variable binding, channel traffic analysis, message routing and repeating and protocol conversion.
- B. Network Management Application shall be based on a graphical object-oriented software system that provides an intuitive interface for network design and installation. Network Management Application shall be compatible with Windows 2000, Windows NT 4.0, Windows 98, and Windows 95 operating systems. This software must allow for creation of multiple logical subsystems within the overall control strategy. The LONWORKS Network Management shall include all software modules necessary to provide complete network management, installation and maintenance.
- C. Network Management Tools and Software Applications shall support multiple service tools in a client/server network fashion. Application Programs shall be based on the latest version of the LONWORKS Network Services Operating System.
- D. Network Management Application shall support a standard for 'plug-in' applets. The network management application should act as a 'director' program that provides a published interface allowing other manufacturers to construct plug-in applets to run within the director application.
- E. Network Management Application shall be capable of scanning network to discover devices, upload a portion of the overall network configuration stored in each device, and deduce from these portions the overall network database. The Network Management Application shall be capable of recovering attributes and configuration properties directly from individual devices on the control network.
- F. Network Management Application shall be capable of merging separate network databases into a common database, so that separate independent network designs each having an independent server can be commissioned independently and be later merged into a single network.
- G. Network Management Application shall be capable of batch design and commissioning operations for speed of deployment.
- H. Acceptable Network Management Application Programs:
  - 1. LonMaker™ for Windows (Latest Released Version)
  - 2. Other \_\_\_\_\_

## 4.3 SYSTEM PERFORMANCE PARAMETERS

- A. The system shall update a graphic with 25 dynamic points with all current data within 5 seconds.
- B. The maximum time between the command of a output point by the operator and the reaction by the device shall be less than 2 seconds.
- C. The maximum time between when a node object goes into alarm and when it is annunciated at the workstation shall not exceed 30 seconds.

**UPDATE THESE WITH CURRENT LNS 3 AND VNI SPECS. GET THESE FROM ALEX CHERVET**

## 4.4 ENGINEER ALARM AND MESSAGE REPORTING SYSTEM

- A. General
  - 1. Provide an auto dial modem and telephony software to manage alarm and message reporting from the User Interface workstation to operating personnel.
- B. Auto-Dial Modem

1. The auto-dial modem shall support both touch-tone and rotary dial, digital and analog phone lines and standard 56K baud phone line communications.
2. The auto-dial modem shall reside in the User Interface Workstation. The auto-dial software shall be resident on the User Interface hard drive and in an active state of operation any time the User Interface Workstation is activated (on).
3. The auto-dial modem shall place calls as follows:
  - (a) Retry same number a programmable number of times in fixed intervals.
  - (b) Retry successive numbers arranged in sequence by priority at fixed intervals a finite number of times.
  - (c) Display on screen notice that placing call that call has been made or that call cannot be made.
4. The auto-dial modem shall maintain an error/failure count as follows:
  - (a) Calls attempted
  - (b) Calls responded with ring no answer
  - (c) Calls responded as busy
  - (d) Calls successfully completed
  - (e) Call prematurely terminated
5. The auto-dial modem software shall have password protection for User Interface security purposes.
6. The auto-dial modem will initiate a call to the remote CRT/Printer, located in the security office or as designated by the Owner in response to alarms and other user defined events.
7. The auto-dial modem shall have a minimum capacity of 10-25 digit phone numbers stored in memory. The auto-dialer shall retry a number a fixed number of times. If no connection is made, it then sequences to a second number in a cascade fashion, and continues to attempt to complete the connection until successful.

C. Pager and Voice Messages:

1. The telephone numbers programmed into the telephony software shall be defined as either pager or voice messages.
2. For pagers an alphanumeric code shall be displayed on the receiving pager in accordance with the pager limitations. The software shall support 24 character pagers and be able to transmit BAS alarm and status messages within this field limitation.
3. The pager messages shall be user defined and editable via a dialog box used to define messages.
4. Voice messages shall be able to be computer generated and user definable. The pre-recorder computer messages shall have computer generated voice date and time stamps inserted into message to alerted the recipient of the exact time the alarm or status message was generated.

#### 4.5 QUALITY ASSURANCE

- A. Utilize LONWORKS Network Management Application Programs that have been developed by LONWORKS Product Developers who have been trained in the use of LONWORKS Network Services (LNS). Qualified firms shall be engaged in development of LONWORKS Network Management Tools and have products that have been in satisfactory use in similar service for not less than one (1) year.

#### 4.6 LONWORKS NETWORK SERVICES (LNS)

- A. General: Provide a 32 bit, object oriented multiple client server based Network Management application program(s) utilizing the latest LONWORKS Network Services (LNS) API.
- B. Network Management clients shall be capable of performing the following network services by accessing the appropriate network node databases from the Network Services Server:
  - 1. Device / node installation.
  - 2. Device / node configuration.
  - 3. Device / node diagnostics.
  - 4. Device / node maintenance.
  - 5. Field programming.
  - 6. Network variable binding.
  - 7. Network variable browsing.
  - 8. Network Recovery
  - 9. Network merge functions
  - 10. Graphical user interface.
  - 11. System diagnostics
- C. The Network Management Network Services Server Application (NSS) shall reside on the BAS Local Area Network (server, Operator Interface Workstation). This application shall support multiple clients on the Local Area Network and by using Operator Interface devices anywhere on the BAS control network.

#### **4.7 FIXED OPERATOR WORKSTATION INTERFACE DEVICE (OWS)**

##### **\*\*\* DETERMINE NEED FOR OPERATOR INTERFACES HERE**

- A. Provide (**XXX**) Fixed Operator Workstation Interface Device(s). The computer device, a combination of hardware and software will allow the operating engineer to access the LONWORKS Control Network., and view or change all, or portions of the system database as well as print system reports. The OWS shall incorporate the following items as a minimum requirement.
  - 1. Network Interface Driver.
  - 2. 10/100 PCI Ethernet Network Interface adapter.
  - 3. Operating System Software.
  - 4. LONWORKS Network Interface API to function as a NSI terminal.
  - 5. 19" SVGA flat screen monitor with 1600 by 1200 resolution, .25 dot pitch, and 72Hz refresh.
  - 6. PCLTA 20 LonWorks Network Interface Adaptor.
  - 7. Enhanced Style Keyboard.
  - 8. 256 MB RAM, minimum
  - 9. Pentium 600 MHz PIII processor ( or faster )
  - 10. One 20 GB hard drive.
  - 11. One 56Kbaud modem
  - 12. Bus or USB mouse
  - 13. One spare each serial and LPT port.
- B. The Fixed Operator Interface Device shall be capable of supporting all LONWORKS network transceiver types (FTT, PL, RF, Ethernet/TCP\IP, etc.) and provide for the ability to serve multiple control channels through Lonworks Networks Interface for the appropriate network type.
- C. The Fixed Operator Interface Device shall include a factory-installed Operating System to include Microsoft Windows 2000 Professional, or latest release.

- D. The Fixed Operator Workstation Interface Device shall include factory-installed client software to include Microsoft Office Professional (Including Internet Explorer).
- E. The Fixed Operator Workstation Interface Device shall include the Network Management Application operating in a client/server fashion to the NSS (Network Services Server).
- F. The Fixed Operators Workstation Interface Device shall be equipped with manufacturer specific program and configuration applications or “plug-ins” for all devices on the control network.

#### **4.8 PORTABLE OPERATOR’S TERMINAL (POT)**

- A. Provide (XXX) Portable Operator Terminal Interface Device(s), for use by the operating engineer to remotely access the LONWORKS Control Network. The POT shall incorporate the following items as a minimum requirement.
  - 1. PCMCIA LonWorks Network Interface (Free Topology Transceiver, FTT-78).
  - 2. PCMCIA or Cad Bus 10/100 Ethernet Network Interface card.
  - 3. Operating System Software.
  - 4. LONWORKS Network Interface API to function as a NSI terminal.
  - 5. User Display Screen (13.3 inch XGA Active matrix.).
  - 6. 128 MB RAM, minimum
  - 7. Pentium 400 MHz PII processor (or greater)
  - 8. One 4.8GB hard drive.
  - 9. One 56Kbaud modem
  - 10. Touch pad mouse
- C. Portable Operator Terminal Interface Device shall be capable of supporting all LONWORKS network transceiver types present on the control network (FTT, PL, RF, Ethernet/TCP/IP, etc.) and provide for the ability to serve multiple control channels by utilizing a PCMCIA network card for the appropriate network type.
- D. The Portable Operator Interface Device shall have a factory-installed Operating System to include Microsoft Windows 2000 Professional, or latest release.
- E. The Portable Operator Interface Device shall have factory-installed client software to include Microsoft Office Professional (Including Internet Explorer.)
- F. The Portable Operator Interface Device shall be capable of Client Server operations to NSS via FTT10, or Ethernet TCP/IP LonWorks channels.
- G. The POT shall be equipped with manufacturer specific program and configuration applications or “plug-ins” for all devices on the control network.

#### **4.9 PRINTERS**

- A. Provide (XXX) printer(s) at the OWS location(s) for recording alarms, operator transactions, and reports, meeting the following minimum requirements:
  - 1. 16 pages per minute print speed.
  - 2. 1200 dpi laser
- B. Provide (XXX) color printer(s) locate as directed by the owner representative during construction for printing of graphics and other screen displays. Printer shall include as a minimum:
  - 1. 8 color pages per minute.
  - 2. Ink jet technology.

#### **4.8 MMI WEB SERVER FUNCTIONALITY**



- A. The MMI Web Server shall be certified under the Cisco NetWorks Program.
- B. The MMI Web Server shall be capable of displaying web pages in HTML without the need for downloaded software applets, or controls.
- C. The MMI Web Server shall be capable of reading and writing to network variables from web pages using a standard web browser such as Netscape 4.0 (or higher), and Microsoft Internet Explorer 4.0 (or higher)
- D. The MMI Web Server shall be capable of supporting non-Windows users with a JAVA enabled platform.
- E. The MMI Web Server shall use a standard HTML and FTP to upload HTML pages.

