SECTION 28 31 11 – FIRE ALARM SYSTEM

PART 1 - GENERAL INFORMATION AND REQUIREMENTS

1.1 ACRONYMS, TERMS, AND DEFINITIONS USED IN THESE SPECIFICATIONS

A. UW = University of Washington

B. SFD = City of Seattle Fire Department

C. EH&S = UW Department of Environmental Health and Safety

D. AHJ = Authority Having Jurisdiction

E. Construction Coordinator = University's Representative

F. Owner = University of Washington

G. Vendor = The local authorized representative of the manufacturer to sell, install and service the fire alarm system

H. Local = The main office and service center are located within 50 miles of the job site.

I. Installer = The installer of conduit, wire and equipment

J. Emergency = A failure of the installed system which, in the reasonable opinion of the UW or AHJ, creates an unsafe or intolerable condition requiring immediate correction

K. Shop Drawings = The drawings created by the Contractor (Installer and Vendor) utilizing AUTOCAD, submitted for approval and then used and modified by the Installer and Vendor during construction

L. As-Built Drawings = A single set of shop drawings which shall be updated daily during construction (See 1.10)

M. Record Drawings = To include all of the information shown on the as-built drawings. This information shall be added to AUTOCAD Architectural backgrounds. (See Section C-2, 4.1 Documents.)

N. FACP = Fire Alarm Control Panel which processes alarm information and controls outputs

1.2 RELATED SECTIONS OF THE SPECIFICATION

1.3 SCOPE OF WORK

A. Work included: This specification establishes the requirements for the design and installation of a complete and renovated fire detection and alerting system as described in this specification and the referenced drawings. The scope of work includes involves installation of a fire alarm system that includes but is not limited to the following:

1. Designing and provision of a complete fire detection and alerting system
2. Permanent signs, labels, and operational instructions
3. All necessary conduit and wiring associated with the fire detection and alerting system *(Exception: The cabling for connection from the master box and the trouble and zone annunciator transmitters to the campus central station loop as shown on the drawings shall be furnished by the Owner and installed by the Contractor.)*
4. Smoke detectors, heat detectors, and manual alarm stations
5. Speakers, horns, strobes and remote lamps
6. Electromagnet door holders
7. Installation of wiring and raceway to door closers and holders
8. Provision of a Gamewell local energy master box
9. Provision of a Digitize Model DET-6B supervisory transmitter
10. Zone advisory code transmitters
11. Remote annunciator panel(s)
12. Provision of a one-way voice communication system as a part of the audio evacuation system
13. Provision of a two-way fireman's telephone system
14. Provision of auxiliary controls and switches including interposing control, monitor relays, and interconnection coordination for the operation of the following systems:

    a. Door control
    b. Fan control, smoke/fire damper interface -
    c. Elevator recall
    d. Sprinkler systems
    e. Commissioning

15. Provision of testing and training as specified in this specification.

B. Work not included:

1. Building system final wire terminations to the campus McCulloh loop will be made by UW personnel. Final wire terminations by the UW will be made only after the Contractor has completed the tasks identified under Scope of Work.

1.4 CODES AND STANDARDS

A. Perform all work in accordance with the requirements of the latest issue of the following codes and standards, unless specifically directed otherwise in this specification in order to allow designs in excess of the code requirements.

1. International Fire Code with local amendments (including SFD Administrative Rulings)
2. International Building Code with local amendments (including DPD Director's Rules)
3. NFPA 72 - National Fire Alarm Code (NFPA 72)
4. WAC - (Washington Administrative Code) 296-46
5. NEC - National Electric Code (NFPA 70)
6. Safety Code for Elevators and Escalators (ANSI A17.1) as amended by DLCU Director's Rule 21-97 (Revised)
7. Americans with Disabilities Act (ADA)
8. Local rules and interpretations required by the authority having jurisdiction, including Seattle Building and Fire Codes.

1.5 APPROVAL AUTHORITIES

A. The approval authority for this section of the project shall be the University of Washington Fire Protection Engineer and the Seattle Fire Department. If there is a conflict in requirements, the University of Washington Fire Protection Engineer has final authority for approvals.

1.6 FIRE ALARM VENDOR QUALIFICATIONS

A. The fire alarm system shall be installed by skilled electricians and mechanics, all of whom are properly trained and qualified for this work. As a minimum, the system must conform to all codes and manufacturer's recommendations.

B. The vendor shall design, supervise, program, test, and commission the installed system and provide warranty service. The vendor design shall complement the design provided by the A/E.

C. The vendor shall be the manufacturer or a local authorized representative of the manufacturer with a proven track record of being responsive, providing accurate and complete submittals, meeting project schedules, and being prepared for system testing and acceptance.

D. The vendor must be able to provide any replacement part on site within 48 hours during the warranty period.

E. The vendor shall be able to provide a fully equipped and qualified factory-trained repair technician at the job site within 4 hours of request for emergency services. This service shall be available 24 hours a day during the term of warranty.

F. The vendor shall have successfully completed similar local (Western Washington) jobs in scope and nature, using the proposed product line, fire alarm panel and equipment, in other buildings over the past three years. For new product lines, one system shall have been completed and in service for at least 18 months.

G. The vendor shall have sufficient means and capacity to provide the required submittals on schedule including, but not limited to, CAD equipment and qualified technicians.

H. The vendor shall employ factory-trained personnel to program, test, and commission the system.

I. The vendor shall be UL certified for Vendor Alarm Service (UUJS).

J. Installers shall have certification (FA-1) from Seattle Fire Department in accordance with SFC Appendix 111-B.

1.7 SITE CONDITION

A. The Contractor is advised that the drawings are diagrammatic in nature and are not intended to show all details.

B. The Contractor is expected to provide all miscellaneous parts and labor required to install a complete workable system.

C. The Contractor shall coordinate with the University's Construction Coordinator to define areas where the installer can store tools, equipment and other materials for this project.

D. The area is to be kept clean and neat at all times. Construction debris shall be removed daily.

E. The Contractor will be responsible for the security of all items stored in this area.

1.8 FIRE WATCH AND FIRE PROTECTION SYSTEM SHUTDOWNS

A. Where it is necessary to shut down existing fire alarm systems for switch-over purposes or any other reason that leaves the building unprotected, the Contractor shall provide a continuous approved fire watch during the shutdown.

