National Manual of Assets and Facilities Management

Volume 5 Chapter 6

Instrumentation Systems Operations – Offices Procedure

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IMPORTANT NOTICE

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1.0 PURPOSE

The purpose of this document is to provide guidelines and minimum requirements to manage the operations of the instrumentation systems of building facilities in the Office facilities sector. It is essential to operate and manage field instruments and devices linked to Building Management Systems (BMS) according to the installation and design methodology to achieve efficient and effective building operations. Guidance on applying best practice and international standards in compliance with the local Kingdom of Saudi Arabia's (KSA) established codes, standards, regulations and decrees may be found with the relevant department's policies and procedures.

Comprehensive knowledge is required to ensure the safety along with Permits-to-Work (PTW) to manage any possible interruption to a system in a facility. This document outlines key personnel involved in the operation, maintenance, and use of a system.

Furthermore, all installations including equipment, data monitoring and communications must be fully compliant with the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) and the Chartered Institution of Building Services Engineers (CIBSE) standards. The document will enable senior management to have a clear understanding of staffing requirements, staff roles and responsibilities, and operational compliance.

2.0 SCOPE

The scope of this document is to provide a description of the various instruments in an Office Entity, and to identify strategies following specific standards needed to ensure that field devices are being monitored to enable the collection of data. With this acquired data, alarms can be in place to notify engineers of potential failing components. Processes can be put in place to set parameters to automatically create notifications to minimize contingent damage to systems.

Qualified staff and contractors are required to maintain the instruments and facilities, to optimize efficiency, and reduce energy consumption. Safe work practices and procedures will be followed as per manufacturer guidelines to ensure the safety of all occupants and those maintaining the facilities. Start-up, shutdown, monitoring, and emergency response plans will be attached to ensure efficient operations. Further to this document, information regarding BMS linked to instrumentation and controls can be referenced in the necessary volumes of the Expro National Manual of Assets and Facilities Management.

Recommendations and final responsibilities in this document are presented for the operations management of Instrumentation systems with the Entity and/or Operations Engineer (OE). For this document, "an Office facility" has been defined as any location where a building, or portion of a building, is used for an organization's workspace (primarily desk-based business purposes), such as but not limited to:

- Commercial
- Office blocks
- Business Centers
- High-rise buildings/Office Towers

3.0 DEFINITIONS

Term	Definition
Accuracy	Where, under normal operating conditions, an instrument can have a limit of error on a value within an accepted standard value.
Building Management System	A building-wide network, which allows communication with building engineering systems. It may also include any third-party systems.
Boost Period	The period when engineering systems operate at full capacity.
Calibration	When a device or instrument delivers a value that can compare to a standard value of known accuracy.

Term	Definition
Condition Monitoring	A measurement of data, indicating a condition of a system, which allows the need to determine any maintenance of that system or device.
Controller	A device, which adjust another device or process variables to how it is programmed, through constant monitoring.
Current	The rate of flow of electricity. Measured in amperes (A)
Direct Digital Control	Implies that the control algorithms are in the form of software. Analog inputs or outputs may coexist with digital control.
Energy Management Control System	A computerized control system which regulates a building's energy consumption by controlling the operation of such systems as the heating, ventilation and air conditioning (HVAC), lighting, and water heating systems.
Field Equipment Controller	Wireless programmable controllers that can be switched between various protocols.
Linear Variable Differential Transformers	Devices that convert linear motion of a mechanically coupled field device in a system into an electrical signal.
Manual Reset switch	When a controller or field device has exceeded a limit or value, a switch trips, to manually reset that controller or field device
Process variable	A monitored or controlled process is measured against a measured value
Rangeability	The ratio of maximum to minimum flowrate of a meter
Relay (mechanical)	An electromechanical device that interrupts a circuit by physically moving electrical contacts into a contact with each other
Resistance Temperature Detectors	Sensors used to measure temperature.
Set-point	A desired (minimum / maximum) value required by the operator of a system. For example, temperature (HI / LO) in an HVAC system.
Span	Difference between the upper range value and lower range value of a system
Transducers	A device that converts physical quantity into an electrical quantity
Transmission	A method of sending data between various instruments of a plant in a standardized form
Transmitter	A device which converts measurement value into a standard signal
Volt	A volt is an (electrical) potential difference between two points in an electrical circuit
Abbreviations	
AE	Authorizing Engineer
AHJ	Authority Having Jurisdiction
AP	Authorized Person
BCS	Building Control Specialist
BMS	Building Management System
BOD	Basis of Design
CCTV	Closed Circuit Television
CM	Control Module
CMMS	Computerized Maintenance Management System
CMT	Crisis Management Team
CP	Competent Person
CT	Current Transformer
DDC	Direct Digital Control
EMCS	Energy Management Control System
EMP	Emergency Management Plan
FEC	Field Equipment Controller
FM	Facilities Manager
FMC	Facilities Management Company

Term	Definition
FOC	Facilities Operations Clients
FOM	Facilities Operations Management
HSE	Health Safety Executive
HTM	Health Technical Memorandum
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Instrumentation Control Engineering
ICU	Intensive Care Unit
KSA	Kingdom of Saudi Arabia
KVA	Kilovolt Amperes (1000 volt amperes)
KW	Kilowatt defined as 1000 watts in an electrical circuit
LVDT	Linear Variable Differential Transformers
NFPA	National Fire Protection Association
O&M	Operations and Maintenance (O&M) of facility and assets.
OE	Operations Engineer
OEM	Original Equipment Manufacturer
PC	Personal Computer
PPE	Personal Protective Equipment
PPM	Parts Per Million
PTW	Permit To Work
QC/QA	Quality Control / Quality Assurance
RA	Risk Assessment
RAMS	Risk Assessment Methods Statement
RTD	Resistance Temperature Detectors
SOO	Standard of Operations
SOP	Standard Operating Procedure
SWP	Safe Work Practice
VESDA	Very Early Smoke Detection Apparatus
VT	Voltage Transformer

