

Engineering Specifications

**SAPPHIRE® PLUS FIRE
SUPPRESSION SYSTEM
WITH AUTOPULSE
IQ-318/IQ-636X-2 AGENT
RELEASING CONTROL
PANEL AND LITHIUM-ION
RISK PREVENTION SYSTEM**

**HYGOOD® SAPPHIRE® PLUS FIRE SUPPRESSION SYSTEM WITH
AUTOPULSE IQ-318/IQ-636X-2 AGENT RELEASING CONTROL PANEL
AND LITHIUM-ION RISK PREVENTION SYSTEM
ENGINEERING SPECIFICATION**

2020-October

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PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

- A. This specification outlines the requirements for a "Total Flood" SAPPHIRE PLUS Clean Agent Fire Suppression System with AUTOPULSE IQ-318/IQ-636X-2 Releasing Panel and the HYGOOD® Lithium-Ion Risk Prevention system. The work described in this specification includes all engineering, labor, materials, equipment, design and service necessary and required to complete and test the suppression system.
- B. In areas where multiple hazard zones are protected with a common bank of containers, the use of selector valves shall be used to direct flow of SAPPHIRE agent to the protected zone(s). Quantity of SAPPHIRE PLUS containers shall be based upon the largest zone of protection. Selector valves shall be provided to deliver the proper design concentration for each specific protected zone.
- C. The contract drawings indicate the general requirements of the areas to receive detection and SAPPHIRE PLUS system protection. Contractor is to review all drawings so that all items affecting the operation of the fire detection/SAPPHIRE PLUS fire suppression system (such as equipment location, air diffusers, damper closures, and door openings) are considered in the design of the engineered system.
- D. The hazards with lithium-ion batteries shall use off-gas monitoring equipment to provide early notification of battery failure prior to thermal runaway conditions. The HYGOOD® Lithium-Ion Risk Prevention system integration shall be configured to communicate with the fire detection panel and the lithium-ion battery management system (BMS). Additionally, a lithium-ion battery shut down relay should be employed in addition to the controls provided by the BMS, in the event the BMS fails.

1.2 APPLICABLE STANDARDS AND PUBLICATIONS

- A. The design, equipment, installation, testing, and maintenance of the SAPPHIRE PLUS Clean Agent Fire Suppression System shall be in accordance with the applicable requirements set forth in the latest edition of the following codes and standards (as applicable to the project requirements):
 - 1. National Fire Protection Association (NFPA) Standards:
 - NFPA 2001: Standard on Clean Agent Fire Extinguishing Systems
 - NFPA 70: National Electrical Code
 - NFPA 72: National Fire Alarm and Signaling Code
 - NFPA 75: Standard for the Fire Protection of Information Technology Equipment
 - NFPA 76: Standard for the Fire Protection of Telecommunications Facilities
 - NFPA 855: Standard for the Installation of Stationary Energy Storage Systems
 - 2. Factory Mutual Systems (FM) Publication:
 - FM 5600: Clean Agent Extinguishing Systems
 - 3. Underwriters Laboratories, Inc. (UL) Publication
 - UL 217: Standard for Single and Multiple Station Smoke Alarms

- UL 228: Standard for Door Closers-Holders, With or Without Integral Smoke Detectors
 - UL 268: Smoke Detectors for Fire Alarm Systems
 - UL 268A: Standard for Smoke Detectors for Duct Application
 - UL 521: Standard for Heat Detectors for Fire Protective Signaling Systems
 - UL 864: Standard for Control Units and Accessories for Fire Alarm Systems
 - UL 1638: Standard for Visual Signaling Appliances - Private Mode Emergency and General Utility Signaling
 - UL 1971: Standard for Signaling Devices for Hearing Impaired
 - UL 2129: Halocarbon Clean Agent Extinguishing System
4. Department of Transportation (DOT)
Title 49 Code of Federal Regulations Parts 100 to 199
Transportation of Hazardous Materials, DOT3AAZ300 or 3AAZ15T
 5. National Electrical Manufacturers Association (NEMA) Publication. Enclosures for Industrial Controls and Systems
 6. Fire Suppression Systems Association (FSSA)
 - a) Guide to Clean Fire Extinguishing Agents & Their Use in Fixed System
 - b) Inspection and Test Guide
 - c) Pipe Design Handbook
 - d) Application Guide Detection & Control for Fire Suppression Systems
 - e) Pressure Relief Vent Area for Applications Using Clean Agent Fire Extinguishing System
 7. U.S. Environmental Protection Agency, Protection of Stratospheric Ozone 59 FR 13044, March 18, 1994 (Final SNAP Ruling)
 8. ISO 9802-2
 9. Requirements of the Authority Having Jurisdiction (AHJ)
 10. Requirements of the Insurance Carrier of the protected space
 11. Manufacturer's Design, Installation, Operation and Maintenance Manual

1.3 APPROVALS

- A. The complete system shall have the following applicable listings and approvals:
 1. UL Listed
 2. ULC Listed
 3. FM Approved
- B. The standards listed, all applicable codes, and sound engineering practices, shall be used as "minimum" design standards.

1.4 QUALITY ASSURANCE

- A. Manufacturer:
 1. The manufacturer of the suppression system hardware components shall be ISO 9001 registered.
 2. The manufacturer's identification mark as applicable shall appear on all major components.

3. All devices, components and equipment shall be supplied by the same manufacturer.
 4. All devices, components and equipment shall be new, standard products of the manufacturer's latest design and suitable to perform the functions intended.
- B. Installer:
1. The installing contractor shall be an authorized HYGOOD® distributor certified for the design, installation, testing, and maintenance of the SAPPHIRE PLUS Clean Agent Fire Suppression Systems.
 2. The installing contractor shall install the SAPPHIRE PLUS Clean Agent Fire Suppression System in strict accordance with the drawings, specifications, and applicable NFPA Standards and code requirements.
 3. The installing contractor shall maintain, or have access to, a Clean Agent refill station. The installing contractor shall provide proof of ability to recharge the largest SAPPHIRE PLUS Clean Agent Fire Suppression System within the period of time specified in the contract after a discharge including holding an appropriate quantity of Clean Agent.
 4. The installing contractor shall be an authorized HYGOOD® distributor of the SAPPHIRE PLUS Clean Agent Fire Suppression System equipment so that immediate replacement parts are available from inventory.
 5. The installing contractor shall show proof of emergency service available 24 hours a day, 7 days a week. Contractor shall be able to respond to an emergency situation within 2 hours of receiving an emergency trouble call. In addition, contractor shall maintain no less than \$2 million in liability insurance.