1. Fire watch shall be performed by licensed security personnel, trained in the use and operation of portable fire extinguishers and instructed in how to contact the UW Police dispatcher by either radio or telephone.
2. Continuous rounds to cover all areas of the building are required every 30 minutes.
3. An evacuation plan which includes a method to notify all occupants is required in occupied buildings.
4. Maintain a log of the rounds and comprehensive notes.
5. Provide a 30-day notice to the Owner’s Representative and attend coordination meetings for fire watch approval.

B. Provide 14 days written notification to the University's Construction Coordinator, requesting approval for fire protection system shutdown or functional impairment; receipt of the approval from the University's Construction Coordinator is required before any system shutdown or functional impairment.

1.9 SUBMITTALS

A. Conform to Section 1300, Shop Drawings, Product Data, Samples, and UW Drawing Standards.

B. Submit the following in accordance with the conditions of Contract and Division 01 Specification Sections:

1. Prepare and submit 6 copies of shop drawings and catalog cut sheets and additional information required in this section, via the Construction Coordinator, to the UW Fire Protection Engineer and Fire Alarm Shop for Owner approval.
2. Upon receipt of Owner approval, shop drawings shall then be forwarded to the SFD for their approval.
3. One copy of Owner-approved shop drawings with SFD approval, and accompanying letter, shall then be submitted to the University's Construction Coordinator. Partial submittals are unacceptable.
4. The Vendor shall not start any construction nor order any materials prior to acceptance of all submittals by the Owner’s Representative and the SFD.
5. Submittals, as a minimum, shall include the following:

    a. Floor plans drawn with AUTOCAD to same scale as the architectural drawings, showing device layout, raceway routing, riser diagrams, conduit and wire size, wire identification numbers, room and floor identification numbers. These drawings shall be produced as follows:

        1) The Owner shall forward a copy of the Architectural backgrounds to the Contractor.
        2) The Contractor’s drawings will show all equipment locations and all wiring requirements, utilizing the UW wiring standards in Table 3.6.B and UW symbols as illustrated on the plans.
        3) With this information and drawings, the Contractor will create a raceway, conduit and riser design meeting the requirements in section 3.6.
        4) The Contractor must then ensure completeness, including wire information, room numbers, devices, equipment and all other pertinent information.

6. Typical point-to-point wiring diagrams of the control panels, including but not limited to, all control and annunciator panel components, field devices, relays, fans, elevators, and other auxiliary control(s), and terminal cabinets showing all installed wiring (not factory wiring harnesses) and wiring connections. All variances from typical shall be illustrated in separate diagrams.
7. Label all components. Identify circuits using identification labels listed in Table 3.6B.
8. Detailed mounting installation diagrams of the control panel(s), remote annunciator(s), Gamewell Master Box, Digitizer supervisory transmitter, and keyed signal silencing switch
9. Battery calculations, speaker, and strobe circuit voltage drop and power consumption
10. Riser diagrams with FACP, terminal cabinets, raceway layout, circuit identification labels per 3.6, riser conduit size, and all devices; horizontal and vertical lines shall be provided to illustrate floors and zones.
11. Functional response matrix identifying all system responses
12. Front view of the control panel(s) and all annunciator panels

13. FACP, labels and labeling schemes for circuits, and field devices; nameplates and messages on the control panel(s) and annunciators shall be provided in actual size.
14. Wire/circuit legend with circuit identification, color, gauge, wire type, number of conductors, etc.
15. Raceway size calculations showing % fill in accordance with this specification (see Section 3.6)
16. Circuit schedules for speakers, strobes, auxiliary controls, and software/advisory code zones
17. Schedule of addressable circuits and corresponding circuit lengths
18. A Materials Submittal cover sheet identifying all FACP equipment, model number, and quantities

C. Within 45 days after Owner approval of shop drawings and catalog cut sheets, submit the following for review and approval via the construction coordinator to the UW Fire Protection Engineer and the Fire Alarm Shop for Owner approval:

1. A written acceptance test procedure (see Section 4.2)
2. A complete fire alarm device point list for all circuits to identify the following:

    a. Device address (initiating only)
    b. Manufacturer fixed labels (device type)
    c. Custom labels (conforming to UW standard format)
    d. Software zone (same as annunciation alarm LED, and Advisory Code zone)
    e. A blank column for Advisory Code number, to be completed by Owner's Representative and returned.
    f. This list shall also include signaling and all other auxiliary circuits.
    g. Prepare this list on Microsoft Excel using 8½" x 11" or larger sheets.

1.10 AS-BUILT DRAWINGS

A. While the system installation is in progress, one set of shop drawings will be kept at the job site.

1. This set will be designated as the As-Built Drawings and will be updated regularly to reflect current as-built information.
2. One set of as-built drawings can be replaced with a fresh updated set of drawings, but there shall never be more than one active set of as-built drawings.
3. The UW shall be given access to this set of as-built drawings at all times so that progress maybe reviewed and copies maybe made.
4. At the end of the project, submit these marked-up as-built drawings as part of the as-built drawings (see section 4.1).

1.11 FIRE ALARM SYSTEM DESCRIPTION

A. Equipment and materials shall include the following:

1. Intelligent (addressable/analog) fire alarm control panel(s), master box, trouble transmitter
2. Equipment and circuits for the following:

a. Alarm initiating devices
b. Evacuation notification devices
c. Fire alarm system monitored, controlled, and powered equipment
d. Communication systems

3. Advisory code transmitters: The advisory code transmitter shall be positive, successive, non-interfering, electronically supervised and located in the FACP. The following types of alarm reporting zones shall be transmitted to the Campus Central Station using a 3-character code, utilizing the digits 1 through 9; wing delineation shall be as identified on the plans.

   a. Automatic detection devices (e.g. area smoke detectors and heat detectors) zoned by floor and wing
   b. Manual pull stations zoned by floor and wing
   c. Water flow detectors zoned by floor and wing
   d. Duct smoke detectors shall, together, transmit as one zone per HVAC system.
   e. Elevator machine room smoke detection shall transmit as one zone per elevator machine room.