Table 1: Definitions

4.0 REFERENCES

- National Institute of Governmental Purchasing (NIGP): The Institute for Public Procurement – Principles and Practices of Public Procurement “US organization National Institute of Governmental Purchasing (NIGP)”
- British Institute of Facilities Management (BIFM) – Sourcing Strategies
- Royal Institute for Chartered Surveyors (RICS) UK – Ethical Procurement Principles
- EOM-ZA0-PR-000004 Asset Register Process
- EOM-ZM0-PR-000001 Formality of Maintenance Performance Procedure
- EOM-ZW0-PR-000006 Estimating Work Procedure
- National Manual of Assets and Facilities Management – Volume 9: Contract Management
- National Manual of Assets and Facilities Management – Volume 11: Quality Execution
- National Manual of Assets and Facilities Management – Volume 11: Quality Assurance Audits
- American Society of Mechanical Engineers (ASME) – Guidelines on Specific use of Valves
- NFPA-72 – National Fire Alarm and Signaling Code
- SBC 501 – Saudi Building Codes Mechanical
- SBC 801 – Saudi Building Codes Fire Protection
- Chartered Institution of Building Services Engineers (CIBSE) Standards

These shall be selectively applied based on the evaluation of individual requirements. Where the standards stipulated conditions conflict, the most stringent shall govern, unless otherwise noted herein. When there is any conflict with the Saudi Building Code (SBC), only the Saudi Building Code will be applied.

5.0 RESPONSIBILITIES

It is the primary responsibility of the Operations Management (OM) Team to ensure that inspections, services, and maintenance activities are carried out safely without any hazard to Operations Team or its stakeholders. Clear lines of managerial responsibility should be in place to prevent any ambiguity for the safe operations of the building engineering systems. A periodic review of the field devices should take place by Operations and Maintenance (O&M) staff to ensure that operational standards are being met, and competent teams undertake these assessments. The O&M Management Team will ensure that staff is adequately trained and competent to carry out the operational tasks which should include but are not limited to:

- Staff briefing
- Safe Work Practices (SWP) and Safe Operating Procedures (SOP)
- Personal Protective Equipment (PPE)
- Quality Control and Assurance (QA/QC)
- Health and Safety Executive (HSE)
- Risk Assessment Methods Statement (RAMS)
- Stakeholder communication
- Training – auditing and periodic reviews

The Entity is the final Authority Having Jurisdiction (AHJ) unless specifically stated otherwise in other sections of the Expro Asset and Facility Management Manual. The following roles are further described in the table below:

- Facility Maintenance Managers
- Specialist Engineers
- Non-technical personnel
- Training personnel
- Subcontractors

Role	Description
Facilities Manager	• Coordinating maintenance of a facilities • Schedules maintenance of the devices in a facility • Coordinates execution of processes • Implements changes to a process if required • Identifying and manages exceptions in workflow • Ensures compliance with standards and procedures • Facilitates and allocates resources for maintenance • Creates process reports • Communicates with clients, service providers, and management. • Acts as the point of escalation for decision-making. • Ensures completeness and accuracy of information collected during normal daily operations. • Defines and monitors Key Performance Indicators to ensure daily operations and maintenance are completed.

O&M Manager	• Overall authority and responsibility for the premises containing the facility equipment, systems supply, and distribution systems within an Office facility. • Has a duty to prepare and issue a general policy statement on health and safety at work.
Duty Holder	• Ensures Health and Safety in the workplace. • Demonstrates the ability to mitigate risks in the workplace, and to ensure the safety of staff responsible for the operations and maintenance of facilities.
Authorizing Engineer(AE)	• A Chartered Engineer, Instrumentation and/or Automation Engineer with appropriate experience. • Possesses the necessary degree of independence from local management and is appointed in writing by the office management, to implement, administer, and monitor the safety arrangements for field instruments, ensuring compliance. • Assesses the suitability and appointment of candidates in writing to be Authorized Persons. Independent of local management to act where necessary and alert the Chief Executive (in the event the local Management do not act to avoid harm). • Ensuring that this information is passed on to the right persons.
Authorized Persons(AP)	An individual possessing adequate technical knowledge and appropriate training responsible for the practical implementation and operation of management's safety policies and procedures.
Competent Person(CP)	An individual who has sufficient technical knowledge and experience to prevent danger when carrying out operations on defined low voltage systems.
O&M Technicians	A person of the engineering staff, BMS manufacturer or operations & maintenance organization, employed by management to carry out duties in the field.
Training Personnel	• All new operators who may subsequently be appointed should also receive proper training, on procedures and safety. • An internal training module could be developed by training personnel.
Subcontractors	• A Subcontractor assists in the operations and maintenance of a facility. • The Subcontractor is managed by a Facility Manager, and given specific duties to ensure that the facility is properly functioning. • Subcontractors normally supply their own tooling and supplies to operate and maintain a building, which is detailed in a contractual agreement.
HSE	• Have a legal obligation for the health and wellbeing of the workforce. • Ensure everyday processes of running an Entity and are an integral part of workplace behaviors and attitudes. • Provide leadership and management using proven business processes. • Ensure that trained/skilled personnel are following the rules and operating procedures of an operations and maintenance contract. • Ensure the Health and Safety of the workplace follows the guidelines set in accordance and compliance with the Expro approach.

Table 2: Responsibilities

6.0 PROCESS

6.1 Instrumentation and Control Engineering

Instrumentation and Control Engineering (ICE) focuses on the measurement and control of process variables.

ICE combines two branches of Engineering: Instrumentation Engineering and Control Engineering. Instrumentation Engineering is the measurement and control of process variables within a facility. Control Engineering provides monitoring and communication with the instruments installed.

Controls include sensors to measure the inputs/outputs of devices, which provide feedback to the controller so that it can make corrections toward desired performance. Automatic control manages system devices without the need of human inputs for correction.

Because instrumentation and control play a significant role in gathering information from a system and changing its parameters, they are a key part of control loops.

A control system must ensure safe operations of the system it controls; it must give adequate warning of any malfunction and if necessary, take appropriate action in the event of an instrument's failure. A control panel employs a variety of alarms, interlocks, and control strategies to automate engineering system operations. These strategies are found over a wide range of different engineering systems frequently, and shall be managed in a controlled manner to avoid recurrences.