1.5 DESIGN DOCUMENTATION

- A. Design and installation of the fire detection/SAPPHIRE PLUS fire suppression system will be in strict accordance with the following guidelines and regulatory agencies:
- NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems
 - NFPA 72 National Fire Alarm and Signaling Code, Latest Edition
 - NFPA 70 National Electrical Code, Latest Edition
 - Americans with Disabilities Act, Title 24, Latest Edition
- B. SAPPHIRE PLUS Fire Suppression System
1. SAPPHIRE PLUS fire suppression system shall be of the engineered, permanently piped, fixed nozzle type with all pertinent components.
 2. All agent storage tank(s) shall be centrally located as vertical, free-standing with wall mounted retaining brackets. Where multiple cylinders are required for the same hazard, a common manifold shall be employed.
 3. On multiple cylinder arrangements (discharging into a common hazard), one cylinder shall be designated as the master cylinder employing the resettable electric actuator, mechanical manual actuator, or both. All remaining cylinders shall be pneumatically operated from the SAPPHIRE agent through the actuation line.
 4. Manifolder cylinders shall employ a flexible discharge hose to facilitate installation and system maintenance. Each cylinder on a manifold shall also include an agent check valve installed to the manifold inlet. An adjustable adapter should also be used to connect the discharge hose to the manifold.
- C. The installing contractor shall submit the following design information and drawings for approval prior to starting installation work on this project:
1. Installation layout drawings having an appropriate scale detailing the location of all agent storage containers, nozzles, pipe runs (including pipe sizes and lengths), electrical control panel(s), and associated devices.

*HYGOOD® SAPPHIRE® PLUS Clean Agent Fire Suppression System with
AUTOPULSE IQ-318/IQ-636-X2 Agent-Releasing Control Panel and
Lithium-Ion Risk Prevention System*

2. Separate drawing layouts, shall be provided for the mechanical and electrical work in the room, floor and ceiling voids.
 3. Drawing to provide legend identifying all symbols used.
 4. Complete computerized hydraulic flow calculations, from the UL/FM approved software, shall be provided for all SAPPHIRE PLUS Clean Agent Fire Suppression System, and shall include the following as a minimum:
 - a) Quantity of agent per nozzle
 - b) Nozzle orifice diameters
 - c) Pressure at nozzle (psi)
 - d) Nozzle body nominal pipe size (inch)
 - e) Number and size of cylinders
 - f) Total agent
 - g) Pipe size per pipe section
 - h) Pipe schedule per pipe section
 - i) Number, size and type of fitting per pipe section
 - j) Actual length per pipe section (feet)
 - k) Equivalent length per pipe section (feet)
 - l) Discharge time (seconds)
- D. The following shall be submitted for approval within 21 days of award and prior to delivery of materials:
1. Material and equipment information shall include manufacturer's catalog cut sheet and technical data for each component or device used in the system. This shall include, but not be limited to, the following:
 - a) Detectors
 - b) Manual discharge switches
 - c) Control panel
 - d) Release devices
 - e) Alarm devices
 - f) Agent storage cylinders
 - g) Mounting brackets
 - h) Discharge nozzles
 - i) Abort stations
 - j) Piping isometrics
 - k) Flow calculations
 2. Contractor shall provide warranty information of each component and device used in the system.
 3. Contractor shall provide the operation and maintenance procedures required of the owner. This information shall explain any special knowledge or tools the owner will be required to employ and all spare parts that should be readily available.
 4. Drawings shall indicate locations, installation details, and operational details of all equipment associated with the SAPPHIRE PLUS system. Floor plans shall be provided showing equipment locations, piping, point-to-point wiring and other details as required. Floor plans shall be drawn to a scale of not less than 1/8 in. (3.2 mm) = 1 ft-0 in. (0.3 m).

Elevations, cross sections and other details shall be drawn to a larger scale as required. Isometric piping layouts shall be provided with the shop drawings. In addition, point-to-point electrical layout drawings shall be provided.

5. Contractor shall provide a complete riser diagram with specific detail regarding connections to all monitor and control functions.
6. Contractor shall provide a testing plan that includes means, methods and schedules for interface testing with systems that will be connected via monitor or control modules.
7. Sequence of operation, electrical schematics and connection diagrams shall be provided to completely describe the operation of the SAPPHIRE PLUS system controls.
8. Contractor shall provide flow Calculations per Section 1.5.B.4

PART 2 – SYSTEM REQUIREMENTS

2.1 SYSTEM DESCRIPTION AND OPERATION

- A. The system shall be a Total Flood SAPPHIRE PLUS Clean Agent Fire Suppression System supplied by Johnson Controls sold under brands including HYGOOD® and SAPPHIRE PLUS.
- B. The system shall provide a SAPPHIRE (3M™ NOVEC™ 1230) agent minimum design concentration based on the lithium-ion off gas components, but not less than a design concentration of 6.8% by volume. System design shall not exceed 10% concentration for normally occupied spaces, adjusted for maximum hazard temperature anticipated, with provisions for room evacuation before agent release.
- C. The system shall be complete, and shall include mechanical and electrical installation, all detection and control equipment, agent storage containers, SAPPHIRE agent, discharge nozzles, pipe and fittings, manual release, delay or abort devices, audible and visual alarms, auxiliary devices and controls, shutdowns, alarm interface, advisory signs, functional checkout and testing, training and all other operations and equipment necessary for a SAPPHIRE PLUS Clean Agent Fire Suppression System.
- D. Contractor shall provide two inspections during the first year of service: Inspections shall be made at 6-month intervals thereafter. It is the joint responsibility of the contractor and system owner to ensure that 6-month inspections are being conducted.
- E. The general contractor shall be responsible for sealing and securing the hazard areas against agent loss and / or leakage during the “hold” period, which is a minimum period of 30 minutes or a time period sufficient to allow for response by trained personnel.
- F. Smoke Detection: The SAPPHIRE PLUS system shall be automatically actuated by either counting zone detection or cross-zoned detection methodology. Smoke sensors / detectors shall utilize photoelectric technology and/or Aspiration Smoke Detectors (ASD) for very early warning smoke detection. Smoke detectors and ASD sample points shall be installed at no more than 250 ft² (23.2 m²) of coverage per detector. When using analog addressable sensors or ASD detectors offering pre-alarm thresholds, further system design consideration is suggested for providing very early warning detection which can offer extended investigation time prior to suppression agent release. In all cases, the compatibility listings of the detectors for use with the control unit should be observed. The system shall require two detectors in alarm prior to automatic agent release.
- G. Both Photoelectric and ASD type smoke detectors can be combined in the releasing process, using one of following methods:
 1. 1st alarm ASD / 2nd alarm ASD
 2. 1st alarm ASD / 2nd alarm Photoelectric Detector
 3. 1st alarm Photoelectric Detector / 2nd alarm Photoelectric Detector

2.2 SEQUENCE OF OPERATION

- A. Activation of one detector, within the hazard area, shall:

1. Cause a fire-stage alarm
2. Energize a lamp on the activated detector and identify detector on the display of the control panel (and remote annunciator, if included).