#### **4.8 MAN MACHINE INTERFACE WEB SERVER (MMI) HARDWARE CAPABILITIES**

- A. The MMI Web Server shall be capable of Rack, Desktop, or Panel mounting and be equipped with front mounted status LED lights for Network traffic and power verification.
- B. The MMI Web Server shall contain a 32 bit RISC processors to allow for high packet throughput in control networks.
- C. The MMI Web Server shall be capable of transceivers for Free Topology (Type 1), Twisted Pair (Type 2), and Ethernet.

#### **4.9 PROTOCOL ANALYZER**

##### **\*\*\*DETERMINE NEED FOR ON-SITE PROTOCOL ANALYZER HERE**

- A. The software package shall include the following three tools for network analysis and monitoring with the listed diagnostics functions:
  - 1. Protocol Analyzer Tool.
    - (a) Packet Display Contents: Packet number, packet size, time stamp, packet attributes, service type, transaction number, source address, destination address, network variable, message class and message code.
    - (b) Packet Display Attributes: Priority, alternate path, authentication and response.
    - (c) Configurable Display Attributes: Visible packet fields, font name and size and column widths.
    - (d) Packet Log Options: Log size and fixed size or circular log.
    - (e) Packet Match Options: Node name, network variable name, message code and transactions.
    - (f) Packet Type Receive Filter Options: Ack, acked, acked/reminder, challenge, reply, request, request/reminder, response, unacked, unacked repeat and unknown.
    - (g) Packet Source Node Receive Filter Options: Node name, neuron ID and subnet/node ID.
    - (h) Packet Destination Node Receive Filter Options: Node name, neuron ID, subnet/node ID, group ID and broadcast address.
    - (i) Packet Source or Destination Receive Filter Options: Network variable name and message code name.
    - (j) Detected Error Conditions: CRC error, time-out error, packet too short, packet too long, preamble too short and preamble too long.
  - 2. Traffic Analysis Tool.
    - (a) Collective Options: Cumulative or snapshot.
    - (b) Summary Data: Start time, update time, elapsed time, total packets received, average packet size, average packets per second, maximum packets per second, bandwidth utilization, packet counts, network error counts, total errors and error rate.

- (c) Packet Count Categories: Ack, acked, acked/reminder, challenge, reply, request, request/reminder, response, unacked, and unacked repeat and unknown.
  - (d) Network Error Count Categories: CRC errors, time-out error, packet too long, preamble too short, preamble too long and packets lost.
  - (e) Data Available via DDE: All summary data.
3. Network Diagnostics Tool.
- (a) Commands: Ping, proxy ping, status (test), proxy status, reset, off-line, on-line, wink and clear error log, reset cause and statistics.
  - (b) Test Data: Software version, most recent error, and most recent reset cause and node statistics.
  - (c) Command Options: Interval or number of operations.
  - (d) Node Statistics: Transaction errors, transaction time-outs, receive transactions full, lost messages, missed messages, number of packets transmitted at layer 3, number of packets received at layer 3, number of packets received at layer 4, retries, backlog overflow, late acknowledgments and collisions.

#### **4.10 PLCA POWER LINE COMMUNICATIONS ANALYZER**

**\*\*\*DETERMINE NEED AND FUTURE INTENT OF USING POWER LINES FOR POSSIBLE NETWORKING MEDIA. DELETE THIS SECTION IF UNUSED.**

##### **A. General:**

1. Provide one Power Line Communications Analyzer for testing the suitability of power mains for use as a transmission network.
2. The analyzer shall automate power line performance analysis and speed the process of isolating marginal circuits. The analyzer will also aid the system integrator to identify the phase of the power circuit and to isolate potential interface sources and network limits.

#### **4.10 CHANNEL CAPACITY PERFORMANCE SOFTWARE UTILITY**

##### **A. General:**

1. Provide a Channel Capacity Performance Utility 'PERF' to estimate peak and sustained channel capacity during the network design period and estimate how many nodes can be connected to a single channel. The input parameters are as follows:
  - (a) Transceiver type.
  - (b) Number of priority slots configured on the channel.
  - (c) The input clock frequency of the slowest Neuron Chip on the channel.
  - (d) The worst case oscillator accuracy on the channel.
  - (e) The worst case time for the oscillator to start up from power up.
  - (f) The average packet size in bits.
  - (g) The bit rate on the channel.
  - (h) Whether the transceiver supports collision detection.
  - (i) The minimum channel backlog.
  - (j) The maximum number of packets that the channel can carry.
  - (k) The percentage of the maximum number of packets that the channel can carry on a sustained basis.

#### **4.11 NETWORK MANAGEMENT DATABASE SERVER**

- ##### **A. Provide one dedicated computer to allow easy network system commissioning and access. The computer shall serve as the network database server during the installation and commissioning of network subsystems or channels that are commissioned prior to the BAS LAN being commissioned.**

B. The network management database server shall include the following minimum specifications:

1. CPU: Processor; highest clockspeed / MIPS (Million Instructions Per Second) available on 'Wintel' standard.
2. 10/100 PCI Ethernet Network Interface adapter.
3. RAM: 64Mb expandable.
4. Hard Drive: Removable 10 Gb.
5. Floppy Drive: 3.5-inch high density (1.44 Mb).
6. Floppy and hard drive controller cards.
7. CD ROM Drive: 40x-speed.
8. (2) RS-232 serial ports.
9. 11-inch active matrix display.

**\*\*\*EDIT THIS EQUIPMENT LIST TO REFLECT LATEST EQUIPMENT AVAILABLE TO SUIT THE NEEDS OF THE INSTALLATION FOR PRESENT AND FUTURE NEEDS.**

#### **4.13 LONWORKS NETWORK MANAGEMENT EXECUTION**

- A. The Systems Integrator shall after all hardware (devices / nodes and wiring) has been installed provide all necessary device installation, device configuration, device diagnostics, network variable binding and systems diagnostics.
- B. The System Integrator shall utilize PERF (Performance Calculator) or similar performance calculation software application to simulate all network traffic in advance to minimize field troubleshooting prior to installation of network control devices. Additional routers and/or repeaters shall be installed by contractor to maintain acceptable network traffic.
- C. The System Integrator shall utilize a protocol analyzer tool to monitor network traffic on all installed control channels for a minimum of 24 hours per channel. Compare actual traffic data versus predicted channel traffic determined using the channel capacity performance utility. Reconfigure nodes and/or install additional routers as necessary to maintain traffic to at least 50% of channel bandwidth capacity.
- D. The System Integrator shall utilize a Power Line Communications Analyzer to establish the integrity of proposed power lines to serve as communication channels for the BAS. If a power load is identified as a major interference source, and no other power circuits exist that can serve the communication requirements, notify the electrical contractor and Architect of the field condition for resolution.

#### **4.14 HARDWARE INSTALLATION**

- A. All node installation and network installation procedures shall be under the direct supervision of a qualified LONWORKS NETWORK INTEGRATOR.
- B. Install and bind nodes in accordance with the manufacturer's written installation instructions.

#### **4.15 START-UP AND TESTING**

- A. Manufacturer's technical representative shall start-up, test, and set all parameters as directed by the system integrator. Manufacturer's technical representative shall demonstrate compliance with all requirements herein. All damaged or malfunctioning software shall be replaced.
  1. Final adjustments shall be performed by specially trained personnel in the direct employ of the manufacturer of the LONWORKS Network Management Tool.
  2. LonMaker Protocol Analyzer shall be utilized to observe, analyze and diagnose the behavior of the installed network.
  3. System commissioning of large systems and associated subsystems (Typical Network Subsystem) shall be accomplished by utilizing multiple Network Services Interface

(NSI) commissioning tools to allow multiple field technicians to work on specific channels.

4. The Graphic User Interface (GUI) and all subsequent graphic monitoring screens shall be operational and demonstrated before final acceptance.

**End of Section**

## **ARTICLE V. LONWORKS MATERIALS AND METHODS**

**\*\*\*THIS SECTION INCLUDES MANY ELECTRONIC INPUT-OUTPUT DEVICES, VALVES, AND DAMPERS THAT MAY BE COVERED IN ANOTHER DIVISION OF THE SPECIFICATIONS. DELETE THESE ARTICLES IF A SEPARATE CONTRACTOR IS SPECIFIED FOR THESE TASKS.**

### **5.1 DESCRIPTION**

- A. This section defines the Basic Materials and Methods used in the installation of the LONWORKS Control Network used in the Building Automation System.

### **5.2 SUMMARY OF WORK**

**\*\*\*EDIT THIS SECTION TO INCLUDE THE LONMARK PRODUCTS PROVIDED BY THE DIVISION NETWORK INTEGRATOR. ALSO INCLUDE HARDWARE REQUIRED FOR THE NI TO INTEGRATE OTHER PRODUCTS AND/OR SUBSYSTEMS PROVIDE BY OTHER DIVISIONS.**

- A. Provide LONMARK compliant products that communicate on multiple channels to meet the functional specifications of this Division and the dedicated product functional specifications and profiles specified in other Sections or Divisions of this Specification.
- B. Provide LonTalk routers as required to combine different communication channels onto a common field bus backbone as depicted on project drawings, i.e. Open System Architecture.
- C. Provide Application Specific Controllers (ASC), Application Generic Controllers (AGC), and Custom Application Controllers (CAC) as herein specified and as indicated on the BAS drawings.

**\*\*\*THE ELECTRICAL INSTALLATION OF THE CONTROL CHANNELS (RACEWAY, IF REQUIRED) WIRING, CONTROL UNITS AND INTELLIGENT DEVICES WIRING TERMINATIONS, AND NODE POWER SUPPLY WIRING CAN BE DESIGNED AND INCLUDED IN THE ELECTRICAL DRAWINGS FOR INSTALLATION BY A GENERAL PROJECT ELECTRICAL CONTRACTOR. SELECT EITHER AS APPROPRIATE FOR THE PROJECT.**

- D. Provide wire, raceway systems, backboxes, 24 DC and/or 24 AC power supplies and final connections to nodes provided by this Division and the following ASC's, AGC's and CAC's as provided by other Divisions.
  - 1. Intelligent Air Terminal Device Controllers (i.e., VAV, Dual Duct, FPB, etc.).
  - 2. Intelligent Occupancy Sensors.
  - 3. Intelligent Damper Operators.
  - 4. Intelligent Valve Operators.
  - 5. Packaged Air Handling Units.
  - 6. Packaged Unitary Air Conditioning Units (i.e., Roof Top Units, Heat Pumps, Condensing Units, etc.).
  - 7. Other HVAC Equipment (Chillers, Steam Generators etc.).
  - 8. Packaged lighting control and power panels.
  - 9. Power Monitoring Control Units.
  - 10. Security System Control Units.
  - 11. Access Control.
  - 12. Fire Alarm System Control Units.
  - 13. Vertical Transportation Control Units.