6.1.1 Instruments Control and Monitoring Elements:

6.1.1.1 Set Points

Office facilities operate under the control of the appropriate staff, whether in-house staff, a contract facilities management team, or other support systems. Set points and ranges are essential as it is expected that the control systems will require some attention with setting ranges of operations of sensors, thermostats, and valves on a day-to-day basis by the control engineers. A stringent process should be developed to ensure that these adjustments are managed in a controlled manner, without having an impact on operational performance, and to maintain operational efficiencies reducing utility waste in that system. Records should also be kept on any changes to set points after an event, or repair of a system.

Set points can be altered manually or automatically depending on the requirements of the system. All set points should be established for the conditions required and based on manufacturer specifications. An instrument's recommended periodic calibration ensures its accuracy. Instruments should be calibrated to ensure that determined margins and operating ranges are within specifications and to avoid faults. Changes to set points should be recorded so that they can be reinstated after a short-term event or reviewed by Facility Managers for future operations, as failure to control changes can have a significant impact upon plant efficiency and overall utility costs.

6.1.1.2 Monitoring

In many circumstances it is possible to monitor the condition of a system or facility. This provides valuable information on an office engineering systems performance and reliability, and can detect early signs of trouble in systems or equipment. Display screen in systems controllers can provide valuable information to the personnel responsible for the daily checks and inspections. This real-time data can be detected but are not limited to the following:

- Pressure drops which can lead to systems failure
- Efficiencies that can be calculated
- Operating variables that can be compromised

6.1.1.3 Metering

Energy metering hardware systems are in place in a facility to measure gas, electrical, and water flow consumption. These devices can read and communicate data to a central computer system, allowing for monitoring of usage and consumption and identifying ways to conserve energy in all areas. Metering consumption is crucial to determining if a system is operating within the ranges it is programmed for. It can be used to detect leaks and inconsistencies in operations to identify problems in a system. Many of the field instruments discussed in section 6.3 of this document are used to enhance the process of metering in a building system.

6.1.1.4 Records/ Drawings / System Architecture

The Entity should have accurate and up-to-date records and/or drawings. Where possible, these should be backed up electronically and made readily available on site, in an appropriate format, to be used by the engineering services and Facilities Management Teams. Manual daily, weekly, and monthly checklists are forms of documentation that are helpful in the success of (O&M). Records, drawings, and system architecture libraries should be readily available to the trained staff to improve the understanding of operations, systems, and maintenance. Original equipment manufacturer manuals should be provided with the equipment used in a facility so that trained staff have access to the proper safe work practices and safe operating procedures to complete their maintenance tasks safely and properly.

6.2 Operations Performance

Within an Office facility, there are critical pieces of equipment (assets) and engineering systems, which have a greater impact on the overall performance of the services. Therefore, there is a need to identify what equipment or system is critical in ensuring the safety, comfort and amenity of a facility, particularly in areas like computer server rooms. The Entity may wish to put a contingency plan in place for major utility service failure, which shall cover the details of equipment or systems and stand by equipment or systems.

The loss of service of these areas would seriously degrade the ability of the premises to deliver optimal services. To ensure reliable service provisions, it is essential to inspect, verify, and maintain healthcare utility systems at appropriate intervals. For many of these systems, a PTW will need to be completed to ensure that taking these systems out of service does not compromise the activities of the user department. In any event, it will be necessary to liaise with the user department when taking the system offline to carry out routine inspections and maintenance. Where necessary, it is important to request the permission of senior office staff to prevent any impact to users/occupants.

6.2.1 Risk Management

In developing Office Operations Management processes, it is vital to consider the risks associated with a lack of scheduled maintenance and monitoring. Troubleshooting, repairs, and maintenance must be made immediately when a fault is detected to prevent damage or a loss of a system in a facility. It is critical that a well-run facility and associated engineering system with maintenance plans are strictly adhered to. Otherwise the following issues could result:

- System failures and contingent damage to facilities, causing increased O&M costs.
- Reduced asset life.
- Violation of codes and standards.
- Decreased operational efficiencies with negative monetary effects.
- HSE risks and infractions.

Categories need to be placed on the faults and incidents determined by the FM and subject matter experts. Below is an example for a Risk and Incident response chart indicating levels of urgency in responding to a fault of incident:

Priority Code	Description	Response Time	Resolution Time
1	Critical	Immediately	1 hour
2	High	2-4 hours	4-8 hours
3	Medium	4-12 hours	12 -24 hours
4	Low	12-24 hours	24-48 hours
5	Very Low	24-48 hours	48-84 hours

Table 3: Incident Priority Chart

6.2.1.1 Shutdown & Outage Management

A Shut down can be defined as scheduled down period for an office facility where maintenance of a large work plan, often including multiple items of plant and equipment, is required to schedule into a relatively short period. Often Gantt charts and critical path methods are used when completing a planned shutdown.

Major equipment overhauls are performed during shutdowns to prevent future breakdowns. In certain instances, specialized tooling and equipment may need to be rented and specialized contractors hired to fulfill the needs of the scheduled work. A successful shutdown maintenance plan should meet the following objectives:

- Stakeholder engagement
- Spares and consumables to be available at time and point of work
- Processes and procedures (RAMS) / O&M Manuals and PTW
- Team competencies and professional staff / contractors
- Access requirements to be arranged
- Where required calibration certificates for inclusion within work documentation

The FM needs enhanced skills in Leadership and Management, to ensure that all Maintenance personnel are competent to complete the work in the specified time. If activities have the potential to ‘run over’, then senior staff responsible for the area or facility must improve then this beforehand.

6.2.1.2 Faults & Incident Response

Plans should be developed to include the most efficient repair without having a major impact on day-to-day facility operations. Alarms will be linked to these faults through the various control systems in an O&M plan. Fault and incident response plans should be current and updated accordingly if conditions in a system change. A chain of command needs to be established to identify and rectify the faults as soon as they occur.