Note: The shutdown of electrical equipment will be optional based on requirements of the local AHJ or applicable standard.

- B. Activation of a second detector shall:
1. Transmit an alarm signal to remote monitoring or building alarm panel.
 2. Cause a second-stage (pre-discharge) Audio/Visual alarm to operate.
 3. Operate auxiliary contacts for air conditioning shutdowns and automatic dampers.
 4. Initiate a programmable time delay (SAPPHIRE agent release).
- C. Upon completion of the time-delay sequence, the SAPPHIRE PLUS Clean Agent Fire Suppression System shall:
1. Cause a discharge alarm to be activated.
 2. Operate auxiliary contacts for emergency power-off of all electrical equipment (excluding lighting and emergency circuits for life safety).
 3. Activate visual alarms (strobe) at protected area entrance.
 4. Energize control solenoid for SAPPHIRE cylinders releasing gaseous agent into the protected area

2.3 AUXILIARY COMPONENTS

- A. Double action manual releasing stations shall be provided at each exit of the protected area and shall, when activated, immediately release the SAPPHIRE agent and cause all audible/visual alarms to activate. In addition, activation of the manual releasing stations shall cause immediate shutdown of air and power circuits.
- B. Abort stations shall be provided at each exit of the protected area and when operated shall interrupt the pre-discharge countdown timer for the discharge of SAPPHIRE agent and emergency power-off functions. The abort stations shall be momentary devices (dead-man) requiring constant pressure to maintain contact closure.
- Note:** Manual Releasing Station activation shall override any abort station. Abort station operation shall be per AHJ and FM guidelines.
- C. Graphic annunciator (optional) shall be provided at the control panel location. The graphic annunciator shall be provided by the equipment manufacturer in an approved NEMA enclosure with keyed face plate. The graphic annunciator shall display the entire SAPPHIRE PLUS protected area and shall indicate each smoke detector and its proximity. Smoke detectors, when activated, will individually annunciate at the graphic annunciator as follows:
1. Ceiling Detector: Red LED
 2. Subfloor Detector: Amber LED

2.4 LITHIUM –ION OFF GAS MONITORING INCIATION SEQUENCE OF OPERATION

- A. Notification from monitoring sensor within The Lithium-Ion Risk Prevention system, , shall:
1. Cause a fire-stage alarm
 2. Activate a relay which will disconnect the specific battery rack or battery system with off gas presence.

Note: The shutdown of the lithium-ion battery that off gassed is critical to ensure the battery stops charging or discharging and allows for the natural cooling of the battery to mitigate the probability of thermal runaway.

B. Operation of Suppression system to inert environment (optional depending on customer risk)

Note: The discharge of agent is recommended to mitigate the ignition of the off gasses from the lithium-ion battery while the disconnected system cools.

1. Transmit an alarm signal to remote monitoring or building alarm panel.
2. Operate auxiliary contacts for air conditioning shutdowns and automatic dampers.
3. Initiate a programmable time delay (SAPPHIRE agent release).
4. Upon completion of the time-delay sequence, the SAPPHIRE PLUS Clean Agent Fire Suppression System shall:
 - a) Cause a discharge alarm to be activated.
 - b) Operate auxiliary contacts for emergency power-off of all electrical equipment (excluding lighting and emergency circuits for life safety).
 - c) Activate visual alarms (strobe) at protected area entrance.
 - d) Energize control solenoid for SAPPHIRE cylinders releasing gaseous agent into the protected area

PART 3 - MATERIAL AND EQUIPMENT

3.1 GENERAL REQUIREMENTS:

- A. The SAPPHIRE PLUS Clean Agent Fire Suppression System materials and equipment shall be of standard products of a single manufacturer (Johnson Controls) latest design and suitable to perform all intended functions. The name of the manufacturer and serial numbers shall appear on all major components.
- B. All relevant devices and equipment shall be listed by the standardizing agencies (UL and/or FM)
- C. The system design can be modular, central storage, or a combination of both design criteria.
- D. Systems shall be designed in accordance with the manufacturer's guidelines.

3.2 AGENT CONTAINER

- A. The Clean Agent shall be stored in SAPPHIRE PLUS Clean Agent Fire Suppression System storage containers. Containers shall be super-pressurized with dry nitrogen to an operating pressure of 70 bar at 68°F (20°C). Containers shall be of seamless high-strength low alloy steel construction and meeting the requirements of the DOT/ISO.
- B. Containers (master) shall be actuated by either an electrical actuator fitted with an integrated placement indicator switch to show correct fitment of the actuator or by pneumatic means from a nitrogen pilot container. The nitrogen pilot container electrical actuator shall be fitted with a placement indicator switch. Explosive actuation devices shall not be permitted.
- C. All containers shall be centrally located as vertical, free-standing with wall mounted retaining brackets. Where multiple containers are required for the same hazard, a common manifold shall be employed.
- D. For systems protecting multi hazards using a central container bank and selector valves, the appropriate full bore selector valve shall be fully opened before the system containers are operated. Selector valves shall be UL Listed and FM Approved, as manufactured by Johnson Controls.
- E. Manifoldded containers shall employ a flexible discharge hose to facilitate installation and system maintenance. Each container on a manifold shall also include an agent check valve installed to the manifold inlet.
- F. Each container shall have a pressure gauge or contacted pressure gauge (optional) to provide visual and electrical supervision of the container pressure. The contacted pressure gauge shall be wired to the control panel to provide audible and visual alarms in the event the container pressure drops below 63 bar for a temperature range of -20 to 122 °F (-20 to 50 °C) or 65 bar for a temperature range of 32 to 149 °F (0 to 65 °C). The pressure gauge shall be color coded to provide an easy, visual indication of container pressure.

- G. Containers shall have a pressure relief device that automatically operates before the internal nominal pressure exceeds 180 bar.