14. Additional Intelligent Devices and Control Units outlined herein or on the Mechanical and Electrical Drawings.

- E. Low voltage wiring and communication media (where indicated) for all project Devices are specified in the Electrical Division Construction Documents. Coordinate final connection requirements for all project devices with the Division E Installer. Submit wiring connection diagrams to the Division E Installer after receipt of approved product submittals from the Architect.

### **5.3 QUALITY ASSURANCE**

- A. Comply with LONMARK Interoperability Association, Interoperability Guidelines for all products. Utilize published functional profiles for all product network message and configuration parameters. Where published profiles do not exist, utilize draft profile standards or submit a proposed draft as part of the submittals required in Section 6. All drafts shall also be submitted simultaneously to the LONMARK Interoperability Association and a copy of such transmittal submitted to the Architect
- B. All products shall conform to the Interoperability requirements outlined in the LONMARK Interoperability Association Guidelines or be submitted clearly marked as non-compliant. All products shall be certified to be LONMARK compliant prior to delivery of submittals to the Architect for review.
- C. Utilize Standard Configuration Parameter Types (SCPT's) for all product configuration parameters. Do not use network variables for this purpose. If User Defined Configuration Parameters (UCPT's) are used, provide resource files to allow installation of device by 3<sup>rd</sup> party tools.

### **5.4 SUBMITTALS**

#### **A. General:**

1. Submit the following according to Section 6 "Submittals".
  - (a) Product data on all components used to meet the requirements of the specifications such as enclosures, network transceivers, XIF documentation, configuration parameter options, mounting details, power supplies, etc. Product documentation shall display the LONMARK logo-indicating conformance to the LONMARK Interoperability Standards.
  - (b) Software documentation regarding the proposed PC operating system, third party utilities and application programs, and the proposed custom application program for the Supervisory Control Units.
  - (c) Logical and physical diagrams for each channel indicating each node (CU's and ID's), node address (domain, subnet and group), channel type and router specifications. Submit performance calculations for each channel.
  - (d) Electrical low voltage power wiring schematic indicating voltage drop calculations, wire size, node power consumption, maximum full load circuit amperage.
  - (e) Submit functional temperature control diagrams for each mechanical system served by the BAS. Indicate and Tag each input/output served by each Control Unit or Intelligent Device.
  - (f) Submit Neuron C code proposed for each PCU. Include any graphical objects linked in a logical circuit diagram by programming tool.
2. Submit operating and maintenance manuals in accordance with applicable section of specification.

### **5.5 APPLICATION SPECIFIC CONTROLLER (ASC)**

#### **A. General Requirements**

1. Application Specific Controllers shall be equipped with either a 3120 or a 3150<sup>®</sup> Neuron microprocessor controller, a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. The ASC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a 2 week period. Include an integral calendar with automatic leap year compensation.
4. ASC packaging shall be such that complete installation and check-out of field wiring can be performed prior to the installation of electronic boards. Make all board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement.

#### B. ASC Interface Software

1. General: ASC shall be configured, not programmed, via PC based interface software. This software shall be a program applet, which runs within the network management tool chosen. Intimate knowledge of operation of ASC shall not be required for configuration.
2. ASC shall provide a selection of control applications performable through configuration of the device. Download of new application should not be required for one of these applications

#### C. ASC Device Software

1. General: An ASC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
2. O.S. software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage network communications, and scan inputs and outputs. O.S. shall also contain built in diagnostics.

### 5.6 APPLICATION GENERIC CONTROLLER (AGC)

#### A. General Requirements

1. Application Generic Controllers shall be equipped with either a 3120 or a 3150<sup>®</sup> Neuron microprocessor controller, a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. The AGC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a 2 week period. Include an integral calendar with automatic leap year compensation.
4. AGC packaging shall be such that complete installation and check-out of field wiring can be performed prior to the installation of electronic boards. Make all board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. Network and power wiring shall allow for 'pass-thru' of signal when electronic boards are removed.

#### B. AGC Interface Software

1. General: AGC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of AGC shall not be required for configuration.
2. AGC shall provide a selection of control function blocks that can be configured. Download of new applications from network management tool shall be possible, but not required.

## 5.7 CUSTOM APPLICATION CONTROLLER (CAC)

### A. General Requirements

1. Custom Application Controllers shall be equipped with either a 3120 or a 3150<sup>®</sup> Neuron microprocessor controller, a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.
3. The CAC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a 2 week period. Include an integral calendar with automatic leap year compensation.
4. CAC packaging shall be such that complete installation and check-out of field wiring can be performed prior to the installation of electronic boards. Make all board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. The complete CAC including accessory devices such as relay, transducers, power supplies, etc., shall be factory-mounted, wired and housed in a NEMA 1 enclosure or as required by the location and local code requirements.
5. Equip CAC's with diagnostic indicators for the following:
  - (a) Transmit.
  - (b) Receive.
  - (c) Power up test.
  - (d) Power up fail.
  - (e) Power up test okay.
  - (f) Bus error.

### B. CAC Software

1. General: A CAC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
2. O.S. software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage CAC to OI communications, and scan inputs and outputs. O.S. shall also contain built in diagnostics.
3. Input/Output Point Processing Software shall include:
  - (a) Continuous update of input and output values and conditions. All connected points are to be updated at a minimum of one-second intervals.
  - (b) Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32 bit floating point format. Both the maximum and minimum values sensed for each analog input are to be retained in memory. It shall be possible to input subsets of standard sensor ranges to the A/D converter and assign gains to match the full scale 32 bit conversion to achieve high accuracy readout.



- (c) A reasonability check on all analog inputs against the previously read value and discard those values falling outside pre-programmed reasonability limits.
  - (d) Assignment of proper engineering units and status condition identifiers to all analog and digital input and outputs.
  - (e) Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and actual alarm) to an input or to assign a set of floating limits (alarm follows a reset schedule or control point) to the input. Each alarm shall be assigned a unique differential to prevent a point from oscillating into and out of alarm. Alarm comparisons shall be made each scan cycle.
  - (f) Debounce of digital inputs to prevent nuisance alarms. Debounce timing shall be adjustable from two seconds to two minutes in one-second increments.
5. Alarm Lockouts
- (a) Alarm lockout software shall be provided to prevent nuisance alarms. on initial start-up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period is to be programmable on a per point basis from 0 to 90 minutes in one-minute increments.
  - (b) A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when true alarm is dependent on the condition of an associated point. Hard lockout points and lockout initiators are to be operator programmable.
  - (c) Design the power supply to accommodate the power requirements of all components (or nodes) connected, plus 50%.
6. Run Time Totalization or Point Trending:
- a. Run time shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Run time counts shall be resident in non-volatile memory and have CU resident run time limits assignable through the operator's terminal.
  - b. Totalized run time or trended data shall be batch downloaded using FTP to the SCU on a daily or weekly basis. Trended data shall reside on the SCADA database server. The automatic update of this data shall be determined by the SCADA and facility management application requirements.
7. Transition Counting: A transition counter shall be provided to accumulate the number of times a device has been cycled on or off. Counter is to be non-volatile and be capable of accumulating 600,000 switching cycles. Limits shall be assignable to counts to provide maintenance alarm printouts.
8. Custom DDC Control Loops
- (a) Custom DDC programs are to be provided to meet the control strategies as called for in the sequence of operation sections of these specifications. Each CU shall have residential in its memory and available to the programs a full library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences:
    - i. Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning): The adaptive control algorithm shall be used on control loops, as indicated in I/O summary, where the controlled medium flow rate is variable (such as VAV units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored

record of the system dynamics so that on system shutdown and restart, the learning process starts from where it left off and not from ground zero. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.

- ii. All DDC setpoints, gains and time constants associated with DDC programs shall be available to the operator for display and modification via the SCU operator interface, 1 portable operator's terminal and SCADA workstation.
- iii. The execution interval of each DDC loop shall be adjustable from 2 to 120 seconds in one-second increments.
- iv. DDC control programs shall include an assignment of initialization values to all outputs to assure that controlled devices assume a fail-safe position on initial system start-up.

## **5.8 LONWORKS ROUTERS, BRIDGES, REPEATERS AND TRANSCEIVERS**

### **A. Routers, Bridges and Repeaters**

1. Equip each router and bridge with a network transceiver on each network port (inbound and outbound) as dictated by the network type (Type 1 - FTT, Type 2 - TP, Type 3 - PL, Type 4 - LP, Type 5 - RF, Ethernet).
2. The network router shall be designed to route messages from a segment, sub-net, or domain in full duplex communication mode.
3. Routers and bridges shall utilize LonTalk protocol transport, network, session layers to transparently route messages bound for a node address in another sub-net or domain.
4. Routers, bridges and repeaters shall be fully programmable and permit a systems integrator to define message traffic, destination, and other network management functions utilizing LONWORKS technology, NetMaker and Net Profiler installation tools through the LonManager Software package or other LonManager API based Network Management tool.
6. Routers, bridges, and repeaters shall be capable of Rack, DIN rail, or panel mounting and be equipped with status LED lights for Network traffic and power.
7. Provide a minimum of (2) Neuron 3150 processors for use as the network router communication controller for all power line, twisted pair and RF routers.
8. ANSI/EIA 709.1 (LonTalk) Ethernet Routers shall have 32 bit RISC processors to allow for high packet throughput in control networks.
9. ANSI/EIA 709.1 (LonTalk) Ethernet Routers shall be capable of installation utilizing LonWorks Installation tools, and supported by Echelon's LNS Network Services architecture.
10. ANSI/EIA 709.1 (LonTalk) Ethernet Routers shall support standard internetworking protocols: TCP/IP, UDP, DHCP, SNMP, (MIB II), ICMP, SNTP, TOS, MD5, HTTP, and FTP.
11. ANSI/EIA 709.1 (LonTalk) Ethernet Routers shall support standard internetworking protocols: TCP/IP, UDP, DHCP, SNMP, (MIB II), ICMP, SNTP, TOS, MD5, HTTP, and FTP.