6.2.1.3 Documentation

Effective record documentation and system logs are essential for the successful day-to-day operations and maintenance of engineering services and field instruments related to office facilities. The documentation should record and include:

- Work orders and any permits for work to be completed
- Control strategies to ensure facilities are able to function or have backups in place in case of equipment failure or malfunction
- Copies of relevant standards and regulations from HSE to O&M
- Instructions for energy isolation, fault finding and emergency conditions if required
- Completion of a Job Hazard Analysis to ensure the safety of personnel
- OEM manuals and instructions for servicing

- Documentation - Initial inspection on failure and post inspection following repair, including instruments to be changed and failure recognition with recorded with to ensure proper operation after repair.
- Quality records kept on inventory of spare equipment/parts lists
- Inspection/maintenance frequency of systems
- Testing frequency and source of the test concentrations or equipment
- Field instrument replacement schedules should be monitored and tracked with alerts given on an automated system to ensure planned preventative maintenance is followed
- Documentation to monitor the service agreements that are in place for equipment and systems
- Monthly check sheets and entry forms for documenting and testing inspections and maintenance performed.
- Test equipment must be fit for calibration and ideally added to the CMMS system as a maintenance task to ensure procedures are undertaken prior to its expiry.

6.2.2 Operational Considerations

- Tuning and optimization of parameter and set points.
- Importance of system documentation, for warranty purposes on the instruments used in the facility systems.
- System maintenance templates indicating maintenance intervals
- Life cycle expectations and considerations.
- Component change out sheets (documents) including serial numbers, date and reason for change.

6.2.3 Health and Safety

The management of occupational health, safety and wellbeing is crucial to the effective operation of any facility. The health and wellbeing of the workforce on site is a legal obligation of the (HSE).

Organizations have a legal duty to put in place suitable arrangements to manage for health and safety. It should be part of the everyday process of running an Entity and is an integral part of workplace behaviors and attitudes. The key to effectively managing health and safety is dependent on:

- Leadership and management using proven business processes.
- A trained/skilled workforce following the rules and operating procedures of an operations and maintenance contract.
- Continuation and refresher training to all staff
- Upholding a culture within the Entity that promotes and exercises ‘safe practices’

Health and Safety of the workplace must follow guidelines set in accordance and compliance with the Expro approach. These rules and regulations will be further defined in additional documents to ensure that the workforce responsible for the operations and maintenance of a facility, are following all policies and procedures to work in a safe, incident-free environment.

6.3 Facility Field Instruments

The fundamentals of the below mentioned field instruments will be linked with monitoring systems through the BMS where they can be controlled and assessed to improve efficiency and maintain levels of reliability to optimize performance.

6.3.1 Motion Sensors/ Detectors

Motion sensors include but are not limited to:

- **Occupancy sensors** – Ceiling mounted sensors, which measure occupancy to provide data to inform systems to turn on/off lighting, and alert heating, ventilation and cooling systems where supply is needed.

- **Window sensors** – Sensors that are mounted on a building window as a glass break detector; can also detect sunlight to control blind operation for window shading.
- **Smoke/Fire sensors** – Sensors installed that, when triggered, set off a building's fire alarm informing a central control system to alert emergency response and unlock emergency doors for a safe exit of occupants.
- **Carbon Monoxide sensors** – can also be integrated into a fire alarm system to ensure safety of occupants by monitoring CO levels in the air.
- **Motion sensors** – A short-range sensor used to unlock or open doors in a facility. These motion sensors can be used to detect an individual as they approach a turnstile or elevator door.
- **Door Contact sensors** – Sensors can activate a security system if an unauthorized lock is accessed.
- **Infrared sensors** – A type of sensor to track how many people are entering/exiting a building; also used to start and stop escalators to conserve energy.
- **Beam Sensors –** When a light beam is interrupted, a switch is activated to perform a specific function.
- **Very Early Smoke Detection Apparatus (VESDA) –** A model of aspirating smoke detectors. These detectors sample air through chambers to detect smoke, in an event of a fire using a laser system.

6.3.2 Analog/ Digital Meters

Analog/Digital Meters are devices used for monitoring and maintenance to measure current voltage and resistance of a circuit to assist with troubleshooting and efficient operation of a circuit. These tools can be placed in series with an electrical device.

6.3.3 Pressure Transmitter

Pressure Transmitters refer to devices used to measure a pressure or level of equipment and system liquid or gas, whereby the output is transmitted to a control system.

- **Dual static pressure transmitter** – A transmitter with an input pressure to suit each individual application. (Refer to manufacturer specifications on range and capabilities as well as installation instruction).
- **Space static pressure transmitters –** A transmitter that has an input range to suit an application, and has an overprotection range, which can be specified.

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6.3.4 Pressure Switch/ Pressure Differential Transmitters

These are devices using a differential air pressure to actuate an electric switch, at a predetermined setting. These switches are most commonly for air systems (air filter status indication) and water-related systems.

6.3.5 Level Switch

Level switches refer to switches with an electrical contact output of a liquid, or powder bulk reservoir, tripped at a certain level, either high or low. This circuit can be in holding tanks, pressurized vessels, or reservoirs. These switches most commonly exist as a float device mounted on a cable with a hermetically airtight sealed mercury switch.

6.3.6 Float Valves/ Isolation Valves/ Earthquake Valves

The BMS subcontractor shall furnish all valves controlled by the BMS as detailed in the trade documents and as indicated on building drawings. Details of the valves shall be provided on the manufacturer's

installation requirements. All valves shall be rated appropriately for the fluid, temperature, and pressure they are designed for.