4. Wire, cable and raceways for interconnecting the above and connecting the system to the Campus McCulloh Loop (Campus McCulloh Loop cable provided by Owner, installed by Contractor, see Section 1.3 A.3)

1.12 SYSTEM OPERATION DESCRIPTION

A. Fire alarm functions: Activation of a pull station, sprinkler water flow or activation of an automatic sensing device for fire, temperature, flame, or smoke shall result in the following:

   1. An audible evacuation alarm signal will continuously sound a “slow whoop” signal until the system is reset or the voice override is utilized.
   2. The visual evacuation alarm devices will flash rapidly until the system is reset.
   3. The master fire alarm box will trip.
   4. The appropriate zone advisory transmitter will operate and transmit to the central station loop.
   5. System will be configured to prevent the Digitizer trouble transmitter from interfering with the zone advisory transmissions.

B. Auxiliary control functions: The fire alarm system shall, during certain alarm conditions, control the following types of equipment: Doors, fans, dampers, elevators, etc. Direct control from detector output contacts is not permissible unless the contacts are fully programmable from the FACP. As a minimum, the controls shall accomplish the following:

   1. Automatically restore the signal to the controlled systems to normal operation after FACP is reset from alarm posture
   2. If there are two or more fans of 20 HP or greater controlled directly from the FACP, then the fans shall "stagger start" with an appropriate delay between each start. The time delay and sequencing shall be incorporated into the ventilation controls or fan motor

controllers by way of time-delay relays, etc. A 10-second delay between fan restart is recommended.

3. Phase I operation of elevator

4. Fan control
   a. Environmental fans: The following general building fans shall shut down upon activation of any fire alarm device via direct control from the FACP. FACP control shall have priority over all other interlocks and controls:
      1) {*Designer:…Insert list*}
   b. Dedicated fire safety fans: The following shaft pressurization and other dedicated fire safety fans shall start and be controlled directly from the FACP:
      1) Fans: {Designer: Provide a list of fans.}
   c. Manual override: Provide on-off-auto manual override switches with priority over local HOA, and other automatic control for all dedicated fire safety fans as identified above.
   d. Fan status:

      1) Provide contact point for positive feedback fan status at the FACP using a current sensor relay (provided in section 15900) located at the load side of the disconnect switch for all dedicated fire safety fans.
      2) Provide a relay on fan control power to indicate ready status. It should be programmed as a supervisory condition.
      3) Provide a red LED for run and a green LED for stop indication at FAP.
      4) Provide specific wiring diagrams for (a) through (d) above. See UW standards details and confirm accuracy for this project.

5. Drop all magnetically-held doors following a 15-second time delay.

C. Supervisory functions

1. Supervise the 120 VAC circuits supplying the FACP.
2. Supervise the master box trip circuit, alarm initiating circuits, building signaling circuits, and auxiliary control circuits, except the door circuits, against grounds, opens, and shorts.
3. Transmit a two-digit, three-round code to Campus Headquarters upon any malfunction or trouble condition of the fire alarm system. Two rounds shall be transmitted upon reset or restoration of system to "normal." Such restoration code shall not be transmitted until all troubles have been cleared.
4. Any equipment trouble or malfunction or activation of a sprinkler system supervisory switch shall sound a local buzzer and turn on an externally visible amber light (LED) in the FACP, and activate a trouble transmitter. If code generators are used, their failure shall be transmitted as a trouble via the Trouble Transmitter.
5. Upon application or reapplication of 120 VAC power, the fire alarm system shall automatically, without any operator intervention, initialize all circuitry and shall be in a normal operating condition. Systems which require operator intervention to reset manual controls following a 120 VAC restoration are not acceptable.

D. Annunciation and manual switches

1. Upon alarm, light red lights (LEDs) in the fire alarm panel, one to indicate general system alarm and one for each software zone in alarm. LEDs shall be visible from front of unit with its doors closed. These LEDs shall operate continuously until the alarm is reset from the FACP.
2. For each red zone LED provided above, provide an amber LED to indicate trouble or activation of sprinkler system supervisory switches which are associated with water flow switches (i.e., floor control valves).
3. The trouble buzzer shall be silenced by a silencing switch (amber trouble LED shall remain lit). When the condition causing the trouble or malfunction has been corrected, the buzzer shall again sound until this silencing switch is returned to the normal position.

    a. Individual, fully supervised, "test and maintenance" switches with amber LEDs shall be mounted inside the door to the FACP and shall prevent operation of the local energy master box; shall bypass the alarm signaling devices (e.g., speakers, horns, strobes); and shall intercept or block fan controls, door controls, elevator controls, dampers and other circuits as specified.

4. In an addressable system, each initiating device shall annunciate at the FACP {and remote annunciator} as a discrete point on an alphanumeric display. In addition, the appropriate software zone LED shall light at the FACP.
5. Provide descriptive alphanumeric program labels for each system-initiating device in accordance with the following format:

    a. Floor-Zone-Device Type-Specific Information and/or Location (and special access notes) Include device type if not included in standard manufacturer preprogrammed label.
    b. Examples:
        1) 4th Fl, C-Wing, corridor by Room 432
        2) 7th Fl, Duct Det, SF-2, in Mech Room 711
        3) 3rd Fl, Tower, in Stair No. 2

6. Provide manual switches and status LEDs at the FACP for fans as described herein and on the plans.

1.13 FIRE CONTROL COMMUNICATION SYSTEMS

A. The fire alarm speaker system shall incorporate a "one way" fire commander's voice communication or paging system. A microphone shall be placed at the main control panel.

B. A "two-way" fire fighter's telephone system with phone jacks shall be installed where indicated on the project drawings. A sounder shall activate at the FACP when a handset is plugged in at any field jack for the system.

1.14 INTERFACE WITH EXISTING FIRE ALARM SYSTEM

A. The existing fire alarm system shall not be disabled at any time.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. All materials and equipment shall be new. Previously used equipment is not acceptable unless specifically identified elsewhere in this specification.

2.2 MANUFACTURER*

A. The fire alarm control equipment shall consist of a system assembled as an approved unit of regularly manufactured components, by a single manufacturer for the purposes described elsewhere in this specification. The fire alarm control equipment must have a proven track record of service and reliability in projects of similar scope to this project. Interconnecting equipment that has not been listed for interconnection, or the creation of components or system into a nonstandard unit that is not normally available from the manufacturer, is not acceptable.

B. All equipment shall be listed, cross-listed, and labeled by Underwriters' Laboratories and approved by Factory Mutual.

C. Providing they meet all specifications, control panels and related equipment shall be manufactured by Simplex, with no exceptions, and no substitutions.