### **B. Transceivers:**

1. Type 1 Network Transceiver, Free Topology, Twisted Pair: Provide a transformer isolated, twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:
  - (a) Meets LONMARK Interoperability Association Standards.
  - (b) Differential Manchester encoded signaling for polarity insensitive network wiring.
  - (c) Transformer isolated for common mode rejection.
  - (d) 78kbs network bit rate up to distances of 2000m.

- (e) Free topology supports star, home run, multidrop and loop wiring topologies.
  - (f) Complies with FCC and VDE requirements.
  - (g) UL recognized component.
2. Type 2 Network Transceiver, Twisted Pair: Provide a transformer isolated twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:
- (a) Meets LONMARK interoperability standards.
  - (b) Differential Manchester encoded signaling for polarity insensitive network wiring.
  - (c) Transformer isolation for common mode rejection.
  - (d) 1.25mbs network bit rate up to distances of 1000 meters.
  - (e) Unspotted construction.
  - (f) Less than 1 mA power consumption with +5VDC input voltage.
  - (g) FCC and VDE Level B requirements compliance.
  - (h) UL recognized component.
3. Type 3 Network Transceiver, Power Line:
- (a) Provide a direct sequence, spread spectrum power line transceiver, which is equipped with the following signal processing and error correction capabilities to provide robust and error free communications.
  - (b) Forward Error Correction (FEC) to enable the system to read and reconstruct corrupted packets without sacrificing throughput. The FEC shall require only six percent overhead for error correction.
  - (c) Automatic sensitivity adjustment algorithm that dynamically changes the receiver sensitivity based on noise characteristics.
  - (d) Over sampling correlation filter and adaptive data recovery algorithm to synchronize instantaneously to incoming packets.
  - (e) Tri-state power amplifier/filter combination to provide a powerful output signal with a minimum number of components.
  - (f) The transceiver shall be able to operate using the controller power supply and coupling circuit. Provide the following general features as a minimum:
    - i. Packaged in a rugged, potted module.
    - ii. Programmable clock output (1.25, 2.5, 5 or 10 Mhz).
    - iii. 10kps network transmission rate.
    - iv. Packet detect output to drive a status indicator LED.
    - v. -20 to +85°C operating temperature range.
    - vi. UL recognized component.
4. Type 4 Network Transceiver, Link Power: Provide a twisted pair transceiver that utilizes the twisted pair communication media to provide power for the LONWORKS Controller(s). The transceiver shall meet the following specifications:
- (a) Free single-in-line package (SIP) construction.
  - (b) Send both network data and power on a twisted wire pair.
  - (c) Meets LONWORKS interoperability standard.
  - (d) Differential Manchester encoded signaling for polarity insensitive network wiring.
  - (e) 78kps network bit rate up to distances of 320 meters.
  - (f) Supports star, home run, multidrop, and loop wiring.
  - (g) Supplies +5VDC @ 100 mA maximum for node power.
  - (h) Compliance with FCC and VDE requirements.
  - (i) UL recognized component.

5. Type 5 Network Transceiver, Radio Frequency: Provide a direct sequence, spread spectrum RF transceiver that meets the following specifications:
  - (a) 100 meter open field range.
  - (b) Wireless communications extends network between buildings and to vehicles and portable devices.
  - (c) FCC type certifiable, 48 MHZ.
  - (d) Low-cost miniature circuit board, SMT components.
  - (e) Carrier detect output to drive a status indicator LED.
  - (f) +7 to +15VDC input voltage.
  - (g) -20 to +60°C operating temperature range.

## 5.9 ELECTRONIC INPUT/OUTPUT DEVICES

### A. Temperature Sensors and Transmitters

1. Provide sensors and transmitters required as outlined in the input/output summary and sequence of operation, and as required to achieve the specified accuracy as specified herein.
2. Temperature transmitters shall be equipped with individual zero and span adjustments. The zero and span adjustments shall be non-interactive to permit calibration without iterative operations. Provide a loop test signal to aid in sensor calibration.
3. Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored. Transmitters shall be equipped with a linearization circuit to compensate for non-linearities of the sensor and bridge and provide a true linear output signal.
4. Temperature sensors shall be of the resistance type and shall be either three-wire 100 ohm platinum RTD, or two-wire 1000 ohm platinum RTD.
5. Thermistors are acceptable provided the mathematical relationship of a thermistor with respect to resistance and temperature with the thermistor fitting constraints is contained with the CU operating software and the listed accuracy's can be obtained. Submit proof of the software mathematical equation and thermistor manufacturer fitting constants used in the thermistor mathematical/expressions. Thermistors shall be of the Thermistor (NTC) Type with a minimum of 100 ohm/°F. resistance change versus temperature to insure good resolution and accuracy. Thermistors shall be certified to be stable  $\pm 0.24^{\circ}\text{F}$ . over 5 years and  $\pm 0.36^{\circ}\text{F}$ . accurate and free from drift for 5 years.
6. CU operating software shall be equipped with a self-calibrating feature for temperature sensors.
7. The following accuracy's are required and include errors associated with the sensor, lead wire and A to D conversion.

<u>Point Type</u>	<u>Accuracy</u>
Outside Air	5°F.
Chilled Water	5°F.
Room Temperature	.00°F.
Hot Water/Steam	.75°F.
Duct Temperature	.50°F.
Sensors Used in Energy Water (BTU) or Process Calculations	1°F.

8. Sensors used in BTU or process calculations shall be accurate to  $\pm 0.10^{\circ}\text{F}$ . over the process temperature range. Submit a manufacturer's calibration report indicating that the calibration certification is traceable to the National Bureau of Standards (NBS) Calibration Report Nos. 209527/222173.

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

B. Thermowells

1. When thermowells are required, the sensor and well shall be supplied as a complete assembly including well head and greenfield fitting.
2. Thermowells shall be pressure rated and constructed in accordance with the system working pressure
3. Thermowells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
4. Thermowells shall be constructed of the following materials:
  - (a) Chilled and Hot Water; brass.
  - (b) Condenser Water and Steam; 316 stainless steel.
  - (c) Brine (salt solutions): marine grade stainless steel.

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

C. Outside Air Sensors

1. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
2. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.
3. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

D. Duct Type Sensors

1. Duct mount sensors shall mount in a hand box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A neoprene grommet (sealtite fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
2. Duct sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. Duct sensors probe shall be constructed of 304 stainless steel.
3. For outdoor air duct applications, use a weatherproof mounting box with weatherproof cover and gasket.

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

E. Averaging Duct Type Sensors

1. For ductwork greater any dimension than 48 inches and/or where air temperature stratification exists, utilize an averaging sensor with multiple sensing points. The averaging sensor shall be a 304 stainless steel tube with holes extending across the duct or plenum to be sampled. A bleed hole outside the duct or plenum causes air to enter the sample tube and exit at the bleed hole, thus bathing the sensor in average air. The averaging sensor shall be installed complete with end cap, compression fittings, gaskets, mounting flange and required accessories.
2. Provide capillary supports at the sides of the duct to support the sensing string.

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

## F. Intelligent LONMARK Room Sensors

1. Room temperature sensors are to be provided with a cover to prevent accidental damage.
2. Terminal unit temperature sensors all be of the thermistor (NTC) type with a 100 ohm/°F. resistance change versus temperature change to insure good resolution and accuracy. Thermistor shall produce 3000 ohms at 77°F. for calibration.
3. Sensor shall be supplied with a vertical base for mounting on a standard single gang junction box supplied by the NETWORK INTEGRATOR .
4. Provide an integrated thermistor, neuron chip and (Powerline, FTT) Transceiver for communication with the VAV power line communication network.
5. Temperature sensor cover plate shall be vandal proof, flush mounted stainless steel with hex head hardware.

### \*\*\*LIST ACCEPTABLE MANUFACTURERS.

## G. Relative Humidity Sensors/Transmitter

1. The sensor shall be a solid state, resistance type relative humidity sensor of the Bulk Polymer Design. The sensor element shall be washable and shall resist surface contaminations.
2. Humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2 wire isolated loop powered, 4-20ma, 0-100 VDC linear proportional output.
3. The humidity transmitter shall meet the following overall accuracy including lead loss and A to D conversion.
  - (a) Room Type Sensor  $\pm 3\%$  RH
  - (b) Duct Type Sensor  $\pm 2\%$  RH
4. Outside air relative humidity sensors shall be installed in a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealite fittings and stainless steel bushings.
5. Provide a single point humidity calibrator, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
6. Duct type sensing probes shall be constructed of 304 stainless steel and be equipped with a neoprene grommet, bushings and a mounting bracket.
7. Acceptable Manufacturers:

### \*\*\*LIST ACCEPTABLE MANUFACTURERS.

## H. Differential Pressure Transmitters and Accessories

1. General Air and Water Pressure Transmitter Requirements:
  - (a) Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
  - (b) Pressure transmitters shall provide the option to transmit a 0 to 5V dc, 0 to 10V dc, or 4 to 20 mA output signal.
  - (c) Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (3 valve manifolds).
  - (d) Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.