- Pressures ratings shall be clearly marked and tagged on the body of the valve and fastened in a manner where they cannot be intentionally removed.
- BMS contractors shall certify that the materials of construction are appropriate for the application. For example, valves used for the control of glycol solutions for Heating, Ventilation and Air Conditioning (HVAC) applications shall have a trim that is suitable for glycol solution.
- Valves used for instrumentation shall be removable and replaceable without the requirement to shut down a pump and without the requirement to drain a pipe of tank.
- They shall be rated for a pressure 50% greater than the system working pressure, or whichever is greater.
- They shall be rated for a minimum of 50°C (90°F), greater than the highest fluid temperature.
- To achieve the required performance and pressure drop, a control valve may be sized up to two nominal sizes below the line size.
- Valves should be capable of a tight shut off when operating at system pressure with the pump operating at shut off head. Leakage rates shall not exceed 0.01% of the rated valve capacity.
- Isolation valves shall be installed in a circuit to be able to install external monitoring equipment. They should also be installed to direct flow or stop flow if mechanical servicing of a circuit is required.
- Earthquake valves installed in-line with a buildings gas line will automatically close and shut off gas supply to a system in the event of an earthquake with a magnitude of 5.1 or greater as an industry standard. The specific information listed in 6.2.6 are referenced from the below guide.

6.3.7 Temperature Sensors

Temperature sensors are used to measure temperature in circuits that control a variety of equipment.

- The temperature sensor should have an operating range to suit the application.
- The sensor should be factory calibrated and should be compatible with analog inputs.
- In a Resistance Temperature Detector (RTD) sensor, the resistance is directly proportional to the temperature.

6.3.8 Solenoid Valve

These valves are control units, that when electrically energized or de energized, will allow or stop the flow of fluid through a circuit. Placed in a fluid, the circuit will allow fluid to flow through a system based on the parameters set by the control system.

6.3.9 Motorized Operated Valve/ Actuator

An electric motor is mounted on a valve in a piping system that when actuated, by a controller the valve will open or close. The motor size for the intended circuit is determined by the manufacturer.

6.3.10 Pneumatic Operated Valve/ Actuator

Air pressure operated valves and actuators may still be in operation on piping systems to control flow of a product. These may be phased out, as facilities move towards systems controlled by electrical devices for greater reliability and stability.

6.3.11 Flow Meters

Flow meters measure the volume or mass of a liquid, gas or steam flowing through a system. They are used in the transfer of fluids in water and gas operations. Flow meters can include the following:

- **Differential pressure flow meters** – In this instance they could commonly be used in HVAC and water applications. They measure the differential pressure across an orifice where flow is directly related to the square root of the differential pressure produced. They are used by maintenance personnel when servicing equipment.
- **Positive Displacement flow meters** – These meters measure a volume filled with fluid, delivering it ahead and filling that volume again which calculates the amount of fluid transferred. It measures actual flow of fluid a fluid by determining its volume. These meters are very accurate.
- **Velocity flow meters** – Velocity of a fluid is measured with this type of flow meter where then a volume can be calculated.
- **Mass flow meters** – This type of flow meter measures mass moved over a unit of time. This meter can be found in a wastewater system of a building. They measure the force that results from the acceleration of a mass.

6.3.12 Photoelectric Sensors

A photoelectric sensor, or photo eye, refers to equipment used to discover the distance, absence, or presence of an object by using a light transmitter, often infrared, and a photoelectric receiver. These types of sensors could be incorporated when installing automatic doors to elevators, entrances and exits.

6.3.13 LVDT (Linear Variable Differential transformer)

LVDT is a transducer that converts a rectangular movement of an object into an electrical signal. It is used for measuring linear displacement.

6.3.14 Dampers

Dampers are plates that control the flow of air through a duct. Their movement is controlled by actuators. They can be used to cut off airflow to rooms that are not being utilized, linked to local or BMS controls. Limit switches can be in-line with these dampers to indicate an open/closed status integrated with a fire alarm system.

- Fire dampers – Are used to prevent the spread of a fire in a HVAC duct system by blocking flow of air to the affected areas. These may be of either MANUAL or motorized types.
- HVAC damper applications can control temperature by restricting the amount of airflow to provide efficient cooling and heating. They also control pressure of an air system in ductwork.

6.3.15 Vibration Sensor

Large Fans in an air system responsible for providing air through ducts require vibration sensors mounted on the fan hub, help determine the bearing health of a fan through real-time monitoring, and trend analysis of vibration levels. These sensors can be connected wirelessly to a control room to assist maintenance personnel with preventative maintenance and reliability.

6.3.16 RTD and Thermocouples

Resistance Thermometers Detectors (RTD's**)** are temperature sensors that operate on the measurement of a material's electrical resistance, changes according to applied temperature. RTD's maximum temperature reading are much more accurate than those of thermocouples are, but do not have the thermal range over thermocouples.

6.3.17 DDC Controls/ FEC Controllers

Direct Digital Control (DDC) controls building systems from one central point. This control needs to be maintained. They can be a central point for HVAC, lighting and alarms, as well as numerous other building systems.

Field Equipment Controllers (FEC) controllers are programmable, with varying capacities based on the needs of the BMS system. It is also a central building control device.

6.3.18 Input/ Output Modules (I/O)

Input/output modules are devices that act as the connective bridge between a computer system at one end and an I/O or peripheral device such as a printer, webcam or scanner at the other.

6.3.19 Temperature/ Humidity Controllers and Thermostats

Most commonly digital controllers used to monitor temperature and relative humidity. They can be configured as a controller or alarm.

6.3.20 Smart Energy Meters

A smart meter is an electronic device that records consumption of electric energy and communicates the information to the electricity supplier for monitoring and billing.

6.3.21 Current Switches

Current switches are used when an application needs to signal the current flow in a system exceeds or drops below a preset value. They monitor this current level and electrical contacts will change state from either an open or closed condition and relay this data to the applicable controller or monitoring system.

6.3.22 Calibration Instruments

These instruments maintain and verify instrument accuracy and are typically used with flow, temperature, and pressure. Calibration is the process of configuring an instrument to provide a result for a sample within an acceptable range. Calibration instruments need to be inspected and tested as well, to ensure accurate testing is completed. Calibration of instruments and calibration of tooling can be completed by competent personnel and should be done as per manufacturer recommendations. Alerts can be programmed into controllers to notify those responsible when such testing must be performed.

6.3.23 Relays

Relays control the flow of electricity in a circuit by opening or closing contacts in another circuit. When a contact in a relay is open, the circuit is not energized so there is no flow of electricity.