2.3 LOCKS

A. Locks for cabinets, enclosures, and manual pull stations shall be keyed for Corbin CAT. 30.

2.4 FIRE ALARM CONTROL PANELS (FACP)

A. FACP shall be microprocessor-operated, power limited, modular in design and equipped with a nonvolatile memory that requires no battery backup: Simplex 4100U no exceptions, no substitutions.

B. A single FACP shall be able to utilize, in combination, addressable, analog, and 2/4 wire NO/NC detectors. (Plug-in "mix and match" modules or similar architecture are acceptable.)

C. Software

1. UW personnel shall be able to create and modify control software with an IBM-compatible PC utilizing MS-DOS-based or MS-Windows based, menu-driven, user-friendly programming.
2. UW personnel shall be able to store the programming on a removable computer disk and pre-program a nonvolatile, transportable memory storage device which can be used for replacement in a FACP as the programming backup. All software including proprietary software shall be provided to the UW as necessary to meet the above requirements.

D. Fire alarm system shall be wired for "Class B" operation on alarm initiating and signaling (notification) circuits.

1. All end-of-line devices shall be located in the terminal cabinet or the end of the corridor for the zone served.
2. Tee tapping is not allowed on conventional or addressable systems.

E. FACP shall incorporate power supplies and all controls for systems except as described elsewhere within the specification.

1. Locate all amplifiers at the head-end (FACP) of the system.
2. Mount all components within a steel enclosure with locked door(s).

   a. Door(s) shall incorporate a transparent window for viewing indicator lights, and other pertinent components.
   b. Mount cabinet(s) as indicated on the drawings.
   c. Provide additional cabinets if required.

3. Transponders and other ancillary control panels may only be used where shown on the drawings unless approved by the Owner's Representative.
4. Circuits shall not be loaded to greater than 80% of their rated capacity.

F. Initiating circuits

1. The FACP shall support independent addressable circuits, originating from FACP-mounted hardware, for each floor and zone. No circuit shall exceed 4000 feet in length.
2. Software zones shall be provided consistent with those required for advisory code zones as described in 1.11.

G. Notification circuits

1. The FACP shall support independent speaker and visual alarm circuits originating from FACP mounted hardware for each floor and zone of the building.

   a. Provide a schedule by performing circuit load calculations considering wire length, gauge, number of devices, and FACP specifications.
   b. Do not use a single circuit for multiple floors or zones; however, a number of circuits maybe required for a single zone.

2. Visual notification circuits shall be synchronized per circuit at each floor's terminal cabinet.
3. No speaker circuit shall exceed 10% voltage loss measured at the end-of-line device. No strobe circuit shall exceed a 2.1-volt line loss measured at the end-of-line device with a 21-volt DC input at the fire alarm panel end of the circuit.
4. Calculate visual alarm (strobe) circuit capacity and line loss using the strobe's 20-volt DC ratings.
5. The FACP shall support independent door and {corridor damper} control circuits originating from FACP mounted hardware for each floor and zone of the building.

H. Power supplies

1. The FACP 24 VDC power supply shall be powered by 120-volt AC power, with a battery backup system regardless of the building's primary or alternate source of power. The system shall also have the following requirements:

   a. *Sealed gelled cell-type batteries
   b. 24-hour system backup capability plus 5 minutes of full alarm operation at the end of the 24-hour period
   c. Charger shall be able to restore batteries to full charge within 48 hours after a complete discharge.
   d. The FACP shall supervise battery and charging system. The FACP shall include trouble annunciation of high/low voltage, shorted cell and open circuits.
   e. A means of disconnecting the 120 VAC feed to the FACP for maintenance shall be provided within the FACP or in a locked enclosure within 10 feet of the FACP.
   f. No power supply shall be loaded to greater than 80% of its rated capacity.
   g. Power supplies must be capable of powering all circuits simultaneously (e.g. Door holder power at the same time notification circuits are active.)

2. Emergency power is not required for the door holders. Doors AUG close upon loss of building power.

I. Other FACP features

1. Walk test: A test mode that causes the system’s signal to sound, and a report to be printed, when a device is activated, or a trouble or supervisory condition identified, followed by a prompt automatic reset of the FACP.

   a. The signal sounding shall be capable of being turned off independent of the printing function.
   b. This feature shall be available for system acceptance testing/commissioning.

2. Alarm verification: An activated smoke detector shall automatically reset and then recheck the atmosphere following a 60-second waiting period.

   a. The fire alarm system won’t activate until detection is confirmed following the waiting period.
   b. Activation of a second detector during the waiting period shall activate the alarm system immediately.
   c. All area and duct smoke detectors shall be enabled with this feature.
   d. Provide a disabling feature at the system keypad for system commissioning and Owner confidence testing.
   e. Disabling this feature shall be accomplished via the keypad on a zone, or group of zones, basis.
   f. Enable the feature following

3. History log: Log a history of alarm and trouble events for the system.

J. Other FACP components shall include the following:

1. Master box supervisory tripping circuit or relays
2. Trouble circuit or relays to operate the Digitize trouble transmitter
3. Zone advisory transmitters or encoders
4. Alarm and trouble lights located to be visible with the door closed
5. System reset switch
6. Trouble buzzer with silencing switch inside locked cabinet
7. Control and time delay relays as required
8. Supervised switches (one for each listed function) installed to allow a complete test of the system without evacuating the building, recalling elevators, releasing doors and/or posturing for smoke control (i.e. bypass switches)
9. Supervised control switches or relays for use in interfacing with other devices as required
10. Permanent printed labels for all interactive equipment, zones, switches, controls, and instruction.
11. Fire sprinkler exterior bell notification device.

2.5 VOICE COMMUNICATION SYSTEM

A. Audio amplifiers shall be sized to provide ½ Watt minimum per attached audio speaker as shown on the drawings. Each audio amplifier shall have 50% minimum spare capacity when attached to the speakers necessary to meet audio requirements.

B. FACP shall incorporate a spare automatic backup audio amplifier equal in size to the largest individual amplifier.

2.6 MASTER FIRE ALARM BOX

A. Master fire alarm boxes shall be Gamewell M34-72 (indoor) and shall be local energy trip, or approved equal.

2.7 TROUBLE TRANSMITTER

A. Trouble transmitters shall be Digitize DET-6B, with no exceptions.

2.8 ADVISORY CODE TRANSMITTER

A. Advisory code transmitters shall be positive, successive, series, non-interfering, and able to transmit all digits from one to nine.