3.3 NOZZLE AND PIPE NETWORK

- A. Discharge nozzles shall be provided within the manufacturer's guidelines to distribute the 3M™ NOVEC™ 1230 agent throughout the protected spaces.
 - 1. The nozzles shall be designed to provide proper agent quantity and distribution.
 - 2. Nozzles shall be available in 1/2 in. (15 mm) through 2 in. (50 mm) pipe sizes.
 - 3. Each size shall be available in 180° and 360° distribution patterns.
 - 4. Nozzles shall be permanently piped, fixed nozzle type with all pertinent components.
- B. Distribution piping and fittings shall be installed in accordance with the manufacturer's requirements, NFPA 2001/EN 15004 / ISO 14520/ FSSA, and approved piping standards and guidelines. All distribution piping shall be installed by qualified individuals using industry accepted practices and quality procedures. All piping shall be adequately supported and anchored at all directional changes and nozzle locations.
- C. All piping shall be reamed, blown clear and swabbed with suitable solvents to remove burrs, mill varnish, and cutting oils before assembly.
- D. All pipe threads shall be sealed with a suitable pipe sealant applied to the male thread only.

3.4 AGENT:

- A. The fire suppression agent shall be 3M™ NOVEC™ 1230 Fire Protection Fluid, supplied by a 3M™ approved OEM partner.
- B. Agent shall not contain any Hydrofluorocarbons (HFC).

3.5 CAUTION SIGNS:

- A. Entrance signs are required at each entrance to a protected space.
- B. Manual discharge signs are required at each manual release station.

3.6 LITHIUM-ION RISK MONITORING CONTROLLER

- A. The controller shall be capable of comparing a reference sensor for normal environmental air conditions and a lithium-ion monitoring sensor for presence of lithium-ion off gas materials.
- B. The controller shall be capable of interfacing with the AUTOPULSE Detection system through digital output or MODBUS communication for trouble/fault and alarm signals.
- C. The controller shall be capable of interfacing with the lithium-ion battery system, allowing for electrical disconnection of the lithium-ion batteries in the event of a battery cell off gassing.
- D. Each controller shall provide input for 12 monitoring sensors and 3 reference sensors (15 total).
- E. The controller shall be capable of operating from 5-24 VDC.
- F. The controller shall be capable of connection and expansion by connecting multiple controllers together

3.7 LITHIUM-ION REFERENCE SENSOR

- A. Compact design to allow for mounting near all room openings (doors, ducts, vents, etc.)
- B. Shall be capable of operation without calibration.
- C. Shall provide signal to controller indicating the condition of "room" atmosphere for use as comparison to local battery rack atmosphere

3.8 LITHIUM-ION MONITORING SENSOR

- A. Compact design to allow for mounting near all room openings (doors, ducts, vents, etc.).
- B. Shall be capable of operation without calibration.

- C. Shall provide signal to controller indicating the condition of atmosphere in close proximity to Lithium-Ion batteries, for use as comparison to the room atmosphere. (If Lithium-Ion battery off gas materials are present)

3.9 ELECTRICAL

- A. All electrical enclosures, raceways and conduits shall be employed in accordance with applicable codes and intended use, contain only those electrical circuits associated with the fire detection and control system and shall not contain any circuit that is unrelated to the system.
- B. Unless specifically provided otherwise, all conductors shall be enclosed in steel conduit, rigid or thin wall as conditions dictate.
- C. Any conduit or raceway exposed to weather or other similar conditions shall be properly sealed and installed to prevent damage. Provisions for draining and/or drying shall be employed.
- D. NEMA rating and/or electrically hazardous classifications shall be observed and any equipment or materials installed must meet or exceed the requirements of service.
- E. All wiring shall be of the proper size to conduct the circuit current but shall not be smaller than #18 AWG unless otherwise specified for a given purpose. Wire that has scrapes, nicks, gouges, or crushed insulation shall not be used. The use of aluminum wire is strictly prohibited.
- F. Splicing of circuits shall be kept to a minimum and are only to be found in an electrical device suited for the purpose.
- G. Wire spliced together shall have the same color insulation.
- H. Wire splices shall be made with appropriate devices suited for the purpose.
- I. All wire terminations shall be made with crimp terminals unless the device at the termination is designed for bare wire terminations.
- J. All electrical circuits shall be numerically tagged with suitable devices at the terminating point and/or splice. All circuit numbers shall correspond with the installation drawings.
- K. The use of colored wires is encouraged but not required unless dictated by state or local authorities.
- L. White-colored wire shall be used exclusively for the identification of the neutral conductor of an alternating current circuit.
- M. Green-colored wire shall be used exclusively for the identification of the earth ground conductor of an AC or DC circuit.

3.10 CONTROL SYSTEM

- A. All control systems shall be UL listed and FM approved utilizing listed or approved compatible operating devices be capable of the following features:
 - 1. Ground fault indication
 - 2. Supervised detection circuit(s)
 - 3. Supervised alarm circuit(s)
 - 4. Supervised manual pull circuit (if applicable)
 - 5. Supervised primary power circuit
 - 6. Alarm overrides trouble logic
 - 7. Battery standby
 - 8. Front panel indicating lamps (LEDs)
 - 9. Key lock steel enclosure
 - 10. Programmable time delay
 - 11. Programmable detection logic
 - 12. Prioritized trouble logic

13. Microprocessor based logic
14. History buffer

3.11 CONTROL PANEL- AGENT RELEASING CONTROL PANEL, IQ-318

- A. The Fire Alarm Control Panel (FACP) shall be an HYGOOD® AUTOPULSE IQ-318 and shall contain a Central Processing Unit (CPU) with integral 3.0 amp of normal operation (6.0 A in alarm) power supply for the IQ-318 system. The CPU shall communicate with and control the following types of equipment used to make up the system: intelligent detectors, addressable modules, annunciators, and other system controlled devices.
- B. System Capacity:
 1. The control unit shall provide up to 318 intelligent/addressable devices per loop.
 2. The system shall include Form-C alarm, trouble, and supervisory security relays rated at a minimum of 2.0 amps at 30 VDC. It shall also include 4 Class B (NFPA Style Y) programmable notification appliance circuits
 3. The control unit shall include a full featured operator interface control and annunciation panel that shall include a backlit liquid crystal display, individual, color coded system status LEDs, and an alphanumeric keypad for the field programming of the control and fire alarm system
- C. System Display: The system shall indicate the status of the following parameters:
 1. AC Power: Green LED
 2. System Alarm: Red LED
 3. Release: Red LED
 4. Supervisory: Yellow LED
 5. System Trouble: Yellow LED
 6. Circuit Trouble: Yellow LED
 7. Alarm Silenced: Yellow LED
 8. Power Trouble: Yellow LED
- D. System General Operation:
 1. The control unit shall provide the following features:
 - a) Drift compensation to extend detector accuracy over life
 - b) Sensitivity Test, meeting requirements of NFPA 72
 - c) Maintenance Alert to warn of excessive smoke detector dirt or dust accumulation
 - d) System Status Reports to display
 - e) PAS pre-signal, meeting NFPA 72.
 - f) Rapid manual station reporting (under 2 seconds)
 - g) Non-Alarm points for general (non-fire) control
 - h) Periodic Detector Test conducting automatically by software
 - i) Pre-Alarm for advanced fire warning
 - j) Cross Zoning with the capacity of: counting 2 detectors in alarm, 2 software zones in alarm, or 1 smoke detector and 1 thermal detector in alarm
 - k) March time and temporal coding options
 - l) Walk Test with check for 2 detectors set to same address
 - m) Control-By-Time for non-fire operations, with holiday schedules
 - n) Day/Night automatic adjustment of detector sensitivity

- o) Device Blink Control for sleeping areas
 2. The control unit shall be capable of coding Notification circuits in March Time (120 PPM), Temporal (NFPA 72), and California Code.
- E. Central Microprocessor:
 1. The microprocessor unit shall communicate with, monitor, and control all external interfaces with the control panel. It shall include EPROM for system program storage, non-volatile memory for building-specific program storage, and a “watch dog” timer circuit to detect and report microprocessor failure.
 2. The microprocessor unit shall contain and execute all control-by-event programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory and shall not be lost even if system primary and secondary power failures occurs.
 3. The microprocessor unit shall also provide a real-time clock for time annotation of system displays and history file. The time-of-day and data shall not be lost if system primary and secondary power supplies fail. The real time clock may also be used to control non-fire function at programmed time-of-day, day-of-week, and day-of-year.
- F. Display:
 1. The display (KDM-R2) shall provide all the controls and indicators used by the system operator and may also be used to program all system operational parameters.
 2. The display shall include status information and custom alphanumeric labels for all intelligent detectors, addressable modules, and software zones.
 3. The display shall provide 80-characters with life-long LED backlight alphanumeric Liquid Crystal Display (LCD) with QWERTY programming and control keypad.
 4. The display shall provide a touch pad with control capability to command all system functions, entry of any alphabetic or numeric information, and field programming. Two different password levels shall be provided to prevent unauthorized system control or programming.
- G. Signaling Line Circuit (SLC)
 1. The SLC interface shall provide power to and communicate with up to 159 intelligent detectors (Ionization, Photoelectric, or Thermal) and 159 intelligent modules (monitor or control) for a system capacity of 318 devices. This shall be accomplished over a single SLC loop and shall be capable of NFPA 72 Style 4, Style 6, or Style 7 wiring.
 2. The loop interface board shall receive analog information from all intelligent detectors that shall be processed to determine whether normal, alarm, or trouble conditions exist for each detector. The software shall automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. The analog information shall also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.
 3. The detector software shall meet NFPA 72, requirements and be certified by UL as a calibrated sensitivity test instrument.
 4. The detector software shall allow manual or automatic sensitivity adjustment
- H. Serial Interfaces:
 1. An EIA-232(TB12) interface between the Fire Alarm Control Panel (FACP) and UL Listed Electronic Data Processing (EDP) peripherals shall be provided.
 2. The EIA-232(TB12) interface shall allow the use of CRT monitors, and PC compatible computers.
 3. The EIA-232 interface shall include special protocol methods that allow off-site monitoring of the FACP over standard dial-up phone lines. This ancillary capability shall allow remote readout of all status information, including analog values, and shall not interfere with or

degrade FACP operations when used. It shall allow remote FACP Acknowledge, Reset, or Signal Silence in this mode. It shall also allow adjustment of detector sensitivity and readout of the history file.

4. The EIA-485 port for the serial connection of the optional annunciators and remote LCD displays shall be provided.
5. The EIA-485 interface may be used for network connection to a proprietary receiving unit.

I. System Control Switch Operation

1. Tone Silence Switch: Activation of the control unit tone silence switch, in response to alarms, troubles, and supervisory conditions, shall silence the local panel piezo electric signal and change the system alarm or trouble LED from flashing mode to steady ON mode. Occurrence of any new alarm or trouble conditions in the system shall cause the control unit to re-sound the local piezo sounder and repeat the alarm or trouble sequences.
2. Alarm Silence Switch: Activation of the alarm signal silence switch shall cause all alarm notification appliances to return to the normal condition after an alarm condition.
3. System Reset Switch: Activation of the system reset switch shall cause all electronically-latched initiating circuits, appliances as well as all associated output circuits, to return to their normal condition. Holding system reset down shall perform a LAMP TEST function and will activate the piezo sounder.
4. Alarm Activate Switch: Operation of the alarm activate switch shall activate both notification circuits and the alarm relay. Alarm activation shall be a latching function.

J. The control unit shall also include the following functions:

1. All interfaces and associated equipment are to be protected so they will not be affected by voltage surges or line transients consistent with UL standard 864.
2. Optional plug-in modules shall be provided for NFPA 72, transmitters as well as a digital alarm communicator/transmitter.
3. The control panel shall have the ability to meet the latest requirements of UL 864 for delayed AC fail reporting
4. An optional module shall provide 6 Form-C relays rated at 3.0 amps. The relays shall track programmable software zones.

K. Power Supply

1. The power supply shall operate on 120 VAC, 60 Hz, and shall provide all necessary power for the FACP.
2. It shall provide 3.0 amps of stand-by power and 6.0 amps in alarm for notification appliance power using a switching 24 VDC regulator. A notification expansion power supply shall be available for the demanding requirements of UL 1971 and ADA devices.
3. It shall provide a battery charger for 24 hours of standby using dual-rate charging techniques for fast battery recharge.
4. It shall provide a very low frequency sweep, earth detection circuit capable of detecting earth faults on sensitive addressable modules.
5. It shall be power-limited using Positive Temperature Coefficient (PTC) resistors.

L. Mechanical Design-Enclosure

1. The control panel shall be housed in a UL listed cabinet suitable for surface or semi-flush mounting. Cabinet and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.
2. The door shall provide a key lock and include a glass or other transparent opening for viewing of all indicators.

M. Batteries

1. Batteries shall be 12 volt, Sealed Lead-Cell type providing 24 VDC (two required)
 2. Batteries shall have sufficient capacity to power the fire alarm system for not less than 24 hours in standby, plus 5 minutes of alarm upon a normal AC power failure.
 3. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks, refilling, spills, and leakage shall not be accepted.
- N. Specific System Operations:
1. Smoke Detector Sensitivity Adjust: Means shall be provided for adjusting the sensitivity of any or all analog intelligent smoke detectors in the system from the system keypad. Sensitivity range shall be within the allowed UL window.
 2. Alarm Verification: Each of the intelligent addressable smoke detectors in the system may be independently selected and enabled to be an alarm verified detector. The alarm verification delay shall be programmable from 5 to 30 seconds and each detector shall be able to be selected for verification. The FACP shall keep a count of the number of times that each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.
 3. Point Disable: Any device in the system may be enabled or Disabled through the system keypad.
 4. Point Read: The system shall be able to display or print the following point status diagnostic functions:
 - a) Device status.
 - b) Device type.
 - c) Custom device label.
 - d) View analog detector values.
 - e) Device zone assignments.
 - f) All program parameters.
 5. System Status Reports: Upon command from a system operator, a status report will be generated and printed listing all system status.
 6. System History Recording and Reporting: The FACP shall contain a history buffer that will be capable of storing up to 800 events. Two hundred alarm-only events, system alarms/troubles/operator actions are also included. Each of these activations will be stored and time-and-date stamped with the actual time of the activation. The contents of the history buffer may be manually reviewed, one event at a time, or printed in its entirety.
 7. Although the foreground history buffer may be cleared for user convenience, a background, non-erasable buffer shall be maintained which provides the last 800 system events.
 8. The history buffer shall use non-volatile memory. Systems that use volatile memory for history storage are not acceptable.
 9. Automatic Detector Maintenance Alert: The FACP shall automatically interrogate each intelligent smoke detector and analyze the detector responses over a period of time.
 10. If any intelligent smoke detector in the system responds with a reading that is below or above normal limits, the system will enter the trouble mode and the particular detector will be annunciated on the system display. This feature shall in no way inhibit the receipt of alarm conditions in the system nor shall it require any special hardware, special tools or computer expertise to perform.
 11. Pre-Alarm Function: The system shall provide 2 levels of pre-alarm warning to give

advance notice of a possible fire situation. Both pre-alarm levels shall be fully field adjustable. The first level shall give an audible indication at the panel. The second level shall give an audible indication and may also activate control relays. The system shall also have the ability to activate local detector sounder bases at the pre-alarm level to assist in avoiding nuisance alarms.

12. Software Zones: The FACP shall provide 99 software zones. All addressable devices may be field programmed to be grouped into these zones for control activation and annunciation purposes
13. Field Wiring Terminal Blocks:
 - a) For ease of service all panel I/O wiring terminal blocks shall be the removable, plug-in type and have sufficient capacity for 18 to 12 AWG wire. Permanently-affixed terminal blocks are not acceptable.

3.12 ADDRESSABLE DEVICES-GENERAL

- A. Addressable devices shall provide an address-setting means using rotary decimal switches.
- B. Addressable devices shall use simple to install and maintain decade (numbered 1 to 15) type address switches. Devices which use a binary address setting method, such as a dip switch, are difficult to install and subject to installation error. This type of device is not an allowable substitute.
- C. Detectors shall be intelligent and addressable, and shall connect with 2 wires to the fire alarm/release control panel signaling line circuits.
- D. Addressable smoke and thermal detectors shall provide dual alarm and power LEDs. Both LEDs shall flash under normal conditions indicating that the detector is operational and in regular communication with the control panel. Both LEDs shall be placed into steady illumination by the control panel indicating that an alarm condition has been detected. If required, the flashing mode operation of the detector LEDs shall be optional through the system field program. An output connection shall also be provided in the base to connect an external remote alarm LED.
- E. Smoke detector sensitivity shall be set through the FACP and shall be adjustable in the field through the field programming of the system. Sensitivity may be automatically adjusted by the panel on a time-of-day basis.
- F. Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72.
- G. The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper-proof feature. An optional base shall be available with a built-in (local) sounder rated at 85 dBA minimum.
- H. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
- I. Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (ION, PHOTO, THERMAL).

3.13 PROGRAMMABLE ELECTRONIC SOUNDERS

- A. Electronic sounders shall be UL Listed or FM Approved and operate on 24 VDC nominal.
- B. Electronic sounders shall be field programmable without the use of special tools to choose 1 of 8 tones with an output sound level of at least 90 dBA measured at 10 ft (3.0 m) from the device.
- C. Electronic sounders shall be flush or semi-flush mounted as shown on plans.

3.14 VISUAL NOTIFICATION APPLIANCES

- A. Strobe lights shall operate on 24 VDC nominal.
- B. Strobe lights shall meet the requirements of the ADA as defined in UL standard 1971 and shall meet the following criteria:

1. The strobe intensity shall meet the requirements of UL 1971 and devices shall be multi-candela 15 cd – 110cd and higher intensity if required by the plans.
2. The flash rate shall meet the requirements of UL 1971.
3. The appliance shall be placed 80 in.(2.03 m) (to the bottom of the appliance) to 96 in. (2.44 m) (to the top of the appliance) above the finished floor within the space

3.15 AUDIBLE/VISUAL COMBINATION DEVICES

- A. Audible/visual combination devices shall meet the applicable requirements of Section 3.5 listed above for audibility.
- B. Audible/visual combination devices shall meet the requirements of Section 3.6 (listed above) for visibility.

3.16 SMOKE DETECTORS

- A. Smoke detectors shall be 24 VDC and shall be UL Listed and FM approved.
- B. Each detector shall include a visual status indicator, provide remote LED output, and include a built-in test capability.
- C. The sensitivity shall be factory set per UL 268.
- D. The detector cover and screen shall be easily removable for field cleaning.
- E. A special vandal-resistant locking screw shall be provided to lock the head to the base.
- F. The head-to-base connection shall be made by use of bifurcated contacts. Terminal connections to the base shall be of the screw type that are accessible with the base installed on the mounting box.
- G. Where specifically identified on the contract drawings, detector bases shall incorporate a relay with Form C contacts rated at 1 amp at 120 VAC, or 30 VDC for remote LED alarm annunciation or the detector.
- H. Photoelectric-type smoke detector shall be light reflective type and compatible with the AUTOPULSE control system. The detector shall have an LED in its base which is illuminated in a steady-on mode when in alarm and pulse mode when in standby. Reset of the detector shall be performed by the control unit reset switch.
- I. The design of the photoelectric detector compensating circuits shall provide stable operation with regard to minor changes in temperature, humidity and atmospheric conditions.
- J. Two-wire detector module shall be addressable and connect one supervised IDC zone of conventional two-wire smoke detectors or alarming initiating devices (and N.O. dry contact device)
- K. The two-wire monitor module shall mount in a 4 in. (102 mm) square, 2 1/8 in. (54 mm) deep electrical box or with an optional surface back box.
- L. The IDC zone may be wired for Class A or B (style D or B) operation. An LED shall be provided that shall flash under normal conditions indicating that the monitor module is operational and in regular communication with the control panel.