6.3.24 CT/VT

These are current and voltage transformers, used for metering and controlling current and voltage loads from high values to low values and visa-versa, depending on what is needed in a circuit. Current and voltage transformers also receive inputs and can protect electrical circuits under abnormal operating conditions

6.4 Procedures

6.4.1 Startup Procedures

A startup procedure is a reference document to be used when preparing a process to operate a system after a repair from an offline position. The actions within the procedure are intended to ensure that a methodological approach is taken when bringing a field device or equipment system back online. Startup procedures shall include the following:

- Health and Safety
- Pre-Approvals
- System Readiness
- Pre-Start Checks
- Start Checks
- Notifications

(Refer to Attachment 1 – EOM-ZO0-TP-000089 – Instrumentation System Start-up Checklist)

6.4.2 Shutdown Procedures

A shutdown procedure is a reference document for a planned activity to take a field instrument or a piece of equipment offline. The shutdown procedure should be clear, prescriptive, and well understood. The specific steps often mirror those taken with a startup procedure, but include additional considerations for the effect on utilities and other building services connected to the process. Shutdown procedures shall include the following:

- Health and Safety
- Pre- Approvals and stakeholder permissions
- Standby System Condition
- Pre Shutdown Checks
- Routine Stops
- Post Stop Checks
- Notifications

(Refer to Attachment 2 – EOM-ZO0-TP-000081 – Instrumentation System Shutdown Checklist)

6.4.3 Daily Reporting / Monitoring

A well designed and managed BMS provides great opportunities for improvements in energy efficiency and monitor early alarms/faults to prevent equipment failures or any catastrophic failures of engineering systems. Therefore, a clearly understood process is required to manage alarms and equipment's events to avoid any incidents related to the operations of Entity facilities. This process shall define timelines required to raise any reactive, corrective or emergency issues occurring in monitoring, control or running the O&M strategy for integrated control systems within acceptable time to address any faults in a timely manner. Daily reports / monitoring provide great opportunities for improvements in energy efficiency by:

- Enabling Facility Managers (FM) to provide an optimal working environment consistent with maintaining a building's energy efficiency rating;
- Early identification of equipment failure through consistent monitoring and data analysis;
- Identification of unusual patterns, trends of energy usage, such as equipment, system being left ON out of required hours in common areas, office areas, etc.;
- Monitoring effectiveness of Energy Management Plans.

(Refer to Attachment 3 – EOM-ZO0-TP-000091 – Instrumentation System Daily Monitoring Checklist)

6.4.4 Emergency Response / Actions

Emergency procedures are intended to highlight the key issues that may arise at a departmental level in the event of monitoring or controls failures. Good practice in emergency management should include development of an (EMP), and actions that outline responsibilities, identification of high-risk areas, and appropriate responses. Clear identification of safe areas during an emergency, an evacuation plan for

disabled persons, and an emergency plan with response actions will be further detailed in Attachment 4 – Emergency Response Actions.

Within the Office Facilities operating procedures, there will be many elements of the overall Facilities Operating Clients (FOC) Emergency Management Plan that the Facilities Management Companies (FMC) plan will need to feed into and take direction from. The response actions required will depend on these plans and integrations

Below is an example of the Facilities Management Companies (FMC) Emergency Plan integration elements, reporting entities, and designated persons are required to build a basic a basic plan.

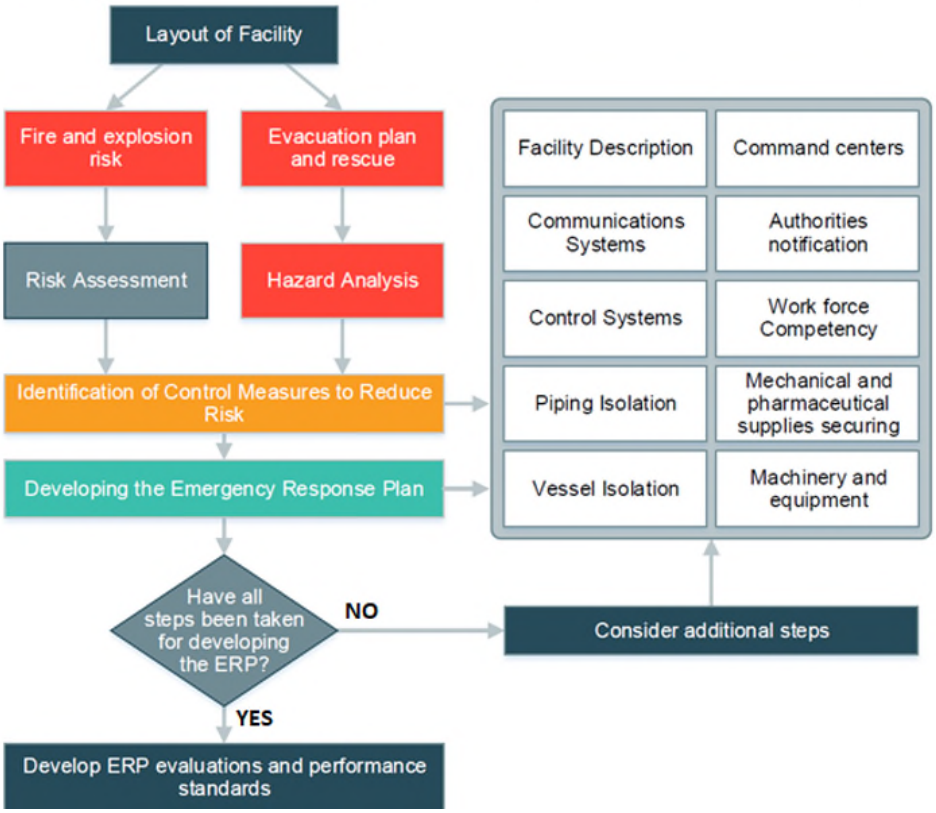

Fig. 1: Emergency Planning response Matrix

Plan development should consider how different emergencies and scenarios would affect the operation of facilities and the areas in which the emergency has originated. It is good practice to prioritize these emergency origins and impact areas, into specific categories and document the influence on site operations that may occur due to these emergencies. Emergency origins may be categorized as:

- **External Disaster** (e.g., earthquake, flooding, weather, multi-discipline disruptions)
- **External Specific** (e.g., major distribution service provider outage, localized area outage, specific transformer outage, local cabling, BMS communication, IT connectivity)
- **Internal Disaster** (e.g., major fire, major flooding, critical site wide systems failure)
- **Internal Specific** (e.g., power failure to the BMS controllers, communication failure, data loss, programming issues or any specific malfunction in system monitoring or control)

From the high-level headings, the impact to other systems and/or facilities can be identified and the action plans can be subsequently formulated.