1. Coders shall be ½ second timing, 4 rounds, with a minimum of 39 pulses per round.
2. Coders shall be field programmable by the Owner without the use of special tools. If coders use EPROMs, then the Contractor shall supply the program and instructions for use on IBM-compatible machines using a standard EPROM burner.
3. Coders shall be solid state with no moving parts.

4. When more than one zone coder is activated, the first coder shall have the highest priority. After the first coder completes four rounds, the second and /or all subsequent codes shall be transmitted in succession.
5. Zone coders shall be UL and FM listed for this purpose and for use with the fire alarm panel supplied.

B. Microprocessor based zone code generators are acceptable provided the requirements of section 2.8 1-5 are met.

2.9 KEYED SILENCING SWITCH

A. Supervised key operated switch in box shall be mounted adjacent to the FACP for silencing audible alarms. Key box shall be Hoffman #E1PB; painted red. Switch shall be Allen-Bradley 800TH33, key # D018.

2.10 MANUAL STATIONS

A. Manual pull stations shall be addressable Simplex 2099 9795 single action or approved equal

1. Reset shall be accomplished with a lock and Corbin CAT #30 key.
2. The station housing shall be fire red factory finish.
3. Exposed back boxes shall be provided by the manual station manufacturer and be designed specifically for the application.

2.11 SMOKE DETECTORS/SENSORS

A. Ceiling or area-type smoke detectors

1. Detectors shall be photoelectric {addressable analog or two-wire type} with separate base.
2. The detectors, complete with terminating equipment, shall be fully supervised and shall not activate alarm due to rapid changes in humidity, or a fan maintenance shutdown, etc.
3. The detector shall be equipped with LED alarm condition indicator light.
4. When exposed back boxes are needed, use round "wire mold" boxes of the smoke detectors appropriate size.

B. Duct type

1. Detectors shall be {addressable analog or two wire type} photoelectric, in an enclosure with remote indicator and reset switch}.
2. The devices shall include necessary sampling tube extensions.
3. The device shall function uniformly in air velocities of 500 FPM through 3000 FPM.
4. Heat sensor feature is not required.
5. Install remote indicating light where shown on the drawings and where detector indicating lights are not readily visible.

6. In finished spaces mount remote indicator lights in close proximity to the duct smoke detector. Remote indicating lights maybe located in the ceilings or walls adjacent to detectors.
7. Device shall be flush or semi-flush mounted with identifying nameplate.

2.12 HEAT DETECTORS

A. Heat detectors shall be combination of fixed temperature and rate-of-rise low profile {addressable} type and shall be "ordinary" temperature range in all areas except where located in a high ambient temperature area.

B. In areas subject to temperature in excess of 140º F, detectors shall be listed for such use.

C. An indicator on the exposed surface of the detector shall display the actuated condition of the detector.

2.13 ADDRESSABLE INTERFACE MODULE

A. Provide addressable interface modules to interface with non-addressable initiating devices, i.e. water flow, tamper switches, kitchen, and fume hood suppression systems. Field control modules are not allowed.

2.14 AUDIBLE ALARM DEVICES

A. Speaker/strobes shall be red, have sealed back, metal grill, with multiple wattage taps including ¼, ½, 1 watt, and 2 watts, and multiple candela taps including 15, 30, 75, or 110. Indoor speaker/strobes shall be Wheelock E70-24 MCW-FR or approved substitution.

B. Install all speakers at the½-watt setting unless indicated otherwise on the drawings. Speakers located in rest rooms and similar enclosed areas where alarm threshold maybe high should be tapped at ¼ watt.

C. Speakers shall be flush mounted.

1. For surface mounting red Wheelock SBB box shall be used.
2. For flush mounting use a 4S deep j-box with an extension ring or the 5S j-box by Randl Industries (note: 5S box allows installations in walls not deep enough to accommodate the 4S box and extension ring).

D. Outdoor and environmental rooms with high humidity and controlled temperature, including coolers and freezers:

1. Speaker/Strobe: Wheelock ET-70WP-247S-FR speaker with Wheelock 10B-R back box or approved substitution.
2. Provide weatherproof back box with weep hole oriented down, and seal conduit penetration with mastic and orient weep holes down. For outdoor and weatherproof

installations exceeding the range of 31 degrees F, 150 degrees F and humidity of 95% RH, provide a separate speaker and strobe devices.

E. For horn-only systems provide separate circuits for horns and strobe devices.

1. Indoor Speaker/Strobe: Wheelock NS4-24MCW-FR or approved substitution.
2. Outdoor and Environmental Rooms:

   a. Horn: Wheelock NH-12/24-R or approved substitution.
   b. Horn/Strobe: Wheelock MTWP-2475W with Wheelock IOB-R back box or approved substitution.

3. Set horns for “slow whoop” tone.

F. An open circuit in any speaker or horn coil shall not prevent the rest of the audio devices connected to that circuit from operating.

1. If a short circuit occurs, the faulted circuit shall not prevent any other circuit from operating, and trouble shall be indicated.
2. If the shorted circuit clears, signaling operation shall be automatically restored.

G. The speaker cable shield or drain wire shall remain intact and be spliced through all terminal cabinets, junction boxes and speakers.

1. The drain wire shall not be grounded for terminated except at the main FACP.
2. Wherever the drain wire is exposed, it shall be wrapped with UL approved electrical tape, in order to avoid shorts or grounds.

2.15 STROBES (VISUAL ALARM)

A. Visual alarm signal shall operate at 24 volts DC and be equipped with a Xenon strobe flashing light which meets requirements outlined in 2.14 above.

1. Use Wheelock series RSS-24MCW-FR.
2. Use Wheelock series RSSWP-2475W strobe with Wheelock WPSBB-R back box for outdoor and environmental rooms.
3. Flashers shall be combined into one unit with speakers (or horns) where appropriate.

B. All strobe circuits to be synchronized at the terminal cabinet with a Wheelock DSM-12/24-R synchronization module.

2.16 DOOR HOLDERS

A. Provide Rixon Style (Simplex series 2088) wall mount and floor mount or approved substitution.

1. Where it is physically impractical to use the Simplex series 2088 style door holders, LCN series 4040 door closers AUG be used with Owner approval. {Refer to Section 8700 Hardware Specialties, for door closers.}
2. Power for door holders shall be 24 VDC and originate from the FACP but shall not transfer to battery power upon loss of 120 VAC.

2.17 ELEVATOR CONTROL

A. Provide relays and wiring from FACP to the elevator machine room as identified on the plans for activation of the elevator phase I recall system. Interposing relays shall be cross-listed with the FACP.