- (e) Low air pressure, differential pressure transmitters used for room pressurization control (i.e. laboratories, OR's clean rooms, etc.) shall be equipped with a LED display indicating the transmitter output signal.
  - (f) Duct sensing pressure applications where the velocity exceeds 1500 fpm shall utilize a static pressure traverse probes.
2. Low Air Pressure Applications (0 to 0.5" WC)
- (a) The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
    - i. Span: Not greater than two times the design space DP.
    - ii. Accuracy: Plus or minus 0.5% of F.S.
    - iii. Dead Band: Less than 0.3% of output.
    - iv. Repeatability: Within 0.2% of output.
    - v. Linearity: Plus or minus 0.2% of span.
    - vi. Response: Less than one second for full span input.
    - vii. Temperature Stability: Less than 0.01% output shift per degree F. change.
  - (b) The transmitter shall utilize variable capacitance sensor technology and be immune to shock and vibration.
  - (c) Acceptable Manufacturers

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

3. Medium to High Air Pressure Applications (0.5" to 10.0" WC)
- (a) The pressure transmitter shall be similar to the Low Air Pressure Transmitter except the performance specifications are not as severe. Provide differential pressure transmitters, which meet the following performance requirements.
    - i. Zero & span: (% F.S./Deg. F): .041% including linearity, hysteresis and repeatability
    - ii. Accuracy: 1% F.S. (best straight line)
    - iii. Static Pressure Effect: 0.5% F.S. (to 100 psig)
    - iv. Thermal Effects:  $\leq \pm 0.03\%$  F.S./Deg. F. over 40°F. to 100°F. (calibrated at 700°F.)
  - (b) Acceptable manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

4. Low Differential, Water Pressure Applications (0" to 20" WC)
- (a) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20mA output in response to variation of flow meter differential pressure or water pressure sensing points.
  - (b) The differential pressure transmitter shall have non-interactive zero and span adjustments adjustable from the outside cover and meet the following performance specifications.
    - i. .01 - 20" WC input differential pressure range
    - ii. 4 - 20 mA output
    - iii. Maintain accuracy up to 20 to 1 ratio turndown
    - iv. Reference Accuracy:  $\pm 0.2\%$  of full span

- (c) Provide a two-year warranty for each transmitter. Replace all transmitters found to be defective at no cost to the Owner during the warranty period.
- (d) Acceptable Manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

5. Medium to High Differential Water Pressure Applications (21" WC to 100 psi)

- (a) The differential pressure transmitter shall meet the low pressure transmitter specifications except the following:

- i. Differential pressure range 21" wc to 100 psi.
- ii. Reference Accuracy:  $\pm 1\%$  of full span (includes non-linearity, hysteresis, and repeatability)
- iii. Warrantee: 1 year.

- (b) Acceptable Manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

- 6. Bypass Valve Assembly: Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided.

7. Intelligent Space Static Pressure Sensors:

- (a) Low pressure type (0 to 0.5" wc) differential pressure transmitter.
- (b) Integrated Neuron chip controller.
- (c) Power Line, Type 3 network transceiver.
- (d) Integral power supply for transmitter controller and transceiver.

I. Electronic Valve & Damper Actuators

A. General Requirements

- (a) Electronic actuators shall be electric, direct coupled type capable of being mounted over the shaft of the damper. They shall be UL listed and the manufacturer shall provide a 2 year unconditional warranty from the date of commissioning. Power consumption shall not exceed 8 watts or 15 VA of transformer sizing capacity per high torque actuator nor 2 watts or 4 VA for VAV actuators. Sound level shall not exceed 45 dB for high torque nor 35 dB for VAV actuators.
- (b) Electronic overload protection shall protect actuator motor from damage. If damper jams actuator shall not burn-out. Internal end switch type actuators are not acceptable. Actuators may be mechanically and electrically paralleled on the same shaft to multiply the available torque. A reversing switch shall be provided to change action from direct to reverse in relation to control signal as operation requires.
- (c) Acceptable manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

B. Control Dampers Actuators

- (a) OA, RA and EXH actuators shall be spring return type for safety functions. Individual battery backup or capacitor return is not acceptable. With approval a



central battery pack NSV system similar to a UPS system may be used with a battery checking circuit to the DDC automation system. Daily verification of battery performance shall be incorporated in the programming.

- (b) The control circuit shall be fully modulating using 2 - 10 volt or 4 - 20 mA signals. Accuracy and repeatability shall be within + or -1/21 of control signal. A 2 - 10 v or 4 - 20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators which are paralleled off a master motor or to provide a feedback signal to the automation system indicating damper position. Accuracy shall be within + or - 2.5%.
- (c) Face and bypass dampers and other control dampers shall be modulating using the same control circuit detailed above but shall not be spring return.

### 3. Miscellaneous Damper Actuators

- (a) OA combustion and ventilation air intake and EXH damper actuators shall be 2 position spring return closed if any water piping, coils or other equipment in the space which the damper serves needs to be protected from freezing. Otherwise drive open, drive closed type 2 position may be used. The minimum torque for any actuator shall be 50 lb-in.
- (b) Provide auxiliary switches on damper shaft or blade switch to prove damper has opened on all air handling equipment handling 100% outside air and greater than 2.5" TSP.

### 4. Air Terminals

- (a) Air terminal actuators shall be minimum 50 lb-in torque and use fully modulating floating (drive open, drive closed) 3 wire control or use control circuit as detailed in control dampers depending on the controllers requirements.

### 5. Inlet Vanes Actuators

- (a) Inlet vane actuators shall provide at least 150% of the minimum torque specified by the manufacturer as necessary to operate vanes properly. Either direct coupled or gear train with linkages are acceptable as required. The control loop for static control or the actuator shall operate slowly enough to avoid hunting and maintain stable control. See automation system specifications for details.

### 6. Combination Smoke and Fire Damper Actuators

- (a) Actuators shall be factory mounted and connected to the damper section and shall conform to UL 555S specifications. They shall be rated for 350°F.

## J. Valve Actuators

### 1. Control Valves Actuators (3 inch and smaller)

- (a) Actuators shall have a gear release button on all non-spring return models to allow manual setting. The actuator shall have either an insulating air gap between it and the linkage or a non-conducting thermoplastic linkage. Care shall be taken to maintain the actuator's operating temperatures and humidity within its specifications. Pipes shall be fully insulated and heat shields shall be installed if necessary. Condensation may not form on actuators and shall be prevented by a combination of insulation, air gap, or other thermal break.
- (b) The control circuit shall be fully modulating using 2 - 10 volt or 4 - 20 mA signals. Accuracy and repeatability shall be within 1/21 of control signal. A 2 - 10

v or 4 - 20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators which are paralleled off a master motor or to provide a feedback signal to the automation system indicating valve position.

- (c) Valve body and actuators shall be shipped fully assembled and tested at the valve factory prior to shipment.
- (d) Acceptable Manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

2. Control Valve Actuators (4 inch and larger).

- (a) The valve actuator shall consist of a permanent split capacitor, reversible type electric motor which drives a compound epicycle gear. The electric actuator shall have visual mechanical position indication, readable from a distance of 25 feet, showing output shaft and valve position. Unit shall be mounting directly to the valves without brackets and adapters, or readily adapted to suit all other types quarter-turn valves.
- (b) The actuator shall have an integral terminal strip, which, through conduit entries, will ensure simple wiring to power supplies. Cable entries shall have UL recommended gland stops within the NPT hole to prevent glands from being screwed in too far and damaging cable.
- (c) The actuator shall be constructed to withstand high shock and vibrations without operations failure. The actuator cover shall have captive bolts to eliminate loss of bolts when removing the cover from the base. One copy of the wiring diagram shall be provided with the actuator.
- (d) The actuator shall have a self-locking gear train which is permanently lubricated at the factory. The gearing shall be run on ball and needle bearings. Actuators with 600 in/lbs. or more output torque shall have two adjustable factory calibrated mechanical torque limit switches of the single-pole, double-throw type. The motor shall be fitted with thermal overload protection. Motor rotor shaft shall run in ball bearings at each end of motor.
- (e) The actuator housing shall be hard anodized aluminum for full environmental protection.
- (f) The environmental temperature range of the actuator shall be -30°C to +60°C (-20°F to +140°F).
- (g) For intermittent on/off service, the actuator shall be rated at a 20% duty cycle (i.e., 12 minutes extended duty in every hour, or alternatively; one complete cycle every 2 minutes). For more frequent cycling and modulating service, an actuator shall be rated for continuous duty. The actuator rated for continuous duty shall be capable of operating 100% of the time at an ambient temperature of 40°C.
- (h) The actuator shall have an integral self-locking gear train. Motor brakes shall not be required to maintain desired valve position. Levers or latches shall not be required to engage or disengage the manual override. Mechanical travel stops, adjustable to 15° in each direction of 90° rotation shall be standard, as well as two adjustable travel limit switches with electrically isolated contacts. Additional adjustable switches shall be available as option.
- (i) Single Phase Motor: The motor shall have Class B insulation capable of withstanding locked-rotor for 25 seconds without overheating. Wiring shall also be Class B insulation. An auto-reset thermal cut-out protector shall be embedded in the motor windings to limit heat rise to 80°C in a 40°C ambient. All motors shall be capable of being replaced by simply disconnecting the wires and then removing mounting bolts. Disassembly of gears shall not be required to remove the motor.

- (j) Materials of Construction: The electric actuator shall have a pressure die-cast, hard anodized aluminum base and cover. The compound gear shall be made of die-cast, hard anodized aluminum or steel. An alloy steel worm gear shall be provided for manual override and torque limiting. Bearings for gears shall be of the ball and needle type; bronze bearings shall be used on the shafting parts.
  - (k) Accessories:
- C. Potentiometer for providing continuous feedback of actuator position at the CU (for valves specified position feedback).

## 5.10 PNEUMATIC EQUIPMENT & ACCESSORIES

**\*\*\*INCLUDE APPROPRIATE ARTICLES HERE IF PNEUMATIC OPERATORS ARE REQUIRED FOR VALVE AND DAMPERS.**

## 5.11 SWITCHES

### A. Differential Pressure Switches

1. All pressure-sensing elements shall be corrosion resistant. Pressure sensing elements shall be bourdon tubes, bellows, or diaphragm type. Units shall have tamper-proof adjustable range and differential pressure settings.
2. Pressure sensor switch contacts shall be snap action micro-switch type. Sensor assembly shall operate automatically and reset automatically when conditions return to normal. Complete sensor assembly shall be protected against vibration at all critical movement pivots, slides and so forth.
3. Differential pressure switches shall be vented to withstand a 50% increase in working pressure without loss of calibration.
4. Acceptable Manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

### B. Electric Low Limit Thermostat (Freeze Stat)

1. Duct type, fixed 5 degrees Fahrenheit differential, range 30 to 60 degrees Fahrenheit. Sensing element shall be a 20 foot long capillary tube responding to the lowest temperature sensed along any 12 inches of bulb length. Switch shall be SPDT 120/240 volts AC, rated for 10 amps at 120 volts full load. Unit shall be manually reset. Provide one low limit thermostat for each 20 square feet or fraction thereof of coil surface area.
2. Provide automatic reset type thermostat set at 35 degrees Fahrenheit on each air handling unit, with a 0 to 120 second delay before the fan shuts down.
3. Provide an additional auto reset type thermostat for remote indication alarm set at 39 degrees Fahrenheit.
4. Provide thermostat override on air handling units for smoke containment in area being served.

### C. Water Flow Switches

1. UL listed, suitable for all service application conditions. Body minimum working pressure rating shall equal or exceed service pressure. Switch electrical rating shall be 230 volts AC 3.7 ampere, 115 volts AC 7.4 ampere, and 125 VAC 115-230 VAC AC Pilot duty. Unit shall have two SPDT switches. Actuating flow rated shall be field adjustable for the specified and indicated service. Switch location shall preclude exposure to turbulent or pulsating flow conditions. Flow switch shall not cause pressure drop exceeding 2 PSI at maximum system flow rate. Manufacturer: McDonnell-Miller FS7-4.

#### D. Strap-On Aquastat

1. UL listed, provided with a suitable removable spring clip for attaching aquastat to pipe and a snap-action SPDT switch. Switch setpoint shall be as indicated. Electrical rating shall be 5 amperes, 120 VAC.

#### E. Duct Type Smoke Detector

1. UL listed; duct averaging, photoelectric type smoke detector with 24 VAC snap-action SPST switch. Provide all fittings, bushings and junction boxes for air tight duct installation.

### 5.12 FLOW, PRESSURE AND ELECTRICAL MEASURING APPARATUS

#### A. Traverse Probe Air Flow Measuring Stations

1. Traverse probes shall be a dual manifolded, cylindrical, type constructed of 3003 extruded aluminum with an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching air flow and without the physical presence of forward projecting sensors into the airstream. The static pressure manifold shall incorporate dual offset static tips on opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as  $\pm 20^\circ$  in the approaching airstream.
2. The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the airstreams. Each airflow-measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.
3. Traverse probes shall be accurate to  $\pm 25\%$  of the measured airflow range down to 0.25" WC static pressure.
4. Acceptable Manufacturers:

#### \*\*\*LIST ACCEPTABLE MANUFACTURERS.

#### B. Shielded Static Pressure Sensor

1. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber with minimum volume of 50 cubic inches, airflow shielding, and 3/8" compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.
2. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow of 1000 FPM from a radial source.
3. The shielded static sensing devices shall be used for both reference and space pressure sensing.
4. Pressure sensors used for outside air pressure reference purposes shall be equipped with a conduit seal for pneumatic tubing and bushings for a weather tight installation.

#### C. Static Pressure Traverse Probe

1. Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.

2. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
3. The duct static traverse probe shall be of 304 stainless steel construction and (except for 3/4" dia. probes with lengths of 24" or less) be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, nonpulsating signal of standard static pressure without need for correction factors, with an instrument accuracy of 21.
4. Acceptable Manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

D. Venturi Flowmeter

1. Pressure drop on venturi type flowmeters shall not exceed 0.25" WC. Each venturi low and high-pressure taps shall be equipped with nipples, valves and quick disconnects.
2. Equip each venturi with a metal identification tag indicating the size, location, GPM and meter reading for the GPM specified.
3. Provide (1) 6" dial differential pressure meter of the proper range to determine piping system flow rate. The meter shall be the property of the Owner.
4. Venturi meters shall utilize flanged or screwed connections for removal purposes and shall be rated for the system operating pressures.
5. The venturi flowmeter shall be factory calibrated to provide a minimum of flow accuracy between actual and factory flow calibration data.
6. Acceptable Manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

E. Current Transformers

1. The current transformers shall be designed to be installed or removed without dismantling the primary bus or cables. The transformer shall be of a split core design.
2. The core and windings shall be completely encased in a UL approved thermoplastic rated 94VA. No metal parts shall be exposed other than the terminals.
3. The current transformers shall meet the following specifications:  
Frequency Limits: 50 to 400 Hz.  
Insulation: 0.6 KV Class, 10 KV BIL.  
Accuracy:  $\pm 1\%$  at 5.0 to 25.0 VA accuracy class with U.P.F. burden.
4. Provide a disconnect switch for each current transformer.
5. Acceptable Manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

F. Current Sensing Switches

1. Current sensing switch shall be self-powered with solid state circuitry and a dry contact output. Current sensing switches shall consist of a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept overcurrent up to twice its trip into range.
2. Acceptable Manufacturers:

**\*\*\*LIST ACCEPTABLE MANUFACTURERS.**

## 5.13 CONTROL VALVES AND DAMPERS

### A. General Control Valve Requirements

1. All automatic control valves shall be linear, fully proportioning, with modulating ball, plug or V-port inner guides unless otherwise specified. The valves shall be quiet in operation and fail safe in either normally open or normally closed position in the event of control air failure or loss of electronic output signal.
2. All valves shall be capable of operating in sequence when required by the sequence of operation. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads as specified. All control valves shall be suitable for the pressure conditions, and shall close against the differential pressures involved. Valve body pressure rating and connection type (screwed or flanged) shall conform to ANSI pressure classifications appropriate for the system working pressures.

### B. Steam Control Valves

1. Steam control valves shall be single-seated type with equal percentage flow characteristics. Preheat valves and direct radiation valves shall be normally open type. Reheat and water heater valves shall be normally closed type.
2. The valve discs shall be composition type for steam pressure up to 35 psig, and shall be of 316 stainless steel for steam pressures above 35 psig or where subject to super heat after pressure reducing valves.
3. Whenever the steam flow rate is such as to require a single valve larger than 2", there shall be installed two valves in parallel (which shall operate sequentially), one of which shall not be in excess of 2" in size.
4. Valves shall be sized for full pressure drop when the inlet pressure is 10 psig or below. When the inlet pressure is above 10 psig the valves shall be sized for a pressure drop equal to 45% of absolute inlet pressure PSIA.

### C. Hot and Cold Water Control Valves

1. Hot and cold water globe type control valves shall be single-seated type, with equal percentage flow characteristics. The valve discs shall be composition type and shall be sized using ISA methods.
2. Pressure drop through the valves shall not exceed 5 PSI unless otherwise indicated.
3. Ball valves shall be equipped with 316 stainless steel trim, Teflon seals and adjustable packing gland nuts. Provide a handle for manual operation during start-up and maintenance.

### D. Air Terminal Reheat Valves

1. Reheat valves shall be modulating logarithmic equal percentage type globe or control ball valves as detailed in paragraph C above. 2-position control is not acceptable. Other general requirements are the same as detailed in Article A.

### E. Two Position Control Valves

1. For open/closed and/or three-way diverting applications, butterfly valves are acceptable and shall be heavy-duty pattern with a body rating comparable to the pipe rating.
2. Provide each butterfly valve with a replaceable lining suitable for temperature and service requirements.
3. Equip each with a butterfly valve with disc and stainless steel stem.
4. Valves used for shut-off or isolation purposes shall be bubble-tight.

## F. Automatic Control Dampers

1. Automatic dampers shall be multiple blade and sized for the application by the BAS Contractor and/or as indicated on the Drawings.
2. Submit a schedule of damper sizes to the Vent Contractor, with a copy to the Architect/Engineer within 15 days after being awarded the contract.
3. Dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation as required. The damper is to be sized so that when wide open the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear. Multi-section dampers must be provided with sufficient interconnecting hardware or jackshaft to provide unison operation of all blades in the entire assembly.
4. Damper frames and blades shall be constructed of either minimum 16 gauge galvanized steel or 14 gauge aluminum and arranged to facilitate field assembly of several individual sections into a large damper area and allow secure fastening of damper frame to the surrounding ductwork, collar or fan housing. Maximum blade length in any section shall be 48". Additional stiffening or bracing shall be provided for any section exceeding 48" in height.
5. Damper blades shall not exceed eight (8) inches in width. All blades except for fume hood exhaust systems shall be galvanized sheet steel. Blades shall be suitable for high velocity performance.
6. All damper bearings to be made of nylon. Bushings that turn in the bearing are to be oil impregnated sintered metal. Dampers shall be tight closing, low leakage type with synthetic elastomer seals on the blade edges and on the top, bottom and sides of the frame. Dampers shall not leak in excess of 8 CFM per square foot when closing against 4" w.g. static pressure.
7. Leakage and flow characteristics charts shall be submitted to the Architect for review.

**\*\*\*EDIT THIS SECTION TO SUIT PROJECTS ELECTRICAL INSTALLATION REQUIREMENTS.**

## 5.14 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

- A. Provide interlock wiring between supply and return fans, electrical wiring for relays (including power feed) for temperature and pressure indication. Provide interlock wiring between refrigeration machines, pumps and condensing equipment as required for the specified sequence of operation and the refrigeration system integral controller(s). Do not provide interlock wiring if a dedicated digital output has been specified for the equipment or the sequence of operation requires independent start/stop.
- B. Provide power wiring, conduit and connections for low temperature thermostats, high temperature thermostats, alarms, flow switches, actuating devices for temperature, humidity, pressure and flow indication, point resets and user disconnect switches for electric heating, appliances controlled by this Section.
- C. Provide all other wiring required for the complete operation of the specified systems.
- D. BAS Network Communication Requirements:
  1. Wired network communication shall be via channels consisting of a 24 AWG twisted pair installed in a 3/4" EMT.
  2. In all communication conduits, provide one spare twisted pair to be installed, tagged and labeled at each end.
  3. Telephone lines, where required as a remote communication source, shall utilize voice band, non-switched, private line channels consistent with Bell Systems Technical Reference Pub. 41001 and shall be four-wire unconditioned 3002 channels. The modems shall have 25 pin EIA connectors and RS-232C interface.
  4. Communication conduits shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible.

5. All shields shall be ground (earth ground) at one point only, to eliminate ground loops.
6. There shall be no power wiring, in excess of 30 VAC RMS, run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, all communication wiring and signal wiring shall be run using separate twisted shielded pairs (24awg) with the shields grounded in accordance with the manufacturer's wiring practices.

#### E. Power & Communication Wiring Transient Protection

1. The control manufacturer's shall submit catalog data sheets providing evidence that all BAS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.
2. Communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General semiconductor, Model #422E device.
3. The communications circuitry, input/output circuitry, and CU's, shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer's catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the BAS controller. Protection shall be provided for the individual communications and input/output terminations for each BAS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

#### F. Input/Output Control Wiring

1. RTD wiring shall be three-wire or four-wire twisted, shielded, minimum number 22 gauge.
2. Other analog inputs shall be a minimum of number 22 gauge, twisted, shielded.
3. Binary control function wiring shall be a minimum of number 18 gauge.
4. Analog output control functions shall be a minimum of number 22 gauge, twisted, shielded.
5. Binary input wiring shall be a minimum of number 22 gauge.
6. Thermistors shall be equipped with the manufacturers calibrated lead wiring.
7. 120 VAC control wiring shall be #14 THHN in 3/4" conduit. Provide 4 or 20% fill extra wire in each conduit.

#### G. Splices

1. Splices in shielded cables shall consist of terminations and the use of shielded cable couplers, which maintain the integrity of the shielding. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties as specified herein.

#### H. Conduit and Fittings

1. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.
2. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.



3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

I. Relays

1. Relays other than those associated with digital output cards shall be general purpose, enclosed plug-in type with 8-pin octal plug and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.

J. Solid State Relays (SSR): Input/output isolation shall be greater than  $10E^9$  ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz. The contact life shall be  $10 \times 10^6$  operations or greater. The ambient temperature range of SSR's shall be 20 to +140F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.

K. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semi permanent magnets. Contractor shall be double-break silver-to-silver type protected by arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

D. EXAMINATION

1. Verify that systems are ready to receive work.
2. Beginning of installation means installer accepts existing conditions.
3. Communication and low voltage power wiring is indicated on the contract documents (BAS, Electrical). Examine this work and be responsible to identify any potential problems or conflicts with this work. Submit recommended modifications and omissions noted to the Architect.

E. GENERAL INSTALLATION REQUIREMENTS

1. Install all control components in accordance with manufacturer's instructions and recommendations.
2. Provide mixing dampers of parallel blade construction arranged to mix streams. Provide separate minimum outside air damper section adjacent to variable outside air damper.
3. Mount control panels adjacent to associated equipment on vibration-free walls or free-standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved lamicoïd nameplates on cabinet face.
4. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.
5. After completion of installation, test and adjust control equipment. Submit data showing setpoints and final adjustments of controls.

## 5.15 ELECTRICAL SYSTEM INSTALLATION

- A. Comply with all Installation Requirements of the Electrical Division.
- B. Install low voltage power and control and LAN communication trunks in conduit in the following locations regardless of local building code allowances otherwise.

1. Mechanical rooms.

2. Electrical rooms.
  3. Vertical risers (exception: fire rated continuous closet like a telephone closet).
  4. Open Areas where the wiring will be exposed to view or tampering.
- F. Conceal conduit within finished shafts, ceilings and wall as required. Install exposed conduit parallel with or at right angles to the building walls.
  - G. Use (electrical metallic tubing (EMT), Teflon coated wire) for all low voltage and control and communication wiring or as approved by local building codes.
  - H. Plug or cap all unused conduit openings and stub-ups. Do not use caulking compound.
  - I. Route all conduit to clear beams, plates, footings and structure members. Do not route conduit through column footings or grade beams.
  - J. Set conduits as follows:
    1. Expanding silicone firestop material sealed watertight where conduit is run between floors and through walls of fireproof shaft.
    3. Oakum and lead, sealed watertight penetration through outside foundation walls.
  - K. Cap open ends of conduits until conductors are installed.
  - L. Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with a minimum length of 18 inches and maximum length of 36 inches shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the rigid conduit.
  - M. Where exposed to the elements or in damp or wet locations, waterproof flexible conduit shall be installed. Installation shall be as specified for flexible metal conduit.
  - N. Provide floor, wall, and ceiling plates for all conduits passing through walls, floors or ceilings. Use prime coated cast iron, split-ring type plates, except with polished chrome-plated finish in exposed finished spaces.

**\*\*\*INCLUDE FOLLOWING SECTION IF PNEUMATIC OPERATORS ARE REQUIRED.**

#### **5.16 PNEUMATIC SYSTEM INSTALLATION**

- A. Install in accordance with manufacturer's instructions.
- B. Mount compressor and tank unit on vibration isolation consisting of springs, with minimum (1.5 inch) static deflection and one inch clearance to floor. Isolate air supply with wire-braid reinforced rubber hose.
- C. Supply instrument air from compressor units through filter, pressure reducing valve, pressure relief valve, with pressure gauges, and shutoff and bypass valves.
- D. Install pressure reducing stations consisting of pressure reducing valve, particle filter, valved bypass, pressure gauge on inlet and outlet, and pressure relief valve.
- E. Locate refrigerated air dryer in discharge air line from tank. Mount dryer on wall on rubber in shear mounts. Install pressure regulator downstream of dryer. Pipe automatic drain to nearest floor drain.
- F. Mechanically attach tubing to supporting surfaces. Sleeve through concrete surfaces in minimum one inch (25 mm) sleeves, extend 2 inches (50 mm) above floors and one inch (25 mm) below bottom surface of slabs.
- G. Purge tubing with dry, oil-free compressed air before connecting control instruments.
- H. Provide instrument air tubing with check and hand valves to expansion tanks with Schraeder fittings and hose. Install pressure gauges on branch lines at each signal line and at each transmitter excepting individual room controllers.
- I. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate room thermostats 48 inches (1 200 nm) above floor. Align with lighting switches.
- J. Mount freeze protection thermostats using flanges and element holders.
- K. Provide separable sockets for liquids and flanges for air bulb elements.
- L. Provide valves with position indicators and with pilot positioners where sequenced with other controls.

- M. Provide pilot positioners on damper operators sequenced with other controls.
- N. Test pneumatic systems to system pressure maximum of 30 psig (200 kPa). Check calibration of instruments. Recalibrate or replace.

#### **5.17 TEMPERATURE SENSORS**

- A. Temperature sensors shall require no field calibrations.
- B. Temperature sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.
- C. Strap-on mountings, utilizing helical screw stainless steel clamps, shall only be permitted on hot water piping up to 2 inches. All other water temperature sensors shall be in wells.
- D. Outdoor installations shall be; of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.
- E. Sensors shall be with enclosure where located in finished space.
- F. Sensors in ducts shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces or positions obstructed by ducts, equipment, and so forth. Locations where installed shall be within the vibration and velocity limit of the sensing element. Ducts shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.
- G. All sensors measuring temperatures in pipes larger than 2 inches in diameter or in pressure vessels shall be supplied with wells properly fabricated for the service. Wells shall be noncorrosive to the medium being measured and shall have sufficient physical strength to withstand pressures and velocities to which they are subjected. Wells shall be installed in the piping at elbows where piping is smaller than the length of the well to effect proper flow across the entire area of the well.



## **ARTICLE VI. SUBMITTALS**

This Section defines the overall submittal requirements for this division including product data, shop drawings, detailed documentation and samples.

### **6.1 SUBSTITUTIONS**

- A. Wherever the words for “review” or “acceptance” are used in regard to manufactured specialties, or wherever it is desired to substitute a different make or type of apparatus for that specified, submit all information pertinent to the adequacy and adaptability of the proposed apparatus to the Architect and secure their approval before apparatus is ordered.
- B. Wherever system performance such as material quantities, operating pressure, network throughput, or the like are specified, or a definite make and size of apparatus is specified, for which such quantities are readily determinable, the make and size of the apparatus proposed must conform substantially to the quantities specified or implied. Critical dimensions relating to the installation of apparatus and coordination with the rest of the system, shall be considered and adhered to whenever possible. Substitution of equipment or apparatus shall include all necessary revisions and their costs required to complete the installation.
- C. Approval of request for substitutions may be given only after receipt of complete and satisfactory performance data covering the complete range of operating conditions in tabular and graphical form. Furnish complete and satisfactory information relative to equipment performance, features and accessories, etc. Additional construction and design costs incurred as a result of any accepted substitution shall be borne by the Systems Integrator.

### **6.2 SUBSTITUTION FORMAT**

- A. Proposed changes and substitutions of systems, apparatus, equipment and manufacturers will be considered subject to the approval of the Architect. The proposal shall include the following information:
  - 1. A description of the difference between the existing contract requirements and that proposed, the comparative features of each, and the effect of the change on the end result performance. Include the impact of changes on other Contractors and/or subcontractors and acknowledge the inclusion of implementation costs.
  - 2. Schematic drawings and details to supplement the descriptions.
  - 3. A list of the contract requirements that must be revised if the change is accepted, including any suggested specification revisions.
  - 4. Complete list of materials and equipment proposed for use in the change.
  - 5. Include a description and estimate of costs the Owner may incur in implementing the change, such as test, evaluation, operating and support costs.
  - 6. A projection of any effects the proposed change would have on collateral costs to the owner.
  - 7. A statement of the time by which a contract modification accepting the change must be issued, noting any effect on the contract completion time or the delivery schedule.
  - 8. A statement indicating the reduction to the contract price if the Owner accepts the change. The Contractor shall be responsible for appropriate modification of subcontractor.

### **6.3 SHOP DRAWINGS AND PRODUCT SUBMITTAL LISTS**

- A. Within thirty (30) days after date of execution of General Contractor/Sub-Contractor agreement, submit for acceptance a list of all material and equipment manufacturers

whose products are proposed, as well as names of all subcontractors whom the NETWORK INTEGRATOR proposes to employ.

B. Submit shop drawings and manufacturer's data.

1. Provide in schedule form on 8\_ x 11 sheets. The schedule shall be organized by columns to define as a minimum the tag location, system served, control unit. The schedule shall indicate performance data, size, range, accuracy, span, operating pressure, etc for all the following:
  - (a) Automatic Valves.
  - (b) Automatic Dampers.
  - (c) Temperature Sensors.
  - (d) Access Doors.
  - (e) Humidity Sensors.
  - (f) Air Quality Sensors.
  - (g) Smoke Detectors.
  - (h) Carbon Monoxide Detectors.
  - (i) Heat Detectors.
  - (j) Pressure Transducers and Transmitters.
  - (k) Digital Input/Output to Pneumatic Transducers.
  - (l) Analog Output to Pneumatic Transducer.
  
2. For each microprocessor based device on the control network (or proposed for the system), submit the documentation detailed below. ANY control device that is furnished without XIF files or object diagrams shall be submitted under separate cover with indication of non-compliance to specification.
  - (a) External Interface Files (XIF) (floppy or Zip disk format), product literature, and Object Diagrams.
  - (b) Listing and explanation of both standard and user defined configuration parameters for the device.
  
3. In addition to the requirements in section, each Custom Application Controller (CAC) should additionally be submitted with the following information. These items shall be grouped together under product model for easy reference.
  - (a) Logical control diagram indicating the Network Variables in and out of control unit with message bindings visually indicated.
  - (b) Descriptive sequence of operation.
  - (c) Programming tool used to produce application
  - (d) Application tool source code
  - (e) Neuron C source code
  - (f) Wiring interconnection diagrams for power, communication and external I/O.
  
4. Provide schematic diagrams for the following systems.
  - (a) Local Area Network and LONWORKS Architecture diagram indicating supervisory controllers, Operator Interface Workstation(s) and database server(s) including all devices and controllers installed by other trade contractors. This should be accompanied by explicit information regarding configuration of Routers, Bridges and Repeaters.
  - (b) Interface requirements with other systems including but not limited to: security systems, lighting control, fire alarm, elevator status, power monitoring system. Diagrams detailing the variables mapped between protocols shall be submitted for all gateways.

5. Provide detailed cut sheets indicating the features, accessories and sub-assemblies of the following:
  - (a) Ethernet LAN Hubs, Switches, and Routers.
  - (b) ANSI/EIA 709.1 Routers and Repeaters.
  - (c) Operator Interface Workstation with all Accessories.
  - (d) Printers.
  - (e) LONWORKS Network Services plug-ins
  - (f) Graphical User Interface Software
  - (g) Network Management Software
  - (h) LonWorks Internet Servers
  
6. Submit performance calculations for all channels to indicate bandwidth utilization and conformance to the requirements outlined in NI Section 1.1, "LONWORKS Network Management".
  
7. Provide AutoCAD or Visio generated floor plans indicating exact installed location of the following equipment and/or devices:
  - (a) Application Generic controllers
  - (b) Application Specific controllers
  - (c) Customer Application Controllers
  - (d) Sensors located in Finished Areas.
  - (e) I/O installed in mechanical systems (ductwork, pipes, AHU's, etc.)
  - (f) Routers, Gateways and Bridges.
  - (g) Units installed by Division M and E trade contractors.
  - (h) Other BAS related components, sensors and actuators.
  
8. Submit User Interface Workstation Node console configuration for the building engineer's office and LNS Database Server Installation as follows:
  - (a)  $\frac{1}{4}$ -inch scale drawing indicating dimensioned location of all systems and components contained therein indicating:
    - i. Arrangement of hardware devices.
    - ii. Power connection requirements including terminal designations.
    - iii. Interconnect cabling between hardware.
  
- B. Within six (6) weeks after date of execution of General Contractor/Sub-Contractor agreement, submit a list of all shop drawings that will be submitted in the course of the project. List shall show disposition of each item, including date of submission, date of acceptance, and the like. List shall be kept current throughout entire construction period.

#### **6.4 LOCAL BUILDING DEPARTMENT SUBMITTALS**

- A. After review and acceptance by the Architect, submit shop drawing and diagrams to the **\*\*\* insert governing body here** as required, particularly with respect to the fire management system.
- B. Submit details defining the proposed method of integration with the fire management systems as required by the authority having jurisdiction.

#### **6.5 SAMPLES**

- A. Submit the following product samples for the review and approval of the Architect. For Intelligent LONMARK products, submit XIF files and an exact sample of the proposed product complete with transceiver.

1. Space Temperature Sensors (Intelligent and Dumb).
2. Occupancy Sensors.
3. Intelligent Wiring Devices.
4. Intelligent Devices:
  - (a) CO Sensor.
  - (b) Humidity Sensor.
  - (c) Actuators.
5. Control Units.
  - (a) Heat Pump.
  - (b) VAV.
  - (c) Rooftop Unit.
  - (d) Fan Coil Unit.
  - (e) Air Handling Unit.
  - (f) General Purpose.

## **6.6 INSTRUCTION OF OPERATING AND MAINTENANCE PERSONNEL**

- A. Submit a syllabus outlining the proposed training program.
- B. Indicate the location, length and proposed format for each phase of the training program. If outside training is proposed, indicate the proposed professional training organization.
- C. Submit resumes and/or company qualifications for all phases of the training program.

**END OF SECTION**



## **ARTICLE VII. OPERATION AND MAINTENANCE MANUALS**

### **7.1 DESCRIPTION**

#### **A. General**

1. Provide maintenance manuals in accordance with the Contract Documents and as modified herein.

### **7.2 OVERVIEW**

- A. General: Provide maintenance manuals in accordance with the Contract Documents and as modified herein.
- B. Provide five (5) copies of each manual.
- C. Manuals shall be standard size for country of operation and provided in hard back 3-ring loose-leaf binders.
- D. Submit one (1) copy of each manual to Architect. After review, assemble other copies.
- E. Manuals shall be completed and in Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

### **7.1 CONTENTS OF O&M MANUAL**

- A. Provide a Table of Contents.
- B. Include the following information in the Maintenance Manual in an Introduction section following the Table of Contents:
  1. Alphabetical list of all system components, with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
  2. Contractor's name, address and telephone number.
  3. Name, signature and title of Contractor's representative responsible for preparation of technical manual.
  4. Date of issuance of manual and revision number.
  5. Contractor's job control number.
- C. Include the following information as a minimum in the sections Number 1, "General".
  1. Valve tag list. (Coordinate with Mechanical Contractor. Use similar format or add onto the procedure initiated by the Mechanical Contractor).
  2. Proper lubricants and lubricating instructions for each piece of equipment, date when lubricated, and recommended frequency of lubrication.
  3. Table of multi-conductor cable tag number and corresponding system and building, floor or area served.
  4. Charts showing normal operating conditions and points of high and low limit alarms.
  5. Routine preventive maintenance procedures and corrective diagnostic trouble shooting procedures.
  6. Parts list with manufacturer's catalog numbers and manufacturer's order information.
  7. Installation instructions for each piece of equipment installed under this division.
  8. List of ordinary and special tools, operating materials and supplies and test equipment recommended for operation and servicing.
  9. Detailed description of modifications made to standard catalog equipment.

### **7.2 CONTENTS OF BAS MANUAL**

- A. Prepare a separate binder for BAS with sections for the following components:

1. General
2. Operator Interface Workstation
3. Operator Interface Software
4. Custom Interface Application Documentation.
5. Network Management Tool Application
6. LNS Network Management Documentation
7. LONWORKS products and equipment.
8. Local Area Network Accessories.

B. In addition, submit the following:

1. Electronic versions of AutoCAD (most current release) and/or Visio Technical (most current release) drawing files for all drawing submittals.
2. Plans, schematics and riser diagrams shall be printed on sheets large enough to be legible and folded to fit in binders.
3. A CD ROM record copy of all submittal data.

### **7.3 MANUFACTURERS LITERATURE**

A. General:

1. Provide manufacturers literature of proper preventative and comprehensive maintenance for all items of equipment and components.

### **7.4 ELECTRONIC SOFTWARE USER MANUALS**

A. Provide Software User Manuals on CD ROM for the following software:

1. Windows 95, NT, 2000
2. Widows NT, 2000 Advanced Server
3. LONWORKS Network Services
4. Network Management Application(LonMaker for Windows or other)

**END OF SECTION**

## **ARTICLE VIII. INSTRUCTION OF OPERATING PERSONNEL**

### **8.1 SUMMARY OF WORK**

#### **A. General:**

1. Provide instruction to operating personnel in accordance with the Contract Documents.
2. The following general requirements are in addition to those in other Sections.
  - (a) Instruct Owner's operating personnel in proper starting sequences, operation, shut down, and maintenance procedures, including normal and emergency procedures.
  - (b) Instruction shall be by personnel skilled in operation of equipment. Instruction for major equipment shall be by equipment manufacture's representatives.
  - (c) Reference instructions contained in the Operating and Maintenance Manuals. Instructions cannot be substituted for manuals.
  - (d) Provide equipment and materials required for classroom training.

### **8.2 TRAINING PARAMETERS**

- A. All training performed shall reference site-specific installation examples when ever possible. Training shall utilize specified manuals, as-built documentation, and the on-line help utilities.
- B. All Operator Interface Training (Windows, GUI, etc.) shall be off-site at a professional training office. Overhead projection equipment may be used when applicable. The training facility shall have the capabilities to train a minimum of three (3) operating.

### **8.3 TRAINING PROGRAM**

- A. Operator training shall include four (4) eight-hour sessions (2 off-site, 2 on site). Provide off site training first to establish a basic understanding of Windows based software, functions, commands, mouse, etc. The training shall encompass as a minimum:
- B. Off Site Training.
  1. Basic Windows NT/2000 Training.
  2. Overview of Operator Interface Software.
  3. Network Tools
  4. Overview of Control strategies for all BAS systems.
  5. Overview of LONWORKS control networks.
  6. LONWORKS Network Services
  7. LONWORKS Network Management.
  8. Overview of installation of LONWORKS products
- C. On Site Training
  1. Purge and/or dump of historical data.
  2. Use of any portable Operators Interface Device (OID).
  3. Troubleshooting of input devices, i.e., bad sensors.
  4. Sequence of operation review.
  5. Sign on - sign off.
  6. Selection of displays and reports.
  7. Commanding of points, keyboard and mouse mode.
  8. Modifying English text
  9. Use of dialogue boxes and menus.

10. Modifying warning limits, alarm limits and start-stop times.
  11. System initialization.
- D. Supervisor training shall include one (1) six-hour session using the on-site User Interface Workstation encompassing as a minimum:
1. Password assignment/modification.
  2. Operator assignment/modification.
  3. Operator authority assignment/modification.
  4. Point disable/enable.
  5. Terminal and data segregation/modification.
- E. Provide an additional 8 hours of on-site training time for the Owners operating personnel to use at their discretion, or to further customize existing control strategies, enhance system graphics, create custom reports, etc.

**END OF SECTION**