Below is an example of how the emergency action planning development may flow for one scenario. Plans applicable to other scenarios should also be put into emergency grab packs, giving the FMC emergency

response staff clear direction on how to handle an emergency while the FMC Crisis Management Team (CMT) and FOC – CMT are convened and become operational.

External Disaster (e.g. earthquake, flooding, weather, multi-discipline disruptions)

Scenario 1 Major Earthquake

1. **Scenario parameters**

- External electrical supply has been lost
- External supply chain is not responding
- Business loss

2. **Initial Actions**

- Relevant grab packs to be distributed to and/or taken by the emergency response engineering staff
- Implement the FMC emergency action plan
- Convene at the FMC crisis management command center/ designated area.
- Establish communication with the FOC (client) Crisis Management Team (CMT)
- Establish the communication process with external governmental departments through FOC - CMT process

3. **Assessments**

- Assess the impacted BMS and other integrated systems
- Formulate action requirements from the emergency grab packs
- Prioritize in conjunction with FOC - CMT direction and/or consultation
- Calculate load shedding requirements to conserve resources (e.g., stored diesel) in line with FOC CMT direction and/or consultation.
- Access the monitoring and control through other redundant BMS measuring points in building network.

4. **Implementation**

- Deploy to FMC - CMT designated command area
- Initiate initial action process
- Establish communications processes
- Initiate initial assessment process
- Select relevant emergency grab packs
- Report initial assessment findings to FOC – CMT
- Take informed direction from FOC – CMT
- Initiate emergency grab pack process
- Initiate staff deployment
- Report, update, and direct FMC CMT ↔ FOC – CMT
- Continue intensive situation assessments until emergency is stabilized
- Initiate forward operation requirements
- Assess staffing requirements
- Assess staffing welfare requirements
- Operate on emergency operations requirements until emergency stand–down is agreed
- Initiate emergency stand-down processes in conjunction with FOC – CMT

The following procedures and checklists have been prepared for FM personnel to meet the needs of their own organizations during failure of a system.

They are not intended to be appropriate or definitive for all facilities, but they provide an idea of the general format that may be used and the different levels of technical content that may be applied to contrasting sites.

Further procedures will be required within office facilities and a regular review is important to ensure that the directives of staff and equipment remain current.

(Refer to Attachment 4 - EOM-ZO0-TP-000092 Instrumentation System Emergency Response Action Checklist)

7.0 ATTACHMENTS

1 Attachment 1 – EOM-ZO0-TP-000089 Instrumentation System Start-up
2 Attachment 2 – EOM-ZO0-TP-000090 Instrumentation System Shut-down
3 Attachment 3 – EOM-ZO0-TP-000091 Instrumentation System Daily Monitoring
4 Attachment 4 –EOM-ZO0-TP-000092 Instrumentation System Emergency Response Action Plan

Attachment 1: EOM-ZO0-TP-000089 Instrumentation System Start-up Checklist

Building NAME:	Reference No.	REV:		
No.	**Shutdown Procedure Checklist**	**CHECKED SATISFACTORY**		
		N/A	YES	NO
	Instrumentation systems - Office Facilities			
	Health and Safety			
1	Required Personal Protective Equipment (PPE) available	☐	☐	☐
2	Risk Assessments Method Statement (RAMS) available	☐	☐	☐
3	Location of first-aid instructions and supplies available	☐	☐	☐
4	Emergency eyewash and showers available	☐	☐	☐
5	Emergency evacuation plan reviewed	☐	☐	☐
6	Emergency contact details of the responsible person and the contractors	☐	☐	☐
7	Life safety systems (fire extinguishers, sprinklers, gas suppression & fire alarm)	☐	☐	☐
8	Job Hazard Analysis completed	☐	☐	☐
	Pre-approvals			
9	System owner / Manager/Engineering Team's approvals available	☐	☐	☐
10	Work orders raised / Scope of task clear	☐	☐	☐
11	End-user department head's approvals available	☐	☐	☐
12	Quality, Health, Safety and Environment Management (QHSE) approvals available	☐	☐	☐
13	Specialist contractor's schedule of work	☐	☐	☐
14	Approved Permit to Work (PTW)	☐	☐	☐
	Stand-by Condition System Checks			
15	Tooling inspected / Housekeeping	☐	☐	☐
16	Data saved	☐	☐	☐
17	Soft shutdown SOP/procedure to follow	☐	☐	☐
18	Auto mode/overrides	☐	☐	☐
19	Events / logs saved	☐	☐	☐
20	Voltage system check and confirm / recorded	☐	☐	☐
21	Mechanical, Electrical and Plumbing (MEP) systems mode of operation/system architecture/control logics	☐	☐	☐
	Pre-shutdown Checks (Integrated system functional checks)			
22	Automatic control panel parameters check	☐	☐	☐
23	Stand by systems working	☐	☐	☐
24	Overrides/auto functions active	☐	☐	☐
	Routine Stop Checks			
25	Lock Off Tag Out (LOTO) checks	☐	☐	☐
26	Server working	☐	☐	☐
27	No events/alarms on standby systems	☐	☐	☐
	Post-stop Checks			
28	MEP system functioning	☐	☐	☐
29	Verify device to be Change out	☐	☐	☐
30	Controller active	☐	☐	☐