2.18 SPRINKLER SYSTEM ALARM AND SUPERVISORY SWITCHES

A. Shall be provided by Division 21, Fire Suppression. Wiring and raceway and final connection to the fire alarm system shall be required by this section.

B. Furnish and connect electric bell for waterflow on sprinkler system. Potter Electric PBD-DC or equivalent.

2.19 PRINTER PORT

A. Provide and install a printer port for use by UW personnel for testing and maintenance. Printer(s) shall receive English language text from the fire alarm control panel in an industry standard ASCII format via an EIA RS-232-C connection.

B. All printed information shall include time and date.

2.20 FIRE ALARM TERMINAL CABINETS AND AUXILIARY CABINETS *

A. Enclosures shall be NEMA Type 1 or Type 12. {The “Terminal Cabinet Sizing” Drawing, page 16X-033, shall be used for sizing the terminal cabinet panel box sizes.} All panels shall be {surface, or flush} mounted with hinged door and latch with lock. All locks shall be Corbin CAT. 30 keys. Box and front shall be steel, painted to match wall in finished areas. Manufacturers: Hoffman, Square D.

B. Fire alarm terminal cabinet shall be labeled with a riveted or screwed laminated plastic nameplate indicating "FIRE ALARM TERMINAL CABINET" in ¼ inch white letters on a red background.

C. Provide a wire scheme similar that specified herein inside of the cabinet door. Also, provide a schedule identifying all end of line resistors for the zone and their respective locations.

D. Provide terminal blocks in all terminal cabinets and auxiliary control cabinets. These blocks shall be sized to accommodate wire from 19 gauge to 10 gauge. Terminal blocks are to be Allen Bradley 1492- W6 or W10 or Entrelec M4/6 with associated partitions, barriers, stops, and rail.

E. Backboards in the terminal cabinets shall be constructed of fire retardant treated ¾ inch exterior grade plywood, painted white.

2.21 REMOTE ANNUNCIATOR

A. Provide an alphanumeric type remote annunciator with 80 character LCD display, and system acknowledge switch(s). Do not provide zone LEDs. Simplex 4603-9101 LCD. Mount annunciator LCD at 6.0 FT AFF

2.22 SPARES

A. Provide FACP spare equipment for 5% (at least two each) spare fully operational speaker, strobe and auxiliary control circuits.

B. Provide 20% spare capacity for FACP I/O points and mapnet.

C. FACP Auxiliary relays, minimum 3 amp. form "C" contacts - {insert value}

D. FACP Control/Bypass switches - {insert value}

2.23 SMOKE/FIRE DAMPERS

A. Dampers shall be provided by Division 21.

B. Interface relays shall be provided to operate 120VAC AC smoke dampers from the 24VDC fire alarm system.

1. Fire alarm contacts shall be rated at 10 amps.
2. The interposing relay is to be normally closed and the damper(s) powered open.
3. Upon alarm or AC power failure, the damper shall close.
4. Interposing relays shall be UL cross-listed with the FACP.
5. Multiple fire/smoke dampers in common area per floor shall be controlled with a single interposing relay

PART 3 - INSTALLATION

3.1 APPROVAL

A. No equipment shall be provided at the job site until shop drawings have been reviewed and approved by the UW and AHJ. A UW and AHJ approved shop drawing set shall be continuously available at the job site during construction.

3.2 MOUNTING POSITION

A. FACP/master box/trouble transmitter: Locate as shown on the drawings.

B. Evacuation speaker/strobe shall be mounted on the walls, 80 to 96 inches above finish floor, in accordance to NFPA 72.

C. Pull stations: 4 feet from floor to center of device

D. Battery cabinet: If shown, locate as illustrated on the drawings. If required due to physical constraints and not shown, consult the Owner's Representative.

E. Duct detectors: Placement must conform to NFPA standards. Coordinate location with mechanical. For assistance consult with UW Fire Protection Engineer or A/E.

F. Remote annunciator panel: Location shall be as shown on the drawings.

G. Fireman's telephone jacks: 4 feet from floor to center of device

3.3 MOUNTING METHODS

A. Conduit, panels, devices and boxes shall be secured by means of expansion shields in concrete, machine screws on metal surfaces, and wood screws on wood construction. Attachment with devices driven in by power charge or nail type nylon anchors is not acceptable in lieu of machine screws.

3.4 AUXILIARY CONTROLS *

A. Provide all wire ways, wiring, control modules, interposing relays, terminal boxes, and relay cabinets for FACP controlled equipment including fans, dampers, doors, elevators, etc.

B. Each type of equipment shall be controlled by dedicated double throw relays.

C. Field control modules AUG be used for addressable systems.

3.5 ELEVATOR CAR EQUIPMENT AND TRAVELING CABLE

A. Traveling cable furnished and installed by Division 14. Coordinate with elevator contractor for circuit requirements and connections.

3.6 WIRING

A. General wiring and raceway system. Raceway installation shall be field reviewed by the Owner’s Representative prior to pulling wire.

1. The manufacturer's recommendations shall only be used as a minimum requirement.
2. All wire shall be new, UL approved and marked and brought to the job site in original packages.
3. Wire insulation shall be one of the types required by NEC. All wires shall be sized per NEC for the load serviced. Field wiring for initiation, supervision and signal circuits shall be solid conductor. All wire shall be approved for fire alarm installations.
4. “Pig tailing" and Tee tapping is prohibited for all system circuits, except door circuits and addressable signaling line circuits.

    a. Addressable signaling line circuits AUG be Tee tapped only in the terminal can for the floor which that circuit serves.

5. Fire alarm system shall be wired "Class B", device to device, with no splicing unless approved by the Owner’s Representative.
6. End of line resistors shall be located in the terminal cabinet or the end of the corridor or other unassigned (public) space for the zone served.
7. Splicing shall be made with Minnesota Mining & Mfg. Co. "Scotchloc" spring connectors with steel cap and PVC insulation, Thomas & Betts or approved equal.
8. Colors shall match when possible and the conductors shall be mechanically secured to each other so that no stress is applied to the splice.
9. Aluminum wire and stranded wire are both prohibited.
10. Wire pulls by powered mechanical means will not be permitted.

    a. Conduit shall be thoroughly cleaned of all foreign material just prior to pulling the wire or cable.
    b. Lubricants shall be compounds specifically prepared for cable pulling and shall not contain petroleum or other products which will affect cable insulation.

11. Wire that has scrapes, nicks, gouges, or crushed insulation shall not be used and must be removed.
12. Do not run low voltage energy limited wiring in the same wire-ways with, or closely parallel to, high voltage and/or switched power wiring.
13. Interposing relays shall be used for all switched power loads and shall be located such that the switched power conductors do not run in the same raceway as the interposing relay coil power or any other energy-limited low voltage conductors.
14. All wiring shall be contained in metal conduit or raceways dedicated to fire alarm service.

15. Conduit size shall be ¾ inch minimum, except, conduit up to 30 feet in length, from junction box to an individual device AUG be ½ inch. Wire mold shall be #700 minimum (also see Section 16A06, Basic Electrical Requirements).
16. No raceway shall be filled in excess of 40%. The Contractor shall demonstrate by performing fill calculations showing that the designs comply with these criteria. Exceptions are only allowed when use of existing wire ways is approved.
17. Provide 6” X 6” or larger junction boxes at all junctions where four or more conduits are combined. Use of extension rings to achieve adequate space for a device or junction is not allowed.
18. The raceway system shall resemble a branch and tree configuration where the main run has limited offsets, and branch lines run perpendicular to the main run.

    a. Each device shall be connected from a junction box on the main FA raceway so that the main raceway does not pass through a device back box.
    b. Branches shall be provided with sufficient junction boxes so that not more than three unassociated circuits pass through a device back box.

19. All raceways shall run parallel or perpendicular to walls, floors, and ceilings.
20. For surface-mounted raceway, runs shall be routed on walls out of visual sight, with vertical drops to wall-mounted devices. Submit routing proposal to A/E for approval prior to installation.
21. Do not encase raceway in concrete unless specifically called for.
22. No wire run or circuit shall be longer than 80% of the maximum allowable length and power consumption for the wire size and application. No output circuit shall exceed 80% of the maximum load capacity specified by the manufacturer.
23. Terminate all wiring for each zone or floor in a terminal cabinet as indicated on the contract drawings prior to running the wires to the fire alarm panel. Provide at least one terminal cabinet for each floor.
24. All solid wire terminations shall be made bare to screw terminals specifically designed for bare wire connection. Make cable shield terminations with T&B "Sta-Kon" (or equivalent) self-insulated spade lugs where connected to screw type terminals.
25. Wiring in all cabinets and terminal boxes shall be neatly arranged and bundled with tie wraps or equivalent.
26. Paint all junction box covers for the fire alarm system red. Paint J-Box covers in finished areas to match the wall or ceiling and put a ½-inch minimum red dot on the cover.
27. All conduit and raceways shall be color-coded by a ¾ -inch red tape band at 10-foot intervals. Use Scotch Brand #35 tape or approved equal.
28. The Utility McCulloh Loop cable is Non-Power Limited, and its raceway must connect into the Non-Power Limited section on the FACP.
29. All inductive loads (door holders, interface relays) without integral reverse EMF suppression must have suppression on those circuits.

B. The following wire will be used unless an alternate is approved by the Owner’s Representative. Color-coding shall be by wire insulation. Single conductor wires shall be solid.

TABLE 3.6.B
Wire and Cable Requirements

Circuit Type	Quantity/Color	Size	Section	ID
Addressable circuit *(Note 1)*	West Penn D975,or Connect-Air W181P1608	#18 #18	0.0450 sq.in. 0.0222 sq.in	L
24 VDC	1 pink (pos.) THHN 1 grey (neg)THHN	#14	0.0174 sq.in.	P
Remote Indicator Light	1 pair TFN (2 pink)	#16	0.0158 sq.in.	R
Monitor Switch (tamper, flow & pressure)	2 pair TFN (2 yellow, 2 brown)	#16	0.0158 sq.in.	T
Audio Alarm (speakers) *(Note 1,2)*	Belden 5120 FL Belden 5120 FL	#16 #14	0.0249 sq. in. 0.037 sq. in	A
Visual Alarm (strobes) *(Note 3)*	1 pair THHN 1 brown (negative) 1 blue (positive)	#14	0.0174 sq.in.	V
Door Holder & Door Lock	1 black, 1 red THNN	#14	0.0174 sq.in.	D
Smoke Control Damper	1 pair THHN (light blue)	#14	0.0174 sq.in.	Z
Fan Control (simple shutdown)	2 orange THNN	#14	0.0174 sq.in.	H
Fan Control (shutdown override and status)	5 orange THHN (3 orange, control) 2 orange, status	#14	0.0435 sq. in.	Q
Fireman's Phone *(Note 1)*	Belden 5320 FL or Connect-Air W181P-16908	#14	0.0189 sq.in. 0.0222 sq.in	F
Elevator Recall	4 yellow THNN	#14	0.0348 sq.in.	E
FACP to Trouble Transmitter	See Figure B	--	--	X
FACP to Master Box	See Figure B	--	--	Y
Panel Ground	1 green THHN	#10	0.0184 sq.in.	--
Panel Power	See Specification Section 16120	#12	0.0234 sq.in.	--

NOTE 1: Cable must conform to FACP system manufacturer's requirements.
NOTE 2: Contractor's option, 14 or 16 gauge (see 2.4). This is a two conductor shielded cable. The same size cable shall be used for the entire system.
NOTE 3: See 2.5. All circuits shall be 14 gauge; twelve-gauge wire is prohibited. Provide multiple circuits for a single zone as required.

C. All circuits and conduits shall be identified in accordance with Table 3.6C, with labels to include circuit type, zone, floor, wing, and conduit number. Labels must be provided at the FACP, annunciator, terminal cabinets, and all junction boxes with more than 5 circuits. Labels shall be produced using an electronic labeler.

TABLE 3.6.C
Wire Labeling

Format:	XX	XX	XX	XX	XX
	ID	Z	F	W	C
Example:	V	12	6	J	26
Circuit (ID)	= Per Wire Table (i.e.. V for Visual)				
Zone (Z)	= 1, 2, 3,,,,,,,,,,,,,,,,,,,, 23, 24				
Floor (F)	= M1, 01, 02,,,,,,,, 10, 11				
Wing (W)	= A, B, C,,,,,,,,,, NN, EA, SW				
Conduit (C)	= 01, 02, 03,,,,,,,, 10, 11, 12				

D. All initiating and signaling circuit devices shall be externally labeled with a printed adhesive label approximately ½” x 1” in size. Identify the circuit and zone, consistent with wire labeling scheme, using a 12 to 14 point font, black ink on white.

PART 4 - FINAL ACCEPTANCE REQUIREMENTS

4.1 RECORD DOCUMENTS

A. As a condition for the project final acceptance, the vendor shall submit the following documents to the UW for approval:

1. Operation and Maintenance Manuals: See Section 01700

   a. Submit a copy of the O&M Manual to the UW Signal Shop
   b. The O&M Manual shall include as-built drawings as listed below catalog cuts, and manufacturer wiring diagrams of all FACP components. Photocopies are not acceptable.

2. As-built drawings:

   a. The as-built drawings shall be neatly prepared on AUTOCAD Release 12 (or higher).
   b. The UW will provide use of a standard template, a library of symbols, colors and layers and one day of support and instruction in the UW protocols.
   c. Provide 2 sets of prints, one set of fixed line reproducible (size 24" x 36" or 36" x 42") and 2 sets of AutoCAD disks. These drawings shall include the following:

      1) All requirements listed for shop drawings per 1.9
      2) Changes as a result of final installation, testing, or a change to the system design
      3) An accurate depiction of risers, raceway, conduit, all wire runs, cable identification, conduit size, location of junction boxes, terminal boxes,

sources of power, devices, sensors, equipment, controlled equipment (motor starters, fans, pumps, valves, dampers, etc.)

4.2 TESTING

A. The completed system shall be subjected to 2 required tests.

B. The initial test shall be a preliminary test which will be conducted by the Contractor and witnessed by the UW Fire Protection Engineer, the UW Fire Alarm shop.

1. This test shall be completed after the system is complete and clear of troubles.
2. Should the results not be satisfactory to the UW representatives, then corrections will be made and a re-test will be required at the Contractor's expense. The Installer and a factory trained technician for the FACP shall be present for all testing.
3. The preliminary test shall be in accordance with a written Acceptance Test Procedure (ATP) to demonstrate and certify proper system operation.

    a. The ATP shall be prepared by the Contractor and submitted to the Owner’s Representative for approval prior to the performance of the ATP.
    b. As a minimum, the ATP shall provide a detailed method of testing and documenting the following to demonstrate to the Owner’s Representative that the system functions as intended by the design.
    c. The document shall be a written test procedure and customized check-off sheets for the following as a minimum:

        1) All detectors shall be removed from their base and checked for trouble. Remove one device per addressable circuit from its box and lift a wire to test for supervision and ground. Failure due to improper system wiring will require a comprehensive test of the circuit.
        2) Remove one device per signaling circuit from its box and lift a wire to test for supervision and ground. Failure due to improper system wiring will require a comprehensive test of the circuit.
        3) All bypass and control switches shall be operated to indicate proper supervision of the switch.
        4) All valve and sprinkler supervision switches shall be operated to verify proper response.
        5) All valve and sprinkler supervision switches shall have one wire removed to verify proper supervision.
        6) Each alarm output, detection or supervision zone be tested for proper response to ground conditions.
        7) Test the Gamewell Master Box for proper operation.
        8) Test the Digitizer supervisory transmitter for proper operation.
        9) All zone annunciator transmitters shall be tested for proper operation.
        10) *AC power shall be interrupted for 24 hours and followed by a 5 minute alarm test.
        11) Remove all critical fuses to check for proper supervision.
        12) Test the firemen's telephone system for supervision of the wiring and for quality of voice transmission.
        13) Test all detectors for alarm operation.

14) Test all signaling devices for proper operation. Devices that fail and are replaced will require a retest.
15) Test all alarm sounding devices for proper operation.
16) *Audibility tests will be conducted by the Contractor to determine compliance with the dBA requirements. For replacement systems in occupied buildings, the audibility test shall be conducted after normal working hours.
17) All elevator, fan, door holder, damper and other control functions and circuits shall be tested for proper operation.
18) Test for proper operation of the Public Address portion of the FACP.
19) Test fan and damper control, including manual override and priorities. Coordinate with other trades.
20) Test magnetic door closers, holders, locking mechanisms. Verify appropriate priority with security and access control systems.
21) Test elevator recall, Phase I and II.
22) Test transfer to emergency power, where provided.
23) Test alarm verification function. Confirm no delay occurs if two detectors are activated.
24) Confirm analog sensor adjustable sensitivity function is operable and properly set.
25) Demonstrate history log and print port functions.
26) Confirm functional performance test with system response matrix.

C. Smoke sensor sensitivity report: Following completion of the preliminary test, the Contractor shall place the FACP on line will outputs bypassed for a period of 10 days.

1. A report of all system smoke sensors with sensor high and low readings and recommendations for alarm threshold settings, and device relocation if necessary, shall then be submitted to the Owner's Representative.
2. Smoke detectors with a reading of 95 and higher are considered dirty and will be required to be cleaned or replaced for final acceptance of the system.
3. The Contractor shall then adjust detector sensitivity as directed by the Owner's Representative.

D. After satisfactory completion of the preliminary testing, the UW will arrange for the SFD to witness a final Contractor-executed acceptance test of the system.

1. Final acceptance will be granted jointly by the SFD and the UW Fire Protection Engineer or the UWs designated representative.
2. Approval of the AHJ shall be evidenced in writing and a copy forwarded to the UW.
3. The requirements for final testing shall be as requested by SFD at the final test.

4.3 TRAINING

A. The vendor shall, after two weeks (minimum) written notification to the Architect and the UW, conduct a training session during which all maintenance and operational aspects of the system will be described and demonstrated to personnel selected by the Owner's Representative. The

session(s) shall be conducted by a manufacturer's representative thoroughly familiar with the characteristics of the installed system.

4.4 OTHER ITEMS

A. At the completion of the installation when the as-built drawings have been submitted and accepted, the Contractor shall submit a letter to the UW certifying that the fire alarm system is completely functional and conforms to all applicable codes, ordinances, and requirements of the contract.

B. Submit installation permit from the AHJ to the UW Construction Coordinator.

4.5 PROJECT COMPLETION

A. Project completion and payment will be based on the following:

1. Completion and approval of acceptance tests
2. Completion of punch list items
3. Delivery and acceptance of the as-built drawings and operation and maintenance manuals
4. Cleanup of installation site to the satisfaction of the University's representative

END OF SECTION 28 31 11