3.17 HEAT DETECTOR

- A. Heat detectors shall be analog addressable devices rated at 135 °F (57 °C) and have a rate-of-rise element rated at 15 °F (9 °C) per minute. It shall connect via 2 wires to the FACP signaling line circuit. Up to 159 intelligent heat detectors may connect to one SLC loop.
- B. The detectors shall use an electronic sensor to measure thermal conditions caused by a fire and shall, on command from the control panel, send data to the panel representing the analog level of such thermal measurements.
- C. An optional, intelligent heat detector shall be available for applications which do not require a rate-of-rise element.

3.18 ABORT SWITCH

- A. The abort switch shall be used where an investigative delay is desired between detection and actuation of the fire suppression system.
- B. This switch shall be a momentary contact "dead-man" type switch requiring constant pressure to transfer one set of contacts. Clear operating instructions shall be provided at the abort switch.
- C. This switch shall be rated for 28 VDC at 1.1 amp make/break or 6 amp continuous carry.
- D. The terminal connections shall be of the screw type.

3.19 MAINTENANCE LOCK-OUT SWITCH

- A. The maintenance lock-out switch shall be used where it is desired to disable the fire suppression system during routine maintenance.
- B. This switch shall be key operated allowing removal of the key only in "Normal" position. A red indicator lamp shall be included on the switch assembly to be illuminated when in the "Lock-Out" position. The control unit is used to indicate a supervisory condition when in the "Lock-Out" position.
- C. The switch shall include 1 set of normally open and 1 set of normally closed contacts rated at 28 VDC at 1.1 amp make/break or 6 amp continuous carry.
- D. The terminal connections shall be of the screw type.

3.20 MANUAL PULL STATION

- A. Addressable manual pull station shall, on command from the control panel, send data to the panel representing the state of the manual switch. They shall use a key operated test-reset lock and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key.
- B. All operated stations shall have a positive, visual indication of operation and utilize a key-type reset.
- C. Manual stations shall be clearly visible operating instructions provided on the cover. The word AGENT shall appear on the front and both sides of the stations.
- D. Stations shall be suitable for surface mounting or semi-flush mounting as shown on the plans, and shall be installed not less than 42 in. (1.1 m), nor more than 48 in. (1.2 m) above the finished floor.
- E. Operation shall require 2 actions

3.21 DRY CONTACT MONITOR MODULE:

- A. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the FACP SLC loops.
- B. The monitor module shall mount in a 4 in. (102 mm) square, 2 1/8 in. (54 mm) deep electrical box
- C. The IDC zone may be wired for Style D or Style B operation. An LED shall be provided that shall flash under normal conditions indicating that the monitor module is operational and in regular communication with the control panel.
- D. For difficult to reach areas, the monitor module shall be available in a miniature package and shall be no larger than 2-3/4 in. x 1-1/4 in. x 1/2 in. (69.9 mm x 31.8 mm x 12.7 mm). This version need not include Style D or an LED.

3.22 DUCT SMOKE DETECTOR:

- A. In-duct smoke detector housing shall accommodate either an intelligent ionization sensor or an intelligent photoelectric sensor, which provides continuous analog monitoring and alarm verification from the panel.
- B. When sufficient smoke is sensed, an alarm signal is initiated at the FACP and appropriate action is taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system

3.23 CONTROL MODULE

- A. Addressable control modules shall be provided to supervise and control the operation of one conventional Notification Appliance Circuit (NAC) of compatible, 24 VDC powered, polarized

audio/visual notification appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contact relay.

- B. The control module shall mount in a standard 4 in. (102 mm) square, 2 1/8 (54 mm) deep electrical box, or to a surface mounted back box.
- C. The control module NAC circuit may be wired for Style Z or Style Y (Class A/B) with up to 1 amp of inductive A/V signal, or 2 amps of resistive A/V signal operation, or as a dry contact (Form C) relay. The relay coil shall be magnetically latched to reduce wiring connection requirements and to insure that 100% of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
- D. Audio/visual power shall be provided by a separate supervised power loop from the main control unit or from a supervised, UL listed remote power supply.
- E. The control module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. An LED shall be provided that shall flash under normal conditions indicating that the control module is operational and is in regular communication with the control panel.
- F. A magnetic test switch shall be provided to test the module without opening or shorting its NAC wiring.
- G. The control module shall be suitable for pilot duty applications and rated for a minimum of .6 amps at 30 VDC.

3.24 ISOLATOR MODULE

- A. Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop. At least one isolator module shall be provided for each floor or protected zone of the building.
- B. If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.
- C. The isolator module shall not require any address-setting and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.
- D. The isolator module shall mount in a standard 4 in. (102 mm) deep electrical box or in a surface mounted back box. It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

3.25 SELECTOR SWITCH

- A. The selector switch shall be used where a connected reserve is required.
- B. This switch shall be key operated allowing removal of the key in either the "Main" or "Reserve" position.
- C. This switch shall be rated at 28 VDC @ 1.1 amp make/break or 6 amp continuous carry.
- D. The terminal connections shall be of the screw type.

3.26 WATER FLOW SWITCHES

- A. Flow switches shall be integral, mechanical, non-coded, non-accumulative retard type.
- B. Flow switches shall have an alarm transmission time delay that is conveniently adjustable from 0 to 60 seconds. Initial settings shall be 30 or 45 seconds.
- C. Flow switches shall be located a minimum of 1 ft (0.3 m) from a fitting that changes the direction of the flow and a minimum of 3 ft (0.9 m) from a valve.

3.27 SPRINKLER AND STANDPIPE VALVE SUPERVISORY SWITCHES

- A. Each sprinkler system water supply control valve riser or zone control valve, and each standpipe system riser control valve shall be equipped with a supervisory switch. Standpipe hose valves, and test and drain valves shall not be equipped with supervisory switches.

- B. Each Post Indicator Valve (PIV) or main gate valve shall be equipped with a supervisory switch.
- C. The switch shall be mounted so as not to interfere with the normal operation of the valve and adjusted to operate within 2 revolutions toward the closed position of the valve control, or when the stem has moved no more than one-fifth of the distance from its normal position.
- D. The mechanism shall be contained in a weatherproof aluminum housing that shall provide a 3/4 in. tapped conduit entrance and incorporate the necessary facilities for attachment to the valves.
- E. Switch housing to be finished in red baked enamel.
- F. The entire installed assembly shall be tamper proof and arranged to cause switch operation if the housing cover is removed or if the unit is removed from its mounting.
- G. Valve supervisory switches shall be provided and connected under this section and installed by mechanical contractor

3.28 SERIALY CONNECTED ANNUNCIATOR REQUIREMENTS

- A. The annunciator shall communicate with the fire alarm control panel via an EIA 485 communications loop and shall annunciate all zones in the system. Up to 10 annunciators may be connected to the EIA 485 communications loop.
- B. The annunciator shall need only 4 wires to connect to the FACP.
- C. The annunciator shall provide a red alarm LED per zone, and a yellow trouble LED per zone. The annunciator will also have an "ON-LINE" LED, local piezo sounder, local acknowledge/lamp test switch, and custom zone/function identification labels.
- D. The annunciator switches may be used for system control such as Global Acknowledge, Global Signal Silence, and Global System Reset

3.29 LCD ALPHANUMERIC DISPLAY ANNUNCIATOR

- A. The alphanumeric display annunciator shall be a supervised, remotely located back-lit LCD display containing a minimum of 80 characters for alarm annunciation in clear English text.
- B. The LCD annunciator shall display all alarm and trouble conditions in the system.
- C. The annunciator shall connect to a two-wire EIA 485 interface. The two-wire connection shall be capable of distances of 6,000 ft (1,828.8 m). The signal may be increased in 3,000 ft (914.4 m) increments with an optional repeater. An optional (UL 864 Listed) module shall be available which allows the EIA-485 signal to be transmitted over fiber optics.
- D. The system shall allow a minimum of 4 LCD annunciators. Each LCD shall be capable of the following system functions: Acknowledge, Signal Silence and Reset.

PART 4 – TESTING AND DOCUMENTATION

4.1 SYSTEM INSPECTION AND CHECKOUT

- A. The completed installation shall be inspected by factory authorized and trained personnel. The inspection shall include a full operational test of all components per the equipment manufacturer's recommendations. A system discharge concentration test may also be performed if the required.
- B. Inspection shall be performed in the presence of the owner's representative, architect, or engineer's representative, insuring authority and/or the local AHJ.
- C. All functions, including system and equipment interlocks, must be operational during the acceptance tests.
- D. All containers and distribution piping shall be checked for proper mounting and installation.
- E. All electrical wiring shall be tested for proper connection, continuity and resistance to earth.
- F. All mechanical and electrical components shall be tested according to the manufacturer's recommended procedure to verify system integrity.
- G. Inspection shall include a complete examination of the detection / control system and certification of

container pressure. A written report shall be filed with the owner.

- H. As-built drawings (two-copies) shall be provided by the contractor indicating the installation details. All routing of piping, electrical conduit, and accessories shall be noted.
- I. Equipment installation and maintenance manuals shall be provided in addition to the as-built drawings.
- J. Prior to final acceptance, the contractor shall provide operational training in all aspects of the system to the owner's key personnel. Training shall consist of:
 - 1. Control system operations
 - 2. Trouble procedures
 - 3. Abort switches procedures
 - 4. Emergency procedures
 - 5. Safety requirements
 - 6. Demonstration of the system (excluding SAPPHIRE agent release)
- K. The quantity of agent shall reflect the actual design quantity of SAPPHIRE agent.
- L. If a discharge concentration test is required, a prior functional test shall be completed consisting of detection, alarm, release, accessories related to the system, control unit, and a review of the containers, piping, fittings, hangers, and container pressure.
- M. Discharge concentration testing shall be performed under the supervision of the contractor's authorized personnel in the presence of the owner's representative, local authorities, and any other authority.
- N. The contractor shall provide a gas analyzer capable of automatically recording sampling points. Concentration recording shall continue until authorities are satisfied with hazard integrity or until 30 minutes have elapsed.
- O. The sampling point(s) shall be located at a strategic area(s) but no higher than the highest combustible contents.
- P. If the test results indicate that the design concentration was not achieved and/or held, the contractor shall determine the cause of the failure. After determination of the cause, the system shall be recharged and again placed in operation. The contractor shall only be responsible for retest based on equipment design failure.

4.2 TRAINING REQUIREMENTS

- A. Prior to final acceptance, the installing contractor shall provide operational training to each shift of the owner's personnel. Each training session shall include control panel operation, manual release and (optional) hold or abort functions, supervisory and emergency procedures.

4.3 OPERATION AND MAINTENANCE

- A. Prior to final acceptance, the installing contractor shall provide complete operation and maintenance instruction manuals to the owner. All aspects of system operation and maintenance shall be detailed, including piping isometrics, wiring diagrams of all circuits, a written description of the system design, sequence of operation and drawing(s) illustrating control logic and equipment used in the system. Checklists and procedures for emergency and maintenance shall be included in the manual.

4.4 AS-BUILT DRAWINGS

- A. Upon completion of each system, the installing contractor shall provide copies of system as-built drawings to the owner. The drawings shall show actual installation details including all equipment locations (i.e. Control panel(s), agent container(s), detectors, alarms, manual release unit(s), and abort / hold switch(s), etc.), as well as piping and conduit routing details. Show all room or facility modifications, including door and / or damper installations. One copy of reproducible engineering drawings shall be provided reflecting all actual installation details.

4.5 ACCEPTANCE TEST

- A. A room pressurization test shall be conducted in each protected space to determine the presence of openings, which would affect the agent concentration levels. The test(s) shall be conducted using a Door Fan Pressurization Equipment System, or equivalent, with integrated computer program. All testing shall be in accordance with EN 15004 / ISO 14520 or NFPA 2001 as applicable.
- B. If room pressurization testing indicates that openings exist which would result in leaks and / or loss of the Clean Agent, the installing contractor shall be responsible for coordinating the proper sealing of the protected space(s) by the general contractor or their sub-contractor or agent. The general contractor shall be responsible for adequately sealing all protected space(s) against agent loss or leakage. The installing contractor shall inspect all work to ascertain that the protected space(s) have been adequately and properly sealed. If the first door fan pressurization test is not successful the installing contractor shall direct the general contractor to determine and correct the cause of the test failure. The installing contractor shall conduct additional room pressurization tests, until a successful test result is obtained. Copies of successful test results shall be submitted to the owner for their record. Upon acceptance by the owner, the completed system(s) shall be placed into service.

4.6 SYSTEM INSPECTIONS

- A. During the one-year warranty period, the installing contractor shall provide two inspections of each system installed under this contract. The first inspection shall be at the 6-month interval, and the second inspection at the 12-month interval. Inspections shall be conducted in accordance with the manufacturer's guidelines and the recommendations of EN 15004 / ISO 14520 or NFPA 2001.
- B. Documents certifying satisfactory system(s) inspection shall be submitted to the owner upon completion of each inspection.

4.7 WARRANTY

- A. Environmental: The manufacturer (Johnson Controls) shall offer a 20-year environmental warranty covering regulations banning or restricting use of the SAPPHIRE PLUS Clean Agent Fire Suppression System due to environmental issues.
- B. Components / System: Limited one year warranty shall be offered for defects in workmanship and material.

Note: Converted metric values in this document are provided for dimensional reference only and do not reflect an actual measurement.

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