Attachment 2: EOM-ZO0-TP-000090 Instrumentation System Shutdown Checklist

Building NAME:	Reference No.	REV:		
No.	**Shutdown Procedure Checklist**	**CHECKED SATISFACTORY**		
		N/A	YES	NO
	Instrumentation systems - Office Facilities			
	Health and Safety			
1	Required Personal Protective Equipment (PPE) available	☐	☐	☐
2	Risk Assessments Method Statement (RAMS) available	☐	☐	☐
3	Location of first-aid instructions and supplies available	☐	☐	☐
4	Emergency eyewash and showers available	☐	☐	☐
5	Emergency evacuation plan reviewed	☐	☐	☐
6	Emergency contact details of the responsible person and the contractors	☐	☐	☐
7	Life safety systems (fire extinguishers, sprinklers, gas suppression & fire alarm)	☐	☐	☐
8	Job Hazard Analysis completed	☐	☐	☐
	Pre-approvals			
9	System owner / Manager/Engineering Team's approvals available	☐	☐	☐
10	Work orders raised / Scope of task clear	☐	☐	☐
11	End-user department head's approvals available	☐	☐	☐
12	Quality, Health, Safety and Environment Management (QHSE) approvals available	☐	☐	☐
13	Specialist contractor's schedule of work	☐	☐	☐
14	Approved Permit to Work (PTW)	☐	☐	☐
	Stand-by Condition System Checks			
15	Tooling inspected / Housekeeping	☐	☐	☐
16	Data saved	☐	☐	☐
17	Soft shutdown SOP/procedure to follow	☐	☐	☐
18	Auto mode/overrides	☐	☐	☐
19	Events / logs saved	☐	☐	☐
20	Voltage system check and confirm / recorded	☐	☐	☐
21	Mechanical, Electrical and Plumbing (MEP) systems mode of operation/system architecture/control logics	☐	☐	☐
	Pre-shutdown Checks (Integrated system functional checks)			
22	Automatic control panel parameters check	☐	☐	☐
23	Stand by systems working	☐	☐	☐
24	Overrides/auto functions active	☐	☐	☐
	Routine Stop Checks			
25	Lock Off Tag Out (LOTO) checks	☐	☐	☐
26	Server working	☐	☐	☐
27	No events/alarms on standby systems	☐	☐	☐
	Post-stop Checks			
28	MEP system functioning	☐	☐	☐
29	Verify device to be Change out	☐	☐	☐

Attachment 3: EOM-ZO0-TP-000091 Instrumentation System Daily Monitoring Checklist

Building NAME:	Reference No.	REV:

No.	Daily Monitoring Checklist	CHECKED SATISFACTORY		
		N/A	YES	NO
	Instrumentation systems – Office Facilities			
	This monitoring checklist is intended to highlight the key issues that may arise day-to-day at local level. The procedure and any supporting information should be reviewed and amended as necessary to ensure the document remains up-to-date and definitive for the facility			
1	Systems inspection	☐	☐	☐
2	System assessment (Is the unit and its associated plant secure from unauthorized access)	☐	☐	☐
3	Remote monitoring of ventilation, air conditioning, and other Mechanical, Electrical and Plumbing (MEP) systems and equipment through controller and BMS	☐	☐	☐
4	System functions/mode of operation	☐	☐	☐
5	Identifying maintenance risks on equipment and raising work orders in case of any discrepancy into MEP systems	☐	☐	☐
6	Investigating fault /alarms for MEP systems (Logged events / Active Codes)	☐	☐	☐
7	Duty/standby system are healthy and communicating	☐	☐	☐
8	Field controllers, routers and switches are online and communicating	☐	☐	☐
9	System architecture functioning	☐	☐	☐
10	Performing emergency repairs promptly and efficiently if any	☐	☐	☐
11	Keeping daily logs and records of all operation functions	☐	☐	☐
12	Ensuring compliance with appliance standards and with occupational health and safety	☐	☐	☐
13	Complying with service standards, work instructions and user requirements	☐	☐	☐
14	Set points accurate (unchanged)	☐	☐	☐
15	Voltages / Pressures / Flow in specification as per manufacturer	☐	☐	☐

No.	Reviewer's Comments	Resolution

Originator's Name/Signature and Date:	Checker's Name/Signature and Date:

Attachment 4: EOM-ZO0-TP-000092 Instrumentation System Emergency Response Action Plan Checklist

Building NAME:	Reference No.	REV:

Instrumentation and Controller System – Office Facilities

This Emergency Response Action (ERA) is a guide intended for areas of a facility with complex services, for example, a major boiler house or specialist plant room. The actions to be taken by designated and authorized persons may be expressed in a checklist.

The steps below are simple indication of some issues that may arise although a more detailed list may be appropriate for each specific area. The designated staff functions of office personnel, needs to be made clear in order that the correct measures are taken to minimize the impact of any crisis.

No.	Emergency Response Action Checklist	CHECKED SATISFACTORY		
		N/A	YES	NO
1	Define ownership of the problem	☐	☐	☐
2	Will patient/public/staff safety/care be affected	☐	☐	☐
3	Will evacuation be required	☐	☐	☐
4	Risk of fire outbreak or reduced re-fighting ability	☐	☐	☐
5	Consider impact on electricity supply and power surges on controls	☐	☐	☐
6	Consider impact on gas supply and electrical controls	☐	☐	☐
7	Consider impact on water supply and electrical controls	☐	☐	☐
8	Consider impact on drainage electrical controls	☐	☐	☐
9	Consider impact on any third party system and BMS controls	☐	☐	☐
10	Consider impact on site security	☐	☐	☐
11	Consider impact on data loss and data security	☐	☐	☐
12	Impact on re-alarms	☐	☐	☐
13	Will critical system be affected and time period of outage	☐	☐	☐
14	Is there an impact on clinical waste	☐	☐	☐
15	Agree responsibility boundaries	☐	☐	☐
16	Clinical department procedures	☐	☐	☐
17	Control of infection team involvement if BMS data not available	☐	☐	☐
18	Do public relations need to be addressed	☐	☐	☐
19	Consider service level agreements with suppliers	☐	☐	☐
20	Involve commercial services	☐	☐	☐
21	Record Entities personnel contact details	☐	☐	☐

No.	Reviewer's Comments	Resolution

Originator's Name/Signature and Date:	Checker's Name/Signature and Date: