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1.0 TELECOMMUNICATIONS

1.1 General

1.1.1 Introduction

1.1.1.1 The Telecommunication Design Guidelines provide:

- The basis to be followed by A/E making calculations and/or preparing drawings and specifications of telecommunications networks within the Entity premises including the engineering design phase of Contracts where Engineering, Procurement and Construction are combined.
- The framework within which work will be performed by A/E to ensure uniformity throughout the infrastructure of the Project and compatibility within the Entity Boundary.

1.1.1.2 This Subsection does not provide design information normally found in available textbooks, handbooks, codes and standards, nor does it attempt to duplicate design criteria within the expertise of the A/E. Decisions are to be developed for specific applications as design progresses.

1.1.1.3 The purpose of this chapter is to indicate the minimum level of quality required by the Entity in order to:

- Define the role of the Authorized Representatives (Client appointed person) and the responsibilities of the A/E, and
- Provide a reference basis for selection of Saudi Arabian and International Codes and standards, and for the Guideline Specifications and Guideline Details issued by the Entity.

1.1.1.4 Where works interface with Telecommunication Service Provider (Example - STC, Mobily, ZAIN, etc.), the equipment/materials and installation shall comply with Telecommunication Service Provider's standard latest revision and shall be reviewed and approved by the Telecommunication Service Provider.

1.1.2 Definitions

1.1.2.1 The following definitions apply to this Subsection:

Definitions	Description
Address	An identifying name, label, or number for a data terminal, source, or storage location calculation.
Alarm Notification Appliance	A fire alarm system component such as a bell, horn, speaker, light, or text display that provides audible, tactile, or visible outputs, or any combination thereof.
Ampacity	The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.
Analog Data	Data represented by scalar values.
Annunciator	A unit containing one or more indicator lamps, alphanumeric displays, or other equivalent means in which each indication provides status information about a circuit, condition, or location.
Application Account	Refers to the account name used to run applications as either a service or a background process.
Application Software	The software written specifically to perform functional requirements for an individual plant when standard software packages cannot be configured to meet the requirements. Application software works with the standard operating software and access the SCADA real-time and historical database data.
Assigned Line	Cable pair which is connected to the Main Distribution Frame (MDF), and currently being used as a subscriber's line.

Definitions	Description
Attenuation	A measure of the decrease in energy transmission “or loss of light” expressed in decibel (dB). In optical fibers, attenuation is primarily due to absorption and scattering losses.
Audible Alarm Notification Appliance	A notification appliance that alerts by the sense of hearing.
Audio Amplifier or Pre-amplifier	Electronic equipment that increases the current or voltage, or both, potential of an audio signal intended for use by another piece of audio equipment.
Availability	The percent of time a system or component remains on line and performs as specified.
Backup Power System	A system of circuits and equipment arranged for automatic, delayed, or manual connection to the alternate power source and that serves all of the loads identified as essential for the facility.
BACnet	A communications protocol for building automation and control networks. It is an ASHRAE, ANSI, and ISO standard protocol. BACnet allows communication of building automation and control systems for applications such as heating, ventilating and air-conditioning control, lighting control, access control, and fire detection systems and their associated equipment. BACnet is addressed in ASHRAE/ANSI Standard 135 - 2012, and became ISO 16484-5 in 2003 - is a communications protocol for building automation and control networks and provides mechanisms for computerized building automation devices to exchange information, regardless of the particular building service they perform.
Bandwidth	In electrical transmission systems, the range between the highest and lowest frequencies of a transmission channel.
Bidirectional	Providing for information transfer in both directions between master and remote terminals (of a communication channel).
Binary Digit	A character used to represent one of the two digits in the binary number system and the basic unit of information in a two-state device. The two states of a binary digit are usually represented by “0” and “1”. Synonym: bit.
Bonded (Bonding)	Connected to establish electrical continuity and conductivity.
Bonding Jumper	A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.
Bonding Jumper, Equipment	The connection between two or more portions of the equipment grounding conductor at the service
Buffer	A device in which data are stored temporarily in the course of transmission from one point to another; used to compensate for a difference in the flow of data, or time of occurrence of events, when transmitting data from one device to another.
Cabinet	A large, above ground connection point.
Cable, Coaxial	A cable constructed with a wire conductor surrounded by a concentric outer conductor spaced by a dielectric.
Cable, Distribution	A cable usually connecting the cross connection point to the subscriber point.
Cable, Feeder	A cable connecting the exchange to a cross-connection point or directly to a subscriber.
Cable, Lateral Distribution	A cable branching from a main distribution cable to access subscribers on side streets.
Cable, Main Distribution	An arterial cable, originating at a cross-connect cabinet, and extending the cabinet pairs to the lateral distribution cables.
Cable, VF Telephone	A number of insulated conductors arranged in pairs, each pair capable of voice frequency transmission.
Cable Count (Reading)	A method of designating and identifying the individual pairs in a multi-pair cable.
Call Up Time	The time between when the operator initially enters a display request and when all objects, lines, values (good or invalid), trends and other parts of the display have been fully presented to the operator.

Definitions	Description
Carrying Plant	That portion of telephone Outside Plant (ducts, jointing chambers, etc.) that is used to carry and route telephone cable and terminals.
Central Office (C.O.)	See Exchange.
Central Office Homerun	Type of Centralized FTTH architecture where splitters are located inside the central office & no splitting beyond.
Centralized Topology FTTH	Type of FTTH architecture where fiber optic cable from OLT is split only once before reaching customers. There are two types of Centralized FTTH topology namely: Central Office Homerun and Local Convergence Point.
Centrex Services	Subscriber group services utilizing the central office PBX facility, rather than a customer owned EPABX.
Circuit Breaker	A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.
Coating	A layer of composite plastic material covering the fiber to provide mechanical protection.
Color Rendering Index	Quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.
Community Antenna Television System (CATV)	A cable system distributing television and radio programs from a central reception/control point to individual subscribers, normally on a coaxial cable.
Command	Commands are sent by operators or by applications. Commands can be binary or analog (set-point). Commands require reliable, secure, and timely delivery. Command data shall be delivered to its target as quickly as possible, typically in the order of seconds or sub-seconds. If a command cannot be delivered or acted upon, the SCADA system shall report this to the operator.
Communication Channel	A facility that permits signaling between two terminals i.e. a path between master station and an RTU, PLC or a subsystem.
Communication Equipment Room (CER)	Buildings drop point to house indoor FDT cabinets, FAT and ONT's.
Communications Subsystem	The hardware and software that performs the transmitting and receiving of digital information. “Computerized Data Acquisition and Control System (CDACS)” refers to an industrial computer based control system that monitors and controls a process. Synonymous to PCS.
Concealed	Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them.
Conduit	Tube used to protect and route electrical wiring.
Configurable	The capability to select and connect standard hardware modules to create a system, or the capability to change functionality or sizing of software functions by changing parameters without having to modify or regenerate software.
Console	A collection of one or more workstations and associated equipment such as printers and communications devices used by an individual to interact with the SCADA and perform other functions.
Continuous Load	A load where the maximum current is expected to continue for 3 hours or more.
Cross-Connection Point (CCP) or Flexibility Point	In the local cable network, equipment which enables an incoming pair in a cabinet to be connected to any of the outgoing pairs in a separate cable, by use of jumper wires or their equivalent.
Cross-Connection or Distribution Area	The geographical area served from a cross-connection cabinet.
Crosstalk	The unwanted transfer of energy from one circuit to another.
Cycle	The scanning of inputs, execution of algorithms and transmission of output values to devices.
Cyclic Polling (Data Request)	The process by which a data acquisition system selectively requests data from one or more of its RTUs. An RTU may be requested to respond with all, or a selected portion of, the data available.

Definitions	Description
Dead Band	The range through which an input signal may be varied without initiating an action or observable change in output signal.
Dead Pair	Within a cable, an extension of a pair that has been used, or a pair that is not terminated at either end.
Demand or Diversity Factor	The ratio of the maximum demand of a system, or part of a system, to the total connected load of a system for the part of the system under consideration.
Device	A unit of an electrical system that carries or controls electric energy as its principal function.
Direct Exchange Line (DEL)	A telephone pair connected between a local switch and subscriber, by whatever means.
Direct Service Area	The area in which subscriber pairs are connected directly to the exchange without passing through a cross-connection point.
Directional Coupler	A splitter in which the attenuation between any two output ports exceeds the sum of the attenuations between the input port and each of those output ports.
Disconnecting Means or Isolator	A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.
Distributed/Cascaded	Type of FTTH architecture where fiber from OLT is split twice (outside the Exchange/ or one in the Exchange & one outside the Exchange) before reaching customers location. Splitting may be located in Exchange, FDT, manholes, handholes or in FAT.
Distribution	In conventional method of FTTH deployment this is equivalent to the secondary cables in copper network. These are the fiber cables that connect FDT or Cross Connect Cabinet to the last distribution point (an FAT or a splice in a handhole) before Drops. In short, it is the cable in between the Feeder and the Drops.
Distribution Amplifier	An amplifier designed to feed one or more branch or spur feeders. Note: This is a general term embracing branch amplifier and line extender amplifier.
Distribution Points (DP)	The last point in the exchange area cable network from which pairs are extended to individual subscribers.
Drops	The fiber from the last distribution point up to customer's location.
Duct	A pipe provided to facilitate the installation of cables and provides protection for the cables.
Duct Bank	A multiple array of ducts.
Electromagnetic Interference (EMI)	The interference in signal transmission or reception resulting from the radiation of undesirable frequency interfering electrical or magnetic and electrical fields.
Emergency Systems	Electrical systems legally required to be installed and that supply loads essential to safety and life.
Emergency Voice/Alarm Communications	Dedicated manual or automatic facilities for originating and distributing voice instructions, as well as alert and evacuation signals pertaining to a fire emergency, to the occupants of a building.
Enclosed	Surrounded by a case, housing, fence, or wall(s) that prevents persons from accidentally contacting energized parts.
Enclosure	The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage.
Enterprise Resource Planning (ERP)	Is software that allows the integration of operations and resources and manages them through one program. This approach to management is called Integration. Most large companies in the world use ERP to manage various aspects of their businesses. These are product planning, parts planning, parts procurement and inventory management, interacting with suppliers, providing customer service, and tracking orders. It can also include applications to manage finance and human resources.
Equipment	A general term, including material, fittings, devices, appliances, luminaires, apparatus, machinery, and the like used as a part of, or in connection with, an electrical installation.

Definitions	Description
Equipment Side	That side of the MDF that is connected to equipment, often called Horizontal side.
Equipment System	A system of circuits and equipment arranged for delayed, automatic, or manual connection to the alternate power source and that serves primarily 3-phase power equipment.
Erlang	A dimensionless unit that is used in telephony as a measure of offered load or carried load on service-providing elements such as telephone circuits or telephone switching equipment.
Exchange (Central Office)	A system of switches enabling individual telecommunication circuits to be automatically connected.
Exchange Area	An area served by the local exchange.
Faceplate	A graphic element that mimics the front panel of an analog controller instrument, hardwired push-button or switch.
Failsafe	A concept in process control that in the event of a specific type of failure, the failsafe device will automatically response in a way to safe position, cause no harm, or at least a minimum of harm, to other device, environment or to personnel
Foundation Fieldbus H1 (FF)	Fieldbus is a fully digital, serial, two-way, multidrop, communication system running at 31.25 Kbits/s which will be used to connect intelligent field equipment such as sensors, actuators and controllers. It serves as a Local Area Network (LAN) for the instrumentation used within process plants and facilities with built-in capability to monitor and distribute control applications across the network.
Fail-Over	Occurs automatically without user intervention, transparent to the user.
Feeder (Telecommunications)	Equivalent to the primary cables in the copper network. The fiber cables that connect the exchange to the FDT or a splice point in manhole that serve as a cross connect to Distribution network.
Fiber Access Terminal (FAT)	A distribution point in the distribution end that distributes the drop fibers to each customer. It can also house splitters to distribute drops to homes and office
Fiber Distribution Frame (FDF)	Exchange termination equipment where fibers from OLT are split and jointed to Feeder cable when there is mass FTTH deployment.
Fiber Distribution Terminal (FDT)	A hub where all the fiber from the telecom provider's central office is split and distributed to the end users.
Fiber Termination Box (FTB)	Customer Lead-In Unit, installed at the customer outer wall for termination of incoming & indoor fibers.
Fiber to the Home (FTTH)	Access technology architecture that brings fiber optic cable from the exchange direct to customer's location at high bandwidth delivering triple play (voice, video and data) from a single fiber.
Fire Alarm	The giving, signaling or transmission to any public fire station, or company or to any officer or employee thereof, whether by telephone, spoken word or otherwise, of information to the effect that there is a fire at or near the place indicated by the person giving, signaling, or transmitting such information.
Fire Alarm Control Unit	A system component that receives inputs from automatic and manual fire alarm devices and is capable of supplying power to detection devices and transponder(s) of off-premises transmitter(s). The control unit is capable of providing a transfer of power to the notification appliances and transfer of condition to relays of devices.
Fire Alarm Signal	A signal initiated by a fire alarm-initiating device such as a manual fire alarm box, automatic fire detector, water-flow switch, or other device whose activation is indicative of the presence of a fire or fire signature.
Fire Alarm System	A system or portion of a combination system consisting of components and circuits arranged to monitor and annunciate the status of fire alarm or supervisory signal-initiating devices and to initiate the appropriate response to those signals.
Fire Command Center	The principal attended or unattended location where the status of the detection, alarm communications and control systems is displayed, and from which system(s) can be manually controlled.

Definitions	Description
Fire Detector, Automatic	A device designed to detect the presence of a fire signature and to initiate action.
Fire Protection System	Approved devices, equipment and systems or combinations of systems used to detect a fire, activate and alarm, extinguish or control a fire, control or manage smoke and products of a fire or any combination thereof.
Fire Safety Functions	Building and fire control functions that are intended to increase the level of life safety for occupants or to control the spread of the harmful effects of fire.
Flag	A character that signals the occurrence of some event. Usually, a field of 1 bit.
Footway	An area not normally accessible to vehicular traffic
Foreign Exchange Line	A telephone connection from one local exchange which serves a telephone station in the serving area of another local exchange (out of area working).
Gigabit Passive Optical Network (GPON)	ITU G.984 Recommendation that describes a flexible optical fiber access network cable of supporting bandwidth requirements of subscriber and covers system with nominal line rates of 1.2 Gbps and 2.4 Gbps in downstream direction; and 155 Mbps up to 2.4 Gbps in the upstream direction.
HART Communication Protocol	Highway Addressable Remote transducer is an early implementation of Fieldbus, a digital industrial automation protocol. Its most notable advantage is that the digital HART signal was embedded in 4-20 mA analog instrumentation loop. The HART Protocol is one of the most popular industrial protocols today, most of the smart instrument will support the HART communication.
Handhole	A small jointing chamber of the joint box category but restricted to footway use only.
Heat Detector	A fire detector that senses heat produced by burning substances.
Initiating Device	A system component that originates transmission of a change-of-state condition, such as in a smoke detector, manual fire alarm box, or supervisory switch.
Initiating Device Circuit (IDC)	A circuit to which automatic or manual initiating devices are connected where the signal received does not identify the individual device operated.
Insertion Loss	The attenuation at a fixed frequency of a test tone inserted at one end of a circuit measured at the far end of the same circuit in a resistive termination, and recorded in dB at 20 °C.
Intelligent Electronic Devices (IED)	An intelligent electronic device that perform specific control and/or data gathering function.
Intercom System	A communication system linking different rooms within a building or other facilities.
Interrupting Rating	The highest current at rated voltage that a device is intended to interrupt under standard test conditions.
Installed Pair	Cable pair that has been placed and jointed.
Isolator	Refer to “Disconnecting Means”.
Jack	A receptacle used with a plug to make an electrical connection between communication circuits. Jacks are considered the female component of a jack/plug connector.
Joint (Splice)	The connection of two or more lengths of wire or cable at a single point.
Joint Box	A jointing chamber the top of which consists of fully removable covers.
Jointing Chamber	A general term for underground structures in which cables are placed and jointed.
Labeled	Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the Royal Commission and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
Line Extender Amplifier	An amplifier to compensate for the attenuation in a spur feeder.

Definitions	Description
Line Side	That side of the MDF that connects to outside plant cable and that includes protectors. Often called Vertical side.
Life Safety Branch	A subsystem of the emergency system consisting of feeders and branch circuits intended to provide adequate power needs to ensure safety to building occupants and that are automatically connected to alternate power sources during interruption of the normal power source.
Listed	Equipment or materials included on a list published by an approved testing laboratory, inspection agency or other organization concerned with current product evaluation that maintains periodic inspection of production of listed equipment or materials, and whose listing states that equipment or materials comply with approved nationally recognized standards and have been tested or evaluated and found suitable for use in a specified manner.
Local Convergence Point (LCP)	Type of Centralized FTTH architecture where splitters are concentrated in an FDT or a manhole outside the exchange.
Local Area Network (LAN)	A LAN is a network used for bit serial communication of information between interconnected, independent devices and is completely under user jurisdiction and limited to being within a user's premises.
Logs	Files or printouts of information in chronological order.
Local Exchange	An exchange which serves subscribers in a defined and limited geographical area.
Local Exchange Code	A letter designation used to indicate the exchange. This alpha designation will be used as part of the designation of each jointing chamber, Interface Cabinet or Cross Connect Cabinet, and each cable.
Loudspeaker	Equipment that converts an AC electric signal into an acoustic signal.
Main Distribution Frame (MDF)	Location where copper OSP cables are terminated inside the exchange for access to Network switch.
Management Information System (MIS)	Provides information which is needed to manage organizations efficiently and effectively. Management Information Systems involve three primary resources: people, technology, and information or decision making. Management information systems are distinct from other information systems in that they are used to analyze operational activities in the organization.
Manhole	A jointing chamber, accessed via a restricted opening in the top.
Manual Fire Alarm Box	A manually operated device used to initiate an alarm signal.
Main Incomer	Refer to "Service".
Maintenance Pair	A cable pair terminated on both ends, one end of which assigns the pair a count and the other end terminated at a subscriber's premises, but not connected to subscriber apparatus.
Master Station	Server or servers and software responsible for communicating with the field equipment (RTUs, PLCs, etc.), and then to the HMI software running on workstations in the control room, or elsewhere. Master station may include multiple servers, distributed software applications, and disaster recovery sites. The Master Station includes all networks switch and connectivity devices required to communicate with RTUs and remote sites.
Multimode Fiber (MMF)	A fiber that allows more than one optical mode to propagate. Used for shorter distances; usually a larger diameter fiber of plastic or other low-cost material.
Multiple-Station Alarm Device	Two or more single-station alarm devices that can be interconnected such that activation of one causes all integral or separate audible alarms to operate. It also can consist of one single-station alarm device having connections to other detectors or a manual fire alarm box.
Multiple-Station Smoke Alarm	Two or more single-station alarm devices that are capable of interconnection such that activation of one causes all integral or separate audible alarms to operate.
Neutral Conductor	The conductor connected to the neutral point of a system that is intended to carry current under normal conditions.
Nonlinear Load	A load where the wave shape of the steady-state current does not follow the wave shape of the applied voltage.

Definitions	Description
Notification Appliance Circuit (NAC)	A circuit or path directly connected to a notification appliance.
Nuisance Alarm	An alarm caused by mechanical failure, malfunction, improper installation, or lack of proper maintenance, or an alarm activated by a cause that cannot be determined.
Operating System	Software that runs on computers and manages the computer hardware and provides common services for execution of application software.
Operating Wavelength	The light wavelength at which a system is specified, normally expressed in nanometers (nm). Most single mode fibers can operate at 1300 or 1550 nm.
Optical Distribution Frame (ODF)	Location where fibers from OLT ports are terminated then interfaced to Feeder cable of FTTH.
Optical Line Terminal (OLT)	Located inside the exchange and serve as the termination point of OSP Feeder fiber cables. This is an FTTH access platform designed for ITU-T GPON standard to easily deliver RF video and TDM voice services while providing a smooth migration path to IP Triple Play services.
Optical Link Loss Budget	Total losses allowed for satisfactory operation of an optical fiber system.
Optical Network Terminal (ONT)	A media converter that is usually installed outside/inside the home or buildings designed for delivering multi line POTS, Data and Video.
Optical Network Unit (ONU)	A unit located outside customer's area to serve more customers.
Outside Plant	That portion of telephone plant (including carrying plant) between the telephone exchange building and the subscriber's premises.
Overcurrent	Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.
Paging	Calling out the names of persons (especially by a loudspeaker system).
Panel board	Refer to “Main Distribution Board”, “Sub Main Distribution Board” and “Distribution Board”.
Passive Optical Network (PON)	An architecture using optical transmission system designed to carry signals via fiber optic cable from the central office directly to end users such as businesses and multi dwelling units. Passive means that there is no active or powered element in between the exchange and the customer's location.
Passive Optical Splitter (POS)	Split the signal bi-directionally from a single fiber to multi fiber without any power application.
Pay Telephone	A coin/card operated telephone for use by the general public.
Plug	The male component of a connection providing a method to connect communication equipment to the communication outlets.
Protocol	A strict procedure required to initiate and maintain communication with the RTU or a PLC. Open Industry Standard communication protocol is defined as a protocol that has a published specification and available for all suppliers to read and implement and will not lock the customer into a particular vendor or group. The Protocol may be extended, or offered in subset form and supported by publication of reference information.
Public Address System	An electronic amplification system used as a communication system in public areas.
Redundant Configuration	A system and/or subsystem that provides for a standby module with automatic switchover from the primary unit to the standby module, in the event of a failure, without loss of a system function. Both active and standby modules utilize diagnostics to assist in identifying and locating failures and to permit modules to be removed for repair and/or replacement.
Registered Jack (RJ)	Registered jack wiring configurations developed by Bell System for the connection of customer premises equipment to the public network. Registered jacks serve telephone and data applications. The most common types are RJ45 and RJ11.
Report-by-Exception	The reporting of data (e.g., from RTU to master station) only when the data either changes state (e.g., for a status or digital input point) or exceeds a predefined dead-band (e.g., for an analog input point).
Right-of-Way (ROW)	A bounded strip of land reserved exclusively for one utility.

Definitions	Description
Round Trip Delay (Latency)	The time required for a packet of data to travel from a specific source to a specific destination and back again. Latency is measured by sending a packet that is returned to the sender and the round-trip time is considered the latency.
Scan	The process by which a data acquisition system interrogates remote terminals or points for data.
Security Code	A group of data bits calculated by a transmitting terminal from the information within its message by use of a prearranged algorithm, appended to the transmitted message, and tested by the receiving terminal to determine the validity of the received message.
Self-Diagnostic	The capability of an electronic device to monitor its own status and indicate faults that occur within the device.
Signaling Line Circuit (SLC)	A circuit path between any combination of addressable appliances or devices, circuit interfaces, control units, or transmitters over which multiple system input signals or output signals or both are carried.
Single Mode Fiber (SMF)	A fiber that supports the propagation of only one mode. Used for maximum distances; usually a small, precise diameter (8 to 9 microns) fiber of monolithic quartz.
Single-Station Smoke Alarm	An Assembly incorporating the detector, the control equipment, and the alarm-sounding device in one unit, operated from a power supply either in the unit or obtained at the point of installation.
Smoke Alarm	A single or multiple-station alarm responsive to smoke and not connected to a system.
Smoke Detector	A listed device that senses visible or invisible particles of combustion.
Spare Pair	A cable pair which has been terminated at one end, but is not in service.
Splice	See Joint.
Splice Loss	The amount of loss of light energy caused by angular misalignment, fiber end separation or lateral displacement of fiber axis.
Splitter	A device in which the signal power at the input port is divided equally or unequally between two or more output ports.
Spur Feeder	A feeder to which splitters, subscriber taps or looped system outlet are connected.
Standby Systems	Include alternate power systems for such applications where interruption of normal power would cause discomfort to personnel or damage to product.
Station Equipment	The portion of telephone equipment installed at the subscriber's premises.
Subscribers' Apparatus	A terminal equipment which may be connected to the public telephone network, such as telephone instruments and sets, data terminals, telex machines, and PBX.
Subscriber's Lead-in	That part of the outside plant that includes the subscriber's line between the distribution point and subscriber's premises.
Subscriber's Lines	The circuits connecting the subscriber's apparatus to the local exchange.
Subscriber's Service Line	That part of the subscriber's lead-in between the distribution point and the telephone set.
Subscriber Termination	That portion of telephone plant that includes the interface between outside plant and station equipment, normally including the station protector.
Supervisory Control	A telemetry based process control command initiated from a Master Central Station either manually by operator or automatically by an application to initiate an action and/or change analog set point in a remotely located Control Stations over a bidirectional communications link using specific communication protocol. Such command is dependent of having quality process related alarm/event data and follows timely bidirectional confirmation and acknowledgment executing sequences between the master and the station known as select/check before Operate (CBO).
Supervisory Control and Data Acquisition (SCADA)	Refers to an industrial computer telemetry based control system that monitors and controls remotely connected processes.

Definitions	Description
Supervising Station	A facility that receives signals and at which personnel are in attendance at all times to respond to these signals.
Supervisory Service	The service required to monitor performance of guard tours and the operative condition of fixed suppression systems or other systems for the protection of life and property.
Supervisory Signal	A signal indicating the need of action in connection with the supervision of guard tours, the fire suppression systems or equipment, or the maintenance features of related systems.
Supervisory Signal-Initiating Device	An initiating device such as a valve supervisory switch, water level indicator, or low-air pressure switch on a dry-pipe sprinkler system whose change of state signals an off-normal condition and its restoration to normal of a fire protection or life safety system; or a need for action in connection with guard tours, fire suppression systems or equipment, or maintenance feature of related systems.
Switchboard	A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets.
System Account	Refers to account names used by the operating system.
Tag	A collection of attributes that specify either a control loop or a process variable, or a measured input, or a calculated value, or some combination of these, and all associated control and output algorithms. Each tag is unique.
Tag ID	The unique alphanumeric code assigned to inputs, outputs, equipment items, and control blocks. The tag ID might include the plant area identifier.
Telephone Density (Line Density or Penetration)	The number of telephones (or lines) relative to a characteristic element such as number of inhabitants (telephones per 100 population), number of house-holds, business premises, area units, income groups, etc., used generally for planning purposes.
Telephone Subscriber	An individual or corporation (including government agencies, municipal authorities) with a current subscription of one line or more.
Telephone Instrument	Any apparatus equipped with a microphone and earphone (sender and receiver) which is or may be connected to a telephone system and which may be used for voice telephone conversation.
Telephone Station	A telephone instrument installed and connected to a public telephone system.
Terminal Block	A passive electrical device used to terminate and cross-connect outside plant and central office equipment.
Termination	The point at which pairs in a cable are terminated.
Toll Cable	The cable that carries toll circuits.
Toll Circuits	Circuits between one toll center and another.
Transaction	A sequence of messages between cooperating terminals to perform a specific function. Usually, a minimum of one message in each direction that is comprised of a command followed by a response.
Trouble Signal	A signal initiated by the fire alarm system or device indicative of a fault in a monitored circuit or component.
Trunk Amplifier	An amplifier to compensate for the attenuation in a trunk feeder.
Trunk Cable (Junction Cable)	A cable connecting two local telephone exchanges.
Trunk Circuit (Junction Circuit)	A circuit between two local telephone exchanges.
Trunk Feeder	A feeder used for the transmission of signals between a head-end station and a distribution point or between distribution points.
Twisted Pair Cable (TP)	A type of communication transmission cable in which two individually insulated wires are twisted together to reduce Electromagnetic Interference from External Fields. The pair may be surrounded by a shield, insulating jacket, to form Shielded Twisted Pair (STP) cable, otherwise it is Unshielded Twisted Pair (UTP).

Definitions	Description
Unit Cable	A unit shall consist of 25 cable pairs, specifically color coded. Cables larger than 25 pairs shall be assembled as groups of units where each unit is separated from all other units by a colored unit binder as defined in the Guideline Specifications.
Visible Alarm Notification Appliance	Notification appliance that alerts by sense of sight.
Voltage (of a Circuit)	The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned.
Voltage, Nominal	A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as per the local SEC standard). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.
Wave Division Multiplexing (WDM)	Multiplexing of signals by transmitting them at different wavelengths through the same fiber.
Wireless Protection System	A system or a part of a system that can transmit and receive signals without the aid of wire.
Zone	A defined area within the protected premises. A zone can define an area from which a signal can be received, an area to which a signal can be sent, or an area in which a form of control can be executed.

1.1.3 Abbreviations

1.1.3.1 The following abbreviations apply to this Subsection:

Abbreviations	Description
A	Amperes
AAC	Advanced Application Controllers
AC	Alternating Current
ACI	Adjacent Channel Interference
ACP	Access Control Point
A/E	Architect/Engineer
AES	Advanced Encryption Standard
AFF	Above Finished Floor
AFFL	Above Finished Floor Level
AIM	Automated Infrastructure Management
ALMS	Alarm Management System
ANN	Artificial Neural Networks
ANPR	Automatic Number Plate Recognition
ANSI	American National Standards Institute
AOS	Application Object Servers
APC	Angled Physical Contact Optical Fiber Connection
APON	ATM Passive Optical Network
ARP	Address Resolution Protocol
ASI	Asynchronous Serial Interface
ATS	Automatic Transfer Switch
BACnet	Building Automation & Control Networks
BAS	Building Automation System
BICSI	Building Industries Consulting Service International
BIL	Basic Impulse Insulation Level
BMS	Building Management System
BYOD	Bring Your Own Device
CAD	Computer-Aided Design
CATV	Community Antenna Television System
CBO	Check Before Operate
CCD	Charge Coupled Device
CCP	Cross-Connection Point
CCSO	Co-located Cabinet for Shared Operators

Abbreviations	Description
CCTV	Closed Circuit Television
CER	Communication Equipment Room
CMS	Condition Monitoring System
CoPP	Control Plane Protection
DAHS	Data Acquisition and Historization System
DAI	Dynamic ARP Inspection
Db	Decibel
dBmV	Decibel-millivolts
DC	Direct Current
DCS	Distributed Control System
DDC	Direct Digital Control
DFS	Dynamic Frequency Selection
DHCP	Dynamic Host Configuration Protocol
DID	Direct Inward Dial
DMS	Dynamic Message Signs
DNS	Domain Name System
DOD	Direct Outward Dial
DSCP	Differentiated Services Code Point
DTMF	Dual-tone Multi-Frequency Signaling
DVB-S	Digital Video Broadcasting - Satellite
EDA	Equipment Distribution Area
EIRP	Equivalent Isotropically Radiated Power
EPABX	Electronic Private Automatic Branch Exchange
ETSI	European Telecommunications Standards Institute
FAT	Fiber Access Terminal
FDF	Fiber Distribution Frame
FDT	Fiber Distribution Terminal
FF	Foundation Fieldbus System
FGS	Fire and Gas Detection System
FIFO	First in First out
FIU	Field Interface Unit
FO	Fiber Optic
FTB	Fiber Termination Box
FTP	File Transfer Protocol
FTTH	Fiber to The Home
GB	Gigabyte
Gbps	Gigabits Per Second
GHz	Gigahertz
GPCS	Guiding Procurement Construction Specifications
GPON	Gigabit Passive Optical Network
GPRS	General Practice Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile
HART	Highway Addressable Remote Transducer
HDMI	High-Definition Multimedia Interface
HDPE	High Density Polyethylene
HDTV	High Definition Television
HFC	Hybrid Fiber Coaxial
HH	Handhole
HMI	Human Machine Interface
HTTP	Hypertext Transfer Protocol
HTTPS	HTTP Secure
HVAC	Heating Ventilation and Air Conditioning
Hz	Hertz
IAMS	Instrument Asset Monitoring System
ICEA	Insulated Cable Engineers Association
ICT	Information and communications technology
IDC	Initiating Device Circuit

Abbreviations	Description
IDF	Intermediate Distribution Frame
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
IGMP	Internet Group Management Protocol
IMS	Information Management System
IP	Internet Protocol
IPxx	International Protection Marking, IP Code
IPTV	Internet Protocol Television
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
ISO	The International Organization for Standardization
ITS	Intelligent Transportation System
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
Kbps	Kilobit Per Second
KHz	Kilo-hertz
KVM	Keyboard/Video/Mouse
KW	Kilo-watts
LAN	Local Area Network
LCD	Liquid Crystal Diode
LCP	Local Convergence Point
LDAP	Lightweight Directory Access Protocol
LED	Light Emitting Diode
LNB	Low-Noise Block Downconverter
MAC	Media Access Control (Common use is MAC Address)
MAN	Metropolitan Area Network
Mbps	Megabits Per Second
MCIT	Ministry of Communication and Information Technology
MDA	Main Distribution Area
MDB	Main Distribution Board
MDF	Main Distribution Frame
MDNS	Multicast Domain Name System
MH	Manhole
MHz	Megahertz
MIMO	Multiple Input/Multiple Output
MIS	Management Information System
MLD	Multicast Listener Discovery
MMF	Multimode Fiber
MPEG	Moving Picture Experts Group
MPLS	Multiprotocol Label Switching
MPLS-TP	Multiprotocol Label Switching Transport Profile
MPTS	Multiple Program Transport Stream
MRO	Multicast Rate Optimization
MTU	Master Terminal Unit
MU-MIMO	Multiple User Multiple Input/Multiple Output
NAG	Needed Acoustical Gain
NAT	Network Address Translation
NFPA	National Fire Protection Association
NVR	Network Video Recorder
OCR	Optical Character Recognition
ODF	Optical Distribution Frame
ODN	Optical Distribution Network
OEM	Original Equipment Manufacturer
OLT	Optical Line Termination
ONT	Optical Network Terminal
OS	Optional Standby
OSP	Outside Plant (Cabling)

Abbreviations	Description
OTDR	Optical Time Domain Reflectometer
PAN	Plant Automatic Network
PAS	Process Automation System
PBX	Private Branch Exchange
PC	Personal Computer
PCS	Process Control System
PD	Powered Device (PoE)
PDU	Power Distribution Unit
PEC	Polyethylene Corrugated
PF	Power Factor
PIP	Picture in Picture
PLC	Programmable Logic Controller
PoE	Power Over Ethernet
PoE+	PoE Plus
PON	Passive Optical Network
POTS	Plain Old Telephone System
PPE	Personal Protective Equipment
PSE	Power Sourcing Equipment (PoE)
PSK	Pre-Shared Key
PSTN	Public Switched Telephone Network
PTP(P2P)	Point to Point
PVC	Polyvinyl Chloride
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RAID	Redundant Array of Independent Disks
R2-MFC	R2 Multifrequency Compelled Signaling System
RF	Radio Frequency
RMU	Ring Main Unit
RJ	Registered Jack
RNC	Rigid Non-metallic Conduit
ROADM	Reconfigurable Optical Add/Drop Multiplexer
RSSI	Received Signal Strength
RTD	Resistance Temperature Detector
RTP	Real-time Transport Protocol
RTSP	Real Time Streaming Protocol
RTU	Remote Terminal Unit
SASO	Saudi Arabian Standards Organization or Saudi Standards, Metrology and Quality Organization
SATV	Satellite Television
SBC	Saudi Building Code
SCADA	Supervisory Control and Data Acquisition
SIP	Session Initiation Protocol
SMF	Single-mode Fiber
SMTP	Simple Mail Transfer Protocol
SNMP	Simple Network Management Protocol
SNTP	Simple Network Time Protocol
SOA	Service Oriented Architecture
SPTS	Single Program Transport Stream
SQL	Structured Query Language (Database Product of Microsoft Corporation)
SSDP	Simple Service Discovery Protocol
STB	Set Top Box
STP	Shielded Twisted Pair
STC	Saudi Telecom Company
TCDD	Typical Construction Drawing Details
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing in Downstream
TIA	Telecommunications Industry Association
TKIP	Temporal Key Integrity Protocol

Abbreviations	Description
TMC	Traffic Management Center
TOS	Type of Service
TPC	Transmit Power Control
TSP	Telecommunications Service Provider
TV	Television
UDDI	Universal Description Discovery and Integration
UDP	User Datagram Protocol
UPS	Uninterruptible Power Supply
UPnP	Universal Plug and Play
USB	Universal Serial Bus
UTP	Unshielded Twisted Pair
UV	Ultraviolet
VESDA	Very Early Smoke Detection Apparatus
VCP	Vendor Control Panel
VGA	Video Graphics Array
VHF	Very High Frequency
VHT	Very High Throughput
VLAN	Virtual Local Area Network
VOD	Video on Demand
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network
WEP	Wired Equivalent Privacy
Wi-Fi	Wi-Fi Alliance Trademark for IEEE 802.11 WLAN Products
WIPS	Wireless Intrusion Prevention System
WLAN	Wireless Local Area Network
WMM	Wi-Fi Multimedia
WPA2	Wi-Fi Protected Access II
WUXGA	Widescreen Ultra Extended Graphics Array
XFP	10 Gigabit Small Form-Factor Pluggable
XML	Extensible Markup Language
ZDA	Zone Distribution Area

1.1.4 Codes

1.1.4.1 All equipment and material and its installation shall conform to the current requirements of the following authorities:

- Saudi Building Code 401 Electrical Requirements
- Saudi Building Code 601 Energy Conservation
- Occupations Safety and Health Act (OSHA)
- Saudi Building Code 501 Mechanical Requirements
- Saudi Building Code 201 Architectural Requirements
- Saudi Arabian Distribution Code
- Saudi Building Code Chapter 801 Fire Protection Requirements
- Civil Defense Department (CDD)
- Communications and Information Technology Commission (CITC)

1.1.5 Standards and References

1.1.5.1 All work shall conform to the applicable industry Codes, Standards and Associations.

1.1.5.2 The latest revision of the referred codes and standards shall be used wherever applicable. These standards are listed alphabetically and do not indicate the priority for application with regards to design of the telecommunications systems. In case of conflict, the A/E shall propose equipment conforming to one group of Codes and Standards.

- AISI American Iron and Steel Institute/Steel Product Manual
- ANSI American National Standards Institute
- ANSI/ISA American National Standards Institute / The Instrumentation Society of Automation
- API American Petroleum Institute
- ASHRAE American Society of Heating, Refrigerating and Air- Conditioning Engineers
- ASME American Society of Mechanical Engineers
- BSI British Standards Institution
- BICSI Building Industries Consulting Service International
- EIA Electronic Industries Alliance
- EPRI Electric Power Research Institute
- ETSI European Telecommunications Standards Institute
- FCI Fluid Control Institute
- ICEA Insulated Cable Engineers Association
- IEC International Electro-Technical Commission
- IEEE Institute of Electrical and Electronics Engineers
- IESNA Illuminating Engineering Society of North America
- INFOCOMM Infocomm International
- ISA The International Society of Automation
- ISO International Organization for Standardization
- MIL-STD Military Standard
- NACE National Association of Corrosion Engineers
- NECA National Exchange Carrier Association
- NFPA National Fire Protection Association
- ONVIF Open Network Video Interface Forum
- SASO Saudi Arabian Standards Organization
- SDMS Saudi Electricity Company Distribution Materials Specification
- SDPS Saudi Electrical Company Distribution Planning Standard
- SDS Saudi Electric Company Distribution Standard
- STES Saudi Electricity Company Transmission Engineering Standard
- SEI Software Engineering Institute
- TIA Telecommunications Industry Association
- UL Underwriters Laboratories, Inc.
- Wi-Fi Alliance Trademark for IEEE 802.11 WLAN Products

CITC Communications and Information Technology Commission (Approval of the Rules for ICT Infrastructure Provision and Deployment in New Developments can be found in the website www.citc.gov.sa, http://www.citc.gov.sa/en/Decisionsoffers/Decisions/Pages/392-1439.aspx).

1.1.5.3 Specific Standards which are referenced in this Subsection used for guidance.

- ANSI/BICSI 001 Information Transport Systems Design Standard for K-12 Educational Institutions
- ANSI/BICSI 002 Data Center Design and Implementation Best Practices
- ANSI/BICSI 003 Building Information Modeling (BIM) Practices for Information Technology Systems
- ANSI/BICSI 004 Information Technology Systems Design and Implementation Best Practices for Healthcare Institutions and Facilities
- ANSI/BICSI 005 Electronic Safety and Security (ESS) System Design and Implementation Best Practices
- ANSI/IES RP-7, American National Standard Practice for Industrial Lighting
- ANSI/INFOCOMM 1M Audio Coverage Uniformity in Enclosed Listener Areas
- ANSI/INFOCOMM 2M-2010, Standard Guide for Audiovisual Systems Design and Coordination Processes
- ANSI/INFOCOMM 3M Projected Image System Contrast Ratio
- ANSI/INFOCOMM 4:2012, Audiovisual Systems Energy Management
- ANSI/INFOCOMM 10:2013, Audiovisual Systems Performance Verification
- ANSI/NECA/BICSI 568-2006, Standard for Installing Commercial Building Telecommunications Cabling
- ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
- ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling
- ANSI/TIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components
- ANSI/TIA-568-C.3, Optical Fiber Cabling Components
- ANSI/TIA-568-C.4, Broadband Coaxial Cabling and Components
- ANSI/TIA-569-C, Telecommunications Pathways and Spaces
- ANSI/TIA-570-C, Residential Telecommunications Infrastructure Standard
- ANSI/TIA-606-B, Administration Standard Telecommunications Infrastructure
- ANSI/TIA-607-B, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
- ANSI/TIA-758-A, Customer-Owned Outside Plant Telecommunications Cabling Standard
- ANSI/TIA-862-A, Building Automation Cabling Standard
- ANSI/TIA-942-A, Telecommunications Infrastructure Standard for Data Centers
- ANSI/TIA-1005-A, Telecommunications Infrastructure Standard for Industrial Premises
- ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
- ANSI/TIA-1179, Healthcare Facility Telecommunications Infrastructure
- ANSI/TIA-1183, Measurement Methods and Test Fixtures for Balun- Less Measurements of Balanced Components and Systems
- BICSI Electronic Safety and Security Design Reference Manual, 3rd Edition
- BICSI Information Technology Systems Installation Methods Manual, 6th Edition

- BICSI Network Systems and Commissioning (NSC) reference, 1st Edition
- BICSI Outside Plant Design Reference Manual, 5th Edition
- BICSI Telecommunications Distribution Methods Manual, 13th Edition
- EIA/TIA-568A commercial building telecommunication wiring standard
- EIA/TIA-569 commercial building standard for telecommunications pathways and spaces
- EIA-RS-278-B: Loud Speaker
- EIA- RS- 310-C (ANSI C 83.9): Racks, Panels, Associated Equipment and Devices
- ETSI ETS 300 119-X Equipment Engineering
- IEC 60332 Tests On Electric and Optical Fiber Cables Under Fire Conditions
- IEC 60581-7 High Fidelity Audio Equipment and Systems: Minimum Performance Requirements. Part 7: Loudspeakers
- IEC 60754 Test On Gases Evolved During Combustion of Electric Cables
- IEC 60849 Sound Systems for Emergency Purposes
- IEC 60364-5-51 Selection & Erection of Electrical equipment's
- IEC 60079 Explosive Atmosphere Standards
- IEC 60529 Degree of Protection(Enclosure IP Code)
- IEC 62443 Cyber Security Fundamentals Specialist Certificate
- IEEE 802.1, Bridging & Management
- IEEE 802.2, Logical Link Control
- IEEE 802.3, Ethernet
- IEEE 802.11, Wireless LANs
- IEEE 802.15, Wireless PANs
- IEEE 802.16, Broadband Wireless MANs
- IEEE 802.17, Resilient Packet Rings
- IEEE 802.20, Mobile Broadband Wireless Access
- IEEE 802.21, Media Independent Handover Services
- IEEE 802.22, Wireless Regional Area Networks
- IES/INFOCOMM RP-38-1X, Videoconferencing Lighting
- INFOCOMM 5M-201X, Display Image Size for 2D Content
- INFOCOMM 8M-201X, Audio System Spectral Balance
- ISA99 Industrial Automation and Control System
- ISA/INFOCOMM 111.01, Unified Automation for Buildings - Part 1: Terminology and Concepts
- ISO 16484-5:2003 Building Automation and Control System
- ISO/IEC 11801 Edition 2.2, Customer Premises
- ISO 11064 Ergonomic Design of Control Centre's
- ISO/IEC 15018 Edition 1.0, Generic Cabling for Homes
- ISO/IEC 14763-2 Edition 1.0, Planning and Installation
- ISO/IEC 14763-3 Edition 1.1, Testing of Optical Fiber Cabling
- ISO/IEC 18598 Draft, Automated Infrastructure Management (AIM) Systems
- ISO/IEC 24702 Edition 1.0, Industrial Premises

- ISO/IEC 24764 Edition 1.0, Generic Cabling Systems For Data Centers
- ITU-T G.652D, Characteristics of Single Mode Optical fibers
- ITU-T G.657A, Characteristics of bending loss insensitive single mode optical fiber and cable for the access network
- Mobily Design Guidelines, Access Network Development (AND+) Phase III Revision – 05 (09.09.2013)
- Mobily Micro Bundled Duct Specification
- Mobily Standard UPL-2012
- NECA/BICSI 607-2011, Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
- NFPA 70 and NFPA 99, Healthcare Facilities Code
- NFPA 101, Life Safety Code
- ONVIF Open Network Video Interface Forum
- Saudi Telecom Company (STC) Engineering Standards and Specifications, latest edition
- Saudi Telecom Company (STC) TS 2111, Cables, Fiber Optic, Single Mode (SM)
- Saudi Telecom Company (STC) TS 2116, Cables, Fiber Optic, Single Mode (SM), Mini Type, (Outdoor)
- Saudi Telecom Company (STC), Fiber to the Home (MoP & Guidelines) STC-2005
- Saudi Telecom Company (STC), FTTH Design Guidelines
- TIA TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems
- TIA TSB-155-A, Guidelines for the Assessment and Mitigation of Installed Category 6 Cabling to Support 10GBASE-T
- TIA TSB-162-A, Telecommunications Cabling Guidelines for Wireless Access Points
- TIA TSB-184, Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling
- TIA TSB-190, Guidelines on Shared Pathways and Shared Sheaths
- TIA/EIA-598A, Optical Fiber Cable Color Coding
- UL 1069, Standard for Hospital Signaling and Nurse Call Equipment's
- UL 2560 , Emergency Call System

1.2 Communication System

1.2.1 Local Area Network

1.2.1.1 System Description

- Where the works interface with Telecom Service Provider (TSP), such as Saudi Telecom (STC) and etc., the equipment/materials and installation shall comply with most recent Telecom Service Provider (TSP) regulation and standards.
- ICT Requirements shall be followed as per Communications and Information Technology Commission (CITC), the updates and required standards can be found on www.citc.gov.sa, http://www.citc.gov.sa/en/Decisionsoffers/Decisions/Pages/392-1439.aspx
- Existing Facilities - the system provided shall be compatible with existing installed Entity network appliances and Network Management System (NMS).

- Local Area Network (LAN) within the Entity facility shall be connected to the Entity Metropolitan Area Network (MAN)/ or Wide Area Network (WAN) via an uplink from the LAN core / distribution switch.
- Internet connectivity for the Entity facilities are generally provided through MAN or WAN, dedicated firewall appliances are not generally provided within local facilities.
- All network solutions must be designed to be fault tolerant, with fallback, diverse routed solution that will allow continued connectivity if single point failures occur.
- All components of the Structured Cabling System shall be supplied from a single manufacturer and be installed by qualified technicians. A manufacturer's warranty for the system shall be issued lasting for a minimum of 10 years commencing from hand over of the building.
- The Entity's A/E shall provide all necessary cable and related hardware to connect all existing servers within the Entity backbone switch that shall ensure dedicated individual communication speeds up to 10 Gbps within the core/distribution down to the access layer. Exceptions exist for facilities that do not require 10 Gbps such as utility equipment buildings and spaces with low bandwidth requirements.
- The project shall include remote management tools that, at a minimum, provide full network management, real time reports of performance, and alert notifications in graphic format, to support groups or helpdesk.
- All site tests in accordance with approved test procedures shall be provided to ensure that the equipment and related accessories comply with specifications and operational requirements. All tests are subject to witnessing by the Entity.

1.2.1.2 Network Equipment

- The network equipment shall be compatible with existing installed network appliances and Network Management System (NMS).
- The cabled LAN components shall be provided in facility Telecom Rooms.
- The LAN shall be provisioned with 20% spare port capacity on all access layer switches for future.
- LAN switches shall have the option of integrated wireless controller capability with up to 40G of wireless capacity per switch, support for up to 50 access points and 2000 wireless clients on each switching entity (switch or stack).
- LAN switches shall be configured with 24 / 48 port 10/100/1000BASE-T Ethernet copper interfaces or 12 / 24 / 48 SFP ports for optical connections.
- LAN access switches shall be built to offer stacking throughput architecture, allowing additions, deletions and redeployment without interruption. Additionally, power stacking among stack members shall permit power redundancy.
- LAN access switches shall be configured with dual redundant, modular power supplies and modular fans providing redundancy.
- LAN access switches shall contain full IEEE 802.3 at (PoE+) with 30W power on all copper ports in 1 rack unit (RU) form factor.
- Provide software support for IPv4 and IPv6 routing, multicast routing, modular quality of service (QoS), Flexible NetFlow (FNF), and enhanced security features.
- Configure LAN access switches for PoE/PoE+ on all ports.
- Configure LAN access switches with uplinks as required supporting single mode fiber. The LAN shall support uplink modules consisting of Gigabit Ethernet or 10 Gigabit Ethernet with Small Form-Factor Pluggable (SFP) and SFP+ receptacles.
- Enable security features for wired plus wireless users such as IEEE 802.1x, port security, Dynamic Host Configuration Protocol (DHCP) Snooping and Guard, Dynamic ARP Inspection, RA Guard, IP Source Guard, control plane protection (CoPP), and wireless intrusion prevention systems (WIPSs).

- The LAN shall be optimized for multicast for wired plus wireless. Implement Internet Group Management Protocol (IGMP) snooping.
- Access switches shall support both layer 2 switching and layer 3 routing protocols.
- Enable Inter-VLAN IP routing for full Layer 3 routing between 2 or more VLANs.
- Provision QoS and VLAN's per the Entity requirements.
- Provide network management software for centralized management.
- A maintenance support contract with next-business day replacement and free phone technical assistance shall be available from the product manufacturer directly.
- In installations where existing switches are in place, PoE injectors may be required:
  - PoE injector shall deliver connectivity to 802.3 at-compliant devices.
  - PoE injector shall provide two 10/100/1000 Megabit Ethernet ports: 1 data uplink, 1 power+data
  - PoE injector shall be equipped with LED to indicate power.
- Proactive Maintenance Program
  - Program shall provide global 24-hour access to system experts
  - Self-help support through online communities, resources, and tools
  - Advanced hardware replacement options, including 2-hour, 4-hour and next business day
  - Operating System software updates applicable to licensed feature set
  - On-site support for remedial hardware maintenance service
  - Proactive diagnostics and immediate alerts on core network devices

1.2.2 Metropolitan Area Network

1.2.2.1 System Description

- Wide Area Network connectivity shall be provided to sites/nodes as identified by the Entity using a Metropolitan Area Network (MAN).

  The network connectivity shall support site/node connections including but not limited to:
  - IP based security cameras
  - Intelligent Transportation System components such as information displays
- The Metropolitan Area Network connects sites/nodes within geographic proximity in a logical access ring topology using the Entity single mode optical fiber strands.
- Access rings are numbered sequentially for administration purposes and typically may contain up to 10 sites/nodes. Each site/node is identified by site number and name, as approved by the Entity.
- New facilities shall be assigned to a new node on a new or existing access ring, with optical fiber strands provided as needed for physical ring connections to adjacent sites/nodes in the ring.
- Each end of an access ring shall be connected to two different backbone nodes to provide redundancy.
- New access rings shall be assigned and connected to a specific node on the backbone ring, as identified by the Entity.
- Optical fiber utilized in the system shall be single mode conforming to the ITU-T G.652 standard.

1.2.2.2 System Topologies

- The MAN shall support Carrier Packet Transport as a carrier class converged and aggregation platform for unified packet transport architectures.

- The MAN shall consist of a Packet-Optical Transport System (P-OTS) built on standards-based MPLS-Transport Profile (MPLS-TP) for Ethernet aggregation and transport.
- The MAN shall provide dense hierarchical QoS and support for Layer 2 services and features, using MPLS-TP, MPLS or Layer 2 Ethernet based technologies.
- The MAN shall support transport-class network timing, support of network-synchronized services and applications such as mobile backhaul and migration of TDM services.
- Dense wave division multiplexing (DWDM) supporting Gigabit Ethernet and 10 Gigabit Ethernet packet-optical transport shall be provided within the core backbone ring.

1.2.2.3 Network Components

- Backbone Ring Nodes
  - The backbone node consists of a rack mounted chassis to be provided in Telecom Room equipment cabinet locations identified by the Entity through coordination with the A/E.
  - The backbone node shall support 480 GB total switch capacity.
  - The backbone node shall support 30 channels of 10 Gigabit Ethernet in the backbone ring.
  - The backbone node shall be a modular platform consisting of transport fabric cards and modules.
  - The backbone node shall be configured to support access ring nodes comprising an access ring. Final configuration of the backbone node cards and modules shall be coordinated with the Entity to meet the requirements of the network expansion.
  - The backbone node shall be connected to the backbone ring through a provider edge router and a DWDM multiservice transport platform supporting reconfigurable optical add/drop multiplexers (ROADMs) for management of fiber wavelengths.
- Access Ring Nodes
  - The access ring node consists of a rack mounted chassis to be provided in Telecom Room equipment cabinet locations identified by the Entity through coordination with the A/E.
  - Typically in new facilities, this shall be located in the main Telecom Room or Server Room.
  - The access node is a satellite shelf that provides remote port expansion for the backbone node. The access node shall be managed virtually as part of the backbone node.
  - The access node is a fixed configuration platform supporting 44 SFP- based Gigabit Ethernet ports and four SFP+ 10 Gigabit Ethernet uplink ports.
  - In order to distribute Ethernet network service within a site, the access node is connected to a 24 port Fiber Optic Ethernet Switch (FOES) utilizing an SFP Gigabit Ethernet port. The FOES then distributes Gigabit Ethernet over optical fiber SFP connections to Power over Ethernet edge switches. Ethernet edge switches provide Gigabit Ethernet utilizing Category 6 UTP copper cables.

1.2.2.4 Intelligent Transportation System

- The Metropolitan Area Network shall be utilized to support network connectivity to systems and devices used in Intelligent Transportation Systems (ITS) where new development occurs. Within existing urban areas, use of other existing communications networks shall be investigated, including service provider leased lines and wireless systems.
- Coordination shall occur with project civil designs that establish the requirements for ITS systems. These design requirements include final locations, quantities, and mounting conditions of devices and equipment as well as device communications interface requirements.
- ITS systems require reliable and some redundant connections. Where practical, redundant and diverse connections shall be available to critical components of the ITS system to minimize outage downtimes. Component bandwidth requirements for ITS systems are typically low with the exception of CCTV video surveillance cameras, which may require up to 5 Mbps of bandwidth each.

- ITS systems are designed to facilitate future growth, expansion, and capabilities. The MAN shall be provisioned to support future needs of the ITS system as planned by the Civil design of the project.
- ITS components requiring MAN connections may include the following:
  - Traffic and transport data gathering
    - Closed circuit video surveillance
      - General monitoring of roads and highways
        - Where recommended by traffic police, provide red light intersection ANPR cameras.
        - ANPR cameras shall be located on selected DMS gantries for freeway data collection and enforcement.
        - In urban areas, significant junctions shall be provided with camera coverage down each arm of the junction providing adequate coverage.
        - On freeways where full surveillance is required, a camera shall ultimately be provided every 1 to 1.5 km. ANPR cameras shall be provided in order to measure link speed and journey times.
        - On Road Intersections, Hybrid Radar and Video Vehicle Detection Cameras shall be installed, these Cameras shall comply at a minimum with the following: Video and radar sensors sealed in waterproof and dust tight housing which meet IP65 standards, Operating Temperature of -40°C to 60°C, MPEG-4 streaming via Ethernet.
      - Bus locations
      - Car park occupancy
    - Traffic counting sensors

      Where appropriate, additional sensors used for counting traffic shall be implemented, in addition to ANPR cameras.
    - Visibility Sensors

      Several visibility sensors shall be provided around the network to detect fog and sandstorms to provide warnings and reduce speed limits.
  - Traffic control
    - Access control to secure areas
    - Traffic and pedestrian signaling
  - Traffic and transport information
    - Dynamic message signs (DMS)
      - Typically located at interchanges, entrances, and exits to provide traffic condition information.
      - DMS provide four lines of text, variable speed limits, and pictographic warnings. In addition, the sign may provide journey time, date, time, and temperature.
    - Provision of data to satellite navigation systems
    - Provision of information to broadcast media for traffic reporting
    - Provision of bus arrival at bus stops
  - Payment Systems
    - Integrating ticketing systems for public transport
    - Car park payment
    - Toll collection
- Traffic Management Center(TMC)
  - The TMC is a facility that shall contain the central computer systems running a suite of integrated ITS programs and sub-systems that allow communication with field equipment, collection of data, and control.
  - The TMC shall contain a server room conforming to TIA/EIA 942 which shall be connected to a MAN access ring.

1.2.3 FTTH (Fiber to the Home)

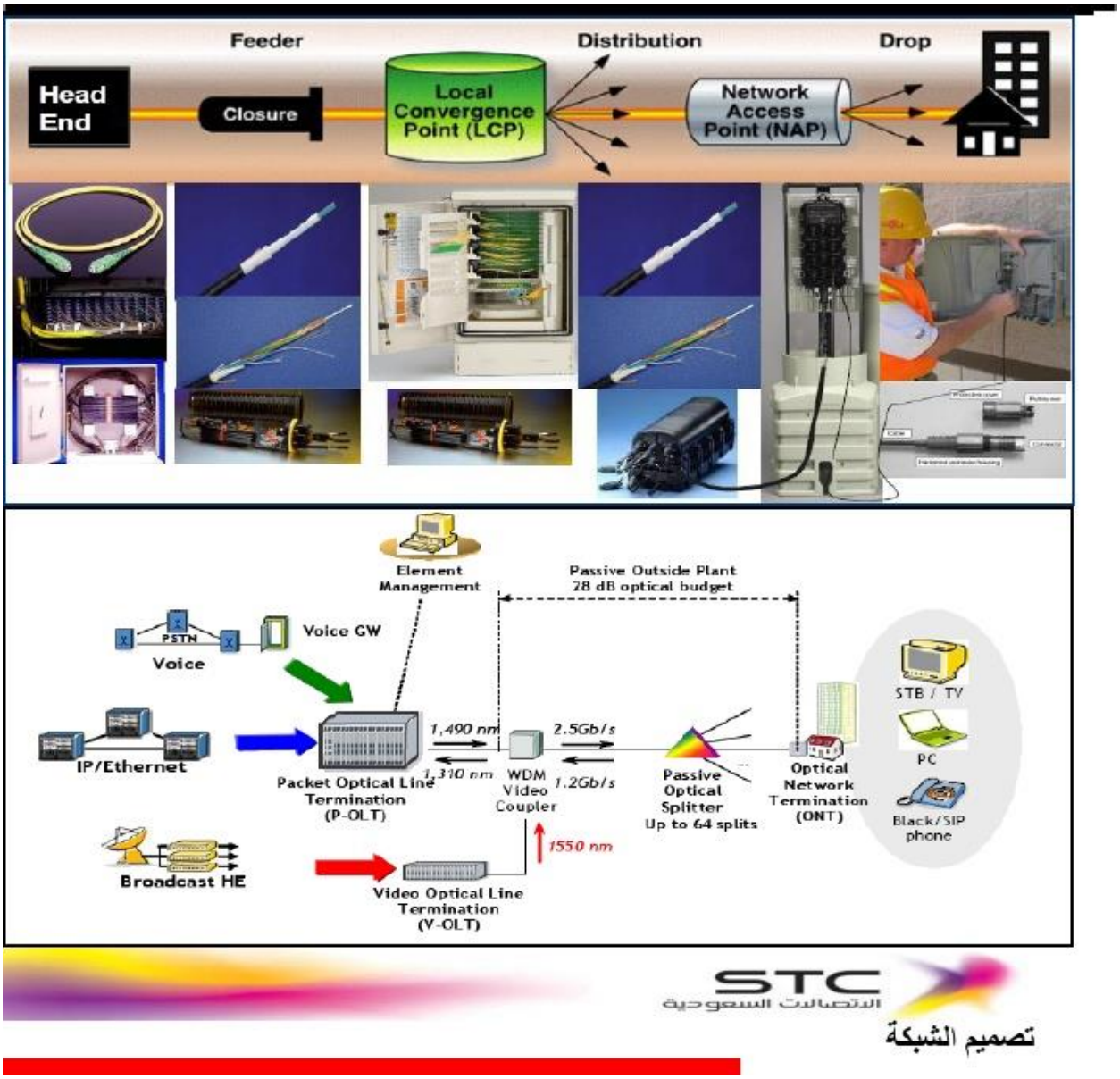
1.2.3.1 FTTH System Deployment Description

The following are two different ways on selection of FTTH/GPON systems:

1. The Entity shall directly own and operate FTTH/GPON (Gigabit Passive Optical Networks) network for their entire development. This Entity system shall consist of a fiber distribution network utilizing GPON wave division multiplexing to extend services to residential homes, apartments, and villas within the premises. This network is implemented primarily for distribution of IPTV services.
    - The TSP (Telecommunication Service Provider) FTTH/GPON is directly provided by either STC or Mobily per STC/Mobily standards. Coordinate with TSP to plan infrastructure components that may be shared between the Entity and TSP FTTH/GPON as required by each project. This may include manholes, duct banks, and FDT cabinets.
2. The Entity FTTH system design shall be similar to the TSP FTTH design, but incorporate specific Entity requirements outlined in this chapter of the Guidelines. The following TSP standards may be used by A/E for reference only during design:
    - Mobily Design Guidelines for Access Network Development(AND+) Phase III – Revision -05
    - STC FTTH Design Guidelines, Doc. Number GL 621211-02-03, (see figure)

      STC Fiber to the Home

      Coordinate with the TSP's (STC and/or Mobily) to request the most recent standard revisions governing the TSP FTTH/GPON networks.



1.2.3.2 System Description (FTTH GPON)

- FTTH GPON system shall accept IPTV system signals which are combined, multiplexed, converted to light signals & interfaced to a single fiber by the Optical Line Terminal (OLT) placed within the exchange. The signals are transported & distributed to the end users, directly or through splitters, where the signals are converted through the Optical Network Terminal (ONT) to electrical signals.
- The system shall support optical access GPON with a minimum 2.5 Gbps downstream line rate, 1.2 Gbps upstream line rate, and a 20 kilometer reach on an IP platform.
- FTTH GPON system is distributed from central IPTV headend building. The central IPTV headend building contains the IPTV headend equipment racks, Optical Line Terminator (OLT) system equipment racks, and Optical Distribution Frame (ODF) equipment racks. For detailed requirements for the IPTV headend, refer to Section 1.2.8: Distributed Television System.
- The ODF contains a Fiber Distribution Frame (FDF) consisting of exchange termination equipment where fibers from the OLT are jointed to feeder optical fiber cables for mass FTTH deployment.
- The OLT and ODF serve as the final termination point of feeder optical fiber cables. The feeder optical fiber cables are distributed directly into the underground duct systems from inside the IPTV headend building.

- The GPON system underground distribution is provided in parallel to a similarly built out, but separate, GPON system provided by the TSP. Within the underground distribution system, generally the same manholes are shared between the Entity GPON network and the TSP GPON network. Underground conduits within duct banks shall be designated for use by the Entity or the TSP.
- Optical fiber feeder cables are routed from the OLT through the underground distribution system to Fiber Distribution Terminals (FDT's). FDT's are located throughout the district area, serving multiple blocks of residential community area. FDT's consist of pedestal style outdoor enclosures that house Optical Distribution Frames (ODF's). ODF's are racked in shelves on a frame within the FDT and provide passive optical splitting. The FDT's are typically located in pairs in the same vicinity, with one designated for the Entity GPON, and the other provided by the TSP for the TSP GPON.
- From each FDT, distribution optical fiber cables are routed through district blocks to Fiber Access Terminals (FAT's). FAT's are located in pairs, one designated for the Entity GPON, and the other the TSP GPON.
- FAT's provide a splicing location for distribution optical fiber cables to interface with drop fiber optic cables. Drop optical fiber optic cables extend to customer premises for termination in Optical Network Terminals (ONT's). The ONT is a media converter that is installed inside the home or buildings designed for delivering IPTV signals.
- Splitter attenuation loss should be within the system standards. Each splitter configuration is assigned a particular maximum split ratio loss, including connectors, defined by the ITU G.671 standard. Optical fiber utilized in the system shall be single mode conforming to the ITU-T G.652 standard.

1.2.3.3 FTTH GPON System Optical Line Terminator (OLT) Requirements

- OLT's shall standardize on line cards with a minimum of 16 PON ports per card.
- The OLT's shall be central office chassis based and mounted in ETSI standard equipment racks within the central IPTV headend building. The equipment rack shall meet the recommendations of the OLT system manufacturer.
- Each equipment rack shall support two (2) OLT chassis' and a system - 48V redundant DC power supply located at the top of the rack.
- The equipment racks shall be arranged in one or more rack lines with overhead cable tray installed above for optical fiber cable management.
- The OLT performs aggregation to the IPTV network switch distribution. The OLT has interface slots for GPON line termination cards and network termination cards. Services are delivered via GPON interfaces using a single fiber with two wave lengths (receive and transmit) multiplexed together. A third wavelength can also be multiplexed for downstream RF video over the same fiber. The line termination cards support a minimum of 4 ports each, permitting a minimum of 56 PON interfaces in total. The GPON interfaces comply with Full Service Access Network (FSAN) recommendations and International Telecommunications Union Telecom (ITU-T) sector standards for optics, line rates, data transfer protocol and management interface.
- IPTV network traffic aggregation and uplink shall be provided by using network termination cards within the OLT. The network termination card shall support a 48 Gbps Ethernet switch fabric with integrated Gigabit Ethernet (1 Gigabit Ethernet) uplink interfaces using small form-factor pluggable (SFP) optics, as well as a single 10 Gigabit Ethernet uplink interface using XFP pluggable optics. Two network termination cards shall be provided for redundancy and load sharing, enabling 96 Gbps switching capacity. A/E shall coordinate with the Entity to determine the IPTV system uplink interfaces required for network termination cards.

1.2.3.4 FTTH GPON System Optical Distribution Frame (ODF) Requirements (ISP)

- Inside plant ODF's reside within the IPTV headend building and contain FDF's accepting optical fibers extending from the OLT's

- The inside plant ODF equipment is mounted in an ETSI standard equipment rack and can accommodate multiples of rack height 1U (44.4 mm) or 2U (88.8 mm). The ODF equipment rack shall have integral large capacity vertical managers, full height on each side, for organization of optical fiber cabling.
- The ODF equipment rack is located at the end of the rack line of OLT equipment racks.
- The ODF serves as the interface/cross connect facility between optical fibers extending from the OLT and the feeder optical fiber cables from the outside plant distribution.
- The ODF optical fiber interconnects and cross connects shall utilize LC/APC connectors.
- A network of 200mm deep, 450mm wide ladder tray with 300mm rung spacing shall be provided over system rack lines for routing OLT power feeds and feeder optical fiber cable sub ducts.
- Optical fiber cabling from the OLT's to the indoor ODF shall be routed in dedicated fiber wire ways, minimum 50mm square, located within the overhead ladder cable tray above the equipment rack lines.
- Each feeder optical fiber cable shall be routed in a dedicated sub duct from the ODF to the IPTV headend building point of entrance for distribution outside plant ducts through the underground distribution system. Refer to sub section 1.4.1: Outside Plant Infrastructure for detailed outside plant requirements.

1.2.3.5 FTTH GPON System Feeder Optical Fiber Cable Requirements

- Optical fiber cabling for feeder cables shall consist of single mode, loose tube available from 12F-288F.
- The feeder optical fiber cable network commences from the exchange (OLT, ODF/ FDF) and ends at the splitter point, at the outdoor FDT Cabinet. The feeder portion of the network is provided over long distances, with the objective of minimizing splice points and splitters in the network.
- The location and routing of feeder fiber routes should take into consideration the overall "link budget" (attenuation) and the position of easy access facilities like FDT's and FAT's that house splitters and drop fibers.
- The minimum feeder optical fiber cables size to each FDT shall be 24F.
- Feeder optical cable size (round off to nearest cable size) = Ultimate number of splitters / FDT sizes + Ultimate demand forecast within FDT serving area to meet multi-tenant buildings + 20 % for maintenance & unforeseen demand. The number of main feeder cables is then determined by dividing the number of fibers calculated above by the size of cable (24F, 36F, 48F, 72F, 96F, 144F or 288F) and the remainder is rounded off to the nearest cable size to obtain total number of feeder cables.

1.2.3.6 FTTH GPON System Outdoor Fiber Distribution Terminal (FDT) Requirements

- The outdoor FDT is placed strategically in the FTTH network to facilitate service connections for fiber serving areas defined by the scope of the project.
- The FDT provides environmental and mechanical protection for cables, splices, connectors and passive optical splitters.
- The FDT provides the transition point and management for feeder and distribution optical fiber cables using ODF splitters and point to point (P2P) connections.
- ODF Splitters
    - The FDT typically accommodates ODF splitters with (1:32) splitting ratio. However, each project may require various splitter ratios to meet project demands such as 1:X where X=2, 4, 8, 16, 32, 64 and 128. Higher split ratios however reduce the effective cabling distances and reduce serving area sizes due to additional optical split ratio loss.
    - ODF splitter modules are provided with connectorized pigtail outputs and one pigtail input. The splitter input is spliced to the feeder cable in the splice shelf using fusion splicing. The

splitter outputs are spliced into the distribution cables in the splice shelves using fusion splicing. LC/APC optical fiber interconnects shall be provided for inputs and outputs to splitter units.

- The FDT outdoor cabinet is sized for the total connections required to connect FATs & ONTs in the fiber serving area plus the total number of splitters required per cabinet based on future tenants forecast.
- Fusion splicing cassettes for feeder and distribution cabling are organized in a cabinet located in the bottom of the FDT. Color coded shelves for splitters are racked and include:
  - Red – Feeder Panel Splitters and Feeder Panel P2P connections
  - Blue – Optical Splitters
  - Gray – ODF/Splitters for distribution cabling
- Fiber managers located on the sides of the FDT organize optical fiber cabling. Each fiber bundle is labeled per system requirements.
- Where required by the project, utilize colocation style FDT's
  - The colocation FDT contains three compartments; the center compartment shall be for cable entrance from the manhole. The two compartments on either side shall be designated for use by the Entity IPTV FTTH GPON and the TSP FTTH GPON.
  - The colocation cabinet shall meet the requirements of the TSP. The A/E shall submit the FDT configuration only for the TSP compartment for approval by the TSP; explaining the requirement of ODF and splitters for 100% customer activation.
- Criteria for locating outdoor FDT's include:
  - The cable distance from FDT to the last customer building shall be within a radius of 500 m; the linear distance from FDT to customer could be more; but should not exceed 600-700 m.
  - Accessibility to the cabinet and installations in all times of the day, especially after work hours for cabinets at subscriber's premises.
  - It should be away from pedestrians, traffic, traffic signals, and road crossings.
  - Locate away from customers' walls.
  - Shall not cause any inconveniences to the public.
  - Shall be placed on solid grounds, not water and flood runways; or in wadis.

1.2.3.7 FTTH GPON System Distribution Optical Fiber Cable Requirements

- The distribution optical fiber cables connect FDT Splitters to FAT closures.
- The distribution optical cables are laid in P2P/Star topology from FDT/Splitter location.
- The cabling shall consist of single mode, loose tube available from 12F- 96F depending upon the grouping of villas and numbers of FAT's.
- The distribution cable shall be labeled as per Entity requirements and appropriate code.

1.2.3.8 FTTH GPON System Fiber Access Terminal (FAT) Requirements

- Fiber Access Terminals (FAT's) are located in manholes/handholes and provide the interface between distribution and drop cables. Based upon final FTTH distribution layouts, two FAT's shall be provided in designated manholes; one for the Entity FTTH GPON, and one for the TSP FTTH GPON.
- The FAT shall contain fusion splice trays or preconnectorized assemblies where individual fiber strands from distribution cables are spliced or interconnected into drop cables. Distribution cables may daisy chain through FAT's with unused loose tube fiber strands left coiled and uncut, and routed continuous in a distribution cable to the next FAT.
- The drop cables are 2F & 4F capacity. The FAT closures are capable to accommodate 24 drop cables.

- The drop closures (FATs) are recommended to be installed inside joint boxes close to group of villas. These have 24 outlets for drop cables.

1.2.3.9 FTTH GPON System Drop Optical Fiber Cable Requirements

- The drop optical fiber cable extends the “last mile” from FAT to the Fiber Termination Box (FTB).
- The minimum bending radius of the drop cable, as stipulated on the manufacturer’s data sheet, shall not be exceeded.
- The drop optical fiber cable shall be single mode, center or loose tube containing 4 cores.
- Drop cables shall be provided containing 4 cores to each unit, villa, or building within the project scope. All fibers to be terminated and labeled to indicate dark fibers.
- The distribution cable shall be labeled as 04:96F(80) S1+S2:1-10+S17- S18 and drop cables as 4F(3).
- In multidwelling units, provide a minimum of 4 core fiber drop cables from the main telecom room to the ONT location of each Flat/shop/office etc. No splices are allowed between the Telecom Room and ONT’s

1.2.3.10 FTTH GPON System Fiber Termination Box Requirements

- The Fiber Termination Box (FTB) is provided at the point of entrance for each customer building to serve as the termination point between the drop cable and customer premises cabling extending to the Home Networking Cabinet.
- The FTB provides the test point for customer connection without entering the premises.
- LC/APC connector interface shall be provided.

1.2.3.11 FTTH GPON System Optical Network Terminal Requirements

- Customer premises equipment which converts the optical signal to electronic signal.
- The ONT consists of the following:
  - Terminal Box – to terminate the drop fiber cable.
  - Power conversion AC/DC. For IPTV GPON ONT’s, a local UPS is required.
  - Converts the optical signals to electrical
- The location of the Indoor ONT Distribution Box shall be within the Home Network Cabinet, where all the internal conduits meet and provide the structured cabling system in a star topology.
- The farthest telecom outlet shall not exceed 90 meters from the ONT.

1.2.3.12 FTTH GPON System Design Requirements

- Fiber Optic cables, splitter cabinet & civil (ducts, joint boxes, etc.) shall be proposed in the most economical way while meeting project scope requirements.
- Optical Link Budget Calculation
  - Total allowed link budget from OLT to ONT is 28db. All FTTH design losses from OLT to ONT should not exceed (not more than) 28db.
  - The following Parameters should be taken into account while calculation dB budget loss of the network.
    - Exchange
      - ODF Connector - 0.2 dB
    - OSP
      - Splice Loss/splice - 0.1 dB

- Cable Loss/ km - 0.35 dB
- FDT
  - Splitter 1:32 - 17.5 dB
  - ODF Connector Loss - 0.2 dB
- Sub Premises
  - Drop cable loss per km - 0.35 dB
  - Fiber Termination Box - 0.2 dB

- The design shall comply with ITU-T Recommendation G.984 Gigabit-capable Passive Optical Network (G-PON). The maximum logical distance from OLT to ONT shall not exceed 60km. The physical distance shall be limited by the optics used and the calculated link loss budget.
- The budget loss is calculated as follows: Losses = (Fiber cable + Connectors + Joint + Splitter) Losses.
- FTTH System Documentation Requirements
  - Route Map: The Route Map shows a geographic overview of cables and conduit routes.
  - Graphic Access for Feeder & Distribution Network: Graphic Access shows a graphical overview of the cable/conduit route including MH/MH distances. These distances depend on type of cable deployed and the pulling tension of the cable as well as splice and splitter locations. Distance between HH/HH depends on the drop fiber distribution, pipe formation, pipe assignment, cable joints for new cables/conduit systems. The minimum information required and to be reflected in this type of drawing is as follows:
    - Cable size & type
    - HDPE duct/subduct assignment.
    - Manhole layout
  - Detailed Conduit Access for Feeder & Distribution Network: The Detailed Conduit drawing shall show in detail the geographic location of the conduit system, manholes, hand holes, FDT cabinet's, FAT locations, distances from reference points to center of MH cover and to various parts of the conduit system. The minimum information required and to be
    - Location of new Manholes/Handholes, e.g. distance from intersection
    - Any "Construction Notes" that may affect implementation
    - MH and duct designation
    - The distance and number of Ducts between MHs and/or HHs
    - FDT Cabinet numbers
    - Crossings Method, for road, pipe line (thrust boring or excavation)
    - Labels and legends
  - Cable Vault Plan: A Cable Vault Plan shall reflect telecommunication facilities in cable vault room, tunnel vault as well as location and position of the cables on cable brackets/ladders and the cable entrance from manhole/tunnel to cable vault room.
  - Fiber Cable Schematic for Feeder & Distribution Networks: A Schematic is to be provided showing the new optical fiber cable, cable type, size, distances between jointing points and termination points. The minimum information required and to be reflected in this type of drawing is as follows:
    - Tabled calculation of cable pulling tension available and acceptable
    - Location of FDT's, FAT's & Terminations
    - Labels and legends
  - Fiber Jointing Schematic for Feeder & Distribution Networks:

    A Schematic is to be provided, reflecting an overview of all new optical fiber cables, fiber termination points, joints, splitter locations and stumped fibers (dark fibers). Distances between joints and termination points/MH shall be noted. The minimum information required and to be reflected in this type of drawing is as follows:
    - Use of fibers (fiber assignment)
    - Fiber termination points at ODF / OLT

- Numbering of FO Cabinets and Splitters
- Numbering of FO cables
- Distances between joints (Feeder cable)
- Distance between splitters (Distribution cable)
- Labels and legends

- Local IPTV Building: An exchange floor plan is to be provided reflecting proposed locations of OLT and ODF locations along with cable routing within the exchange building. Distances of cable from Cable Vault to ODF / OLT locations should be provided
- Test Plan
  - The test plan will describe the acceptance Testing that will be carried out to ensure the deployment of FTTH.
  - Attenuation per unit length and splice, splitter loss is measured with an OTDR to verify the integrity of fiber and splices in the optical transmission path. A Laser source and an optical power meter is used to test the attenuation of the fibers from the OLT to the ONT (customer premises), insuring that the transmission system loss design requirements are within the maximum permissible dB loss. These tests will be recorded on power meter test sheets along with OTDR graphic printouts as required.
  - Before performing any optical test, Instrument Calibration Certificates of the test equipment to be used and has to be presented to the Entity for approval. The equipment serial numbers and calibration dates will be recorded accordingly

1.2.3.13 FTTH GPON System Outside Plant Design Parameters

Refer to sub section 1.4.1: Outside Plant Infrastructure, for detailed requirements for providing FTTH outside plant infrastructure.

1.2.4 Data Centers

1.2.4.1 Data Center Design Overview

- Data Centers shall be designed in accordance with the following:
  - TIA-942-A -Telecommunications Infrastructure Standard for Data Centers and ISO/IEC 24764 Edition 1.0 “Information Technology - Generic Cabling Systems For “Data Centers”.
  - ANSI/BICSI 002-2011, Data Center Design and Implementation Best Practices, and BICSI International Standards Supplemental Information 001: Methodology for Selecting Data Center Design Class Utilizing Performance Criteria
- The A/E shall implement Best Practices recommended by the Uptime Institute.
- Tiering Structure - A/E shall coordinate with the Entity to determine the appropriate Tiering Structure required on a project by project basis.
- When designing a data center, it is essential that all systems be coordinated as follows:
  - Provide estimate of anticipated power, space, cooling and required telecommunications equipment based upon full capacity and with future needs considered.
  - Provide required space power, cooling, security, floor loading, grounding, electrical protection and other requirements to design team. These requirements shall also include requirements for operations center, loading dock, storage room, staging areas, and other support areas.
  - Work with architect and engineers for the space planning. Revise design as necessary to accommodate facility needs.
  - Develop floor plan requirements with placement of major rooms. This shall indicate entrance rooms, main distribution areas, horizontal distribution areas, zone distribution areas, and equipment distribution areas. Power, cooling and floor loading requirement for equipment shall be provided to the engineering team as well as the requirements for telecommunications raceways.

- Review the updated plan with the requirements for the telecommunications pathways, electrical equipment and mechanical equipment (at full capacity).
- Design the telecommunications cabling distribution system based upon the equipment to be housed in the data center.

1.2.4.2 Telecommunications Spaces and Topologies

- Major Spaces and Organization
  - Provide authorized access and monitoring
  - Coordinate floor loading requirements
  - Coordinate service clearance requirements
  - Verify airflow requirements
  - Verify DC power requirements and circuit length restrictions
  - Telecommunications rooms and other equipment rooms serving spaces outside the data center shall not be housed within the data center.
  - Data Center may be comprised of:
    - Data Center Support staff offices
    - Data Center entrance room
    - Data Center Electrical and Mechanical Rooms
    - Data Center Operations Center
    - Telecommunications Room(s) serving data center spaces
    - Data Center Storage rooms and loading docks
    - Data Center Computer Room
  - Where not a dedicated building, other tenant spaces shall be nonindustrial, with use that is non-intrusive to the data center.
  - Where on an upper floor, adequate shaft space shall be provided for generator, security, telecommunications and electrical conduits in addition to HVAC, grounding, antennas and other services as required.
- Relationships and Adjacencies
  - Locate away from EMI sources. Sources of EMI/RFI shall be located at a distance that reduces the interference to 3.0 volts/meter throughout the frequency spectrum.
  - No exterior windows
  - Unrelated equipment shall not be installed in, pass through, or enter the area. The Room shall not be located below plumbed areas such as rest rooms, janitor closets, kitchens, laboratories, or mechanical spaces.
  - Telecommunications Design
    - Building shall be equipped with multiple fiber optic entrance rooms with services from different local access providers.
    - Cabling may be distributed overhead or under floor.
- Entrance Room Requirements
  - Access Provider Coordination
    - Coordinate to provide maximum circuit lengths in conformance with access provider requirements.
    - Entrance Rooms may be located inside or outside the computer room.
    - Where Entrance Rooms are located inside the computer room, typically separate rooms are not required unless the access provider leases the space.
    - Entrance rooms shall have pathways specific for access provider pathways.
  - Telecommunications Design
    - Equipment cabinets or racks shall be provided with minimum of 1m clearance in front of the rack. Where deeper equipment is anticipated, a minimum clearance of 1.2m shall be

provided. Rear clearance shall be 0.6m. Coordinate final clearance requirements with equipment provided.

- Spaces shall be configured with equipment racks having a “cold” air aisle in the front of the cabinet and “hot” air aisle in the back.
  - Perforated floor tiles shall be utilized along the cold aisles to improve circulation. No cable trays shall be placed below the cold aisles.
- Placement of racks, cabinets and other equipment shall be coordinated with the floor grid. Racks supported by the access floor shall be attached to the slab through threaded rods or otherwise secured.
- Cabinets shall be placed at the same location on each floor tile to allow standardization of floor tile cuts. Spaces shall be utilized to ensure each cabinet begins at the edge of a floor tile.
- Rack/cabinets shall be 2.1 meters tall for access to equipment and interconnection of devices.
- Racks shall be powder coated or other scratch-resistant finish.
- Power strips shall be provided for all cabinets with active equipment. Power strip plugs shall have locking mechanisms to prevent accidental disconnection.
  - Label power strips with panel number and circuit.
  - Provide clearance on racks to accommodate power strips.

- Distribution Areas
  - Main Distribution
    - MDA’s shall be centrally located to minimize cabling lengths.
  - Horizontal Distribution
    - HDA’s shall be centrally located to minimize backbone cabling lengths.
  - Zone Distribution
    - Overhead, or under floor Zone Distribution Areas shall serve a maximum of 288 twisted-pair or coaxial connections.
    - Active equipment shall not be housed in the zone distribution area.
- Equipment Distribution
  - Equipment distribution does not include telecom rooms, entrance rooms, main distribution areas, or horizontal distribution areas. EDA’s house telecommunications and headend equipment, typically in floor mounted equipment racks or cabinets.
  - Power shall be provided to accommodate equipment housed in racks and cabinets.
  - Cabling extending between devices within the EDA shall not exceed 15m.
- Cabling Topologies
  - Entrance room (ER)
    - Entrance Room houses the interface between the inter-building cabling (access provider and customer owned) as well as the structured cabling associated with the data center.
    - Houses demarcation hardware and access provider equipment
    - May be located outside the computer room if the data center is in a building that includes spaces outside of the data center, or if additional security is required.
    - Multiple entrance rooms may be required for additional redundancy or due to cabling lengths.
    - Entrance Room may be adjacent to or combined with the main distribution area.
  - Main Distribution Area (MDA)
    - MDA houses the main cross-connect (MC). This is the central point of distribution for the data center structured cabling system. This may also include the horizontal cross-connect (HC) if the equipment areas are served directly from MDA. This is typically housed in the computer room, unless it is a multi-tenant data center, in which case it may be a separate dedicated room.
    - Every data center requires at least one MDA. This is the central point for the data center cabling, housing computer room core routers, LAN switches, SAN switches, and PBX.

- Access provider equipment may be located in this space due to length restrictions.
- MDA's may serve one or more horizontal distribution areas or equipment distribution areas.

- Horizontal Distribution Area (HDA)
  - HDA's serve equipment areas when the HC is not located in the MDA. HDA may include the HC.
  - HDA is within the computer room; however, it may be within a dedicated room for security.
  - HDA includes LAN switches, SAN switches, and keyboard/video/mouse (KVM) switches for end equipment located in the equipment distribution areas.
  - Where data centers extend over multiple floors, each floor may have its own HC.
  - Typical data centers have multiple HDA; however, small data centers may not require HDA as the entire computer room may be able to be supported from the MDA.
- Zone Distribution Area (ZDA)

  ZDA is between the HDA and the EDA allowing interconnection of the horizontal cabling for frequent reconfiguration and flexibility.
- Equipment Distribution Area (EDA)

  EDA is space dedicated for end equipment, including computer systems and telecommunications equipment. This equipment does not serve ER, MDA, or HDAs.

- Pathways
  - Access Floors
    - Cabling under the access floor shall be provided in ventilated cable trays permitting airflow. Multiple layers of cable tray may be required.
    - Cable tray shall be grounded as required.
    - Access floors shall use bolted stringer styles (1.2 m long) with pedestals to improve stability.
  - Overhead trays
    - Cable trays may be installed overhead. Tray type may be:
      - Basket
      - Center spine
      - Ladder
    - A separate duct/tray system may be utilized for fiber.
    - Maximum tray depth shall be 150 mm.
    - Overhead tray placement shall be coordinated with other services to prevent obstruction of lighting, sprinklers, and other devices.
- Infrastructure Identification
  - Floor space shall be utilized to organize the identification of data center components. Data centers shall be designed in a grid format with every 600 mm x 600 mm floor tile designating a block of the grid.
  - Cabinets and racks shall be labeled in front and back with the grid letter and number.
  - Where data centers extend to multiple floors, the floors shall be added as a prefix to the cabinet number:
    - nx1y1:
      - Where n = floor that houses data center
      - x1y1= one or two alphanumeric characters followed by to alphanumeric characters designating the location on the floor space grid where the right front corner of the rack or cabinet is located
    - Similarly, for patch panel ports, label as x1y1-an, where:

      n=one to three characters designating the port on a patch panel. Where patch panels are for fiber, alpha characters shall be utilized starting with "A" excluding "I" and "O" with numeric characters designating a fiber strand.

        - Patch Panels, label as p1 to p2:
            - p1 = near end rack or cabinet, patch panel sequence and port number range
            - p2 = far end rack or cabinet, patch panel sequence and port number range
        - Path cord identifiers p1n/p2n:
            - p1n = near end rack or cabinet, patch panel sequence, and port designator assigned to that cable
            - p2n = far end rack, cabinet, patch panel sequence and port designator assigned to that cable

- Redundancy and Infrastructure Tiering
    - Redundancy Overview - Reliability of system depends upon the redundancy of the infrastructure components. The A/E shall coordinate with the Entity to determine the appropriate level of redundancy required on a project by project basis.
        - N+1 Redundancy
            - This system provides one additional unit or pathway in addition to the minimum provided as part of the original system. This allows the failure of one leg or component of the system to not disrupt operations.
        - 2N Redundancy
            - This system provides two complete (N) units or pathways or systems. This allows the failure of an entire unit, path or system to not disrupt operations.
    - Tiering Structure - The A/E shall coordinate with the Entity to determine the appropriate Tiering Structure required on a project by project basis. The Entity facilities may use elements of Tier II and/or Tier III structures in Data Center designs
        - Tier II Data Center: Redundant Components
            - Less likely to require disruptions from planned and unplanned activities.
            - Equipped with raised floor, UPS, and generator. These systems are built with capacity of need plus one (N+1) to allow maintenance.
            - Critical power path and other infrastructure components may require a shut down for maintenance.
            - This system has redundant components but only a single path.
        - Tier III Data Center: Concurrently Maintainable
            - Allows for planned site activity without interruption.
            - Planned activities include: additions, removal, repair, replacement, and preventative maintenance.
            - System must be able to simultaneously carry load of one path while maintenance or other planned activities are performed on the other.
            - This system has multiple power and cooling distribution paths.
            - This system requires personnel 24/7.
- Temperature and Humidity Requirements
    - Temperature: 18-27°c (64-81°f) dry bulb
    - Maximum Relative Humidity: 60%
    - Maximum dew point: 15°c (59°f)
    - Maximum Rate of Temperature Change: 5°c (9°f) per hour

1.2.5 Wireless Local Area Network

1.2.5.1 All WLAN hardware including Access Points shall, at minimum, support the IEEE 802.11ac wireless standard and be backward compatible with IEEE 802.11a/b/g/n standards. Where possible, the design of the wireless local area network shall support draft recommendations of future upcoming standards under development by the IEEE. Coordinate with the Entity for final approval to implement recommendations. Technologies implemented shall be backward compatible with existing Entity installations. (If Applicable).

1.2.5.2 WLAN Design Criteria

- Access Point Ethernet Connections
  - Provide two or more category 6A or higher rated cables as specified in ANSI/TIA-568-C.2, deployed as part of an overall structured cabling system, to every 802.11ac access point. These connections shall properly service link aggregation of two (2) 802.11ac radios supporting 1.3 Gbps data rates as well as future 2.6 Gbps and higher data rate implementations.
  - Follow the recommendations of TIA TSB-162-A, “Telecommunications Cabling Guidelines for Wireless Access Points.
  - Temperature rise resulting from Type 2 PoE used to power 802.11ac access points shall be considered. The use of solid equipment cords, which exhibit better thermal stability and lower insertion loss than stranded conductor cords, is recommended for access point connections for this same reason.
  - Verify the system authentication server can support the inrush and outrush of users at fixed times (such as a class start and stop bell). Ensure that the server can accommodate the expected peak number of authentications per second.
  - Ensure sufficient addresses are available to support not only laptops but also smartphones and other future Wi-Fi compatible devices that may expect connectivity. Surplus space will be necessary to support inrush and outrush of users in a transparent fashion and in concert with the DHCP service lease times in order to prevent address exhaustion.
  - The DHCP server for the WLAN must also be able to accommodate an appropriate inrush peak load of leases per second. Lease times must be optimized to the length of sessions in the room so that the address space can be turned over smoothly between classes or meetings.
- Power Over Ethernet (PoE) Services
  - Validate the availability of Power over Ethernet (PoE) Power Sourcing Equipment (PSE) to support access point and WLAN equipment.
  - Power Sourcing Equipment (PSE) consisting of powered network switches (endspan) or power injectors (midspan) shall be properly planned to support the quantities and power levels of Powered Devices (PD’s) required in the wireless network.
  - In new building projects, endspan powered network switch ports shall be provided. In renovation and upgrade projects where existing non-powered network switches are used, provide midspan power injectors.
  - Power over Ethernet (PoE) equipment shall conform to IEEE 802.3at Type 2 PoE Plus at minimum and be backward compatible with IEEE 802.3af (IEEE 802.3at Type 1) Powered Devices. Proprietary Power over Ethernet equipment may be utilized with approval from the Entity.
  - Future PoE equipment shall conform to the forthcoming IEEE 802.3bt standard with Type 3 (≤ 60W at the PSE) and Type 4 (≤ 100W at the PSE) utilizing all four pairs of approved Category 6/Class E and Category 6A/Class EA cabling. The cabling shall be warranted to support IEEE 802.3bt per the structured cabling system 25-year extended warranty requirements.
- Wireless Infrastructure Design Criteria
  - In order to provide seamless interoperability across facilities, all access points must adhere to the IEEE 802.11ac wireless specifications at minimum. The WLAN shall operate at 5 GHz as well as continue to support 2.4 GHz devices.
  - The WLAN shall support Very High Throughput (VHT) data specification.
  - The WLAN shall support 80 MHz wide channels with future upgrades to support 160 MHz wide channels.
  - The WLAN shall support 256 QAM.
  - The WLAN shall provide standard beam forming to focus energy on a specific client, improving reliability and thus throughput and capacity.
  - The WLAN system shall support a minimum of three (3) MIMO streams with future growth of up to eight (8) MIMO streams and Multiple User MIMO (MU-MIMO).

- Dynamic channel and power selection features shall be provided.
- Provide spectrum load balancing to ensure even allocation of clients across available channels including dynamic client distribution features to steer 5-GHz-capable clients to that band.
- Include airtime fairness for a heterogeneous client environment with an unpredictable mix of legacy and new wireless adapters. Older IEEE 802.11a/b/g clients that require more airtime to transmit frames must not be allowed to limit newer high throughput clients.
- There must be adequate address space to accommodate all of the expected devices, including a reserve capacity for leases that straddle different meetings in the same room.
- To minimize unnecessary rate adaptation due to higher collision activity, it is a requirement to reduce the number of supported client device low rates.
- Wherever chatty protocols that produce small frames at frequent intervals are not needed, they should be blocked or firewalled. These protocols include IPv6 if it is not in production use, netbiosns, netbios-dgm, Bonjour, mDNS, UPnP, and SSDP.
- Multicast optimization shall be configured to make reliable, high quality multicast transmissions over WLAN possible. To ensure that video data is transmitted reliably, multicast video data is transmitted as unicast, which can be transmitted at much higher speeds and has an acknowledgement mechanism to ensure reliability. Transmission automatically switches back to multicast when the client count increases high enough that the efficiency of unicast is lost.
- Enable Internet Group Management Protocol (IGMP) snooping to ensure that the wired infrastructure sends video traffic to only those access points that have subscribers.
- Multicast over WLAN, by provision of the IEEE 802.11 standard, needs to be transmitted at the lowest supported rate so that all clients can decode it. Provide Multicast Rate Optimization (MRO) to track the transmit rates sustainable for each associated client to use the highest possible common rate for multicast transmissions.
- Where voice or video clients are expected, enable Quality of Service (QoS) both in the air as well as on the wire, end-to-end between the access points and the media distribution infrastructure.
- Receive sensitivity tuning shall be used to fine tune the access points to “ignore” clients that attempt to associate at a signal level below what is determined to be the minimum acceptable for a client in the intended coverage zone. This tuning helps to reduce network degradation to outside interference and/or client associations that may be attempted below the minimum acceptable signal level based on the desired performance criteria.
- Use very low equivalent isotropically radiated power (EIRP) on the access point in a high-density deployment. Enable Transmit Power Control (TPC) to lower client device power to match the APs.

- WLAN Design Planning Methodology
  - Unless specifically approved by the Entity, the WLAN coverage is throughout facilities.
  - Provide a coverage based wireless design in facilities where the goal is to provide good quality of service (in terms of RF signal strength) in as much of the area as possible with a single or multiple access points. Examples of coverage based deployments include but are not limited to sites where there is a relatively large area with few Wi-Fi devices/users such as:
    - Warehouses
    - Industrial Sites
    - Mechanical and Electrical equipment rooms and buildings
    - Clinics
    - Hotels with single occupancy rooms
    - Office Buildings
    - Retail
  - Identify and provide a capacity based high density deployment where the goal is to provide good quality wireless service to a concentrated set of concurrent users in a confined area. Generally, this occurs when more than 25 concurrent users are expected within the coverage area. Examples of capacity based deployments include but are not limited to sites such as:

- Classrooms
- Lecture halls and auditoria
- Libraries
- Stadiums
- Offices
- Conference Centers

- Follow a design process described below that establishes a WLAN capacity goal, determines the number of usable Wi-Fi channels, chooses a concurrent device target number, and validates the capacity goal is achieved.
- In coordination with the Entity, establish a capacity planning goal defining the application-layer throughput target.
  - Estimate the quantity of devices (MAC addresses) by considering the quantity of users and number of devices per person in areas to be covered.
  - Establish the minimum bandwidth required per device in consultation with the Entity. This is primarily driven by the mix of data, voice, and video applications that will be used. Request LAN traffic studies to precisely quantify this value. Consider the actual duty cycle of each device type. Incorporate diversity in that it is unlikely that maximum throughput will be required simultaneously to each device, unless required by certain applications such as interactive learning systems. Include forecasted future capacity requirements.
  - Differentiate between theoretical and practical access point throughput by accounting for protocol and packet overhead, distant clients, uneven distribution of clients on different bands (2.4 GHz vs 5 GHz), control traffic, and co-channel/adjacent channel interference.
- Determine the usable number of Wi-Fi channels. Establish an approved channel plan in coordination with the Entity.
  - The WLAN design shall ensure that non-overlapping channel within the 2.4 GHz band are used should it be necessary to provide service within this frequency. Within the 5 GHz band the design should not reuse any of the secondary frequencies should channel bonding be used to increase channel bandwidth from 20 MHz up to a maximum of 160 MHz Only channels approved within the 2.4 GHz and 5 GHz band by the CITC (Communications and Information Technology Commission) shall be used. The design shall take into consideration channels that are subject to Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC) for avoidance of interference with RADAR. If a C band (IEEE defined as 4 to 8 GHz) RADAR source is operating in the area the design shall take account of this as certain channels may automatically be disabled.
  - The WLAN should utilize the 5 GHz band for primary client service where possible because there is greater channel capacity in this band.
  - Identify and discount any reserved channels that are required for indoor or outdoor mesh backhaul.
  - Channels may be reused within clusters serving large areas, where the radios are separated from one another by free space, walls, or other structures. Typically a minimum of two cell isolation distance shall be required within large open spaces.
  - In high density applications such as very large auditoria, channel reuse is driven by the number of devices to be served. Each radio can serve a finite number of devices without either oversubscribing the access points or reusing the allowed radio channels. Channel reuse in combination with low gain antennas, Transmit Power Control (TPC) and correct positioning shall be considered in order to provide suitable coverage and performance.
  - In high density applications, use of 20 MHz channel widths (HT20) shall be evaluated to accommodate a higher total quantity of devices than is possible through use of fewer 40 MHz, 80 MHz or 160 MHz channel widths.
  - Provide 40 MHz, 80 MHz or 160 MHz channel widths in 5 GHz bands where the ability for individual stations to burst at the maximum PHY rate is required.
- Determine a concurrent user device limit for each access point radio.
  - Determine the practical limit for the number of client devices that can transmit simultaneously on each radio while still achieving the capacity goal.

        - Follow system manufacturer recommendations. For high density applications, typical rule of thumb approximations shall not be used. Where large numbers of heterogeneous users are to be covered with relatively few radios, adjust for the expected mix of legacy and high-throughput devices. Per client limits are primarily determined by the mix of legacy IEEE 802.11a/b/g, 802.11n, and 802.11ac devices expected in the high density application. The more legacy devices that are present, the lower the limit will be.
    - Determine the number of devices supported in the WLAN application using the number of non-overlapping channels available along with the number of concurrent devices planned. Validate that the WLAN meets the capacity requirements for the application. In challenging high density applications, follow an iterative process, balancing between channel count, radio loading, and minimum per client throughput to best meet the requirements of the Entity.

- Access Point Coverage Strategy
    - Wherever possible, access points shall be located overhead on ceilings with cabling concealed in finished construction. Where ceiling heights, ceiling construction, or aesthetic requirements do not permit ceiling mounting, use of side wall mounting shall be provided. Do not mix mounting strategies in the same room. When planning adjacent WLANs, use the same strategy in all rooms.
    - Access points with integrated antennae shall typically be provided. Select mounting locations that have no obstructions between the front of the integrated antenna access points and the intended wireless clients. Mount antennas with built-in down tilt parallel to the ceiling or floor so that the beam is exactly vertical.
    - Use of external antennae shall be minimized and used to provide coverage for special case applications and conditions. If external antennas are being used, plan to mount access points as close to the antennas as possible. If absolutely necessary, low-loss coaxial cable shall connect the access point to the antenna when mounting remotely.
    - Access points in overhead applications shall be distributed evenly to optimize system performance. Observe minimum physical separation distances. Access points using non-overlapping channels shall be separated so the interference target is -85 dBm to ensure that no channel bandwidth degradation occurs and all data rates are available.
    - Keep a minimum of 6” of clearance from the integrated antenna access points and any location where people will be present to observe Specific Absorption Rate (SAR) requirements.
    - Design the AP placement in high density areas such that each client sees two to three access points. If one or two access points are overloaded at any given time, the client can be load balanced to another access point without any negative impact to the end user.
    - Provide and position access points to permit power level settings to one half at 2.4 GHz and 5 GHz to mitigate co-channel and adjacent channel interference.
    - Site Survey Requirements
        - Predictive Surveys
            - Use computer-based software applications to model the facility and RF environment shall be performed.
            - Outline the required coverage areas using facility CAD or BIM files. Define facility structures to aid in estimating RF signal attenuation.
            - Establish thresholds for minimum signal strength and application throughput that clients must achieve.
            - Predict the quantity, location, and type of access points that should be installed.
            - Provide channel and power settings that maximize spectral capacity while minimizing co-channel and
            - Adjacent-channel interference (CCI/ACI).
        - Pre-deployment Site Survey
            - A pre-deployment survey shall be performed prior to WLAN network installation to determine the actual RF signal propagation characteristics of the environment.
            - The preliminary Wi-Fi network design shall be verified by using a predictive site survey and shall reduce the need for network adjustments once WLAN equipment is procured and installed.

  - Spectrum analysis shall be performed through a Calibrated Spectrum Analysis equipment to detect possible interferences that could cause WLAN performance issues. A copy of the Calibration Certificate of the equipment shall be issued to Entity. Remediate sources of interference prior to deployment.
  - Test transmitters' proposed AP locations with data points taken to establish the predicted wireless coverage for each location. The transmitter shall simulate the AP positioning and determine the actual coverage.

- For mobile devices to be tracked properly, a minimum of three access points (with four or more preferred for better accuracy and precision) shall be detecting and reporting the received signal strength (RSSI) of any client station, asset tag, or rogue device being tracked. It is preferred that this detected signal strength level be -75dBm or better.
- WLAN Controllers shall manage the WLAN.
  - The controller shall support all modes of access point operation and will provide scaling up to the quantity of access points and clients required by the Entity.
  - The controller shall offer redundancy offering sub−second failover of thousands of access points to a standby controller.
  - The controller shall offer service provider features such as Wi−Fi Certified Pass point (HS2.0) for secure public connectivity and Proxy Mobile IPv6 (PMIPv6) to ensure seamless mobility between Cellular and Wi−Fi.
  - The controller shall regulate the power output of each AP to adjust the coverage zone. Additionally, they optimize the number and placement of access points.
  - The controller shall detect the status of access points to determine if any have failed.
  - The controller shall provide security by denying network access to improperly configured devices
  - The controller shall detect and locate the unauthorized access points.
  - The controller shall balance the load of network traffic among the access points in the area.

- Security
  - The use of WPA2-CCMP/AES is required. Avoid selecting TKIP or WEP, which would result in limiting client operation to legacy (802.11a/b/g) data rates per Wi-Fi Alliance certification requirements.
  - Use one of the following network security options: WPA2 802.1X (Enterprise) or WPA2 PSK (Personal).
  - When enabling Layer 2 security, ensure WPA2-Enterprise or WPA2-Personal key management and CCMP/AES encryption is selected. Avoid selecting Auto (WPA or WPA2) or WPA for the key management and TKIP for the encryption cipher, which could result in clients using WPA (TKIP) instead of WPA2 (CCMP/AES) and being limited to legacy (802.11a/b/g) data rates.
  - Use Quality of Service (QoS) mechanisms through Wi-Fi Multimedia (WMM) to prioritize latency and jitter-sensitive traffic such as voice and video.
  - Require users to provide authentication credentials before they are allowed to use a wireless network. Provide authentication via RADIUS (RFC 2865) which can be back-ended an LDAP enabled directory.

- Implementation Policies
  - All departments that wish to deploy wireless networks must work with and obtain certification for any wireless design from Entity.
  - To facilitate IP address assignment via DHCP, the wireless network card's address can be registered in the Entity central DHCP database.
  - Access to the wired campus network from wireless APs must be controlled via secure authentication where the authentication credentials can be associated with a unique individual.
  - MAC (network card) address authentication can be employed by pointing access points to a RADIUS server containing the allowed MAC addresses, but shall be used in conjunction with WPA2- CCMP/AES.

1.2.6 Telephone and Intercom

1.2.6.1 Telephone and intercom systems provided in new and renovation projects shall be IP based systems only. Refer to additional sections below for descriptions of existing legacy Entity telephone systems (If applicable).

1.2.6.2 IP Telephone System

- IP Telephone system service shall be provided for Entity operated facilities only.
- To support IP telephony, a multi-service network shall be provided on which voice, video, and data can coexist over a single IP-based infrastructure.
- The network shall support traffic prioritization mechanisms using Layer 2 (IEEE 802.1p/Q) and Layer 3-IP type of service (TOS), IP precedence, DiffServ Code Point (DSCP), UDP/TCP Port and/or IP address.
- The system shall provide voice, signaling, central processing and communications resources including voice mail, ACD (automatic call distribution), and systems management.
- The network shall support open standards that promote interoperability with VoIP products.
- Plan for the provisioning of Entity Metropolitan Network MAN connectivity to support the IP Telephone system with sufficient bandwidth. Determine the additional bandwidth and performance that will be required for new voice services. The link must be provisioned with sufficient bandwidth to simultaneously support the maximum number of desired voice calls and business-critical data applications. Each active telephone call shall typically require 100 Kbps of bandwidth for each uncompressed (G.711) and 40 Kbps for each compressed (G.729) telephone conversation.
- In addition, the system shall have to ability to support digital trunks to PSTN and connectivity for analog trunks and telephones (POTS). Provide failover transfer for direct connection between an analog telephone and loop start trunk in the event of a system or power failure.
- Provide a complete management application to control the operation and management of the IP Telephone system using web based system management tools.
- Provide interface permitting building paging and public address capabilities.
- DHCP service shall be configured for IP phones.
- Coordinate with the Entity to configure the dial plan and emergency call services.
- The IP telephone network shall have port security, DHCP snooping, DAI, and other mechanisms to protect Layer 2 enabled.
- Quality of Service
    - Provide end to end Quality of Service (QoS) to ensure that voice quality is protected in the presence of bursty data traffic.
    - For toll-quality voice, provide packet loss of less than 1%.
    - For toll-quality voice, ensure jitter of less than 50ms variation in delay of sequentially transmitted packets.
    - For toll-quality voice, provide latency less than 150ms end-to-end delay. For the MAN links, provide a one-way delay of 80ms or less.
    - To deliver toll-quality voice on an end-to-end basis, voice traffic must be prioritized higher than bursty data traffic on every link along the data path between IP telephones.
- VLAN Implementation
    - VLAN topologies shall be implemented to fully isolate voice and data networks with no routing between them. Create end-to-end QoS policies in a heterogeneous suited to a multi-vendor deployment of switches, routers and end-hosts.
    - VLANs shall also ensure that excessive broadcast and multicast packets present on many data networks will not disrupt IP telephony equipment or affect voice quality.

- Because the VLAN tag is not retained when the frame is forwarding over WAN links, enable a Layer 3 prioritization method as well.
- Assign different subnet addresses to voice and data VLANs for increased security between voice and data traffic and ensuring that all call control and voice traffic gets the appropriate level of priority.

- System Resiliency
  - Provide redundant IP call manager appliances, voice gateways, core network devices, and access network devices in a distributed, physically separated fashion. Configure the IP telephone system such that no single point of failure will result in a total system outage.
  - To ensure resiliency in the event of a MAN failure, provide a migration path with a legacy PBX systems, and allow staged VoIP deployments, the IP Telephone system shall facilitate a variety of trunks for publicly switched transmission network (PSTN) or analog connections. The local PSTN also ensures that local phone service does not need to traverse the MAN link and provides service to analog devices such as fax, modem, and emergency services.
  - UPS power shall eliminate the impact of power glitches and allows for a graceful system shutdown in the event of an extended outage.
  - IP Telephone equipment shall be configured with redundant power supplies.
- Telephone Units
  - Develop an equipment list for each project indicating quantities, locations, and types of handsets to be deployed.
  - IP Phone must support pass-through to connected PC equipment with switched 10/100/1000 Base-T with VLAN priority tagging (802.1p/Q).
  - Support Quality of Service (QoS)
  - Support programmable station keys and support basic call features such as hold and speed dial.
  - Support the IEEE 802.af or 802.at PoE standards.
  - Built-in compression with G.711, G.729 codecs, and SIP v2 Protocol
  - 128-bit AES (Advanced Encryption Standard)
  - IP Telephone Handsets
    - Identify as part of project equipment lists the types, quantities, and locations for IP telephone handsets.
    - IP telephones shall have the following properties:
      - Integral switch supporting 10/100/1000 Ethernet.
      - Speakerphone
      - Message waiting indicator
      - Handsfree support
      - Power over Ethernet, minimum IEEE 802.3af compliant
      - IEEE 802.1p/q compliant
      - DHCP compliant
      - Codecs: G.711a, G.711μ, G.729, G.729a, and G.729b
    - Basic IP telephones
      - Integral switch supporting 10/100 Ethernet
      - Monochrome LED pixel-based display
      - Wall Mounted
        - Wall mounted telephone mounting heights shall be proportional to the height of the person of use.
        - Provide wall phones in utility spaces
    - Office
      - Integral switch supporting 10/100/1000 Ethernet.
      - 127 mm graphical, 320 x 240, backlit, 16-bit, color display
      - Dual-port, multi-line display, IP speakerphone with programmable keys

  - 4 soft keys, 6 line keys for use as lines, speed dials or programmable keys.
  - Third party XML support
  - These phones also support new modes of collaboration, such as: integrated high-definition voice, video, and conferencing; instant messaging and presence; instant access to cloud services; USB peripherals for extensibility; and Bluetooth.
- Conference Room Phones
  - Integral switch supporting 10/100/1000 Ethernet
  - Conference phones shall be full duplex audio
  - Wired or wireless microphone kit

- Voicemail Requirements:
  - System shall provide voicemail for all extensions.
  - Directory lookup by called party's last name shall be available.
  - System shall have the ability to clear out and initialize all mailboxes using a bulk administration tool for summer time maintenance.
  - Message Indication – the receipt of a message in a mailbox shall initiate a message waiting light or a stutter dial tone to indicate a new message condition.
  - System must have both Global and per Mailbox settings.
  - System must allow programmable mailbox features such as, but not limited to:
    - Size of mailbox
    - Length of greeting
    - Maximum recorded message length
    - Message full warning indicator
    - Internal and external greeting
    - Reporting by mailbox
- Call Accounting
  - System shall include built in reporting capabilities.
  - Call Record fields need to include, but are not limited to the following:
    - Date
    - Time
    - Called Number
    - Calling Number by Extension
- Voice Gateways
  - Voice gateways may be required on per project basis where it is a requirement for buildings to access local TSP telephony services for connection to the IP telephone system.
  - Voice gateway shall convert TDM telephony traffic from the Publicly Switched Telephone Network (PSTN) into digital IP packets for transport over IP network. It shall also convert digital IP packets into TDM telephone traffic for transport across the PSTN.
  - The Gateway shall bring application intelligence into the network and enable efficient deployment of secure, reliable, and accelerated Extensible Markup Language (XML) applications and Web services. This shall enable the intelligent network to support service-oriented architecture (SOA) implemented using web services technologies and to accelerate, secure, and scale XML applications.
  - Gateway shall permit auto-provisioning of web services from Universal Description Discovery and Integration (UDDI) registry and application servers, and provide transport and message-level security for XML - based network traffic.
  - Gateway shall enable a shared-service environment, reducing end-to- end latency, and enabling business services to scale to meet capacity imperatives while improving server utilization.
  - Gateway shall permit XML messages of all sizes to be processed without compromising security, interoperability, or system reliability.

1.2.6.3 Existing Telephone Systems: The following is a description of existing systems and applies only for minor moves, additions, and changes required in renovation projects, where telephone system upgrades to current technologies are not in the scope of work.

- Existing EPABX With Public Switched Network Description
  - General
    - In order to conserve manpower resources, to minimize call holding time and usage, to provide for maximum signaling control on the public switched network and to be consistent with the Kingdom Standards, all EPABX applications shall be equipped for the following:
      - Outgoing to Public Switched Network
        - One-way, 2-wire, direct outward dial (DOD), loop start PABX to exchange trunks.
        - The method of pulsing shall be DTMF as per ITU-T Recommendations.
        - Upon seizure from the PABX (polarity reversal), the public exchange switch shall transmit 425 Hz continuous dial tone at a nominal -13 dBm toward the PABX. The public exchange dial tone shall be transmitted through the PABX switch matrix to the PABX extension originating the call. The PABX extension shall then dial (DTMF transmitted to the public exchange switch) the desired number.
      - Incoming from Public Exchange Switch
        - All PABX applications shall be equipped for direct inward dial (DID) directly to PABX extensions from the public switched network using one-way trunk circuits consisting of loop start line signaling and R2-MFC inter-register pulse signaling.
    - Numbering Scheme
      - The numbering scheme used in the PABX must be coordinated with the Entity so that the numbering plan will match the local public network switch.
      - The National Numbering Plan requires 10 digit numbers of which the first 3 are the public exchange Switch NXX code. The last 7 digits identify the particular number of the lines associated with that code. A maximum of 4 digits shall be used for PABX extensions.
      - The number of DID trunks depends on the volume of inward traffic to the PABX. Sufficient numbers of trunks must always be available to provide non-blocking access into the PABX the public network service exchange to a PABX shall be 95% or better. If subscriber equipment performance or capacity limitations degrade the public network standard and adversely affect other subscriber usage, the Entity will take any measures deemed necessary to protect the public network.
      - DID trunk circuits are comprised of two factors; line signaling and line pulsing (inter-register).
        - Line signaling shall be 2-wire loop start (a and b wire battery reversal).
        - Line pulsing shall be accomplished by means of ITU-T based, Saudi Telephone modified, R2-MFC inter-register signaling.
        - Upon special request and following review and approval by the Entity, a separate PABX attendant 2- way, 2-wire trunk group may be established using the PABX main number, if the PABX application is large enough to require full-time attendant(s) operation.
        - In cases when small PABXs up to 120 extensions, are considered and trunk R2-MFC interface is not yet available from manufacturers, the system application should be reconsidered for a large hybrid EKTS or for Special Business Service. If all desired features cannot be provided in the EKTS or Centrex mode, then a deviation request may be submitted to the Entity.
    - Deviation
      - If any deviation is required from the standard DOD, DID R2- MFC for any PABX applications, a deviation request must be submitted to the Entity for review and/or approval.
      - The PABX shall have means to internally test any DOD or DID trunk appearance.

- The PABX customer shall perform tests the interface point before any PABX trunk faults are reported to the Entity.

- PABX

  PABX trunk blocking, automatically or manually, shall be accomplished by disconnecting either the trunk battery negative polarity, positive polarity, or both, from the battery supply.

- Transmission Parameters
  - The trunk interface for all EPABX's shall be analog/digital.
  - The following technical criteria shall be required of any PABX equipment operating within the Entity switched network:
    - Signaling Frequencies
      - The frequency tolerance shall be ± 4 Hz.
      - Power level of each un-modulated signaling frequency shall have a value of -14.5 dBm ± 1 dB.
      - Signaling frequency power level of any leak current transmitted to the Entity facilities must be at least 50 dB below the nominal level of anyone frequency when no multi-frequency combinations are being sent, and at least 30 dB below the level of either one of the signaling frequencies when a multi-frequency combination is being sent.
      - The inter-register receivers may be sensitive to the transmission characteristics of the unloaded cable plant with respect to frequency attenuation and balance return loss. Provision shall be made for field adjustable compensation options to accommodate mixed or single gage, (0.4, 0.5, 0.65) non-loaded, 600 ohm outside plant facilities with a range from 0 to 8 dB.
      - The sensitivity range of the multi-frequency signaling equipment shall be -5 dBm to - 35 dBm.
      - The total power level of all frequencies due to harmonic distortion and inter-modulation between 300 and 3400 Hz shall be at least 37 dB below the power level of any one frequency.
      - The time interval between the start of sending of each of the 2 frequencies constituting a multi-frequency combination shall not exceed 1 ms. The time interval between the cessation of sending of each of the two frequencies shall not exceed 1 ms.
      - The operate and release times of the receive section of the multi-frequency signaling shall be (To + Tr) = 70 ms.
      - When multi-frequency combination has caused the receive section of the multi-frequency signaling equipment to operate, the latter shall not release if the signaling frequencies are interrupted for less than 7 ms.
      - The longest signal to be ignored by the receive section of the multi-frequency signaling equipment shall be 8 ms.
      - The acceptable difference in power level of the 2 frequencies of a multi-frequency pair shall be less than 5dB for adjacent frequencies and less than 7 dB for nonadjacent frequencies.

- Traffic Parameters
  - The PABX matrix and processor shall be designed, and the number of trunk circuits from the public switched network calculated to provide free access into the PABX, thereby protecting the public switched network against congestion caused by unnecessary call attempts.
  - To ensure an acceptable grade of service for PABX users, the PABX switch matrix, processor and trunks should be engineered for the following busy hour parameters:
    - 0.12 Erlangs per extension (combined originating and terminating).
    - 0.24 Erlangs per PABX - exchange trunk.
    - Blocking factors should be 1:200 (0.005) for originating, terminating and intra-PABX calls.
    - Local Call Average Holding Time: 100 s.

  - Long Distance Call Average Holding Time: 120 s.
  - Dial Tone Delay to PABX Extension: No call attempts delayed over 3 s.
- The processor capacity shall be engineered to accommodate nonblocking during busy hours for switching, special feature processing, maintenance diagnostics, traffic measuring and message recording.
- The switch matrix may be either time- or space-based; however, the switch cross points must be solid-state.

- Signaling Tones and Announcements

  The following signaling tones are Ministry of Communication and Information Technology (MCIT) standard and in order to present the minimum contrast to the user should be closely approximated:
  - Dial Tone: 425 Hz, continuous.
  - Ringing Tone: 425 Hz, 1.2s on, 4.65 s off.
  - Busy and Congestion Tone: 425Hz 0.5s on, 0.5 s off.
  - Intrusion Tone: 425 Hz, 0.17s on, 0.17s off, repeated.
  - Number Unavailable Tone: 425Hz, 0.2s on, 0.2 s off, repeated.
  - Signaling from a PABX that affect the performance measurements of the public network or cause confusion to the public network administration shall not be accepted.
- Announcements
  - No information signals or announcements are allowed from the PABX before the answer signal except ringing tone.
  - Announcements provided by the PABX shall convey only PABX related messages (limited to PABX or business identification).
- Additional Requirements
  - A negative 48V DC power plant shall be supplied with capacity to provide DC power for the PABX and all peripheral equipment. If critical peripheral equipment is AC powered such as the maintenance teletype, and user determined critical message detail recording equipment, a DC to AC inverter shall be provided. The DC power plant shall be able to provide power at the required operating voltage for a minimum of 48 hours.
  - A rectifier capable of charging the batteries from a fully discharge state to fully charge in an 8-hour period while maintaining normal PABX load shall be provided. The rectifier shall be of an automatic constant voltage and current limited type.
  - Batteries shall be lead calcium or nickel cadmium type. During normal operation, the batteries shall be floated across the load.
  - Remote power alarms shall be provided for:
    - AC power failure
    - Rectifier failure
    - Low voltage
    - High voltage
- PABX System Requirements
  - The PABX system shall physically consist of free standing cabinet(s) of modular construction or wall mount.
  - The stored program control (SPC) operating features and configurations shall be executed from the attendant console or the maintenance console.
  - The generic program must be non-volatile or be protected in the event of AC power failure.
  - The system alarm shall be provided with a remote major alarm to indicate call processing failure or AC power failure.
  - Generic programs and feature releases shall be easily updated as released.
  - The equipment cabinet should be arranged to permit all circuit board replacement and provide maintenance access points, while operating from the front. If rear access is required, the installation shall provide for such access.

- The system shall be provided with complete sets of installation and operations documentation.
- All specialized tools, circuit board extenders, backup program tapes shall be provided for the PABX and DC power systems.
- Consumable and component spares shall be provided for a minimum of 2 years' service.

- Main Distribution Frame
  - A main distribution frame, using the "quick-connect" termination technique, shall be provided. All PABX system extension lines, PABX to exchange trunks, consoles and peripheral equipment shall be terminated on the MDF.
  - All outside plant cable pairs shall be terminated on MDF blocks equipped with protectors. The protection devices shall be 3-element, fail safe ionizing discharge tubes.
  - The terminal blocks shall normally be mounted on industry standard steel framework.
  - If there is inadequate equipment space, industry standard 1-sided, wall mounted terminal block arrangements may be provided.

- Modifications to Existing Tertiary Telephone Cabling for Residential Housing
  - Refer to TSP standards for most up to date requirements.
  - The tertiary network is defined as the portion of the telephone networks from the telecommunications handhole, provided by others and located at the Subscriber Property Line, to the telephone outlets in the subscriber's residence. This includes but is not limited to ductwork, cables, protectors, splitters, amplifiers and jacks. All defined equipment and fittings must be provided and installed by the Contractor building the individual house or apartment.
  - The telecommunications handhole shall be equipped with two 32 mm (ID) HDPE duct stubs for each individual residence or small apartment building.
  - The ducts shall be joined to the duct stubs and extended to the building, maintaining a minimum of 600 mm of cover from final grade to top of duct and having the lowest point of the duct run at the handhole entrance.
  - At the building, the ducts shall be joined to factory preformed 90 degree bends.
  - The telephone cable shall be installed in a 50 mm duct and shall terminate in separate flush mounted wall boxes.
  - Wherever practical, handholes shall be placed at the property line between adjacent residences and subscriber cables installed for each building. Handholes shall serve a maximum of ten adjacent subscribers. The only allowable exceptions to serving more than ten residences from one handhole are as follows:
    - A subscriber cable duct may be extended from a handhole to serve the last residence on the street if no future duct extensions will be required such as at the end of a cul-de-sac or where common property lines abut a street at one point, again as at the end of a cul-de-sac or along the inside radius of a sharp curve.
    - Separate conduit runs shall be provided for telephone and TV cables within the buildings.

- Modifications to Existing Telephone Tertiary Network
  - The Telephone Tertiary Network consists of provision and installation of an outdoor telephone cable conforming to the requirements stipulated by the Entity from the telecommunications handhole to the residence telephone protector access box. An indoor telephone cable conforming to the requirements stipulated by the Entity shall be extended from the protector to all telephone outlets.
  - Connection to the telephone distribution cable in the handhole will be done by the A/E, as applicable.
  - Wall outlets shall be installed at 300 mm AFFL, in a standard flush wall box for desk type telephones and at 1350 mm AFFL for wall mounted telephones.
  - The indoor cable may loop from outlet to outlet.
  - The outdoor telephone cable shall be a paired, 0.9 or 0.65 mm conductor non-armored polyethylene sheath filled cable containing a minimum of two 4 pair for each single residence. (or else, as per the standard, code and specification)

- The indoor telephone cable to standard telephone sets shall be a minimum of one 3 pair 0.9 or 0.5 mm copper conductors individually color coded with polyethylene conductor insulation and enclosed in a polyvinyl chloride jacket. (or else, as per the standard, code and specification).
- Both indoor and outdoor telephone cables shall be free from opens, shorts, grounds and transpositions on all pairs.

- Existing Telephone Line Protection
  - All subscribers' equipment shall be connected to the outside plant entrance facilities via a 3 element, 350 V DC ionizing discharge tube, inserted in every pair entering and/or leaving the building.
  - These protection devices shall be installed at the common point of entry to the building and shall be connected to the building grounding system via an isolated and independent ground lead
  - In the event that a building ground is not readily accessible at the common point of entry, it shall be the A/E responsibility to establish a ground point that conforms to Guideline Specifications.
  - The line shall be capable of withstanding the following conditions without damage to subscriber equipment:

TABLE - CONDITION TO WITHSTAND

Applied Voltage	Period of Application
1000 V	20 microseconds
900 V	100 microseconds
500 V	400 microseconds
100V	1 second
+/- 20%	Normal working condition

- Existing Protector Outlet Box
  - General

    The Residence Protector Outlet Box shall be flush mounted, accessible from the outside and of sufficient size, for the telephone service to:
    - Contain two 3 element 350 V Fail-Safe Gas Discharge Tubes.
    - Terminate 50 mm duct from telecommunications handhole.
    - Terminate conduit runs for telephone outlets.
    - Terminate 25 mm conduit nipple from the CATV service box.
    - Terminate a 25 mm conduit for the ground lead and for the CATV service to:
      - Contain an over voltage protection unit.
      - Terminate a 50 mm duct from the telecomm handhole.
      - Terminate conduit from internal CATV outlets.
      - Terminate a 25 mm conduit nipple from the telephone service box.
  - Protector Outlet Box for Apartments

    The apartment protector outlet boxes shall be of sufficient size to house the above items as required for each residence in the building.

1.2.6.4 Intercom Systems

- Intercom systems provide building audio or audio and video communication between designated locations using a two-way connection between a substation and master station.

- The intercom systems shall utilize building IP network based communications and be connected through the building telecommunications structured cabling systems.
- Intercom systems shall be provided within various facilities/locations for the following applications as directed by the Entity on a per project basis.
  - Schools
    - Door/Gate Entry Access Control
    - Emergency Communications
  - Residential Facilities
    - Door Entry/Gate Control
    - Multi-tenant Entrance Communications
  - Industrial Facilities
    - Door/Gate Entry Access Control
    - Emergency Communications
  - Healthcare
    - Door/Gate Entry Access Control
    - Emergency Communications
  - Commercial/Retail
    - Door/Gate Entry Access Control
    - Security Transaction Window
  - Transportation/Car Parks
    - Door/Gate Entry Access Control
    - Security Transaction Window
    - Emergency Communications
- Door/Gate Entry Access Control Requirements
  - Door intercom stations shall be located at normally locked building visitor entrances, after hour entrances, service door locations, gates and other locations determined through the project planning process.
  - Door intercom stations shall permit hands free communications with a master station with activation of the call button with LED status indicator.
  - Door intercom stations shall be of stainless steel construction and rated for interior or exterior environments. In new construction, doors stations shall be recess mounted flush with finished construction.
  - Concealed conduit pathway, minimum of 75 mm diameter shall be provided to serve the door station backbox.
  - Indicate mounting height of door stations to permit call button activation at standard switch height and permit video camera view area to capture face and torso of visitor.
  - Locate door intercom stations adjacent to door entrance with clear approach to unit. Stations serving vehicle entrances shall be bollard mounted and permit operation through driver side vehicle windows. Avoid locations where direct sunlight will interfere with system camera. Provide shrouds around the devices where necessary at exterior locations to mitigate environmental interference with system operation.
  - The door station shall be IP addressable and powered by Power over Ethernet (IEEE 802.3af, at, or bt). The station shall be connected to the building LAN through structured cabling using one (1) minimum ANSI TIA Category 6/ ISO-IEC Class E cable Ethernet connection. Network connections shall be provisioned with quality of service, VLAN separation, and multicast support.
  - The door substation shall support video surveillance through a fixed ONVIF compatible integrated IP camera. Constant video streaming from the door station shall be provided. Digital pan, tilt, and zoom camera with wide angle lens shall be provided.
  - The door substation shall permit mounting of an integrated card reader connected to the building access control system (if available) to unlock the door for valid credential holders.

Access control system cabling shall be provided into the substation for connection to the card reader.

- Form C relay outputs shall be available with a connection to the local door hardware power supply to permit remote release unlock of the door for authorized visitors.
- Door intercom stations shall be capable of communicating with all building master station locations.
- Master stations shall be located within buildings at reception points, service desks, security offices, maintenance management offices, or other monitoring locations deemed required by the project planning process.
- Master stations shall provide hands free communication with handset for privacy to any substation.
- The master station shall be IP addressable and powered by Power over Ethernet (IEEE 802.3af, at, or bt). The station shall be connected to the building LAN through structured cabling using one (1) minimum ANSITIA Category 6/ ISO-IEC Class E cable Ethernet connection. Network connections shall be provisioned with quality of service, VLAN separation, and multicast support. Network protocols accepted shall include: IPv4, IPv6, TCP, UDP, SIP, HTTP, HTTPS, RTSP, RTP, RTCP, IGMP, MLD, SMTP, DHCP, NTP, and DNS.
- The master station shall have an integrated color LCD display to view substation video surveillance.
- The master station shall have programmable Form C dry contact multipurpose relays to enable remote release of access controlled doors triggered by the operator.
- The master station shall be desk, wall, or rack mounted depending on project requirements.

- Security Transaction Window
  - A window security intercom system shall be provided where determined on a per project basis to permit secure and environmentally protected public communications.
  - The attendant shall utilize a gooseneck microphone and mono type headset.
  - Communication shall be voice activated requiring no additional operations during conversation.
  - The system may be placed in standby by the operator, muting the attendant and playing public side audio at a reduced level.
  - A detection sensor shall be used to signal the system when a customer is present.
  - An external speaker and acoustic tube or microphone shall be provided to communicate with the public side. Lobby or waiting area paging speakers shall be connected to the attendant's station to permit queued pages.
  - Noise cancellation shall be used in the system to reduce background noise.
- Emergency Communications
  - Emergency communications station locations shall be determined by the project planning process or by the Entity after review of building and site plans. Propose locations based upon project security risk assessments.
  - Typical emergency communications station locations include but are not limited to:
    - Elevators
    - Car parks
    - Pedestrian walkways
    - Public building corridors
    - Parks
    - Universities
  - Emergency communications stations shall permit hands free communications with police or designated security personnel capable of providing emergency assistance, with activation of the call button with LED status indicator.
  - Emergency communications stations shall be labeled with "EMERGENCY" lettering in English and Arabic.

- Each station shall automatically place a call to preprogrammed number when activated. In the event that the call is not completed, the station shall rollover to a second and third preprogrammed number until completion of the call.
- Emergency communications stations shall be of stainless steel construction and rated for interior or exterior environments. In new construction, stations shall be recess mounted flush with finished construction. Stations may stanchion mounted where designated as freestanding in the site.
- Concealed conduit pathway shall be provided to serve the emergency communications station backbox.
- Indicate mounting height of door stations to permit call button activation at standard switch height and permit video camera view area to capture face and torso of visitor.
- Locate door emergency call stations with clear approach to unit. Provide shrouds around the devices where necessary at exterior locations to mitigate environmental interference with system operation.
- The emergency communications station shall be IP addressable and powered by Power over Ethernet (IEEE 802.3af, at, or bt). The station shall be connected to the building LAN through structured cabling using one (1) minimum ANSI-TIA Category 6/ ISO-IEC Class E cable Ethernet connection. Network connections shall be provisioned with quality of service, VLAN separation, and multicast support. Where call stations are located on sites not in direct vicinity of buildings, connection shall occur through one of the following means:
  - Underground single mode fiber from the Entity Metropolitan Network. Final device connection will be supplied through a fiber to copper media converter.
  - Cellular Gateway
  - The station may be powered through utility service drop, solar array module/battery, or night charge/battery
- The emergency station shall support video surveillance through a fixed ONVIF compatible integrated IP camera. Constant video streaming from the station shall be provided. Digital pan, tilt, and zoom camera with wide angle lens shall be provided.
- Form C relay outputs shall be available and used to a trigger beacon strobe light integral to the unit housing. This feature shall be provided in outdoor areas and car parks.

- Harsh Environmental Conditions
  - In industrial or otherwise harsh environments subject to dirt, dust, and water infiltration, provide IP66 or IP67 rated components to suit location requirements
  - Components shall incorporate noise cancellation technologies.
  - Housings shall be constructed of rugged antistatic plastic or aluminum and stainless steel housings.
  - Stations shall permit integration of push to talk microphones.
- Multi-tenant Entrance Communications
  - In multi-tenant, residential developments, provide a visitor entrance communications intercom system.
  - The system shall permit visitors to announce their presence to individual residences through a video entrance station.
  - Entrance stations shall be located in the main vestibule or lobby of the facility and provide the following functionality:
    - Wide angle camera allows user to view up to 170° of the entry area
    - Direct digit dialing, alphabetical scrolling, or jump scrolling by letter to select tenant name
    - Digital panel stores tenant names/number locations and unique access codes to activate door release
    - Built-in motion sensor to detect presence of a visitor (optional)
    - PC software for loading resident information, access codes, and welcome message
    - Hands-free communication
- Tenant intercom stations shall be provided within residences wall mounted near entrance. Intercom stations shall provide the following functionality:

- Color LCD screen with picture memory for recording visitor images
- Hands-free or push-to-talk communication
- Door release and security guard / concierge call buttons
- Security inputs for alerting tenant and guard

1.2.7 Structured Cabling

1.2.7.1 General

- Structured cabling systems shall comply with the following standards:
  - Structured Cabling Component Standards
    - ANSI/TIA-568-C.2: Balanced Twisted-Pair Telecommunications Cabling and Components.
    - ANSI/TIA-568-C.3: Optical Fiber Cabling Components
  - Project Type Structured Cabling Standards
    - Commercial Buildings - ANSI/TIA-568-C.1 Commercial Building Telecommunications Cabling
    - Residential Buildings - ANSI/TIA-570-C Residential Telecommunications Infrastructure Standard, and ISO/IEC 15018 Edition 1.0: Information Technology – Generic Cabling for Homes
    - Data Centers – ANSI/TIA-942-A Telecommunications Infrastructure Standard for Data Centers, and ISO/IEC 24764 Edition 1.0: Information Technology – Generic Cabling Systems for Data Centers
    - Industrial Facilities - ANSI/TIA-1005-A Telecommunications Infrastructure Standard for Industrial Premises, and ISO/IEC 24702 Edition 1.0: Information Technology - Generic Cabling - Industrial Premises
    - Educational Facilities - ANSI/BICSI 001-2009, Information Transport Systems Design Standard for K-12 Educational Institutions
    - Healthcare Facilities - ANSI/BICSI 004-2012, Information Technology Systems Design and Implementation Best Practices for Healthcare Institutions and Facilities
  - System Level Standards
    - Implementation of Structured Cabling Systems - ISO/IEC 14763-2 Edition 1.0: Implementation and Operation of Customer Premises Cabling – Part 2: Planning and Installation
    - Telecommunications Cabling and Terminations - ANSI/TIA-568-C.0: Generic Telecommunications Cabling for Customer Premises, ISO/IEC 11801 Edition 2.2: Information Technology – Generic Cabling for Customer Premises, and ISO/IEC 14763-2 Edition 1.0: Implementation and Operation of Customer Premises Cabling – Part 2: Planning and Installation
    - Telecommunications Pathways and Spaces - ANSI/TIA-569-C: Telecommunications Pathways and Spaces
    - Telecommunications Labeling Criteria - ANSI/TIA-606-B Administration Standard Telecommunications Infrastructure, and ISO/IEC 18598: Automated Infrastructure Management (AIM) Systems – Requirements, Data Exchange and Applications
    - Telecommunications Grounding Requirements - ANSI/TIA-607-B Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises, and NECA/BICSI 607-2011 - Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
    - Building Automation Systems - ANSI/TIA-862-A: Building Automation Systems Cabling
    - Outside Plant Cabling Systems - ANSI/TIA-758-A Customer-owned Outside Plant Telecommunications Infrastructure Standard
- Structured cabling for LAN's within buildings shall be based on a star topology unless otherwise stated.

- The structured cable plant shall be installed by a manufacturer certified contractor using approved components such that the manufacturer provides an extended applications assurance warranty for a period of 10 years as a minimum. The structured cabling system performance shall be warrantied to exceed all relevant global cabling system standards, including Category 6 and Category 6A as well as ISO/IEC 11801 Class E and Class Ea.
- Singlemode optical fiber shall be provided in the intra building backbone and conform to the ITU-T G.652 standard.
- Unless otherwise directed by the Entity, provide spare fibers and conductor pairs in cables; positions in patch panels, cross-connects and terminal strips and space in conduit, pathways, cable trays and wire way to accommodate 20% future increase in active workstations. Cable pathway fill percentages shall observe requirements of ANSI/TIA-568-C.0, ANSI/TIA-569-C, and ISO/IEC 14763-2 ed1.0.
- In order to minimize costs over the long term, it is highly desirable to develop a comprehensive building network design that takes into account the needs of all of the building occupants. Once that design has been developed, it can be implemented in phases as funding permits.
- Building networks that adhere to structured wiring specifications typically have one central wiring closet called a main distribution frame (MDF) and one or more distributed wiring closets called intermediate distribution frames (IDFs).
- Each IDF shall be star wired back to the MDF via fiber optic cabling. Fiber cabling supports longer distances than twisted pair copper wiring and it is immune to electrical interference and grounding problems. It also has the potential for supporting high data transmission capacities (gigabits per second).
- Twelve strands of fiber cabling shall be run from MDF to each IDF to provide for future growth and redundancy.
- The LAN components of an IDF minimally consist of one or more rack mounted switches (either modular chassis or stackable, shared and/or switched) with each hub port connecting to a port on a rack mounted patch panel via a stranded wire Category 6A UTP patch cable. Each port on the patch panel is connected to an RJ-45 wall plate in an office through a solid conductor horizontal Category 6A UTP cable running through the building infrastructure.
- The networked device is connected to the wall plate via a stranded wire Category 6A UTP station cable.
- The total cable length for CAT 6A UTP wiring is 100 m (90 m for horizontal cabling and 10 m for both station and patch cables combined). As indicated above, fixed horizontal cables must use solid copper Category 6A wire, whereas, patch cables must be stranded copper Category 6A wire. When designing and installing Category 6A wiring, it is important to stay away from sources of electrical interference, e.g., 300 mm from light ballasts and 1.2 m from electrical devices such as high-voltage transformers, electric motors, microwave ovens and Xerox machines.
- Cable trays shall be installed above ceilings to provide clearly defined paths for horizontal Category 6A wiring, and can keep cables from sources of electrical interference. They also protect cables from damage by other personnel working above ceilings.
- Rack mounted patch panels shall provide the direct termination points for Category 6A wiring in the IDF. Although Category 6A cabling can be terminated in 110-type punch down blocks, it is not recommended unless that type of termination block will be installed for both telephone and data services.
- Under no circumstances shall 66-type punch down blocks be utilized since they can adversely affect data signals. One shall also not plan to allow two signals (either LAN-LAN or LAN-VOICE) within the same four pair of a Category 6A cable.
- Cable installations must comply with appropriate building codes. All penetrations through rated fire walls, ceilings and floors must be fire sealed.
- Cabling with required fire rated shall always be utilized, but it is required when installed in air plenums or traversing floors of the building. SASO and IEC 60754 and 60332 requirements shall be followed.

- Before attaching networking equipment to the cable infrastructure, each terminated cable shall be tested with Category 6A certification equipment (level III or IIIe scanner/tester respectively). Each cabling link shall pass all Category 6A standards and be submitted to the system manufacturer to obtain the required minimum 10 year structured cabling system warranty.

1.2.7.2 Structured Cabling Components

- Work Area
  - Work area is considered telecommunications outlet/connector (including multi-user outlet assembly, consolidation point, and transition point), work area cable (patch cord), and work area equipment.
  - Work area outlet shall house a minimum of two cables per outlet box location.
  - A minimum of two outlet box locations shall be designed per space.
  - Telecommunications outlets shall be located directly adjacent to an electrical receptacle and shall typically be mounted at the same height.
- Horizontal Distribution Systems
  - Horizontal pathways include the raceways utilized for routing telecommunications cabling such as j-hooks, conduit, and cable trays.
  - Horizontal Pathway Systems
    - Raceways shall be designed to accommodate the maximum amount of work areas. Where pathways include additional cabling requirements, capacity shall be increased accordingly.
    - Access to pathways shall be maintained.
    - Pathways shall be designed for a 40% fill capacity maximum including space allocated for future, with each work area outlet allowing for at least three cables.
    - Cellular floors may be utilized in spaces where:
      - Increased flexibility is required (large office layouts)
      - Large capacity is required
      - Increased security is necessary
      - Electrical interference is an issue
    - Conduit pathways shall have bend radii six times the internal diameter of the conduit for conduit smaller than 50 mm. For conduit with an internal diameter larger than 50 mm, the bend radius must be 10 times the diameter.
    - Conduit runs shall be designed to have no more than two bends.
      - Where more than two 90-degree bends in a conduit run are necessary, provide pull boxes between sections with two bends or less.
      - Where a bend between 100 and 180 degrees is required, provide a pull box at each bend.
      - Where conduit runs exceed 30 m, provide a pull box.
    - Conduit ends shall be equipped with insulated bushings to prevent cable damage during installation or use.
    - Access Floors
      - Raised floors may be utilized in data centers and telecommunications equipment rooms.
      - Cabling in raised floors shall be fire rated to permit usages of space as air handling plenum.
      - Standard height for access floors shall be 150mm or higher, with 50mm between the top of tray and the bottom of the underside of the stringer allocated for accessibility.
      - Floors shall be designed with aluminum locking pedestals to support and interlock with lateral bracing.
    - Ceiling Systems

- Maintain 75 mm clear vertical space above conduit and cables.
- Maintain 300 mm clear vertical space above cable trays.
- Cable tray support span shall not be greater than the length of a section of tray.
- Cable trays shall be utilized to support cabling in areas of cabling that converge and route to the Telecommunications Room.
  - Cable trays shall be supported by either trapeze supports, cantilever brackets, individual rod suspensions brackets.
- Cable trays accessories shall be provided by manufacturer. to facilitate cable terminations and bends.

- Horizontal Cabling Systems
  - Horizontal cables shall consist of:
    - 4 pair 100-ohm balanced Category
    - Two or more strands of 50/125micron multimode fiber optic cable (terminated utilizing Duplex LC connectors)
  - Service loops at the TR shall be 3m; service loops at the work area outlet location shall be 1m.

- Backbone Distribution Systems
  - Backbone systems shall be comprised of:
    - Cable pathways
    - Equipment Rooms
    - Telecommunications Rooms (typically containing HC)
    - Telecommunications enclosures (typically containing HC)
    - Entrance Facility
    - Transmission media (cables)
    - Miscellaneous support facilities
  - Backbone Building Pathways
    - Distribution shall be in a star topology with no more than two levels of cross-connects.
    - Telecommunications Rooms shall be stacked in multilevel facilities.
    - Sleeves shall extend a minimum of 25 mm above the floor.
    - Sleeves shall be provided (103mm) to allow four sleeves or conduits, plus one additional spare for every 4000 m2.
    - All penetrations shall be fire stopped as required.
    - Coordinate all penetrations with structural team.
  - Backbone Building Cabling

    Backbone cabling shall typically consist of:
    - Single-mode fiber optic cable
    - 100ohm balanced twisted pair cabling
  - Fiber optic cable may be utilized for:
    - Interbuilding backbone cabling
    - Intrabuilding backbone cabling
    - Horizontal cabling
    - Patch cords and equipment cables
  - Tight buffered fiber optic cables
    - 900micron plastic coating surrounding fiber
    - Utilized for:
      - Intrabuilding backbone cabling
      - Horizontal distribution cabling
      - Patch cords and equipment cables
  - Loose buffered fiber optics

        - Outside plant cabling
        - Select inside plant cabling
    - Hardware/equipment mounting may be:
        - Wall mounted:
            - When rack mounting of equipment is not a possibility
            - Equipment requires wall mounting
        - Rack mounted (in 480 mm racks or cabinets) in:
            - Telecommunications Rooms
            - Equipment Rooms
            - Computer Rooms
        - Provide splicing, termination and patch panels as required for cabling being utilized.
- Campus Cabling
    - Indoor backbone campus fiber optic cabling shall have minimum bend radius of 10 times the cables outside diameter installed, and 15 times the outside diameter during installation.
    - OSP backbone fiber optic cabling shall have minimum bend radius of 10 times the cables outside diameter installed, and 20 times the outside diameter during installation.
    - Install fiber optic cabling in inner duct to allow for sectionalization for future cable pulls.
    - Splicing
        - Fusion
    - Terminating
        - Pigtail splicing with duplex LC connectors
        - Pre-connectorized cables with duplex LC connectors
- Telecommunications Rooms (TR) and Enclosures (TE)
    - TR's may house:
        - HC (horizontal crossconnect)
        - IC (intermediate crossconnect)
        - MC (main crossconnect)
        - EF (entrance facility)
        - Passive components
        - Active components served by backbone cabling
    - TE's may house:
        - HC
        - IC
        - MC
    - Clearances:
        - Provide 1 m (minimum) in front and rear of each equipment rack or cabinet.
        - Reserve minimum of 1m clear working area around cross connects for accessibility.
- Equipment Rooms
    - Equipment Rooms serve a building, campus or tenant, while TR's serve portions of a building.
    - ER's may house:
        - EF (entrance facility)
        - TR
        - Cross-connect facilities
        - Active components served by backbone cabling
        - Building facilities
    - TR size:
        - Where usable floor space being served is less than 500 m2:

        - Interior TR dimensions shall be 3.0 m x 2.4 m.
    - Where usable floor space being served is greater than 500 m² and less than or equal to 800 m²:
        - Interior TR dimensions shall be 3.0 m x 2.7 m.
    - Where usable floor space being served is greater than 800m² and less than or equal to 1000m²:
        - Interior TR dimensions shall be 3.0 m x 3.4 m.
    - Clearances:
        - Provide a minimum of 1 m in front and rear of each equipment rack or cabinet.
        - Reserve minimum of 1m clear working area around cross connects for accessibility.
- Telecommunications Entrance Facilities and Termination
    - Separate entrance facilities may be required for:
        - Access Provider
        - Campus distribution
        - CATV network
        - FTTH system
    - A/E shall work to coordinate right of way easements and permits as applicable to the project.
    - In some cases, full route diversity may be required. This requires a completely (physically) separate route for cabling to provide redundancy in the case that emergency backup is required. This is typical for:
        - Hospitals
        - Airports
        - Police/Fire/Emergency Services
        - Military
        - Radio and TV stations
        - Computer centers

1.2.8 Distributed Television System

1.2.8.1 A/E should be coordinated with the Entity while Implementation of Distributed television systems which includes various system such as IPTV, Hybrid Fiber Coaxial (HFC) and Satellite Master Antenna (SMATV)

1.2.8.2 The IPTV system, utilizing FTTH GPON networks for distribution, shall be provided for new projects. In case, the Entity has established the IPTV Headend Building within the Buffer Zone, each local IPTV Building should be connected to the IPTV Headend Building utilizing single mode fiber in the underground distribution system

1.2.8.3 HFC (Hybrid Fiber Coaxial) system (Both the existing and new projects) -Prior to design A/E should be coordinated with the Entity for utilizing HFC system.

1.2.8.4 SMATV systems shall be used in residential projects for distribution of satellite IF (Intermediate Frequency) signals to complement the IPTV service or where IPTV systems are not available. An example of this a group of satellite dishes for an apartment building being shared through a multi-switch to every apartment (alongside IPTV / HFC). Additionally, a more complex system could use an optical LNB to distribute the signals from a satellite dish farm to all the buildings within a given area.

1.2.8.5 IPTV System Description

- The project requiring television service shall be provided with IPTV system service utilizing IPTV signal distribution across dedicated GPON FTTH networks as described here.

- The IPTV signal originates within the central IPTV headend building shall be in the Buffer Zone. The IPTV system equipment is provided in equipment racks and is interfaced directly with GPON Optical Line Terminals (OLT's) or other IP access networks for transmission across the FTTH network.
- The location of Local IPTV buildings within the development shall be practically planned in coordination with community planning to minimize optical fiber distribution lengths throughout the district served. The GPON FTTH system supports optical fiber distribution of up to a maximum logical distance between OLT and ONT of 60km, physical distance is dependent on the optics currently available and split ratios employed.
- At customer premises, optical fiber GPON FTTH service extends to the Optical Network Terminator (ONT) and interfaces with the building network structured cabling system. IPTV network addressable set top boxes are provided at each designated television location in the building and connected to the network structured cabling system.
- The existing IPTV headend equipment is located in ETSI standard for post equipment rack, suitable to support system servers.
    - Feeds into the existing IPTV Headend Building include satellite television dishes for reception of cable/satellite TV networks as well as programming transmitted to the headend over single mode optical fiber.
    - Existing satellite reception shall occur through a modular Integrated Receiver Decoder (IRD) that accepts DVB-S/S2 sources, provides descrambling, and outputs IP signals.
    - The IP streams are then directed to a content processor which shall perform the following tasks:
        - Rate shaping of real-time, broadcast-quality MPEG
        - Grooming, de-jittering, and seamless localized ad insertion
        - Switched Digital Video, VOD Playlist Advertising, IPTV, and Bulk Encryption
    - Existing digital feeds are brought to the central IPTV Headend Building on single mode fiber and shall be converted to broadband signals, demodulated, and IP encoded for distribution through the IPTV headend content processor.
- Redundant network switches shall provide connectivity from the FTTH OLT's in Local IPTV buildings in each district with the central IPTV Headend Building.

1.2.8.6 Existing IPTV System Components Description

- Fiber Optic Receiver/ Demodulator/Encoder
    - The Fiber Optic Receiver accepts digital television signals over single mode optical fiber with SC/APC connection
    - The fiber optic receiver module is integrated with a rack mounted broadband distribution amplifier. System outputs include RF Output and Test Ports.
    - The fiber optic receiver shall be connected to a demodulator to extract designated channels for local insertion into the IPTV system.
    - The demodulators shall be frequency agile with broadcast quality.
    - The demodulated signal shall be extended to IP encoders and connected into the content processor.
    - The IP encoder can maximally encode four (4) channels video and audio and multiplex corresponding 4 SPTS into MPTS output. It shall comply with MPEG-2 standard and has high encoding quality and efficiency.
- Integrated Receiver Decoder (IRD)
    - The modular Integrated Receiver Decoder (IRD) is based on a flexible platform hosting different modules allowing for a configuration to meet the requirements. The platform supports signal reception, descrambling, and Asynchronous Serial Interface (ASI) outputs through modules containing multiple inputs such as QAM, ASI, DVB-S/S2. The received services are descrambled using DVB (common interface) or AES with virtual smartcards, as required.

- The system contains an intuitive web-based user control, Dual redundant hot-swap power supply, and monitoring of system power and fans.
- A switch module in the IRD is used to enable MPEG traffic distribution within the chassis and provides configuration and management of the chassis.
- Input modules in the IRD analyze incoming transport streams and extracts selected MPEG services from the DVB-S/S2 physical input interface. The system shall permit the ability to mix input types freely within a chassis enables multiple MPEG transport streams originating from a variety of sources to be received and processed in parallel. Received signals shall be demodulated, de-multiplexed and distributed to other modules inside the chassis via the backplane.
- ASI output modules with independent ASI outputs shall be provided.

- ASI to Gigabit Ethernet Bridge
  - ASI to Gigabit Ethernet Bridge provides ASI to Gigabit Ethernet bridging for video services. It shall bridge traffic from ASI-output IRDs, Encoders, video routers, and other video sources to a common Gigabit Ethernet IP backbone.
  - ASI to Gigabit Ethernet Bridge contains twenty-four ASI inputs, system Ethernet control ports, and an IP payload Gigabit output port.
- Content Processor
  - The content processor provides IPTV system with optimal rate shaping, re-multiplexing, and ad insertion capability at IPTV head end location.
  - The content processor provides a software application for rate shaping of real-time, broadcast-quality MPEG-4/AVC and MPEG-2 SD and HD streams and handles up to 2Gbps of aggregate video stream throughput.
  - The content processor possesses additional applications, such as grooming, dejittering, and seamless localized ad insertion, and has the performance needed to support mission-critical initiatives like Switched Digital Video, VOD Playlist Advertising, IPTV, and Bulk Encryption.
  - The system has carrier-class reliability and high availability needed for high stream counts with redundant and hot-swappable power supplies, hot swappable fan trays, with 1:1 and N:1 redundancy, and field replaceable input/output cards and processing modules.
- IPTV and FTTH OLT Network Connections
  - Gigabit Ethernet connections shall be provided from the central IPTV Headend Building to each Local IPTV Building network termination card on the FTTH OLT's through implementation of network switches.
  - Network switches shall contain autosensing 10/100/1000 ports (IEEE 802.3 Type 10BASE-T, IEEE 802.3u Type 100BASE-TX, IEEE 802.3ab Type 1000BASE-T). The network switches shall also contain Layer 4 prioritization to enable prioritization based on TCP/UDP port numbers, Traffic prioritization (IEEE 802.1p), and managed Layer 2 feature set. Optical uplinks shall be required.
  - Size the quantity of network switch ports based upon quantity of OLT and IPTV system connections required, with a minimum of 20% spare. 48 port network switches shall be provided.
  - Provide structured cabling systems to support network connections conforming to ANSI/TIA 568-C and ISO/IEC 11801 Edition 2.2 for TIA Category 6A/ISO Class Ea/6a. In addition, cabling within the IPTV headend building shall conform to ISO/IEC 24764 Edition 1.0 "Information Technology – Generic Cabling Systems for Data Centers".
  - Optical fiber utilized in the system shall be single mode conforming to the ITU-T G.652 D standard.
- IPTV Set Top Boxes
  - IPTV Set Top Boxes (STB's) are used to accept IPTV streams provided from Local IPTV Buildings. These streams are transported across the system FTTH GPON network to the building where it interfaces with the building structured cabling system through an ONT. Provide IPTV STB's located adjacent to user television displays, with video and audio connections from the STB to the display. IPTV STB's may also be integrated into audiovisual systems as a media source in installations where CATV programming is required.

- The STB supports all necessary technologies for deployment of the IPTV services including:
  - High definition decoding and output
  - MPEG2 and MPEG4 video formats
  - AAC audio formats
  - Hardware supported descrambling of media signals
- Ensure building infrastructure to support IPTV Set Top Boxes (STB's) is provided locally at each device including an IP network outlet and building power.
- Typically, in villas and apartments, IPTV STB's do not require fixed mounting. Where required, ensure provisions for mounting the IPTV STB are provided as needed including brackets, shelves, blocking, and cable management. Mounting conditions shall accommodate device passive ventilation requirements through proper device orientation and clear space required by device manufacturer. Mounting conditions may include:
  - Cabinet entertainments centers
  - Equipment rack mounting
  - Wall or post shelf mounting adjacent to the television display
- Where projects require the television display to be included in the scope of work, provide audiovisual cable patch cord connections from the IPTV STB to the display.

1.2.8.7 CATV Tertiary System

- CATV Tertiary Network
  - The tertiary network is defined as the portion of the CATV networks from the telecommunications handhole, provided by Local Network and located at the Subscriber Property Line, to the telephone and CATV outlets in the subscriber's residence.
  - The CATV Tertiary Network consists of provision and installation of a 75-ohm coaxial cable, suitable for use with CATV frequencies up to 1000 MHz from the telecommunications handhole to the individual CATV outlets in the residence.
  - The CATV cable shall be placed in the duct from the handhole to a wall mounted apparatus cabinet dimensioned to contain over-voltage protection, splitters and where applicable amplifier or other equipment required for system operation. From this point the cable will be extended to all CATV outlets. No splicing of cable is permitted inside the duct.
  - The CATV outlets shall be flush mounted jacks with covers that automatically provide a 75 ohm termination on the cable when a plug is not inserted into the jack. Splitters or tap-off shall be used at each branching point in the cable. Any output of a splitter not used at a branch point shall be terminated in a 75 ohm resistor. Locate CATV outlets directly adjacent to electrical outlets with a matching faceplate construction and color.
  - The intent of all distribution design is to provide a test signal level of 0 dBmV, flat from 52 to 1000 MHz at each subscriber outlet. As a practical approach to this objective, the signal level provided by the distribution network at the subscriber's connection point will be set between + 18 and + 22 dBmV. From this input level, the tertiary network design shall provide for signals within the range - 3 to + 20 dBmV at the subscriber's outlet. The CATV distribution system is designed for 31 TV channels and the worst-case receive signal condition (i.e., following 35 trunk amplifiers, 1 bridging amplifier and 2 line extenders) shall be:
    - Signal to Hum: 41.49 dB.
    - Signal to Noise: 44.73 dB.
    - Signal to Cross-Modulation: 51.45 dB.
    - Signal to 2nd Order Intermode: 59.55 dB.
  - Each apartment shall be provided with a separate coaxial cable feed from the main distribution box, located for convenient access in the entry to the building.
  - The CATV cable shall terminate first on a lightning protection block before entering the building distribution system.
  - Trunk, Distribution and Line Extender Amplifiers

- Broadband push-pull amplifier is used for amplification of the signal in the trunk and spur feeds. Devices shall power powered through a local power supply and shall be located in the equipment rack.

- Distribution Amplifier
  - Distribution amplifier is utilized to raise the output level of the headend signal for insertion of the lower pilot frequency.
  - Distribution amplifiers main features
    - Nominal impedance input and output 75 ohm.
    - Frequency range 47 to 870 MHz
    - Input level 78 dBµV and output level 92 dBµV.
    - Gain 12 to 14 dB.
    - Frequency response ± 0.4 dB.
    - Isolation of test points, input and outputs - 20 dB.
    - Pilot insertion level adjustable over ± 1 dB.
    - Maximum admissible spurious emissions 4 x 10–9 W.
- Directional Coupler

  Directional coupler shall be two-way coupler with cast-aluminum enclosure, 75 Ohm, and shall be used for connection of cables with a maximum outer connector diameter of 12.7 mm.
- Line Splitter

  Line splitter shall have cast-aluminum enclosure with a maximum outer connector diameter of 12.7mm.

1.2.9 Master Clock System

1.2.9.1 The master clock system shall provide synchronized time throughout the facility.

Time source shall be provided through a network connection communicating via Simple Network Time Protocol (SNTP) and Network Time Protocol (NTP) RFC-1305 to an internet based stratum-1 network time server. This shall be the Entity- NTP server if the facility is connected via the Metropolitan Area Network (MAN) or an internet based time server otherwise. If no network or internet source is available time can be sourced via the GPS (Global Positioning System) time signal.

1.2.9.2 Master Clock System Types

- Wired Clock Systems
  - Clock system shall allow for combining data and electrical power signals over the same cable.
  - Clocks shall correct themselves upon receipt of digital signal.
- Wireless Clock Systems
  - Clocks shall self-synchronize upon receipt of wireless signal.
  - Diagnostic function shall permit monitoring of last received wireless signal.
  - Web interface shall permit monitoring of system status.
- Wireless Talkback Clock Systems
  - Master clock with wireless talkback technology transceiver
  - Clocks shall self-synchronize upon receipt of wireless signal.
  - Diagnostic function shall permit monitoring of last received wireless signal.
  - System shall not require physical servers or additional hardware or software to function.
  - Talkback functionality permits communicating vital information such as battery life, status updates, clock status, and signal strength to the master clock. Any changes in this information shall be automatically reported to the facility's manager via email.

- IP Clock Systems
  - IP clocks shall utilize PoE to IEEE 802.3af/at or bt.
  - System shall allow for monitoring of clocks through software, including:
    - Uploading and downloading configuration capabilities
    - Sending countdown functions to digital clocks
    - Displaying clocks not receiving signal
  - Power interruption to clocks shall not cause system failure.

1.2.9.3 Clocks Types

- Analog Clocks

  Clocks shall have round or square 12/24 hour face with shatter-proof case.
- Digital Clocks

  Clocks display high-efficiency LED numeric values with shatter-proof case.

1.2.9.4 Locations, Mounting, and Sizes

- Provide minimum of one clock per occupied space.
- Approximate mounting height shall be 2.4 m above finished floor. Final location and mounting height shall be coordinated with other equipment and furnishings prior to installation.
- Typical clocks shall be 300 mm in diameter (round clocks) or 230 mm on a side (square clocks).
- Large group spaces shall require larger clocks – 410 mm in diameter (round clocks) or 300 mm on a side (square clocks).
- Double sided clocks shall be provided in corridors.

1.2.9.5 Accessories

- GPS

  GPS shall be capable of receiving synchronization signal from satellites.
- Wireless Transmitter

  Capable of wirelessly transmitting data for synchronization of clock time.
- Wireless Repeater

  Capable of wirelessly transmitting and receiving data for synchronization of clock time.
- Network Repeater

  Capable of receiving time signal through TCP/IP from master clock.
- Environmental Protection

  In gymnasiums and other potentially high impact spaces, provide wire guards on clocks.

1.2.9.6 Cabling for wired aspects of systems shall meet system manufacturer requirements for types of communication protocols and cabling distances used.

1.2.10 Public Address and General Alarm

1.2.10.1 General

- The Public Address System for offices shall be designed for transmission of general announcements, emergency alarms and music.

- Public Address systems for Mosques shall be designed for voice only.
- Public Address and General Alarm (PAGA) for Industrial Areas shall include Amplifiers, Speakers and Loudspeakers to broadcast general and emergency announcements and Industrial Intercom Stations to provide important plant communication functions in operational or emergency events (according to IEC 60849 standard).

1.2.10.2 Public address system shall consist of the following but not limited to:

- Network Audio Adapter
  - The network audio code shall be IP-addressable and convert analog audio (mic or line level) to standard IP packets for transport over an IP based network including local area, wide area and the Internet. The device shall be capable of simultaneous transport of audio, serial RS-232 data and contact closures. The device shall have variable sample rate and audio bandwidth with a minimum latency/delay of 20 ms.
  - The network interface shall be 10BASE-T/100BASE-TX, Auto-Negotiation and utilize the network protocols TCP/IP, UDP, HTTP and RTP. The audio input shall be balanced, transformer-isolated, MIC/LINE switchable with adjustable volume control.
  - The audio output shall be balanced, transformer-isolated, (0 dBV, 600 ohms), with plug-in screw connector. Specifications shall include frequency response of 50 to 14k Hz and distortion of under 0.3% (1k Hz, sampling frequency 32 kHz).
  - The unit shall be capable of Unicast transmission to up to 4 simultaneous units/locations over LAN/WAN/Internet, and Multicast transmission to up to 64 simultaneous units/locations over LAN/WAN.
  - The device shall include software for configuration, operation and management with password protected access. The device shall include a built-in web server for control and monitoring from any network-based PC with password protected access.
- Main Amplifiers
  - The amplifiers shall have the following main features:
    - Frequency response 60 Hz to 20 kHz ± 2 dB or better
    - Maximum distortion 100 Hz to 16 kHz - 0.25%
    - Signal to noise ratio 45 dB or better
  - Balanced 70/100 V outputs shall be available at a screw terminal strip.
  - The equipment shall have protection circuits to protect the amplifiers from damage under all normal and abnormal operating conditions.
- Control Pre-Amplifiers
  - Control Pre-amplifiers shall be supplied by the Contractor to accept such inputs as may be required under the terms of the Contract. All inputs shall be preferably of 600 Ohm balanced or 50M Ohm single ended configuration.
  - There shall be at least one spare input in addition to the inputs required by the Contract Drawings.
  - Control Pre-amplifiers shall be equipped with mixable inputs, convertible for various sources with supplementary modules and adapter kits. Remote controllable priority switching for each input and separate controls for treble and bass shall be provided.
  - The output from the pre-amplifier shall be at a level compatible with the input requirements of the main power amplifier.
  - All inputs to the pre-amplifier shall be shielded and grounded cables.
- Low Powered Amplifier (for Mosques Only)
  - The amplifier provided shall consist of the pre-amplifier, power amplifier, zone selector and a mixer in a single assembly.
  - The input signal shall be balanced.
  - The amplifier shall be equipped with tone control facilities to tailor the audio response to suit the input signals and the required performance detailed in this Specification.

- Tone Signal Generator
  - This unit shall generate various signals e.g. fire alarm, air raid warning, air raid imminent and all clear etc. according to requirements of the Civil Defense Bureau.
  - External warnings may be initiated from Civil Defense Bureau installations through dedicated links.
  - Automatic release through systems such as fire alarm and burglar detection and manual release must be possible.
- Loudspeakers
  - Performance of loudspeakers shall be not less than that specified in IEC 60581-7.
  - Wall Speakers
    - These speakers shall be provided with a resonating board and an aluminum grille for universal application for flush or surface mounted enclosures.
    - The speaker shall be a high performance type and shall be provided with an autotransformer with taps for 1/4, 1/2 or 1/1 of output capacity.
    - The unit shall incorporate a volume control. Frequency response shall be ± 2 dB from 60 Hz to 16 kHz.
  - Ceiling Speakers
    - These speakers, including their accessories, shall be designed for recess installation in various suspended ceiling types.
    - The grille shall be aluminum. The speaker itself shall be the same type as wall mounted loudspeakers.
  - Column Speakers
    - These speakers shall be for interior, or in weatherproof design, for exterior installation. The enclosure shall be of aluminum and shall be for wall or pole mounting, with suitable accessories.
    - A transformer with taps for 1/4, 1/2 or 1/1 capacity shall be built in. Frequency response shall be at least ± 2 dB from 150 Hz to 15 kHz.
  - Horn Speakers
    - These speakers shall be for exterior installation in weatherproof design. The enclosure shall be of impact resistant plastic with swivel brackets.
    - The built-in autotransformer shall have taps for 1/8, 1/4, 1/2 and 1/1 of output capacity. The frequency response shall be within ±2 dB from 200 Hz to 10 kHz.
  - Microphones
    - Microphones shall be selected for the special usage. They shall have a super re-inform characteristic, and shall be equipped with an adjustment device for 5 step tone characteristics, and a presence switch.
    - The frequency response shall be between 30 Hz and 20 kHz and the feedback damping shall be approximately 20 dB at 130 Ohm.
    - Connection cables and supports shall be provided to suit the special usage.
    - All microphones shall be provided with desk mount or floor mount as suitable for application.
  - Passive Combiner
    - The passive combiner shall consist of a resistive network to combine the outputs from the microphones and enable the connection of all three microphones to a single pre-amplifier channel.
  - Headsets
    - The headsets shall be of robust design and incorporate lightweight components and level control.
    - The frequency response shall be 20 Hz to 20 kHz.
  - Industrial Intercom Station
    - Handset channel.

- Hands-free microphone channel.
- Output channel for handling an external amplified Loudspeaker.
- Capacity to activate an emergency call.

1.2.11 Audio/Visual Systems

1.2.11.1 System Type Descriptions

- Auditorium
  - The auditorium shape and acoustical treatments shall meet project requirements and be designed by an acoustician or acoustical consultant.

    Provide room calculations for the following:
    - Reverberation Time
    - Noise Criteria (NC)
    - Potential Acoustic Gain (PAG)/Needed Acoustic Gain (NAG)
  - The room shall typically have pendant mounted projectors and motorized projection screens. The projector can be floor mounted if a projector room is provided. The projectors shall be native WUXGA resolution, have a minimum 6000 ANSI lumens, and be a 3-chip LCD.
  - Each projector shall have the capability to display independent images.
  - Power, network, and twisted pair audiovisual connections shall be provided to the projector locations.
  - Motorized tab tensioned front projection screens with low voltage control interfaces and wall switches shall be provided. The screens shall be ceiling recessed.
  - The screens shall have a 16:10 aspect ratios and be sized to maximize viewing distances as required.
  - The screens shall be supplied with black drop and the viewable surface bottom edges shall be approximately 4’ above finished floor (AFF).
  - The screen surface is matte white to facilitate general presentations.
  - A lectern (not mobile) shall be provided for the classroom and connected into a floor box input/output plate beneath the lectern.
  - The lectern shall have a goose neck microphone with shock mount.
  - Laptop video/audio, power, network, and microphone patch cables shall be stored in a cable cubby in the lectern surface.
  - A power receptacle with USB charging shall be located in the lectern.
  - The lectern shall have equipment rack rails and contain the following major components:
    - Blu-ray player
    - Permanent PC with wired mouse and keyboard
    - Media presentation matrix switcher with amplifier and control processor
    - Twisted pair extenders
  - A ceiling document camera shall be provided over the instruction table.
  - Signal distribution shall utilize HD Base technology or other enhanced proprietary technology.
  - A scaling twisted pair receiver shall be mounted with the projectors to receive the video and control signals. The video signal sent from various sources shall be scaled to match the native resolutions of the projectors.
  - Wall mounted front speakers in the room will operate to provide program audio.
  - BYOD (Bring Your Own device) collaboration shall be. Up to four (4) student tablet devices shall be capable of presenting simultaneous on the projection screen using Campus WiFi.
  - Lighting and shade control for the rooms shall be integrated into the AV control system using serial RS-232/485 or network connection interfaces.
  - Integrated video conferencing capabilities shall be supported in the systems.
  - A system input for a camera shall be provided in the rear of the room.

- A wall mounted touch panel/button controller will be used to operate the system. This panel shall permit control of the following:
  - Intro screen
  - System on/off
  - Source selection
  - Video mute
  - Video freeze
  - Blu- Ray device control
  - Ceiling document camera controls
  - Program volume
  - Audio mute
  - Help

- Classrooms
  - The Classroom audiovisual shall facilitate classroom lecture, presentation, and collaboration.
  - The room shall have one (1) ultra or extreme short-throw projector. The projector shall be native WXGA resolution, have a minimum 3000 ANSI lumens, capable of displaying 95”, and be a 3-chip LCD.
  - Power, network, and twisted pair, audiovisual connections (HDMI (High Definition Multimedia Interface)shall be provided to the projector location.
  - A smart interactive board with integrated sound and wall/floor outlets shall be provided. The screen shall support multiple simultaneous touches.
  - The screen shall have a 16:10 or 16:9 aspect ratio and be sized to maximize viewing distances as required.
  - The screen surface shall be matte white to facilitate general presentations.
  - One (1) HDMI/VGA with 3.5mm stereo audio twisted pair transmitter plate shall be available as inputs for the system from a designated presentation location at the front teaching wall. This shall provide a connection for Instructor laptops. The twisted pair transmitter shall utilize HD BaseT technology or other enhanced proprietary technology.
  - A scaling twisted pair receiver shall be mounted with the projector to receive the video and control signals. The video signal sent from various sources shall be scaled to match the native resolution of the projector.
  - BYOD (Bring Your Own device) collaboration shall be supported. Up to four (4) student tablet devices shall be capable of presenting simultaneous on the projection screen using building Wi-Fi.
  - The classroom shall also contain a media presentation switcher with integrated amplifier, twisted pair extender, and control processor.
  - Lighting and shade control for the rooms shall be integrated into the AV control system.
  - Integrated videoconferencing capabilities shall be supported in the systems; however the system shall also support PC based Web conferencing.
  - A wall mounted touch panel/button controller may be used to operate the system. This panel shall permit control of the following:
    - Intro screen
    - System on/off
    - Source selection
    - Video mute
    - Video freeze
    - Blu- Ray device control
    - Program volume
    - Audio mute
    - Help

- Conference Room
  - The room shall have one (1) large 2,032 mm nominal flat panel display wall mounted with a swing arm mount and recessed back box.
  - The room shall have a table based room collaboration system consisting of four (4) HDMI connections and two (2) VGA/Stereo connections. “Show me” selector cables in a cable cubby shall provide source control. The cables shall be located in retractors mounted under the table.
  - A presentation switcher shall be secured under the table. An HDMI output from the switcher shall be connected to a twisted pair transmitter located in the floor box. A twisted pair receiver, audio de-embedder, and mini amplifier shall be located behind the flat panel display.
  - The collaboration system shall control the flat panel display using an RS-232 based control processor and button panel controller.
  - Two (2) mono 70V ceiling speakers shall be located in the room to provide program audio.
  - Lighting and shade control for the rooms shall be integrated into the AV control system.
  - Integrated videoconferencing capabilities shall be supported at the discretion of the Entity.
- TMC Video Wall
  - The Traffic Management Center (TMC) shall contain a large and flexible video wall. The video wall is typically used to provide a real-time display from ITS system servers of road networks, sensor data, and video surveillance.
  - The size of the video wall shall be coordinated with the ITS system design requirements and be proportional to number of operators required within the control room.
  - The video wall shall consist of an array of flat panel displays or small form factor video cubes supported from an engineered framing system. The displays shall have zero or narrow mullions designed for video wall applications. The Video Wall should have a maximum Bezel Size of 1.0 mm in order to guarantee the correct operation for the Integrated Security System which requires detailed visualization of Maps, Road Routes, etc.
  - The panel framing system and mounts shall provide rear access or scissor supports permitting removable or maintenance of single panel in the array. The framing systems shall accommodate cable management for power and video distribution.
  - The video wall shall be provisioned with a hardware based video processor to collect video source inputs from numerous ITS servers including video surveillance network video recorders and storage area networks. Coordinate the quantities of inputs required with the ITS system design.
  - Any system input can operate as a Native High Resolution Channel, Scaled PIP, Scaled Background, or Key Channel – on any display in the system. The video processor shall provide blending, windowing, mixing and scaling along with key frame effects. Operators shall control the video wall from PC workstations.

1.2.11.2 System Components

- Projection Screens
  - Types shall include: front projection and rear projection
  - Gain: Indication of screen's luminance or brightness, measured perpendicular to screen center and relative to magnesium carbonate block, which serves as standard for 1.0 gain. Higher numbers indicate greater brightness.
  - Viewing Angle: Horizontal angle from perpendicular center of screen at which gain or brightness decreases by 50%.
  - Format: Proportion of projection screen viewing area expressed as a ratio of width/height.
    - HDTV Format: 1.78:1.
    - 16:10 Wide: 1.60:1.
  - Types shall include:
    - Manual

- Screen Operation: Manually operated, retractable projection screen mounted on ball bearing rigid steel spring roller with controlled screen return mechanism.
  - Form screen bottom into pocket holding tubular metal slat with attached steel pull bail
  - Protect slat ends with heavy-duty end caps
  - Pull cord
- Adjustable roller mounting brackets to allow centering or offsetting the screen within the case.
- Screen Mounting Type: Ceiling Recessed
- Screen Viewing Surface:
  - Permanently attached to roller
  - Front projection, flame retardant, mildew resistant, fiberglass fabric, black backed typically with standard black borders, easily cleaned with mild soap and water solution

- Motorized
  - Screen Operation: Electrically operated, retractable, with rigid metal roller
    - Motor: Housed inside metal roller and including automatic thermal overload protection, integral gears, capacitor and electric brake to prevent coasting
    - Type: 3-wire with ground with quick connect male plug-in connector, permanently lubricated, quick reversal type designed for mounting inside roller
    - Include preset, adjustable limit switches to automatically stop viewing surface in UP or DOWN position
  - Electric Controls: Wall-mounted switch
    - Switch: 3 position type with cover plate for UP, DOWN and STOP functions
    - Junction Box: attached to screen case
- Portable

  Free-standing, manufactured, collapsible, portable, projection screen with pneumatic spring system allowing screen to be raised and lowered with minimal effort
- Table Top

  Compact, free-standing, manufactured, collapsible, portable, projection screen suitable for tabletop presentations
- Tripod
  - Free-standing, manufactured, collapsible, portable, tripod type projection screen
  - Aluminum housing case for screen on shall be on spring roller. Attach case to tripod support. Provide with built-in lock to secure screen fabric during transport and use to prevent shifting.
  - Tripod support: Extruded aluminum legs with toe release mechanism. Legs mounted on self-locking extension support tube with high and low case adjustment.

- Flat Panel Displays
  - Displays shall be professional grade displays capable of operating 24 hrs/day, 7 days a week.
  - Tamper resistant control locks shall prevent unauthorized adjustments at standalone locations or non-monitored public locations.
  - Display shall allow for both vertical and horizontal mounting.
  - Display shall be of high durability in exposure to moisture, smoke, and well as dust and temperature changes.
  - Display shall allow a variety of input terminal cards as well as multiple inputs.
  - Viewing angle shall be a wide angle to allow screen to retain color when viewed at a wide angle.
  - Displays shall permit RS-232 control.
  - Screen shall be equipped with rear speakers.

- Screen may offer touchscreen capabilities.
- Types:
  - LED
  - LCD
  - Monitor
  - 3D

- Audiovisual Control Systems
  - Audiovisual control systems shall be IP network based.
  - Audiovisual control systems shall have the following capabilities:
    - Control panel integration
    - RS-232c control ports
    - IR control ports
    - Relay control ports

1.2.12 Nurse Call System – Healthcare

1.2.12.1 General

- The Nurse Call System and Emergency Call System of Healthcare Center shall be designed for audible and visual communication between the patients and Nurses according to ANSI/ UL 1069: Standard for Hospital Signaling and Nurse Call Equipment's, ANSI/UL 2560: Emergency Call System and equivalent.

- Nurse Call System shall include Patient Station, Bath Station, Emergency Station, Corridor Light and Domeless Controller, Console, Power and Control, and etc. This System shall consist of the following but not limited to

  - Visual Nurse Call System

    - Patient Bed Station
    - Toilet Emergency Station
    - Duty Station
    - Dome Light (Corridor or Bed)
    - Master Station Annunciator

  - Audiovisual Nurse Call System

    - Patient Bed Station
    - Patient Station Cord set
    - Toilet Emergency Station
    - Duty Station
    - Dome Light (Corridor or Bed)
    - Master Station Annunciator- Microprocessor controlled system

1.2.12.2 The A/E shall coordinate with the nurse call system specialist and prepare documentation to summarize the recommended approach for the nurse call system designed for the facility. This enhancement documentation shall be submitted to the Entity for review and approval

1.2.12.3 Wiring Requirements

- The wiring network for nurse call system must be designed in accordance with the applicable codes and the specialist recommendation.

1.2.12.4 Power Source Requirements

- Power for the nurse call systems shall feed from the critical branch of the electrical emergency system and incorporate sufficient Power over Ethernet sources to serve devices. These recommendations shall be submitted to the Entity for review and approval.

1.2.12.5 The nurse call system shall also be integrated to main Building Management System and Life Safety System to assist patients for any emergency evacuation. Call and presences shall be displayed in the duty room. By activating a presence push button the call from the concerned room is cancelled, the call transfer shall be activated and the emergency call is prepared. The system should have the “follow me facility” (Calls from other rooms should be forwarded and audibly indicated to rooms where presence is set). The system must be flexible to adapt the room numbers and the call names according to the healthcare center requirements and recommendations. In corridors, calls are visually indicated by corridor lamps and information displays that can be wall or ceiling mounted. Room equipment Various devices can be installed in the rooms, e.g. the bed combination for hands-free speech at the bed, call modules, call push-buttons, pear push-buttons, pull cord for call release, as well as presence and cancel push-buttons for call answering. The information in the nurse call system shall be shown on display modules/room terminals. Existing calls are to be indicated according to their urgency in clear text. If no calls exist, then presences shall be shown. Answered calls shall be remotely cancelled via the function buttons; emergency calls on the other hand cannot be remotely cancelled.

1.2.12.6 Features

- PATIENT STATION
  - Nurse regular call system is intended for routine communication between each patient and the nursing staff. Activation of the system at a patient's station will sound audible signal at the nurse station, indicate type and location of call on the system monitor, and activate a distinct visual signal in the dome light outside the patient room door.
  - The audible signal shall be canceled and two-way voice communication between the patient room and the nursing staff shall be established at the unit's nursing station when the nursing staff answers the call. The visual signal(s) in the corridor shall be canceled upon termination of the call.
  - Patient handset (multiple push buttons) functions:
    - Nurse call release
    - Auto-release unbreakable plug system with 2 m cord length.
    - Automatic call release as a plug call when plug ejected from the auto release plug system
    - Easily repaired and changed if require

- NURSE EMERGENCY CALL SYSTEM
  - Nurse emergency call system is intended for patients to signal the nursing staff in an emergency. Activation of the system shall sound audible signal at the nurse station, indicate type and location of call on the system monitor, and activate a distinct visual signal in the dome light outside the patient room door.
  - Nurse emergency call system shall include an anti-microbial pull cord extending to within six inches of the floor accessible to a collapsed patient lying on the floor.

- Nurse station function
  - Call and status identification with following indicators: patient room, bed, normal call, bathroom/WC call, emergency call, bathroom/WC emergency call, doctor call, answered call in remind function, presence, fault, following calls.
    - Call activation (call button).
    - Cancel and presence button.

- Call reminder.
- Free selection of zone linking from a special module.
- Simultaneous display of several calls and presence's.
- Can be upgraded to have speech and public addressing with no major changing in the system wiring.

- STAFF EMERGENCY ASSISTANCE CALL SYSTEM
  - A staff emergency assistance call system (code blue) is intended to be used by staff to signal additional help in an emergency.
  - Activation of the system will sound an audible signal at the nursing unit's nurse's station, indicate type and location of call on the system monitor and activate a distinct visual signal in the dome light outside the patient room door

1.2.12.7 Nurse Call System shall interface or integrate with RTLS System (Real Time Locator System)

1.2.12.8 Nurse Call System Systems shall be a IP based system

1.2.12.9 Nurse Call System vendor shall be responsible for the supply of all aspects including design, engineering, configuration, programming and integration

1.3 Safety and Security Systems

1.3.1 Access Control System

1.3.1.1 The access control system consists of a controller and associated hardware. This provides for the physical connection to readers, locking hardware, door status switches, and request to exit devices. Access Control Door Types and Locations

- Typically access control doors permit free egress at all times.
- Monitored only – Doors are equipped with door status switches reporting to the centralized control system.
  - Passive infrared detectors or request to exits shunt the alarm triggered by activation of door status switch.
- Electrified Doors – Doors may be programmed to allow access during scheduled building hours. Otherwise access may be granted through:
  - Authorized Access – Authorized credentials shunt the alarm triggered by activation of door position switch from exterior. Interior passive infrared detectors, or request to exits shunt alarm triggered by activation of door status switch from interior.
    - Access control system keeps log of authorized entry.

1.3.1.2 User Credentials and Access Readers may include:

- Proximity card
- SMART card
- Outdoor card reader
- Wireless card reader
- Key fob
- Biometrics
- Keypad

1.3.1.3 Access Control System Panels

- Panels shall have sufficient capacity for input and outputs to provide for the card readers, electric strikes, door monitors and other devices as required.
- Control system shall have features to reduce false alarms.
- Controllers shall interface between the central station and remote sensors and controls.
- Panels shall include main Controller Cards and have capacity to expand the doors quantity to be monitored through Expansion Cards.

1.3.1.4 Cabling and Pathways

- Cabling shall be plenum rated where exposed in environmental air plenums.
- Cabling shall include low-voltage control cabling, control-circuit conductors, and identification products.
- Wiring within Enclosures:
  - Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
  - Install lacing bars and distribution spools.
  - Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.
  - Install conductors parallel with or at right angles to sides and back of enclosure.
  - Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks.
  - Mark each terminal according to system's wiring diagrams.
  - Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
  - Cabling shall not be spliced.
- Pathways
  - Cabling shall be supported in conduit to headend location. Where conduit is not provided, cabling shall be supported using open top cable supports or cable tray as required.
  - Outlet boxes, connection panels, cameras, card readers and other devices shall be weatherproof gasket type, IP52 or IP65 in the following instances:
    - On surface of exterior face of building, including areas where not under canopies, cast boxes with threaded hubs must be used and under canopies steel boxes with gasket connections to devices
    - In any areas where specifically noted "WP" or required by the local regulation
    - Within air conditioning enclosures
    - In underground splice boxes
    - On building roof
    - Within vivarium locations
    - In unconditioned spaces subject to exterior ambient conditions such as loading docks and parking garages
  - Pathway Fittings: Compatible with pathways and suitable for use and location
    - Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated.
    - PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
    - EMT: Use compression, steel fittings.

- Flexible Conduit: Use only fittings listed for use with flexible conduit.
- Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

1.3.2 Automatic Number Plate Recognition (ANPR)

1.3.2.1 System Description

- ANPR is a technical method of using closed circuit video surveillance cameras coupled with processors to determine vehicle license plate numbers. ANPR shall be used to automatically read and recognize vehicle registration number plates, which can then be cross-checked against a linked database.
- The ANPR system will have the following capabilities:
  - Locate and to isolate the number plate in the image
  - Correct the brightness and the contrast of the number plate
  - Separate each character of the number plate
  - Recognize each character of the number plate through optical character recognition
- The ANPR capture unit contains the camera, housing, mounts, and infrared focusing detectors. The ANPR process unit contains the computer, image frame grabber, and recognition engine. The process unit can control one or more capture units simultaneously.
- Fixed ANPR cameras shall be situated in designated traffic and entrance areas and be mounted in weatherized enclosures.
- The ANPR camera shall be served by a local weatherized terminal box providing easy access to all hardware interfaces and power supplies.
- The terminal box shall interface through approved wired or wireless connections to the Entity network to communicate with database system software.
- The database system software shall be the central repository to all number plate data along with tools to support data analysis, queries, and reporting for investigative purposes. It shall provide administrative and data analysis functions for both mobile and fixed deployments of ANPR.
- Each ANPR system shall be capable of performing at traffic volumes of 1,000 vehicles per hour at a minimum.

1.3.2.2 System Selection and Fixed Locations

A/E shall confirm the locations where ANPR Systems are to be provided with the Entity. The location and application of the ANPR system shall determine the components and configurations required for the system. Examples locations where ANPR systems may be required by the Entity include:

- Car Parks
  - The ANPR system shall provide automated parking facility management and security for airports, hospitals, universities, arenas, stadiums, and other locations as designated.
  - The system shall record parking ticket number, day, and time which are linked in a management application.
  - The system shall permit correct amounts to be charged for lost tickets.
  - Ticket interchange shall be blocked where vehicle number plates do not match with the entrance tickets.
  - The system shall provide visitor history reports and identify unusual parking behaviors.
  - Tabulation of occupancy levels shall be a feature of the system.
- Access Control

  ANPR shall be used in conjunction with driver personal access control credentials to permit vehicle access at designated gated entrances.
- Public Safety

Where designated by the Entity, the ANPR system shall provide continuous surveillance of high-traffic areas to enables rapid, efficient, and appropriate deployment of public safety resources.

1.3.2.3 Cameras

- Cameras types shall be selected based upon application requirements and include:
  - Compact ANPR Camera
    - Compact cameras shall be used in temporary or fixed applications where visual aesthetics is a project goal, or project budgets require a cost-effective option.
    - The controller shall be integral to the camera unit with a single point connecting cable.
  - Fixed Single Lane ANPR Camera
    - Single lane cameras shall be used in single lane applications or in dense areas such as busy intersections where small sized systems are required.
    - The camera shall provide a minimum of 1.5m of horizontal traffic lane coverage.
  - Fixed Wide Lane ANPR Camera
    - Wide lane cameras shall be used to capture multiple license plates in the same field of view across the minimum width of a highway lane.
    - The camera shall be used where interfacing with external devices such as radar, weigh-in-motion, or ticketing systems is required.
  - Fixed High Resolution ANPR Camera
    - High Resolution cameras shall be used to capture multiple license plates in the same field of view across a minimum width of 2.8m of horizontal traffic lane coverage.
    - The camera shall contain high-power IR pulsed illuminator LEDs to permit high resolution imaging.
    - Real time video triggering upon number plate presence shall provide optimum plate detection. A vehicle presence detector input may also be provided for capturing vehicle overview images when no license plate is present.
    - The camera shall be integrated with third party devices including Weigh-in motion, radar, lane controllers for tolling, and loop detectors for parking as required by the application.
- The camera units shall be fully integrated and rugged incorporating the fixed ANPR camera, illuminator and processor within a single sealed enclosure.
- Dual lens cameras shall be provided with channels for integrating infrared and color images. Infrared capability shall capture the plate number regardless of sun glare, headlights, darkness, or weather conditions.
- The system optical character recognition (OCR) engine shall be specific to the region. The system shall operate under conditions of skewed and off-axis plate reads, various plate sizes, syntax rules, and designs.
- The system shall vary the flash, shutter and gain settings of the camera to capture multiple plate images, ensuring the highest quality photo regardless of light or weather conditions. The image determined to produce the highest quality read shall be used for processing.
- Camera lenses shall be selected based on required depth and field of view.
- Camera enclosures shall be weatherproof sealed to IP67 Standards minimum and the Operation Temperature range shall be -20 to 75 °C.
- The system shall support TCP / IP Ethernet with socket and FTP protocols, Wireless LAN connectivity, relay output, RS232, or true IP connectivity over GPRS / GSM.
- The cameras shall be web-enabled IP-addressable devices.

1.3.2.4 Software and Databases

- Database

- Database system software includes administration utilities permitting for customization of screens, setup of users, and specification of databases for comparison purposes.
- The software shall permit data mining, allowing users to locate and map hits based on a wide range of criteria including partial plates, street address, GPS coordinates, and time and date.
- Remote camera health notifications shall be provided via email.
- Car Park Monitoring Software
  - The software shall be web based and track items such as:
    - Mean stay times
    - Total vehicle in/out
    - Current occupancy levels
  - The software shall offer graphing functionality to provide visual depiction of key trends.
  - The software shall also identify unusual behaviors, such as repeat visitors or long stay visitors.
  - The software shall create hotlists to flag vehicles known for suspicious activity and alert management when such vehicles are present.

- User Portals
  - User software shall have a web enabled interface permitting remote mobile users to perform queries and receive hit alerts from local servers using laptops or PDA's. The system shall permit efficient allocation of enforcement resources for fixed camera deployments.
  - The application software shall be intuitive and configured to permit individual selection of device(s) and hotlist(s) of interest.
  - The software shall display reads including license plate number, time & date, device and location (GPS coordinate).
  - The software shall be username and password protected requiring preset VPN or firewall recognition.

1.3.3 Intrusion Detection Systems

1.3.3.1 General

- This Subsection applies to the intrusion detection systems inside residential, commercial, institutional and industrial facilities.
- Purpose
  - The primary purpose of the intrusion detection system is to notify public safety personnel and/or facility occupants upon system alarm, providing the location and type of secure perimeter breach.
  - The secondary purpose is to initiate security functions which are building functions intended to increase the protection of the individuals and physical property.
- The intrusion detection system shall be provided in accordance with the physical security requirements of the facility.
  - The A/E shall collaborate with the Entity to determine the following project intrusion detection system requirements prior to the 10% design submission.
    - Project site security perimeters
    - Building security perimeter
    - Layered security perimeters within buildings
      - Public Areas
      - Employee Areas
      - High Value Asset Areas
    - Intrusion Detection Zones
    - Alarm Types and Zones

- Building Hours of Operation
- System Arming/Disarming Positions
- System Monitoring Positions
- System Reporting Locations and Means
- Building Systems Interface Requirements
  - Fire Alarm System
  - CCTV Video Surveillance System
  - Access Control System
  - Lighting Control System
  - Building Automation Systems

- The A/E shall prepare documentation to summarize the recommended approach for the intrusion detection system designed for the facility. This documentation shall be submitted to the Entity for review and approval and shall include the following:
  - Floor plans illustrating the locations for all required intrusion detection system equipment
  - Description summarizing the detection methods selected for the various spaces throughout the facility
  - System operational description

1.3.3.2 System Description and Requirements

- The intrusion detection systems shall consist of modular architecture, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.
- The intrusion detection system shall be a component of an integrated security management system that performs additional related functions such as access control, security video surveillance, and emergency communications.
- System components shall be continuously monitored for normal, alarm, and trouble conditions.
- Alarm signals shall display at a master control unit and actuate audible and visual alarm devices.
- Trouble signals shall indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
- A master control unit shall directly monitor intrusion detection devices and connecting wiring in a multiplexed distributed control system or as part of a network.
- The system shall interface with computer software with the capability to fully program the panel by connecting to the panel through a standard phone line connection, Ethernet network connection, or network connection across the Internet.
- The system areas and zones shall be programmable and can be assigned to time schedules. The system shall store, log, display, and transmit specific custom designations for system areas, zones, and user names.
- The system shall support user interaction by way of a keypad, web browser, system software, key switch, or radio frequency wireless control.
- System operators shall have the ability to acknowledge alarms, arm/disarm zones, and conduct system tests.
- Alarm or supervisory signals from certain intrusion detection devices shall permit the intrusion detection system to control the following functions in related systems:
  - The system shall interface with computer software capable of locking down all access controlled doors.
  - The system shall interface with computer software capable of monitoring and logging all events.
  - The system shall interface with computer software capable of exporting reports.
  - Switch selected lights.

- Shift elevator control to a different mode.
- Open a signal path between certain intercommunication stations.
- Switch signal to selected monitor from CCTV camera in vicinity of sensor signaling an alarm.

1.3.3.3 Detector Operation and Selection

- The most common detector sensor devices which are generally used include motion sensors, photoelectric beams, and glass break detectors.
- Specialty detectors such as shock detectors may be considered for special applications in appropriate facilities.
- Motion Sensors
  - Motion detectors determine if someone is moving in protected rooms or areas. Ceiling or wall-mounted devices detect movement within the protected area and analyze the motion to determine if an actual intrusion occurred.
  - If the sensor detects motion when the system is armed, an alarm message is sent to the central monitoring station. While the system is disarmed, it monitors the motion throughout the day, but does not send alarm messages. It can, however, send messages if someone tampers with the detector.
  - Motion detectors may utilize various technologies to detect motion including passive infrared (PIR) technology, microwave motion technology, and dual motion technology.
    - Passive Infrared Technology
      - The PIR detector can be made up of one or more elements that are precisely arranged and aimed so that the sensor can judge the size and speed of travel related to a moving object within its view pattern.
      - This can help to minimize false activations from rodents or other small animals, yet trigger accurately when a person walks within its viewing pattern.
      - When the detector senses motion in the protected area, its relay output changes the state of a zone input on the system. The control panel responds to this change according to its program.
      - PIR detectors contain optical mirror or lens configured to create a viewing pattern.
      - There are three major types of PIR sensor visual patterns including:
        - Wall-mounted long-range curtain or barrier pattern
        - Wall-mounted wide angle, volumetric
        - Ceiling-mounted 360 degrees wide angle, volumetric
    - Microwave Motion Technology
      - The sensor uses the Doppler Effect to sense a change in the frequency of a low-power microwave signal. As an object moves toward the sensor, the reflected frequency increases. As an object moves away from the sensor, the reflected frequency decreases.
      - By comparing these characteristics with the frequency being transmitted, the detector can accurately sense an object as it moves through the protected area.
      - When the detector senses motion in the protected area, its relay output changes the state of a zone input on the system. The control panel responds to this change according to its program.
      - K-Band microwave technology shall allow a precise pattern wave less likely to activate when objects outside of the protected room move, such as in the case with store-front display windows or multi-tenant office complexes.
    - Dual Technology Motion
      - Dual technology motion detectors use both PIR and Microwave technologies to determine if there is motion within a protected area prior to alarming.
      - The major advantage of using dual technology motion detectors is the built-in validation of motion within the protected area. Both sensors detect motion, but sense

it in different ways. This helps to minimize false activations caused by environmental changes, small animals and other unexpected conditions.

  - In some cases, the detectors can conserve power by allowing the PIR to remain active while allowing the microwave sensor to sleep. If the PIR senses motion, the microwave sensor activates and verifies the motion. If there is no motion sensed, the detector does not change the state of its alarm output.
  - When the detector senses motion from the PIR and microwave sensors in the protected area, its relay output changes the state of a zone input on the system. The control panel responds to these changes according to its program.

- PIR detectors shall be used only in stable environments with no open windows and minimal air flow.
- Dual technology motion detectors shall be used in harsh environments such as drafty areas in front of windows, warehouse and storage environments or in multi-tenant facilities.
- Motion detectors may be wall or ceiling mounting. Observe product guidelines for permissible mounting heights.
- Motion detectors located in public areas or otherwise potentially subject to intentional tampering shall have cover and base tamper supervision and anti-mask supervision to avoid blockage of view.
- Motion detectors shall be connected to the intrusion detection system using independent zone inputs or be installed as part of an addressable system.
- The pattern diagrams of each motion detector shall be verified to ensure coverage of area to be protected. Detectors shall have pattern shaping capabilities to provide coverage in zones as required.
- Motion detectors to be installed in areas where animals or pests may be present shall have animal immunity features.
- Motion detectors shall have LED status indicators to permit visual confirmation of operation.
- Motion detectors shall be discrete and low profile where space aesthetics is a project goal.
- The motion detectors used shall resist false alarms.
- Where approved by the Entity, wireless motion detectors may be used for specific deployments.
  - Wireless connections shall be fully supervised.
  - Batteries shall have a minimum 5-year life.
- Outdoor rated motion detectors shall be used in the case of secured outdoor areas, infrastructure sites, building sites, and industrial yards.

- Photoelectric Beams
  - Photoelectric beams detectors shall be used in indoor or outdoor applications to provide a line of sight detection barrier between a transmitting and receiving unit.
  - It shall detect an interruption of a pulsed, infrared, light beam that links transmitter and receiver.
  - Photoelectric beam detectors may be used for outdoor applications such as fence lines, parking areas, outdoor stock areas, buildings, driveways, and roadways.
  - Photoelectric beam detectors may be used for indoor applications such stock isle protection and shipping and receiving doors.
  - The detector shall have adjustable optics and obscuration timing to calibrate to environmental issues.
  - The detector shall require two mounting locations that are within an open line of sight.
  - The receiving unit shall be mounted closest to the control to minimize cabling of tamper and alarm outputs.
- Glass break Detectors
  - Glass break detectors shall be used to detect unique airborne acoustic energy spectrum and high-frequency vibrations caused by breaking glass associated with unlawful intrusion through windows.

- The detector shall sense the characteristics and patterns associated with a wide variety of common glass types such as plate, tempered, laminated, coated, wired, double pane, sealed and insulated.
- The detector shall be designed to suppress very loud noises associated with a window break occurring in close proximity to the sensor.
- The detector shall permit remote testing using handheld simulator/test equipment.

- Shock Detectors

  Shock detectors shall detect tampering and movement and be used to protect high value assets such as safes, vault doors, computer equipment, electronics, tools, building materials, and pieces of art.

1.3.3.4 Intrusion Detection Control Panel

- Control panels shall be designed to meet the unique requirements of each building and occupancy. Control panels shall be located in secured environmentally conditioned areas within proximity of facility access control and security video surveillance equipment panels.
- The control panel shall contain the following features:
  - Hardwired zones
  - Support for wireless zones
  - Power limited bell circuit
  - Dialer
  - Accommodation for user codes, authority levels, and keypad macros
  - Scheduling
  - Event logging
  - Pager support
  - Printer support
  - Multiplexing loop interface
  - Programmable auxiliary relays
  - Partitioning for independent control of areas
- Zoning

  The building area may be divided into zones as required to allow for accurate and rapid determination of the intrusion location and the type of detectors being activated.
- Control panels shall have spare zone capacity.
- The control panels shall be a multi-processor based networked system designed specifically for intrusion detection. The control panels shall include all required hardware, software, and site specific system programming to provide a complete and operational system.
- The control panel shall be diagnostic type and shall be designed such that interactions between any applications can be configured and modified using software provided by a single supplier.

1.3.3.5 Keypads

- Keypads shall be provided for system user interfaces. They shall be located at designated building access points.
- The keypads shall have LCD or graphic displays with menu driven prompts for clear operation without the use of complicated command strings.
- The keypads shall display current system status and alarm locations.
- Authorized building users shall be able to arm and disarm the intrusion detection system through the keypad interface.

1.3.3.6 Intrusion Detection Sounders

- The intrusion detection system shall be designed with sufficient notification devices to provide ample notification for the building occupants. Notification shall include both audible and visual devices.
- Audible
  - Audible devices consisting of horns, bells and/or speakers shall be located throughout each facility to provide audible notification of the intrusion condition. Audible devices shall be specified with multiple tap settings to facilitate adjustment of the sound intensity to adapt to the final installed conditions.
  - The type of audible device shall be determined from the requirements of the facility. The A/E shall develop a recommendation for the type of audible device and submit to the Entity for review and approval
  - Audible devices located outdoors shall be specified with a weather-proof enclosure.
- Visual
  - Strobes shall be located throughout each facility to provide visual notification. Strobes shall be specified with multiple candela ratings to facilitate adjustment of the light intensity to adapt to the final installed conditions.
  - Visual devices located outdoors shall be specified with a weather-proof enclosure.
- Audible/Visual Combination Devices

  The use of combination audible/visual devices is permitted and is the preferred approach.

1.3.3.7 Power Source(s)

- Power to the control panel must be fed from a reliable source of supply which will not be disconnected for maintenance on other electrical systems. The circuit breaker shall be labeled "Intrusion Detection - Do Not Switch Off" and shall be capable of being locked.
- Standby power shall be available to the system in case of failure of the main power source. Integral backup provision with nickel cadmium batteries shall be located in the control panel. The backup batteries shall be sufficient to operate the system for a minimum of 24 hours.
- Where the building is furnished with a backup power source (generator, battery, or UPS) the system shall be supplied from the life safety emergency power branch in addition to the integral batteries.
- Power supplies shall initially be sized with 20% spare capacity to accommodate future system modifications.

1.3.3.8 Wiring Requirements

- General

  The wiring network for the intrusion detection system must be designed in accordance with the applicable codes and must address the criticality of the facility. The extent of redundancy and survivability must be determined to properly specify the appropriate wiring system.
- Installation
  - The intrusion detection cabling shall be installed in a dedicated raceway system.
  - Minimum conduit sizes shall be 20 mm.
  - All wiring shall enter panels from the bottom to prevent moisture from entering the panel through the conduit.
  - All wires shall be numbered and labeled.
  - Provide separate circuits for audible and visual devices.

1.3.4 Vehicle Barriers

1.3.4.1 Bollards

- Provide bollards for protection of pedestrian areas and buildings as required by the project.
- Bollards shall provide protection of areas from accidental or intentional acts.

1.3.4.2 Active Barriers

- Retractable Vehicle Barriers
  - Retractable vehicle barriers shall be provided at secured entrances and checkpoints as required by the project.
  - The system shall operate in either a normally open or closed state.
- Active Cable Barriers

  Active cable barriers shall be provided at critical check point locations as required by the project.
- Drop Arm Crash Beams

  Drop arm crash beams shall be provided at critical check point locations as required by the project.

1.3.5 Video Surveillance Systems

1.3.5.1 Description of System

- Video surveillance systems shall permit real time and recorded video monitoring of building and site areas as required by the project.
- The video surveillance systems shall consist of surveillance camera, wired or wireless connectivity; network based video transport and switching, network video recorders, and monitoring software and stations.
- Design of the surveillance system shall be based on Open Network Video Interface (ONVIF) profile S in order to assure cross vendor compatibility.

1.3.5.2 Camera Selection and Location

- Interior, Controlled Environment: System components installed in temperature controller interior environments are rated for continuous operation in ambient temperatures of 0 to 50° C dry bulb and 20 to 90% relative humidity, noncondensing. Use IP10 rated enclosures.
- Interior, Uncontrolled Environment: System components installed in non-temperature rated controlled interior environments are rated for continuous operation in ambient temperatures of -17 to 60° C dry bulb and 20 to 95% relative humidity, noncondensing. Use IP52 rated enclosures.
- Exterior Environment: System components installed in locations exposed to weather are rated for continuous operation in ambient temperatures of minus 34 to plus 75° C dry bulb and 20 to 95% relative humidity, condensing. Rate for continuous operation as specified in IEC 60529.
- Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence, the housing shall be IK10 Rating.
- Cameras shall be selected to allow high definition video recording.
- Dynamic range of the camera shall be selected based on the expected lighting conditions at the site. Cameras with more than 100dB dynamic range shall be used when facing exterior doors.
- Panoramic view cameras are to be selected in order to minimize the number of cameras.
- Cameras with built-in SFP ports shall be used in order to minimize the need of media converters, or industrial switches at the edge. However, for those applications where Outdoor IP Cameras shall be installed at locations with more than 90 meters from the nearest Telecom Room, the connections shall be done through Ethernet Media Converters with PoE and Fiber Optic Cables.

- System shall be designed with no exposed cabling near the cameras. All power and communication cables shall be secured.
- Perimeter Fence Cameras in Wide Industrial Areas: In those Wide Industrial Areas where an important quantity of Industrial Plants and Buildings are located, Multi-sensor Thermal Cameras with Continuous Zoom Lens shall be installed along the Perimeter Fence. These Cameras shall comply at a minimum with the following: Simultaneous analog video outputs (Thermal and Visible Light), easy integration into IP Networks, Continuous Thermal Zoom available, P/T with continuous 360° pan, Combined Technology of Infrared and CCD imagery in real time, Multiple lens combinations for tailor-made range performance, IP65.

1.3.5.3 Network and Video Transport Requirements

- Surveillance systems shall be served with IP network connectivity
- The IP network shall be configured as a dedicated network or subnet.
- Network ports or power injectors shall be capable of supplying Power over Ethernet compliant with IEEE 802.3af.
- IP networks shall be fault tolerant utilizing redundant uplinks, and redundant power supplies.

1.3.5.4 Network Video Recording Requirements

- IP Network based network video recorder (NVR) storage appliances or Network attached storage solution shall be used to record video.
- Whenever the sites are connected to the Entity Metro Network, all recording shall be done centrally in the Entity datacenters. Edge storage is only allowed upon approval from Entity.
- All network recording appliances shall be ONVIF Profile G compliant.
- For edge storage, storage appliances shall be secured, both physically and environmentally.
- Configure devices with storage capacity to meet requirements for number of cameras to served, recording rates, and archival time periods needed. Provide spare capacity to meet 5-7 year anticipated future growth of the system.

1.3.5.5 Video Analytics

NVR systems shall permit various software based video analytic features.

1.3.5.6 Monitoring Workstation Requirements

- Monitoring workstations shall be PC based and be connected to the video surveillance IP network
- Supplemental flat panel monitors shall provide viewing capability for additional cameras.

1.3.5.7 Cabling and Pathway Requirements

IP network connected devices shall have cabling requirements that meet the building telecommunications structured network cabling plant requirements.

1.3.5.8 Power Source Requirements

Incorporate sufficient Power over Ethernet sources to serve devices. Power supplies shall be redundant.

1.3.6 Security Screening

1.3.6.1 Security screening requirements shall be based upon project risk assessments and may include the components as required on a per project basis:

- Divest and Composure Tables
- Walk Through Metal Detectors
- Baggage X-ray Machines
- Explosives Detection and Trace Systems
- Officer Station
- High Speed Operational Communications
- Video Surveillance Coverage
- Under Vehicle Surveillance
- Vehicle Recognition
  - Weight Sensors
  - Traffic/Flow Control
  - Explosives Detection
  - Trunk X-Ray
  - Undercarriage Scanning
  - Personnel Credential Access Control
  - Barricades

1.3.7 Carbon Monoxide Detector System (CO)

1.3.7.1 An integrated CO system with smoke sensors shall be provided at basement levels to prevent any damage occurs due to gases in Car Parking. A control panel shall be installed in security control room and connected with BMS system.

1.4 Utilities

1.4.1 Outside Plant Infrastructure

1.4.1.1 The principles and criteria specified in this Section are applicable to the telecommunications outside plant/buildings provided between the local exchange and the subscriber's plot boundary, and also applicable to any section of outside plant/buildings within this area that has to be determined by A/E.

1.4.1.2 Sub/ducts between handholes or manholes (Fiber Optic Cable Distribution): A/E shall make use of HDPE duct materials and microduct configurations that provide enhanced densities and compatibility with air blown fiber installation techniques. Polyethylene Corrugated (PEC) duct shall only be provided where existing PEC installations are altered or backwards compatibility is otherwise required. In these cases, final configuration of ducts shall match existing.

1.4.1.3 In the existing Manholes which belong to third parties (such as Service Provider) and where are installed main Trunk Lines/Backbone Cables connecting Feeders, a Mechanically Stabilized Earth (MSE) Wall is required around the Telecommunication Manhole and this structure

1.4.1.4 FTTH GPON and Metropolitan Networks OSP Infrastructure

- OSP Ductbank Requirements Spanning from the FAT to the FTB.
  - The OSP ductbank shall be shared between the Entity networks and TSP networks. OSP design shall conform to the requirements of the TSP. color coding shall be used to identify the duct use.

- The maximum distance between the FAT and FTB shall typically not exceed 160 m. In special cases where distances are permitted to be exceeded, additional One Cover Handholes shall be provided for ease of pulling cabling.
- The minimum trench size shall typically be 150 mm wide and 500 mm deep, but this shall be adjusted as required to facilitate final quantity of ducts within a segment.
- The trench shall be backfilled by concrete up to asphalt level and asphalt shall be reinstated with milling and paving.
- The ductbank shall typically consist of twenty- five (25) x 20 mm HDPE ducts situated in a5-wide by 5-deep arrangement. Each duct shall have 20 mm outside diameter/16.2 mm inside diameter and nominal wall thickness of 1.9 mm.
- Ducts extend in pairs to a customer location where one shall be used for FTTH networks and the second duct shall be used for TSP services or spare. A maximum of twelve (12) buildings shall be connected from one handhole including vacant lots, and can go up to fifteen (15) buildings in special cases only.
- HDPE duct material shall conform to the following construction classifications: PE-100, PN-16, and SDR-11.
- Spacers shall be installed with the duct at every 1.5 m to keep the duct straight and in position.
- Pairs of 20 mm HDPE ducts exit the trench to extend to customer locations. These shall be routed in an offset trench with minimum size of 90 mm wide and 400 mm deep situated in a 2-wide by 1-deep arrangement.
- U-guard shall be installed on customer wall to protect the poke out pipe. The length of the U-guard shall be of 1.5 m from the finished surface. There shall be no gap between U-guard and FTB. The duct should enter/flushed with FTB. The clamps shall be securely placed with Aluminum screws.

- OSP Ductbank Requirements Spanning from the FDT to the FAT.
  - The OSP ductbank shall be shared between the Entity networks and TSP networks. OSP design shall conform to the requirements of the TSP. color coding shall be used to identify the duct use.
  - The distance between the MH to MH or MH to HH shall be within 250 m to 350 m. The minimum distance requirement shall be 25 m.
  - The minimum trench size shall typically be 200 mm wide and 650 mm deep, but this shall be adjusted as required to facilitate final quantity of ducts within a segment.
  - The trench shall be backfilled by concrete up to asphalt level and asphalt shall be reinstated with milling and paving
  - The ductbank shall typically consist of twelve (12) HDPE ducts in a 3- wide by 4-deep arrangement. Each duct shall have 32 mm outside diameter28.2 mm inside diameter and wall thickness of1.9 mm.
  - Four (4) of the twelve (12) ducts are to be orange color and are dedicated for use by the TSP. Likewise four (4) ducts are to be blue in color and dedicated for use by the Entity. In addition, four (4) ducts are black in color and designated for common use applications. Each set of color coded ducts are arranged adjacently in a 1-wide by 4-high configuration.
  - To facilitate efficient use of trenches, this trench is also used for routing ducts for FTTH drop cabling from each FAT to the FTB at customer premises. These ducts consist of twenty- five (25) x 20 mm HDPE ducts grouped in pairs and situated in a 3-wide by 4-deep arrangement. The ducts are positioned directly above the twelve (12) 50 mm HDPE ducts within the trench. Each pair of ducts extends to a customer location where one shall be used for the Entity FTTH networks and the second duct shall be used for TSP services or spare. Each duct shall have 20 mm outside diameter/16.2 mm inside diameter and nominal wall thickness of 1.9 mm.
  - HDPE duct material shall conform to PE-100, PN-16, and SDR-11 construction.
  - Spacers will be installed with the duct at every 1.5m to keep the duct straight and in position.
- Manholes and Handholes
  - Mini Manhole – Type 1

- The precast manhole shall have a single round cover and be provided at network locations encountering widths of roads 30 m and more.
- This manhole shall also be installed at junctions where a third duct bank will join the manhole or where determined to be required by the network layout.
- The distance between manholes shall be minimum 50 m and maximum 300 m with +/- 50 m.
- Outer dimension requirements: 1,550(L) x 1,550(W) x 1,990(H) mm
- Inner Dimension requirements: 1,200(L) x 1,200(W) x 1,200(H) mm
- Circular duct penetration openings shall be provided on two opposite walls for main duct entrance terminations. In addition, a rectangular opening shall be provided for poke-out termination to accommodate a minimum of thirty (30) 20 mm ducts on two opposite walls.
- The cover of the hand-hole shall be rated with a minimum 350 kN design loading.

- Two Cover Handhole
  - A two-cover precast handhole shall be provided at network locations encountering widths of roads less than 30 m.
  - A two cover handhole shall be used either at the end of the trench or in a straight duct for breaking the length.
  - Outer dimension: 1,550(L) x 1,000(W) x 950(H) mm
  - Inner Dimension: 1,250(L) x 800(W) x 800(H) mm
  - Circular duct penetration openings shall be provided on two opposite walls for main duct entrance terminations. In addition, a rectangular opening shall be provided for poke-out termination to accommodate a minimum of thirty (30) 20 mm ducts on two opposite walls.
  - The cover of the hand-hole shall be rated with a minimum 350 Kn design loading.
- Manhole – Type A
  - Type-A manholes shall be provided front of FDTs. The maximum distance from FDT to manhole shall be 5 m.
  - The distribution cable shall be extended directly into the FDT cabinet. Only joint closure shall be installed for the feeder cable to extending to the Entity ODF equipment at the local exchange.
- Manhole Covers
  - Manhole covers shall be cast iron construction from a TSP approved manufacturer where shared manholes are required.
  - The cover of the hand-hole shall be rated with a minimum 350 Kn design loading.
  - The manhole cover shall have lock with unique head.
  - Where required by the Entity for telecom manholes, a clearly visible inscription shall be provided on each cover. In addition, the manufacturer name and load rating shall be clearly marked on the cover.
- Manhole Cable Service Loops
  - Manhole Type-A and Mini Manhole

    Cable service loop lengths shall be provided within each manhole:
    - Distribution cable without splice - 5 m
    - Distribution cable with splice closure - 8 m, with 4 m for each side
    - Drop cable from customer building - 4 m
  - Two Cover Hand-Holes

    Cable service loop lengths shall be provided within each manhole:
    - Distribution cable with splice closure - 5 m, with 2.5 m for each side
    - Drop cable from customer building - 2.5 m

- FDT Pedestals

- The pedestal of FDT shall be pre-cast and approved by the TSP where shared colocation cabinets are to be provided.
- Protection posts (bollards) shall be installed around the FDT

- Micro ducts
  - HDPE micro ducts are utilized in duct bank trenches to provide enhanced cabling densities and compatibility with air blown fiber installation techniques.
  - Where large numbers of optical fiber cables are required within a duct bank for backhauling of communities and districts, micro ducts shall be implemented in main duct banks to enhance duct capacity. A minimum of two ducts within the trench shall consist of micro ducts with additional added as required to meet duct bank forecasted capacity requirements.
  - Micro ducts may be implemented in two (2) configurations:
    - Where service is to be provided through existing duct bank systems, the micro ducts shall be provided through existing ducts.
      - Four (4) micro ducts with 14 mm outside diameter/11.5 mm inside diameter shall be installed in an existing duct of 50 mm outside diameter/40.8 mm inside diameter.
      - The four micro ducts shall be provided either individually or bundled with a skin jacket and installed by blowing or pulling techniques.
      - To enhance the capacity to existing ducts which are already occupied by cabling; provide a micro duct with micro cable installation. Manufacturers' recommended procedures and practices shall be followed.
    - Where new duct banks are provided, mini/micro ducts shall be installed directly in the trench among other ducts.

      Four mini ducts with 16 mm outside diameter/12 mm inside diameter bundled with a hard jacket can be installed directly in the trench and encased in concrete among and in lieu of other main ducts of 50 mm outside diameter/40.8 mm inside diameter.
  - The micro duct orientation with adjoined duct segments must be consistent throughout trenches and entering/exiting manholes/handholds. This is critical to prevent difficult physical transitions while joining micro ducts.

1.4.1.5 Blown Fiber Design

- Blowing Fiber is a method where the fiber is guided through micro ducts using a flow of air that evenly distributes the installation force along the entire length of the fiber. Blown fiber installations shall be provided for extending single mode optical fiber through duct bank systems for implementation of FTTH GPON and metropolitan networks.
- The blown fiber system is an enterprise network system comprised of interconnecting microducts and distribution hardware to provide reusable pathways for reusable microcables, bundled fiber optic cabling containing single mode fiber strands.
- Microcable Requirements
  - Microcables shall be installed in the same color of microduct throughout the span.
  - The fibers used for blown fiber cables shall be a single mode, coated with two layers of acrylic that gives excellent protection to the fibers and also arrange fibers in bundles for easy identification.
  - The cable construction has outer diameter of 1.0 to 5.5 mm depending on the number of fibers and can easily be deployed in empty microducts.
- Microduct Requirements
  - Microducts consist of small diameter low friction HDPE tubes providing the dedicated pathway for the optical fiber microcables.
  - Microducts may be provided into existing ducts, concrete encased, or inside buildings (internal). Select the appropriate rating for the microducts based on the environment in which they are installed.
  - Provide microduct tubes sizes and quantities to facilitate the quantity and strand count of the microcables that are to be provided, including anticipated future growth. Microducts are

available in a variety of sizes and combinations including but not limited to, 5/3.5 mm, 7/5.5 mm, 10/8 mm, and 12/10 mm (outside/inside) diameters, loose, or with protective layer system.
    - Microducts may consist of bundled tubes in typical sizes of 1, 2, 4, 7, 12, 19, 24 or more tubes.
- Microduct Accessories
    - Microducts shall be connected together sealed from water or gas ingress, reduced from one tube size to another, or sealed with end caps.
    - Compact Node Closure: A closure used in manholes where blown fiber cables are spliced (to traditional or blown fiber cables). It is supplied with splice trays and sufficient components for installing cabling and enabling the breakout of fibers to customer drop cables.
    - Branching Unit (Tube Distribution Center): Used for management and distribution of fibers to the customers. The unit provides in-line and diversion connections with the use of "Y" and "T" tube joints.
    - Entry Kit: Installed at the customer premises for termination of incoming tube microducts and optical fibers at the Fiber Termination Box (FTB).

1.4.2 Power Distribution, Uninterruptible Power Supply (UPS)

1.4.2.1 System Description

Uninterruptible Power Supplies shall be provided where sensitive telecommunications systems shall not experience sudden power failures or anomalies.

1.4.2.2 UPS Selection and Locations

- The UPS shall be sized to support equipment required plus spare capacity as needed by the project.
- UPS units shall be mounted on equipment racks or floor mounted.
- Provide battery run time as required by the project to permit orderly shutdown, or ride through outages of a given duration.

1.4.2.3 Management

UPS units shall be SNMP compatible with network connections for management.

1.4.2.4 PDU Requirements

Determine requirements for UPS power outlets including:

- Quantity
- Amperage
- Voltage
- Device types

1.4.2.5 References

Refer to Document Number EPM-KEE-GL-000001: Electrical Design Guidelines for Backup Power Systems.

1.4.3 Earthing and Bonding

1.4.3.1 The grounding shall include all cable and installation hardware required. All equipment shall be connected to earth ground via internal building wiring according to ANSI/TIA-607-B, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.

1.4.3.2 Standards

This includes:

- Coaxial cable shields
- Equipment racks and cabinets
- Cable ducts and trays
- Conduits

1.4.3.3 Earthing materials shall be as follows:

- Ground Rods
  - Ground rods shall be solid, of bounded copper or copper-clad steel, not less than 16 mm in diameter and 3 m long, driven full length into the earth.
  - The copper-clad steel ground rod shall be manufactured by a fusion weld process resulting in an electrolytic copper sheath homogeneously welded to and inner steel core. The thickness of the copper sheath shall be approximately 10% of the overall rod diameter. Copper electroplated steel is not acceptable.
  - The rod shall be of sufficient strength to be driven through the soil found at site location. The upper end shall either be equipped with or capable of accepting a clamp that will also be capable of accepting a 16 mm^2 ground wire.
  - The clamp shall furnish an electrical connection between the ground wire and the ground rod so that the electrical resistance is not more than 100 mΩ.
- Ground Wire

  The ground wire shall consist of a 16 mm^2 solid, annealed copper wire, covered with a PVC outer sheath for corrosion protection. The minimum thickness for the sheath to be 0.76 mm.
- Grounding System Accessories
  - Ground system accessories shall include without limitation:
    - A connector for connecting the ground wire to the ground bus so that the electrical resistance across the connection will be less than 100 mΩ.
    - Connectors for connecting the ground conductor of each splice to the ground bus so that the electrical resistance across the connector is less than 100 mΩ.
  - Ground Bus
    - The ground bus shall consist of a tinned copper ribbon of 16 mm^2 cross-sectional area. This bus shall appear in each bay equally spaced between the cable racks. It shall begin 300 mm above the floor and shall be mounted vertically to a height of 100 mm above the cable rack.
    - Each vertical bus shall be electrically connected to the other vertical buses.
    - Fastening shall be by drive-in anchors of 10 mm diameter, 25 mm long at a distance of 300 mm apart for both vertical and horizontal runs, with a drive-in at each termination and each change of direction. The vertical runs shall have a lapped projection of 15 mm every 200 mm.

1.4.3.4 Building Telecommunications Grounding Systems

- Each building shall be equipped with a grounding system.

- The grounding system shall compromise of a telecommunications main grounding bus bar (TMGB) to be installed in the TER. The TMGB shall be directly bonded to the building ground grid via a grounding conductor. The location of the grounding conductor, to the building grounding grid, must be coordinated.
- A standard insulated copper lead of 16 mm 2 - 7 strands shall be run from the ground point of the protection blocks and body of the terminal boxes to ground, connected by exothermic weld or equivalent means to the ground system.
- The CATV and telephone boxes shall be joined by a 25 mm conduit nipple to allow the CATV protector ground to be connected to the telephone ground lead. The run shall be as direct as possible and contain no kinks or sharp bends. A separate lead shall be run for each box installed within a building that contains protector blocks, joining to the ground underground.

2.0 INSTRUMENTATION AND CONTROLS

2.1 General

2.1.1 Introduction

This Subsection includes automation systems (and less complex systems) that require separate focus, and provides the basis for design and technical criteria for the following to meet the engineering requirements of the Entity designated areas.

- The Integrated Building Automation Systems for commercial buildings, schools, universities, hospitals etc.
- Instrumentation, Automation, and Process Control Systems (PCS) for other industrial and/or treatment facilities to include sea water cooling, potable water, sanitary waste treatment, industrial waste treatment, Fuel Pipeline, etc.
- SCADA systems
- RTU and SCADA system for Automatic Irrigation system
- Fire Alarm, Gas Detection and Fire Supersession Control System.

2.1.2 Scope

2.1.2.1 The scope of the guideline provides:

- The basis to be followed by A/E making calculations and/or preparing drawings and specifications of Integrated Automation Systems within Entity premises, including the engineering design phase of Contracts where Engineering, Procurement and Construction are combined (EPC Contracts).
- The framework within which work will be performed by A/E to ensure uniformity throughout the infrastructure of the Project and compatibility within the Entity premises.
- Mandatory, minimally acceptable requirements for the Entity new and retrofit projects.
- The basis, on which the Integrated Automation Systems, Instrumentation and Control Systems and services shall be programmed, designed and installed.

2.1.2.2 This Subsection indicates the minimum level of quality required by the Entity to:

- Define the role of the Authorized Representatives and the responsibilities of the A/E,
- Provide a reference basis for Saudi Arabian and International Codes and standards, and for the Guideline Specifications and Guideline Details
- Ensure flexibility and adaptability to accommodate future developments and expansion.

2.1.2.3 This Subsection does not provide information normally found in available textbooks, handbooks, codes and standards, nor does it attempt to duplicate design criteria within the expertise of the A/E.

2.1.2.4 Design decisions are to be developed for specific applications as the design progresses. Project conditions may dictate the need for design that exceeds these minimum requirements.

2.1.2.5 In the event there is a conflict between the Guidelines, the requirements of the Entity and End Users, the conflict shall be brought to the attention of the Entity. The Entity shall provide resolution or direction on how to proceed.

2.1.2.6 The design of the Entity Control system requires full coordination and integration with other disciplines such as, but not limited to electrical, mechanical, piping, plumbing, environmental, Lift, ELV System which includes the telecom, fire alarm and access control system, loss and prevention design and etc.

2.1.3 Exclusions

While there are a number of similarities, the following standards/guidelines are not in the scope of this document:

2.1.3.1 Telecommunication Technology and /or topology is outside the scope of this section. The applicable design guidelines can be found in subsection 1.0: Telecommunication.

2.1.3.2 Where works interface with Saudi Electrical Company (SEC), the equipment/materials and installation shall comply with SEC standards latest revision, and shall be reviewed and approved by the SEC.

2.1.3.3 Where works interface with Saudi Telecommunication Company (STC) or service provider, the equipment/materials and installation shall comply with STC or service provider standards latest revision, and shall be reviewed and approved by the STC/ service provider.

2.1.4 References - Units of Measurement

2.1.4.1 Where applicable, the design, construction, commissioning and operation and maintenance of Instrumentation and Control systems shall satisfy and comply with the requirements and standards of the organizations and publications listed in this Subsection.

2.1.4.2 References

All work shall conform to the applicable industry codes, standards and associations. Refer to Subsections 1.1.4: Codes and 1.1.5: Standards for a listing of the codes and standards.

2.1.4.3 Units of Measurement

- All new facilities shall be designed for operation in SI units. Refer to NIST Special Publication 811 2008 Edition “Guide for the Use of the International System of Units (SI). Section 2.3 SI Units and Conversions of this document also has reference.
- Exception: Upgrades or modifications to existing facilities may retain existing operating units unless otherwise specified in project documentation.
- The International System of Units (abbreviated SI) is the modern form of the metric system. It comprises a coherent system of units of measurement built around seven base units, 22 named and an indeterminate number of unnamed coherent derived units, and a set of prefixes that act as decimal based multipliers. The standards, published in 1960 as the result of an initiative started in 1948, are based on the meter–kilogram–second (MKS) system, rather than the centimeter–gram–second (CGS) system, which, in turn, had several variants. The SI has been declared to be an evolving system; thus prefixes and units are created and unit definitions are modified through international agreement as the technology of measurement progresses, and as the precision of measurements improve.

- Standard conditions for bulk flow measurement and transfer of Sea Water Cooling is detailed further in this Section.

TABLE 2.0 A: STANDARD CONDITIONS FOR SEA WATER COOLING TRANSFER METERING

	SI Unit
Pressure	101.325 kPa (abs)
Temperature	15.00°C

2.1.5 Definition

Refer subsection: 1.1.2

2.1.6 Abbreviation

Refer subsection: 1.1.3

2.1.7 Codes & Standards

Refer subsection: 1.1.4 and 1.1.5

2.1.8 Environmental Condition

2.1.8.1 The following environmental conditions shall be applied to all components of the control systems as required.

- Air-Conditioned Building - General Purpose Areas

  Equipment located in air-conditioned interior building areas, are subject to ambient temperatures varying from 10°C to 35°C with ambient relative humidity levels between 20% and 80%.

- Unclassified Light Industrial Locations
  - Field equipment located in unconditioned interior process areas, which are not classified as corrosive or hazardous locations, are subject to ambient temperatures varying from 0°C to 40°C with relative humidity levels of 100%.
  - There may be incidental quantities of corrosive gas and dust. Therefore, the equipment shall be designed with materials for use in corrosive areas.
  - In exterior areas, ambient temperatures vary from 0°C to +55°C with strong direct radiation from the sun. The relative humidity in these areas may range from 85% to 100% with condensation occurring. All areas may have trace quantities of corrosive gas with windblown dust, sand, and rain.
  - In case of close proximity to the sea, there is a high level of salt in the air which is detrimental to unfinished metals and copper wiring and electronics.
  - Controllers, panels, etc., shall be located in environmentally protected enclosures or buildings wherever possible – see the following guidelines below.
    - Outdoor Sheltered - Maximum 55°C, Minimum 0°C, refer to Paragraphs below.
    - Outdoor Unsheltered - Maximum 65°C, Minimum 0°C, refer to Paragraphs below.
      - "Sheltered" refers to permanent, ventilated enclosures or buildings, or permanently fixed sunshades with a top and three sides.
      - For instruments, which dissipate internal heat and are installed in custom engineered enclosures (e.g., enclosures not included in the original manufacturer's temperature certification), an additional 15°C shall be added to the above maximum temperatures. An example, for "indoor air conditioned" installation, the equipment must perform at 35 + 15 = 50°C.
      - Similarly, for the "outdoor unsheltered" case, the equipment shall be designed for a maximum operating temperature of 65 + 15 = 80°C.

- For the outdoor installations only, the designer can take credit for forced or passive cooling to eliminate or reduce the 15°C heat rise. For example, if vortex coolers are used, the heat removal capacity of the coolers may be subtracted from the generated heat. No more than 15°C reduction in temperature will be given as credit. The designer shall substantiate his claim by providing the support data and calculations.
- All equipment specified for outdoor installation shall be compliant with the following contaminant levels:
  - Dust Concentration - Usual airborne dust concentration is 1 mg/m³. During sandstorms, dust concentrations may reach 500 mg/m³. Particle sizes are as follows:
    - 95% of all particles are less than 20 micrometers
    - 50% of all particles are less than 1.5 micrometers
  - Elements present in dust include compounds of calcium, silicon, magnesium, aluminum, potassium, chlorides and sodium. When wetted (high humidity conditions) these compounds function as electrolytes and can result in severe corrosion.
  - Other pollutants present in the atmosphere under the most extreme conditions are:
    - H2S 20 ppm (vol/vol)
    - Hydrocarbon 150 ppm (vol/vol)
    - SO2 10 ppm (vol/vol)
    - CO 100 ppm (vol/vol)
    - NOx 5 ppm (vol/vol)
    - O3 1 ppm (vol/vol)
  - Equipment which is not enclosed or hermetically sealed, but is situated outdoors offshore or outdoors near-shore shall be protected against corrosion and operational failure due to wind-borne sea water spray and the accumulation of wetted salt (sodium chloride).
  - Near-shore is defined as within one kilometer from the shoreline of the Arabian Gulf, or within three kilometers from the shoreline of the Red Sea.

- Classified Field Locations

  The equipment located in classified areas shall be designed to meet the classification of the area in accordance with the IEC 60079 series standards and SBC Chapter 401.

- Corrosive Locations

  The equipment located in areas that are subject to corrosive fumes or spills shall be selected and erected in accordance with the requirements of IEC 60364-5-51 and SBC Chapter 501. Corrosive area locations for PLCs, panels, etc., shall be avoided wherever possible. Equipment required to be installed in corrosive locations shall be specifically designed to withstand the conditions.

- Noise Levels

  The noise levels for all equipment shall be less than or equal to:

  - 55 dBA for equipment installed in continuously manned areas.
  - 60 dBA for equipment installed in other areas.

- Equipment Enclosures
  - All equipment enclosures shall meet the following Ingress Protection rating as defined by IEC 60529. The object of these standards is to give:
    - Definitions for degrees of protection provided by enclosures of electrical equipment as regards:
      - Protection of persons against access to hazardous parts inside the enclosure;
      - Protection of the equipment inside the enclosure against ingress of solid foreign objects;

- Protection of the equipment inside the enclosure against harmful effects due to the ingress of water.

▪ Measures to protect both the enclosure and the equipment inside the enclosure against external influences or conditions such as:

- Mechanical impacts
- Corrosion
- Corrosive solvents (for example, cutting liquids)
- Fungus
- Vermin
- Solar radiation
- Icing
- Moisture (for example, produced by condensation)
- Explosive atmospheres
- And the protection against contact with hazardous moving parts external to the enclosure

○ All enclosures located outside which are not sheltered or made from stainless steel shall have a white finish to lower the internal temperature.

○ All enclosures with a lens or transparent display cover subject to direct sunlight shall be glass or as a minimum UV resistant.

- Sunshields

  All field instruments with local LCD or LED displays shall be equipped with sunshields to allow viewing of the displays and to shield the instrument enclosures from the heating effects of direct sunlight. In addition, instrument displays shall be north facing where possible to prevent direct sun exposure.

2.1.8.2 System Reliability

- All Field Instruments, Instrument Control Panels, Controllers, Network and Communication equipment, Servers and Workstations shall be provided with backup power during power failure transitions with an Uninterruptible Power Supply (UPS). The UPS shall provide a reliable source of uninterruptible power with no break in AC output power during a complete or partial interruption of incoming line power. The UPS shall include audio/visual alarms. The rating shall be adequate to provide uninterrupted conditioned power under fully loaded conditions for at least 30 mints. UPS status shall be monitored by the control system.
- Communication links between all controllers and facilities shall be continuously monitored and safe operating modes assumed whenever a communication failure has occurred. Normal operation modes will only resume when communications have been restored, depending on the process, safety issues, etc. Restart procedures following a communication or power failure shall be defined for each facility or process during preliminary design.

2.2 Control System Architectures

2.2.1 General

2.2.1.1 Control System is actually an integration of several sub-systems into a functional single platform. A Control System will ideally provide the highest level of safety for the Community, the Entity personnel and operations staff and must incorporate the principles of environmental safeguards, the protection of the process equipment, economy of operation in all regards, with high reliability and expansibility.

2.2.1.2 The Control System Architecture shall maximize single window concept, and the Operation Centre HMI Workstations such as PCS /SCADA/BAS shall integrate with all sub-systems and provide a single platform to control and monitor all facilities in the plant.

2.2.2 Scope

This Subsection describes the design elements and technical criteria for establishing an appropriate Control System Architecture for each of the following systems:

2.2.2.1 Building Automation System (BAS) is the more recent terminology adopted by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and shall be used in lieu of Building Management Systems (BMS). BAS is a distributed control system - the computer networking of electronic devices designed to monitor and control designed to monitor and control or interface with otherwise standalone systems – typically security (access control, CCTV, PA), fire and flood safety, fire pumps, fire suppression, lighting (especially emergency lighting, Energy Efficiency Control system), generators, HVAC and humidity control, ventilation systems and mechanical packages such as potable water pumps, lift stations, chiller package etc. in a building.

2.2.2.2 Process Control Systems (PCS) are typically used in industries such as water, oil, gas, pipeline, chemicals plant. PCS is the current general term that encompasses several types of control systems used in industrial production, including distributed control systems (DCS), Emergency Shutdown System (ESD) and other third party control systems such as package programmable logic controllers (PLC), machine conditioning monitor system, pipe leak detection system, custody metering system, fire and gas alarm system, analyzer, etc., often found in the industrial sectors and critical infrastructures.

2.2.2.3 Supervisory Control and Data Acquisition (SCADA) describes a system operating with telemetry communications to provide for monitoring and control of remote processes and equipment. SCADA systems distinguish themselves from other PCS systems by being processes that can include multiple sites, and large distances.

SCADA provides the means for the Operators to monitor and control remote facilities from a central location utilizing various different forms of data communications. The SCADA system will be either a Master/Remote Terminal Unit MTU/RTU based system of standard (not custom) manufacture or a Programmable Logic Controller (PLC) based system incorporating PLCs communicating with a central personal computer (PC) based Human Machine Interface (HMI) software package of standard (not custom) manufacture.

2.2.2.4 Fire and Gas detection and suppression control systems are critical life safety / protection equipment in building or process plant. The purpose of a Fire and Gas Alarm and Suppression Control System is to detect a fire and gas release and automatically initiate audible and visual alarms in the building or plant and prompt panel operator for actions and alert personnel in the vicinity of the hazard area. Fire protection system may be able to be automatically or manually activated by mechanical or control systems and provide protective actions to mitigate the accident circumstance. All fire detection and fire suppression devices shall be networked to a central Fire Workstation to display alarms, troubleshooting, confirm fire and activate fire suppression devices.

2.2.3 Building Automation System (BAS) Architecture

2.2.3.1 Refer to Document Number EPM-KEM-GL-000001: Mechanical Design Guidelines, specifically:

- Additional requirements associated with HVAC Software.
- Additional requirements associated with Building Automation (Management) System.
- Additional requirements and design details associated with Direct Digital Control (DDC) System Controls.

2.2.3.2 The following is a brief description of BAS fundamentals:

- Building automation is the goal that a Building Management System or a (more recent terminology) Building Automation System (BAS) attempts to achieve. BAS core functionality keeps building climate within a specified range, lights rooms based on an occupancy schedule (in the absence of overt switches to the contrary), monitors performance and device failures in all systems, provides malfunction alarms (via typically email and/or text notifications) to building

engineering/maintenance staff and contractors. BAS reduce building energy and maintenance costs compared to a non-controlled building.

- A building controlled by a BAS is often referred to as an intelligent building, "smart building", or (if a residence) a "smart home". Commercial and industrial buildings have historically relied on robust proven protocols like BACnet.
- BACnet is a network communications protocol for building automation and control systems that has been adopted worldwide as ISO 16484-5:2003.
- Almost all multi-story green buildings are designed to accommodate a BAS for the energy, air and water conservation characteristics. Electrical device demand response is a typical function of a BAS, as is the more sophisticated ventilation and humidity monitoring required of "tight" insulated buildings. Most green buildings also use as many low-power DC devices as possible, typically integrated with power over Ethernet wiring, so by definition always accessible to a BAS through the Ethernet connectivity.
- The building automation server shall be able to support various communication protocols to be integrated with other standalone systems through networks for control and monitoring purposes, such as Fire & Gas Detection System status, Fire Suppression Control status, Elevator and Intercom status, UPS status, Access Control status, CCTV camera, mechanical packages (pump station PLC, RTU) etc.
- The building automation server shall collect data and interface with DDC controllers, other standalone control system through facilities local area data network provided by telecom.

2.2.4 Process Control System (PCS) Architecture

2.2.4.1 The PCS concept for future projects is to provide with a powerful and integrated control system platform that bundles together the operating, configuration, documentation, and connectivity tools, to give a truly intuitive and windows compliant control environment.

2.2.4.2 The term “Process Control System” is synonymous to Process Automation System (PAS) and any one of these terms take the same meaning. It describes a computer based control system that provides a means to monitor and control automatic processes from a central control room.

2.2.4.3 A PCS is typically an integration of various computerized servers and controllers, smart instrumentation and software applications for data acquisition and control purposes. Control systems could include any combination of the following basic components:

- Distributed Control System (DCS)
- Programmed Logic Controllers (PLC)
- Alarm Management System (ALMS)
- Data Acquisition and Historization System (DAHS)
- Emergency Shutdown System (ESD)
- FOUNDATION™ Fieldbus System (FF)
- Condition Monitoring System (CMS)
- Packaged - Vendor Control Panels (VCP)
- Instrument Asset Monitoring System (IAMS)
- Plant Automation Network (PAN)
- Plant Information Network (PIN)
- Gas Leak Detection system
- Demilitarized Zone and Cyber security
- Web Terminal and Remote Access Control

2.2.4.4 Wet utilities shall be provided with a PCS or SCADA system and a dedicated control room to monitor and manage the infrastructure controlled by DCS's, PLC's, RTU's etc. or any combination of these controllers. The wet utilities are as follows:

- Potable Water System
- Sea Water Cooling System
- Industrial Waste Water System
- Sanitary Waste Water System
- Irrigation Water System

2.2.4.5 (SCADA) systems associated with light industrial and Wet Utilities is described in more detail under item subsection -2.2.5: SCADA.

2.2.4.6 PCS shall use standard Industrial Ethernet communication protocols between servers or workstations on the network. PCS shall incorporate redundant servers with client workstations to provide a Graphical User Interface GUI and operator functionality for complete monitoring and control purposes. Graphics, schedules, set points, trends and alarms specified as per sequences of operation shall be objects.

2.2.4.7 Availability and Reliability - The PCS architecture including the control system network design shall provide a 99.50% hardware and software availability and reliability.

2.2.4.8 PCS shall consist of a high-speed, peer-to-peer network of distributed controllers and operator interface terminals.

2.2.4.9 The PCS shall include redundant controller and redundant power supply, be designed with no single point of failure and shall include the communication modules and communication links to the distributed controllers and remote I/O equipment.

2.2.4.10 The entire PCS, including hardware and software, must be specified as manufacturer's standard project line. System components and subassemblies must have proven installed base with successful track record.

2.2.4.11 PCS VENDOR shall be responsible for the supply of all aspects of the PCS including design, engineering, fabrication, procurement, configuration, programming, integration, inspection, testing, site support and documentation.

2.2.4.12 PCS VENDOR shall have total system responsibility for the Integration, performance and functionality of all hardware, firmware and software items being furnished for the PCS.

2.2.4.13 PCS VENDOR shall be responsible for the integrity of the overall control system design, including the co-ordination of communications interfaces.

2.2.5 Supervisory Control and Data Acquisition SCADA

2.2.5.1 SCADA systems are provided for various utilities within the Entity premises. The various SCADA systems can be described as follows:

- Wet utilities - including Potable Water Systems, Sea Water Cooling Systems, Industrial Waste Water Systems, Sanitary Waste Water Systems and Irrigation Water Systems.
- Environmental SCADA is provided in a control room with various stations located, operated and maintained by the Entity. The fiber optic cable network shall use to transfer Data's from stations to the SCADA.
- Gas SCADA (if applicable) - Operational responsibility for the gas supply network

- The Traffic SCADA is to be provided with the traffic signals and cameras operated from a control room and managed by Entity. The fiber optic cable network shall use to transfer Data's from stations to the SCADA.
- Electrical SCADA - The electrical infrastructure systems will be operated by SEC (where, applicable) and incorporate a SCADA system connected through a control room. Data is transferred by the fiber optic cable network from the substations to the SCADA.

2.2.5.2 SCADA systems associated with Environmental, Gas, and Electrical Utilities, and other heavy industrial facilities are not in the scope of this document.

2.2.5.3 SCADA is provided to a control room with various stations. Although wireless applications are available, data is usually transferred by the fiber optic cable network from remote stations to the central SCADA head-end. The SCADA system can support any type of telecommunication technologies. However, the selection of the telecommunication technology and/or topology is outside the scope of this document.

2.2.5.4 The following design requirements shall be complied with to provide highly efficient and reliable SCADA system performance for each application using the provided technology.

- General - Detailed Performance Analysis shall be conducted for each application (Project) to specify the optimum architecture to meet the performance requirement expected. The analysis shall be based on the expected data scan frequency and spare capacity, and shall address SCADA server(s) loading, bandwidth capacity and utilization of each telecommunication channel.
- Design Architecture - The SCADA Host station software shall be based on fully redundant Client/Server architecture. Processing load shall be balanced and distributed among the system components to achieve the scalability and highest performance levels.
- SCADA networks shall be physically and logically isolated from all other non-SCADA network traffic. Voice, CCTV and non-process control traffic shall not share the SCADA network hardware.
- The SCADA server(s) shall be dedicated to perform the real-time data acquisition and telecommunication processing functionalities and shall not be shared and/or used to perform any non-SCADA related data processing functions.
- For application requiring redundant RTU communication modules, the design shall provide dedicated communication path from each communication module to the telecommunication network.
- Availability and Reliability - The SCADA System architecture including the telemetry network design shall provide a 99.50% hardware and software availability and reliability.
- The SCADA Host Station including the SCADA LAN shall be designed with no single point of failure. For application where redundant RTU/PLC is required, the no single point of failure requirement shall include the communication modules and communication links to the RTU/PLC.

2.2.6 Fire and Gas Alarm and Fire Suppression System

2.2.6.1 The Fire and Gas Alarm and Fire Suppression Control System concept for future projects is to provide the complete status indication and controls for fire and gas detection and protection systems, to form a powerful and integrated control system platform that bundles together the monitoring, operating, diagnostic, networking, configuration, documentation, and connectivity tools, to give a truly intuitive and windows compliant control environment.

2.2.6.2 The Fire and Gas Alarm System and Fire Suppression System typical include any combination of the following basic components:

- Microprocessor based intelligent Fire Alarm Panel (FACP) with all necessary accessories, such as loop isolator, backup batteries.

- Addressable Fire Alarm Devices, such as smoke detectors, heater detectors, and manual pull stations.
- Duct Smoke Detectors
- Fire Alarm Audio and Visual Alarm Devices, such as bell, horn, beacon, strobes.
- Gas Detection Devices, such as H2, CO2, Cl2, etc.
- Gas Detection Control Panels
- Smoke Control System
- Very Early Smoke Detection Apparatus (VESDA)
- Automatic Sprinkler System and control devices
- Clean Agent System and Control Panels
- Electric Fire Water Pump Control Panels
- Fire Water Jockey Pump Control Panels
- Diesel Fire Water Pump Control Panels
- Emergency Diesel Generator Control Panel
- Fire and Gas Alarm and Fire Suppression System centralize supervisory Server
- Fire and Gas Alarm and Fire Suppression System supervisory workstation
- Fire and Gas Alarm and Fire Suppression System network components
- Integration / Interface with other systems such as HVAC, Elevator, Door Access Control, CCTV, Public Address system etc.

2.2.6.3 System Availability and Reliability

- The F&G system shall be subjected to careful component level subsystem and system testing. The availability of the F&G system shall then be part of the guarantee of the system.
- The system availability is usually expressed in terms of two factors:

  Mean Time Between Failures (MTBF).
  Mean Time to Repair (MTTR).
  The system availability shall be guaranteed at 99.99%.
  (Assuming average MTTR = Four hours).

2.2.6.4 The Fire and Gas Alarm System and Fire Suppression System shall provide fully autonomous control in the covered area, loss of network connection with fire supervisory server / operator workstation shall not jeopardize the local control and monitoring functionalities.

2.2.6.5 All Fire Alarm panels (FACP), Fire Protection Control Panels and Fire Water Pumps Control Panels shall be part of the fire network to the central location for supervisory monitoring and controls.

2.2.6.6 From fire, supervisory server workstations, the panel operator shall be able to monitor, program, diagnose, maintenance and inhibit the individual integrant fire devices. Value engineering can be taken as per project discretion to determine the feasibility of combining fire Server / workstation with BAS server / workstations in the buildings.

2.3 Control Strategies

2.3.1 General

2.3.1.1 The objective of this Subsection is to present the concepts and principles underlying the design of the Plant Instrumentation and Control System.

2.3.1.2 A PCS is actually an integration of several sub-systems into a functional single system. This system must provide the highest level of safety for the Community, the personnel and must incorporate the principles of environmental safeguards, the protection of the process equipment, economy of operation in all regards, and high reliability. This Subsection addresses each of these requirements and their influence on design choices.

2.3.2 Principals of Automation

2.3.2.1 Safety in Control

- The controlled equipment and the control system itself must include “fail-safe” operation such that upon loss of power or control signal, the equipment will go to the pre-determined “safe” state.
- All equipment interlocks which are classified as “life safety” interlocks must be “hard wired” or “mechanically interlocked” and shall not rely on data communications or wireless transmission for their operation.

2.3.2.2 A typical Control System hierarchy consist of four (4) levels:

- Level 1 - Field Mounted Instruments and Equipment
  - This level includes all field-mounted instruments and equipment that directly or indirectly have some effect on the process. This will include temperature, pressure, flow and level transmitters, control valves, on-off valves, Motor Operated Valves (MOVs), fans, heaters, pumps, blowers, etc.
  - This information is transferred to Level 2 and the control commands generated at higher levels are carried out. Equipment at this level will include local manual controls.
- Level 2 - Controllers
  - This is the level at which the main body of most of the control system and the control program, resides. This level represents the gateway between Level 1 and Level 3. All information, alerts and commands to and from Level 1 and Level 3 must pass through this level in order for them to be executed or used.
  - Level 2 consists of distributed Controllers (DCS Controllers, PLCs, RTU’s etc.) and/or a number of Original Equipment Manufacturer (OEM) packaged controllers.
  - The Controller is the communication hub by which all information is collected from the control system. The control program that resides in these controllers is responsible for the automatic operation of the facilities equipment and ancillary systems.
  - The Level 2 Controllers in local areas shall be fully autonomous, with the exception of operator-entered set points, no operator intervention is required for the facility to operate automatically. Therefore, if there happens to be an interruption in communication between Level 2 and Level 3, normal system operation shall not be affected.
  - Equipment supervision and alarm generation are tasks that are performed at this level and reported to Level 3.
- Level 3 - Supervisory Control and Graphical User Interface
  - This level provides the Human-Machine Interface (HMI) and Information Management System (IMS). The system would typically consist of Application Object Servers (AOS) suitably located in equipment or server rooms. Operator Workstations connect through industrial Ethernet networks with the Server to provide a graphical representation of the various field devices.
  - The HMI features of the system shall enable the operators to alter equipment set points, start/stop equipment and monitor system operations. The IMS features of the system shall provide the user with real-time and historical trending of important process information and provide user initiated report generation. The system shall generate alarms and prioritize these based upon overall importance. A Level 1 alarm is considered critical to overall process integrity and is of the highest importance and shall initiate an alarm dialer during after hour’s operation. Level 2 alarms, although important, are of lower priority relative to Level 1 alarms.

- The complete HMI system shall operate as one integrated system based on a single window concept. The Workstations shall provide operator access to the system for monitoring and control purposes and reporting programs. Where applicable Historian software shall provide the collection and archiving of facility historical data for retrieval from the historian clients for trending analysis and reporting at each operator workstation or the view-only desktop clients in managers and supervisor's office.
- Historical Servers shall function as the primary means of archiving data within a SQL database. All trends, reports and supporting data shall be provided in electronic format for special studies and long term strategic planning. Detailed trend data shall be kept for all important analog process measurements.

- Level 4 - MIS/ERP Central Monitoring
  - The MIS/ERP for the wet systems will be under the direct control of the Entity.
  - The PCS/SCADA systems supporting the wet systems infrastructure will control and record activities within their remits. The MIS/ERP system provided by others will collect data from the PCS/SCADA collate and make available for others to interrogate and use.
  - The system critical alarms must be monitored and annunciate abnormal events and detrimental conditions for the systems to make the operator/s aware of the situation and will need to be coordinated.
  - Access is by an approved secure login. The HMIs required to access the system will be a normal PC with the appropriate access.
  - Cyber security technology shall be strictly studied between Level 3 local area (LAN) PCS /SCADA and level 4 Business wide LAN (WAN) MIS/EPR system to protect the control system from hackers, intruders, and malicious code.
  - The protocol, which has to be used inside the local area network including the communication between the individual systems, shall comply with the TCP/IP protocol stack.

2.3.3 Advanced Control Systems

2.3.3.1 Advanced or Intelligent Control Systems offer an enhancement to the conventional loop-based and operator-governed controls which will be fundamental to the Plant's operation. Artificial Neural Networks (ANNs) which are a proven component of existing treatment facilities will be elemental in the PCS.

2.3.3.2 The targets of these Intelligent Systems will be improved output water quality and production, and cost savings through optimization of process chemicals and consumed and produced energy.

2.3.3.3 The ANNs require a significant amount of historical operating data, spanning a period typically from 18 months to 3 years or more in order to "learn" and "understand" the process. As a result, provision for the ANN requirements will be made, and following the startup of the Plant the data gathering and learning process can begin, with the intent of integrating the ANNs into the Plant operation, possibly in year two or year three.

2.3.4 Equipment Operating Modes

2.3.4.1 Typical local selector switch modes are designated as follows:

- HOA – Hand, Off, and Auto.
- LOR – Local, Off, and Remote.
- Duty / Standby
- Note that additional selector switch designations are used for certain pieces of equipment, refer to the associated P&ID for details.

2.3.4.2 Local Mode - In LOCAL mode the equipment is capable of operation from the local start/stop, on/off, or close/stop/open hand switches associated with the equipment. This mode is applicable to most actuated equipment including valves, gates and motors.

2.3.4.3 Off Mode - In OFF mode the equipment will not respond to any operator commands. This mode is applicable to most actuated equipment including valves, gates and motors.

2.3.4.4 Remote Mode - In REMOTE mode, the equipment is capable of operation from a location other than at the local station. This is either another hand switch (i.e. Motor Control Center (MCC) door mounted) or, if all field switches are in remote then by Central HMI or SCADA.

2.3.4.5 Remote Manual - In the Remote Manual mode the operator may operate the equipment from the HMI in the control room or an operator interface panel in the field.

2.3.4.6 Remote Auto - In the AUTOMATIC mode the equipment is either automatically controlled by programmed logic within the PCS when the selector switch is in the AUTOMATIC or REMOTE position.

2.3.4.7 The Duty/Standby arrangement allows a set of devices - typically pumps or variable speed drives - to be operated with an element of sequence of operating duty pumps and remaining standby pumps as backup. During normal operation, the duty devices are running capable of matching the plant demand, should the running device fail or the process demand is higher than the total duty pumps capacity, the remaining devices are requested to run to fulfill the process demand requirements.

2.3.5 Consoles, Workstations and Control Networks

2.3.5.1 General

- Consoles, including panel and HMI mounting structures shall be equipped with tabletop work surfaces.
- Where required, telecommunication equipment (i.e., telephones, plant paging system, CCTV, PA system) and emergency shutdown pushbuttons shall be incorporated in separate bay within the same console furniture.
- Each workstation shall have access to a printer networked within the PCS network.
- Printers shall be free standing, or tables shall be provided. Printers that utilize fanfold paper shall be equipped with pedestal (noise absorption enclosures) with paper stackers.
- PCS servers and workstations operating systems shall be configured to capture all necessary systems related events to detect performance and availability related information.
    - System alarms and failures
    - CPU utilization
    - Memory utilization
    - IO rates (i.e., physical and buffer) and device utilization
    - File store utilization (e.g., disks, partitions, segments)
    - Applications
    - Databases (i.e., utilization, record locks, indexing, contention)
    - Network utilization (i.e., transaction rates, error and retry rates)
    - Response time for PCS and application transaction

2.3.5.2 Operator Consoles

- Each station in the operator console shall have access to a networked printer(s) for alarm logging, reporting and graphical printing.
- Consoles that are manned on a continuous basis shall have access to a networked graphics printer for making hard copies of active displays.
- Each Operator Console shall be equipped with a minimum of two workstations.
- Operator Workstations shall be equipped with annunciators / buzzers, operator keyboard and activate in the event of alarms to gain the operator’s attention.

2.3.5.3 Engineering Workstation

- Engineering consoles shall consist of a minimum of one workstation.
- Each engineering workstation shall have access to a networked printer.
- Each engineering workstation shall be capable of performing all operator workstation's functions.

2.3.5.4 HMI Control and Monitoring System Functions will include:

- Dynamic Authority Handling and Multiple system Access protection levels.
- HMI views and operator dialogs
- Dynamic process equipment coloring
- Analogue Measurement
- Events /Alarms processing
- Logging, Printing and Plotting
- Historical information system
- Data Archiving, outputting and Retrieval
- Data quality attributes
- Manual data entry and updating
- Values calculation
- Real-time and historical process values trending
- Automatic generation of predefined Daily, Weekly and Monthly water flow and energy consumption reports
- Process Equipment Operation Count and maintenance Statistics

2.3.6 Redundancy - Fault Tolerance

- The following equipment shall be supplied in redundant or fault-tolerant configuration unless otherwise specified in the project specific Functional Specification Document:
  - All Process Controllers
  - All Power supply modules
  - All DCS Control Network Communications Equipment
  - All communications equipment required for communications between controllers and I/O modules
  - All Input and Output modules used for critical regulatory control
  - All Foundation Fieldbus Host interface modules
  - All Foundation Fieldbus power supply and conditioning modules
  - All data storage devices (e.g., hard-drives) used to store system configuration information or control strategy configuration information
  - All auxiliary systems communications interface modules, including communications paths, where either the communications channel is used to send commands from the PCS to the auxiliary system or data from the auxiliary system is used within a regulatory control strategy within the PCS.

    Commentary Note: Regulatory control refers to control which is implemented at the PCS layer. This can be either analog (e.g., 4-20 mA to control valves) or Foundation Fieldbus or discrete (e.g., 24 VDC to Motor starters). Critical regulatory control refers to control of equipment which does not have an installed spare or backup or where failure of the equipment would result in a significant loss of production or an unsafe operating condition.

Inputs and Outputs used for regulatory control in critical applications shall be supplied with redundant I/O modules.

- A minimum of two electrically and electronically independent operator workstations shall be provided for each operator's console.

2.3.7 Centralized Enterprise, MIS/ERP System

2.3.7.1 The infrastructure systems will each have their own independent SCADA systems to operate, monitor and control the equipment for which they are responsible.

2.3.7.2 The collection of operational information is required to enable to monitor the operations but also to provide a corporate level system to enable access to the various systems. This system is independent of the operational SCADA systems but will collect information from these systems and can be described as a Management Information System (MIS) or Enterprise Resource Planning (ERP). The proposed system collects information that can assist with hydro modelling, billing, planning, operation performance, plant running status and measuring the operation performance etc. The information can also, with additional work, be used to develop early warning of breakdown.

2.3.7.3 The information is secure and can be accessed from anywhere with interconnection available. The Management information system provides the monitoring of the following facilities:

- Wet Utilities
- Existing SCADA System
- Environmental System
- Gas System
- Traffic and Transportation System
- Electrical Supply
- Security

2.3.7.4 Wet utilities are provided with access to the MIS/ERP systems. The server is installed inside the corporate enterprise control room located in the potable water premises.

2.3.7.5 The other systems e.g. traffic, security, SEC, etc. can also be provided with access to the MIS/ERP system after agreed procedures for secure access and limitations to what information is accessible to which parties. It might even be the case that to ensure security of data that there are several MIS/ERP systems supporting the different activities.

2.3.7.6 The wet utilities shall be provided with a SCADA system and a dedicated control room to monitor and manage the infrastructure controlled by PLC's and RTU's, etc. The wet utilities are as follows:

- Potable Water System - The potable water system consists of a RO Plant, storage tanks and pumping stations. There are bulk storage tanks as well as distribution storage and pumping station. The storage tanks and pump stations shall be provided with PLC's installed at the plant for the automation to monitor and control all the activities at the plant. These PLC's and RTU's are hooked up to the SCADA system located inside the local control room at the potable water facility. Data is transferred by a dedicated fiber optic cable network from PLC to the SCADA.
- Sea Water Cooling System - The SWC system consists of a large intake pump station and a piped network to distribute the sea water to the industrial plots. There shall be PLC'S installed at the plant for the automation to monitor and control all the activities at the plant. These PLC's and RTU's are hooked up to the SCADA system located inside the control room at the sea water facility. Data is transferred by a dedicated fiber optic cable network from PLC to the SCADA,
- Industrial Waste Water System - The industrial waste water system consists of pumping stations, pressurized mains and an Industrial Waste Water Treatment Plant (IWTP). Each pumping station shall be provided with the PLC located inside the room to monitor and control of all the activities at the pumping station automatically. The PLC is hooked up by the field

instruments to monitor at the PLC. There shall be PLC'S installed at the treatment plant for the automation to monitor and control of all the activities at the plant. These PLC's and RTU's are hooked up to the local SCADA system located inside the control room at the waste water treatment plant facility. Data is transferred by the fiber optic cable network from PLC to the SCADA. Uplink from IWTP plant SCADA system for level 4 remote monitoring in the MIS/EPR system shall be established, Data is transferred by the fiber optic cable network from IWTP facility local control room SCADA system to MIS/EPR centralized SCADA system inside the control room.

- Sanitary Waste Water System - The sanitary waste water system consists of pumping stations, pressurized mains and a Sewage Treatment Plant (STP). Each pumping station shall be provided with the PLC located inside the room to monitor and control of all the activities at the pumping station automatically. The PLC is hooked up by the field instruments to monitor at the PLC. There shall be PLC'S installed at the treatment plant for the automation to monitor and control of all the activities at the plant. These PLC's and RTU's are hooked up to the local SCADA system located inside the control room at the waste water treatment plant facility. Data is transferred by the fiber optic cable network from PLC to the SCADA

  Commentary Note: The Industry / Sanitary waste water collection system have many lift stations geography widely distributed within the development, there shall be RTU installed at each lift station for monitoring the lift station level, pump / odor control status. These RTUs shall hook up with central SCADA system by means of radio communication network. However, if these lift stations are located within the building compound, the RTU shall be hook up to the compound BAS system for status monitoring

- Irrigation Water System - The irrigation transmission pumping system will consist of bulk storage tanks containing Treated Sanitary Effluent (TSE), and transmission pumping station. There shall be Programmable Logic Controllers (PLC) and Remote Terminal Unit (RTU) installed at the transmission pump station for automation, monitoring and controlling of all the pumping activities and the transmission mains. A link will be provided from the distribution storage tanks to monitor the level in these tanks and adjust the transmission supply accordingly. These PLC's and RTU's will be connected to SCADA system located inside the control room at the SWTP/IWTP Treatment facility.

  The irrigation distribution network will be operated and maintained by the Entity, and will consist of distribution storage tanks containing Treated Sanitary Effluent (TSE), distribution pumping stations, Valve Chambers, pressurized mains and irrigation controllers. There shall be Programmable Logic Controllers (PLC) installed at the pump station and Remote Terminal Unit (RTU) at valve chamber for automation, monitoring and controlling of all the activities of the irrigation network. These PLC's and RTU's are connected to the local SCADA system located inside the control room at the Irrigation pump station facility. Data is transferred by the fiber optic cable network and radio communication from PLC / RTU to the SCADA system.

  Irrigation controller shall be used to control the solenoid valve for scheduled irrigation activities, and shall be control and monitored directly from central SCADA system. Data is transferred from irrigation controller to central SCADA system by means of radio communication network.

  The irrigation system control facility shall consolidate data associated with the irrigation system. A separate central MIS/ERP system will be provided by others and will collect data from the SCADA from various infrastructure systems and collate data and make available for the Entity to interrogate and use.

  A telecommunication network from the central facility will link the primary and secondary irrigation system monitoring and controls data to the separate facility by others.

  The RTU shall be able to store and forward Data. To act as a repeater for other RTUs in case of obstacles or more covering distances required. The communication protocol should make the communication system between the FIU- RTU and the RTU-RTU in Contention Transmission of events upon change of status by the RTUs to the FIU and central control room without interrogation of the FIU. And Transmission of the events upon change of status by the Slave RTUs to the Master RTUs without interrogation of the Master RTU and RTU/FIU components of the Irrigation Water System have been detailed further in the GPCS and TCDDs.

2.3.8 Segregation - Risk Levels – Safety Integrity levels

Process Control Systems shall be segregated into risk areas to increase system and process availability. Risk Areas shall be defined in three levels. Separate segregation requirements apply to each risk level.

2.3.8.1 Level 1 Risk Area Segregation

- Level 1 (L1) segregation provides the greatest degree of segregation. L1 segregation is used to segregate plant operations based on a 50% production loss rule.
- Where a plant is designed with parallel processing trains, control systems equipment shall be segregated such that a total loss of process control equipment contained within a single L1 risk areas shall not result in the loss of more than 50% of the total plant processing capability.
- Equipment located in separate L1 Risk Areas require separate:
  - UPS Power Circuits
  - Power Supplies, Power Distribution circuits or panels
  - Operator workstations and alarm panels
  - Process controllers, Safety Instrumented Systems, Compressor or Turbine Control Systems and associated I/O subsystems for each.
  - Process Control Network equipment and cabling
  - System and marshalling cabinets
  - Auxiliary systems interfaces.
- A double failure of any redundant component in one L1 Risk Area shall not affect the operations of equipment in any other L1 Risk Area.
- Where a single operator console is used to monitor two or more L1 risk areas, each risk area must have a dedicated Operator Workstation. Requirements for Operator Workstation redundancy (i.e., the backup operator workstation) can be a met using a workstation dedicated to another risk area as long as that workstation has full monitoring and control capabilities of both risk areas.
- Where a single operator console is used to monitor two or more L1 risk areas, control network communications equipment and cables shall be segregated between risk areas. Communications cables may terminate on a common network switch associated with the console provided the switch is supplied in redundant configuration and both are dedicated for the operator console.

2.3.8.2 Level 2 Risk Area Segregation

- Level 2 (L2) segregation is used to segregate parallel processing units within a Level 1 risk area. Level 2 (L2) segregation is also used to segregate major process equipment installed within Utilities plant areas.
- Process Control Equipment shall be segregated into separate Level 2 (L2) risk areas as follows:
  - Parallel processing trains or parallel processing units within a Level 1 risk area shall be segregated into separate L2 risk areas.
  - Redundant or parallel processing equipment located within utilities plant areas shall be segregated into separate L2 risk areas such that a complete failure in any single L2 risk area will only result in a loss of no more than 50% throughput of the utilities area.

    Commentary Note: In most instances, it is impractical to segregate equipment located in the Utilities plant area into separate L1 risk areas. Equipment such as boilers, air compressors, nitrogen systems, hot-oil systems, etc., feed a common header which is used plant-wide and therefore feeds two separate L1 risk areas. For this reason, Level 2 segregation is applied for utilities equipment using a similar 50% production loss rule as is applied for Level 1.
- Equipment located in separate Level 2 (L2) Risk Areas require separate:
  - Process Controllers and associated IO modules, IO communications equipment and communications cabling.

- Marshalling Cabinets.

- Where two or more operator consoles are used to control equipment within a single L1 risk area, equipment operated by each console shall be segregated into separate L2 risk areas.
- Parallel processing trains within an L1 risk area which have been segregated into separate Level 2 risk areas require separate Emergency Shutdown Systems for each L2 risk area.
- An exception is allowed for segregation of I/O communications cables when I/O modules are located remote from the controllers and fiber optic cables are used for communications. In this case, controllers in two separate L2 Risk areas may share the same fiber optic cable provided that,
  - Dedicated fiber strands are used for each controller.
  - No Fiber optic converters are shared between controllers.
  - Communications between the controller and I/O is redundant and the redundant cables are installed in separate routes.

2.3.8.3 Level 3 Risk Area Segregation

- Level 3 segregation is used to segregate parallel process equipment or equipment installed in redundant configuration in order to increase process availability. Level 3 segregation requires segregation of equipment at the IO card level.
- Level 3 (L3) Risk Area Segregation shall be applied for parallel process equipment or any equipment installed in redundant configuration.
- Any equipment which serves the same purpose but is provided in redundant configuration to increase a process

  Commentary Note: Redundant or parallel processing equipment are equipment such as: Booster Pumps, Blowers, Compressors, filters/separators, etc. which is installed in redundant configuration.
- Equipment located in separate L3 risk areas shall not share the same IO card. Field cables for equipment located in separate L3 risk areas may be terminated in a common marshalling cabinet and use a common (redundant) external field power supply if required.

2.3.9 Spare and Expansion Capabilities

2.3.9.1 Each system shall be supplied with 5% spare IO points. The spare I/O shall be licensed, installed, and wired to termination points. Spare IO shall be provided in approximately the same ratio as that of the installed types and shall be distributed between risk areas in the approximate ratio as the required IO.

2.3.9.2 Where both redundant and simplex IO models are used for a signal type, the requirement for spare IO shall apply for both types.

2.3.9.3 Each system shall be installed with 10% spare slots in IO chassis or baseplates to accommodate addition of IO modules without requiring additional chassis or baseplates to be added to the system. Power supplies for IO modules shall be sized to accommodate the additional 10% expansion requirement.

2.3.9.4 Each Foundation Fieldbus installation shall have a 20% spare capacity for Foundation Fieldbus communication modules and power conditioners

2.3.9.5 Each system shall be capable of expanding the number of controllers by 20% from that installed in the base system.

Commentary Note: Requirements for expansion capacity and spare IO do not apply to expansion projects where control and I/O are being added to an existing system. For expansion projects, the requirements for spare IO and expansion capability may differ. If none are specified then the requirements above shall apply.

2.3.9.6 The average CPU Loading of any controller during normal operating conditions shall not exceed 65% overall or 75% of the manufacturers recommended maximum loading specification, whichever is lower. The spare capacity is required to accommodate peak loads during upset conditions and to provide additional capacity required for configuration of spare IO points and associated control algorithms and to enable the utilization of the spare IO slots.

2.3.9.7 Servers and/or Engineering Workstations shall be configured with additional spare capacity of 40% minimum for hard-drive space, memory, and CPU. CPU and memory spare requirements shall be verified on the running system during steady state conditions with all applicable software running on the system.

2.4 Instrumentation – Basic Design Criteria

2.4.1 General

2.4.1.1 The objective of this Subsection is to provide the basic criteria for instrumentation selection, and installation.

2.4.1.2 The design requirements for each type of instrument are covered by the individual standards and specifications.

2.4.1.3 Instrumentation shall be designed consistent with the design pressure and temperature of the proposed service. All wetted parts shall be 304 stainless steel as a minimum. Higher corrosion resistant materials may be substituted on an application specific basis as required.

2.4.1.4 Temperature and/or pressure compensation for flow or level shall be provided as required to maintain measurement accuracy.

2.4.1.5 Transmitters shall have less than 0.25% shift in output with a 50 DEGC change in ambient temperature. The accuracy shall be ±0.25% of the calibrated range or better. Repeatability shall be ±0.1% or better.

2.4.1.6 Flow transmitters shall produce signals which are linear or square root with respect to flow within ±1% of full scale flow when operating between 25% and 100% of full scale flow.

2.4.1.7 Pressure transmitters shall produce a signal which is linear with respect to the measured pressure within ±0.25% of the measured span.

2.4.1.8 Level transmitters shall produce a signal which is linear with respect to the measured level within ±1% of the measured span based on a specific gravity of 1.00.

2.4.1.9 RTDs shall have resistance characteristic which is linear with respect to temperature within ±0.5% of the top range value.

2.4.1.10 Electronic signal converters shall have an accuracy of ±0.25% of span. Electronic signal converters for movable core transformer systems shall have an accuracy of +0.5% of span.

2.4.1.11 Process measurement instrumentation shall not contain mercury.

2.4.1.12 The design and selection of instrumentation shall include consideration of the following:

- Application suitability
- Reliability and availability
- Quality
- Accuracy
- Repeatability
- Life cycle cost
- Previous acceptance as a stock item and compatibility with existing equipment (i.e., savings on spares)

- Compatibility with the environment (climatic and electrical classification)

  Commentary Note: The priority of the above aspects will depend on the application and equipment under consideration. Other pertinent factors and design issues that are not listed above shall also be considered.

2.4.1.13 Instrument Mounting Locations

- Field instruments shall be mounted as close as possible to the process connection to minimize the length of instrument impulse lines. Where practically possible, the length of the impulse line shall not exceed 6 m.
- Instruments shall not protrude into or obstruct access ways so as to inhibit area personnel egress.
- All instrumentation and associated control equipment shall be readily accessible from grade, platform, fixed walkway, fixed stairway or a fixed ladder. Local indicating instruments shall be visible from where related equipment is operated or primary instruments are tested or calibrated.
- Instruments mounted outside a handrail shall be located to allow maintenance from the walking/working surface without reaching through or leaning over the handrail.
- Instruments shall be located to allow performance of routine services with unobstructed access.

  Commentary Note: Clearances shall be provided for the removal of covers and cases and the opening of doors and enclosures. Access for appropriate lifting equipment shall be provided when necessary for control valves or other large in-line instruments.
- Pressure and D/P instruments in liquid or condensable vapor service shall be self-venting (i.e., mounted below the process connections) with all impulse lines sloping downward approximately 1:12 minimum toward the instrument.
- Pressure and D/P instruments in gas service shall be self-draining (i.e., mounted above the process connections) with all lines sloping downward approximately 1:12 minimum toward the process connection.

2.4.1.14 Instrument Process Connections

- A line class root or isolation valve shall be provided at each process connection. This valve shall be specified and provided by the piping discipline.
- All process connected instruments shall be equipped with block and bleed mechanism to allow isolation, drainage and maintenance.
- Pressure and differential pressure transmitters shall be equipped with manifold assemblies.
- Instrument process connections shall conform to the requirements specified in the relevant instrumentation specifications and standard drawings.

2.4.1.15 Instrument Support

- Direct-reading instruments such as gauges shall be supported by piping, panel board or equipment.
- Except for close-coupled instrument, all field instruments shall be mounted on instrument supports designed for that purpose.

  Commentary Note: Attention shall be paid to process instruments that are close -coupled (installed directly on the piping). Effects of instrument size and weight as well as heat or vibration in piping systems shall be carefully evaluated.
- When pipe stand is used as an instrument support, it shall be made of a prefabricated, 50 mm, schedule 40 pipe. The pipe stand shall be hot-dipped galvanized. The top of the pipe shall be plugged or sealed to prevent water entry.
- Pipe stands shall be securely anchored.

2.4.1.16 Instrumentation Tagging

- All instruments shall have engraved phenolic/ Bakelite-laminated nameplates showing instrument tag numbers. The nameplates shall be installed with stainless steel screws. Using glue to install nameplates is not acceptable.
- Panel mounted instruments shall be provided with two nameplates, one on the front and one on the back; rack mounted instruments shall have front mounted nameplates only.
- For RTD and thermocouple heads, stainless steel nameplates that are chained to the head may be used.
- All field junction boxes, other instrumentation enclosures and process automation cabinets shall be equipped with nameplates.

2.4.1.17 Instrument Piping and Tubing

- Instrument Piping

  When piping is used for process connection, the piping specification and installation shall follow the relevant piping standards. From the root valve to the instrument, the instrument piping specification, material of construction, pressure rating, fittings, and valves shall meet or exceed applicable piping specifications for the process service.

- Instrument Tubing
  - When tubing is used for process connection, the process sensing tubing (impulse line), fittings, and instrument valves shall be compatible with the process medium. The tubing and fittings shall be made of the same material. As a minimum, the tubing shall be Type 316 seamless, annealed stainless steel per ASTM A269, 6 mm OD, hardness Rockwell B80 maximum.
  - As a minimum, pneumatic signal (10 - 100 kPa signals) tubing shall be Type 316 seamless, annealed stainless steel per ASTM A269, 6 mm OD, hardness Rockwell B80 maximum. The minimum design pressure shall be 2 MPa.
  - Tube fittings shall be, as a minimum, 316 stainless steel and shall be compression type.
- Instrument Piping and Tubing Support
  - Instrument process piping and tubing shall be supported as necessary to maintain structural integrity.
  - All instrument piping and tubing between the instrument and process equipment or pipeline shall be properly supported to prevent strain on the instrument, equipment, and piping connections. The supports shall be designed so that the effect of any equipment vibration is eliminated.
  - Tubing shall not be routed along or supported from handrails.
  - Tubing supports shall be spaced not more than 1.2 meters apart.
  - In locations where mechanical damage is likely, tubing may be installed in dedicated structural channel, angle, or in trays.
  - Tubes and tube bundles and their support channels and trays shall not be supported from process or utility piping.
  - Tubing channels or trays shall not be supported by bolting to transmitter brackets or control valves.
  - Tubing shall be installed in a manner that allows for calibration of instruments and easy removal of adjacent instruments, equipment, and tubing.

2.4.2 Online Continuous Measurement or Analog Type Instrumentation

2.4.2.1 All continuous measurement electronic field instruments, and control valve positioners, shall be smart.

- Signal Ranges and Communications Protocols - Acceptable field transmission signals are Foundation™ fieldbus, or 4-20 mA with superimposed HART.
- Vendor proprietary digital protocols are acceptable for plant expansions when matching existing instrumentation. In the context of this standard, field transmission signals are defined as signals from field devices to a control system, or signals from a control system to field devices.
- HART communication protocol shall not be used for plant control.
- Foundation™ fieldbus based instrumentation and control systems shall meet the requirements detailed further in subsection-2.7.7: ProfiBus.
- Wireless process instrumentation shall not be used.

2.4.2.2 Continuous measurement systems and/or instrumentation includes but is not be limited to - Flow, Level, Pressure, Temperature, Analytical, Environmental, and Miscellaneous equipment.

- Flow - Field Mounted Instruments and Equipment
- Level - Field Mounted Instruments and Equipment
- Pressure - Field Mounted Instruments and Equipment
- Temperature - Field Mounted Instruments and Equipment
- Analytical - Field Mounted Instruments and Equipment
- Environmental - Field Mounted Instruments and Equipment
- Miscellaneous - Field Mounted Instruments and Equipment

2.4.2.3 Specific performance criteria and detailed specifications for each type of instrument are provided in the standard specifications.

2.4.2.4 Power Monitoring

Power monitoring is provided under electrical package requirements under Document Number EPM-KEE-GL-000001: Electrical Design Guidelines

- however, the interface with the control system shall be based on standard protocols such as Modbus, Profibus, Ethernet etc.
- Power monitoring instrumentation shall be included to provide to support the following minimum monitoring functions:
  - kW
  - kVAr
  - V for all phases P-P and P-N
  - I for all phases
  - PF
  - Circuit breaker and switch status indication for: facility main and feeder breakers and disconnect switches, generator breakers, Auto Transfer Switches, and electrically operated low voltage breakers.

2.4.2.5 Offline continuous measurement electronic field instruments shall be provided for specific analytic sampling systems.

2.4.3 Online Discrete Type Instrumentation

2.4.3.1 Fail Safe Design Requirements - Unless otherwise specified in other standards, all discrete instrumentation such as switches, solenoids, relays, etc., shall be designed so that they are energized during normal operation and shall de-energize to initiate a shutdown, an alarm or any other control action

2.4.3.2 On-line Discrete digital switching type measurement systems and/or instrumentation includes but is not be limited to - Flow, Level, Pressure, Temperature, Analytical, Environmental and Miscellaneous equipment.

2.4.4 On-line Final Control Elements

2.4.4.1 Control Valves Actuators

- Notwithstanding the requirements set forth in this Subsection – coordinate with the following mechanical and civil requirements and refer Document Number EPM-KEM-GL-000001: Mechanical Design Guidelines and Document Number EPM-KEC-GL-000004: Utilities.
  - Mechanical Piping Systems
  - Potable Water
  - Sanitary Sewer System
  - Recycled Water System (Irrigation)
  - Recycled Industrial Water System
  - Sea Water Cooling
- Valve size shall be such that equal percentage valves shall be approximately 75% to 85% open and linear valves shall be approximately 50% open when operating at normal flow and pressure drop condition.
- Valve capacity rating (Cv) shall be calculated at maximum and normal flow rates at their respective pressure drop to be assured that overall operating range is satisfied. The manufacturers published Cv's shall be used to determine valve size. Valve sizing calculations shall be based on equations and data by the manufacturer supplying control valves for the project or ISA S75-01 "Flow Equations for Sizing Control Valves".
- Noise-level within 1 M of any noise producing control valve shall not exceed 85 dBA. Control valve sizing shall take into account any noise attenuating devices, such as special trim and diffusers, which may be considered to reduce the noise level within specified limits.
- Valves, in general, shall be globe type. Where low pressure drop or high recovery is required, butterfly or characterized ball valves may be considered. Special body types such as angle, "Y" etc., shall be considered when the process fluid may be erosive, viscous or carrying suspended solids. Flushing connections shall be provided for slurry service. Flangeless, insert type valves may be considered for utility service or where material is other than carbon steel.
- Where a hand wheel is required, the shaft-mounted declutchable type shall be furnished. "Fishtail" disc shall be considered on all high torque requirements. Bronze "oilite" bushings shall be used for outboard bearings. Inboard bushings shall be manufacturing standard. Roller or needle bearings shall not be used.
- Minimum body size for flanged valves shall be 25 mm with reduced ports, as required. Steel valves shall have at least 150 lb. body and flanges shall have face to face dimensions in accordance with ANSI B16.10. Valve body connections shall normally conform to ANSI B31.1. Body material shall normally be cast or forged carbon steel for non-corrosive process applications. Chromemoly steel shall be considered for service where temperature exceeds 343 °C.
- Packing Glands shall be equipped with flanged bolted-type gland stuffing boxes. Packing shall be Teflon for liquid and gas service up to an inlet pressure of 1000 psig, and a temperature not to exceed 177 °C. Grafoil shall be used for steam service with temperatures above 177 °C. Packing gland followers shall be the same as body material.
- Control valve plugs shall normally be cage guided. Unbalanced type shall preferably be used for tight shut off. Where balanced valves are used, the valve shall be installed in horizontal lines only with stem vertical.
- Characteristic and shape of the inner valve shall be determined by each system characteristic. In general, equal percentage characteristic shall be used. Linear characteristic may be used for flow control and level.

- Plug and seat rings shall be stainless steel up to 100 psi drop and up to the temperature rating of the body. Other conditions may require special trim consideration and shall be in accordance with good engineering practice. When severe corrosion is expected, or pressure drop exceeds 100 psi, fullbore satellite or hardened stainless steel shall be furnished.
- Special alloys, balanced plugs, soft seats, etc., shall be considered where warranted by the application. Valves on oxygen service shall be degreased. When tight shut off is required, soft seat trim or lapped seats shall be used, provided temperature limits are not exceeded; soft seat trims shall be of fire safe design.
- Guide bushings shall normally be hardened stainless steel and preferably shall be a minimum of 125 Brinnel harder than the trim. Control valve leakage shall conform to ANSI B106.4 Quality Control Standard for Control Valve Seat Leakage.
- Control valves are used for block valves, where leakage is not permitted when tripped, or for safety requirements, shall be specified for tight shut-off. Tight shut-off leakage for valves with metal seats shall be Class V; 0.0005 ml/min. per 25 mm of port diameter per psi pressure drop.
- Self-contained control valves used pressure or temperature control of air, water, oil, steam or process fluids in utility piping systems shall be limited to a maximum regulated pressure of 150 psig and maximum valve size of 50 mm.
- Self-actuated pressure reducing stations on process fluids shall conform to the line specification in which the valve is installed. Threaded bodies may be used if permitted by the piping specification.
- Self-actuated temperature regulators on steam or water service shall be of the vapor pressure type with copper bulb and copper capillary with stainless steel armor and stainless steel thermowell.
- Accessories such as limit switches, air sets, and solenoid valves shall be rigidly mounted and bracketed to the valve. Valve position limit switches shall be of the snap acting type with IP65 weatherproof housing suitable for the area electrical classification. Switches shall be furnished with DPDT contacts.
- Control valve data sheets shall be provided for all control valves.

2.4.4.2 Valve Actuators

- A filter-regulator air set shall be provided for air-operated actuators. Air sets shall consist of a combination air filter, pressure regulator, and integral relief valve. Connections shall be 6 mm or more if required for speed of response of the device being supplied. An output gauge shall be supplied at the outlet of each air set. Tubing shall be sufficiently large so as not to unduly restrict air flow or dynamic response. Bug screens shall be installed on all open port or piping connectors. Where air sets are required for control valves they shall be directly mounted on the valve positioner.
- Actuator position shall be clearly indicated.
- Actuators shall fail-safe upon trip or loss of power and/or loss of power to the controller, transmitter, and other associated logic elements. Upon restoration of power, the actuator shall become available for operation without changing its position.
- The full stroke time shall not impede or limit the performance or safe operation of the associated equipment
- Positioners or booster relays shall be force balance type with pneumatic output. Positioners shall be SMART, HART compatible, and shall accept 4-20 mA directly. Separate I/P converters are not allowed.
- Valve actuators shall be preferably diaphragm type. Piston operators may be used in severe pressure drop services or on rotary valves.
- Electrical motor-operated valves shall have a torque limit switch which shall be used as a back-up switch to stop the motor when the valve is at full limit travel. Electrical motor operator suppliers' recommendations shall be used for stopping the motor. The stopping requirements

will differ depending on the type of valve. Motors and starters shall be in accordance with area electrical classification and the specified voltage levels. Enclosures shall be weather proof.

- Motor actuators are commonly used; however, their use as modulating final control elements is limited due to design limitations.
- Three-way direct acting solenoid valves shall be used to actuate control valves when interlocked with fail safe or shutdown circuits. The coil shall be molded design with weatherproof housing furnished to meet area electrical code classifications. Outdoor installations shall be weatherproof. Solenoid vents shall have bug screens. Solenoids with top mounted vents shall be piped so that moisture does not enter the valve. Universal (reversible ports) are preferred and shall be selected where air pressure is to be blocked at the vent port. Pilot operated solenoid valves shall not be used.

2.4.5 Custody Metering

2.4.5.1 This Subsection is intended to define the minimum requirements governing the design of custody transfer metering stations used for the measurement of Seawater Cooling Liquid.

2.4.5.2 Custody Transfer Measurement is a specialized form of measurement that provides quantity and quality information used for the physical and fiscal documentation of a change in ownership and/or responsibility of commodities. The following measurements are custody transfer measurements:

- Measurement of Seawater Cooling Liquid (deliveries or receipts)

2.4.5.3 A Meter Station shall be defined as a facility that is primarily dedicated to the measurement of the quantity and quality of seawater cooling liquid. The facility may include, but not be limited to pipelines, piping, regulators, valves, strainers/filters, flow straightening and conditioning equipment, samplers, measurement elements, Remote Terminal Units (RTU), pumps, communications (data and SA telephone), metering shelter, UPS, area fencing, area paving, area lighting, and associated instrumentation, alarms, computers with software programs, peripheral equipment and associated control functions.

2.4.5.4 A Metering System shall be defined as a complete assembly of equipment that is designed to measure the quantity and quality of seawater cooling liquid. The metering system includes, but is not limited to, the meter skid (meters, filters, analyzers, flow conditioning sections, valves), samplers, and control system (flow computers, metering supervisory computers, etc.).

2.4.5.5 Units of Measurement – the metric (SI) system of units shall be used per below Table

TABLE: PROFESSIONAL UNITS OF MEASUREMENT
ITEM METRIC (SI)

ITEM	METRIC (SI)
Volume	Cubic Meters, Liters, (m3, L)
Temperature	Degrees Celsius (°C)
Pressure	Kilopascals Gauge, (Kpa (ga))

2.4.5.6 Reference Conditions – Due to the nature and volumes of Seawater Cooling Liquids, no corrections will be necessary due to liquid pressure or temperature changes as the impact will be negligible.

2.4.5.7 A typical Seawater Cooling Liquid custody transfer metering station will include the following measurements:

- Flow
- Pressure
- Temperature
- Chlorine Residual CL2

- Dissolved Oxygen

2.4.5.8 The performance specifications for these measuring instruments are detailed in the standard specifications.

2.5 Instrumentation and Control System Cabinets

2.5.1 General

2.5.1.1 The objective of Subsection is to provide the basic criteria for instrumentation and control system cabinet construction, selection, and installation.

2.5.1.2 Outdoor Environmentally Controlled – IP65

- Typically all outdoor enclosures shall be made of stainless steel materials.
- In outdoor plant areas, the panel/cabinet shall be IEC 60529, Type IP65.
- In outdoor plant and other industrial areas located in severe corrosive environments, enclosures shall be IEC 60529 Type IP66, manufactured of 316L stainless steel. Galvanized and/or painted or coated carbon steel sheet metal enclosures are not permitted.
- Door hardware (hinges, latches, handles, bolts and nuts) shall be made of 316 stainless steel.
- The enclosure size and dimensions shall be appropriate for the application with a minimum of 20% spare capacity for growth. The enclosure shall include a full-length front door to provide access to all components mounted inside.
- Notwithstanding item 3 above - the enclosure shall be sized to ensure maximum temperature inside the enclosure due to internal heat dissipation pulse heat rise due to solar radiation will not exceed 55°C for sheltered cabinets and 65°C for unsheltered cabinets. All electronic components to be mounted inside the enclosure shall have 75°C temperature rating minimum.
- The enclosures may be surface mounted or rack mounted depending on the specific design.
- The enclosures shall have locking doors. Each enclosure shall be supplied with at least two (2) keys.
- Enclosure shall be fitted with sufficient number of conduit entries at the bottom.
- Terminal strips shall be provided in the enclosures to terminate instrument cables from field signals and for power distribution.
- Each item of equipment and accessory inside the cabinet shall be correctly tagged, if possible, immediately below the corresponding equipment or accessory. All nameplates on the exterior surface of the cabinet shall be attached with stainless steel screws. Internally mounted nameplates may be attached with two-component epoxy adhesive. Nameplates shall be made from laminated plastic, white-black-white (information engraved into the black core with white surface, dull finish).
- Each cabinet design shall be appropriately laid out with sufficient workspace to allow for installed equipment field wiring termination and access for future maintenance and installation.
- The panel/cabinet and all components within the panel shall be suitable for the electrical area classification where the panel will be installed.

2.5.1.3 Indoor - General Purpose IP10 and IP52

- All cabinet equipment and wiring shall be designed for continuous operation at 50°C, and relative humidity 80% maximum (non-condensing) and 20% minimum.

  Commentary Note: The temperature of 50°C allows for a 35°C room ambient plus a 15°C rise within the cabinet.

- The cabinets shall be rigid and self-supporting. By default, all cabinets shall be free standing, floor mounted type.

- Indoor cabinets shall be made of metal. When multiple cabinets are provided, they shall be identical in construction and external appearance.
- The cabinet shall be IP52 as a minimum prior to fitting of louvers or fans as per IEC60529.
- Cabinets requiring heat dissipation shall be convection-ventilated.
- Convection-ventilated cabinets shall be provided with readily accessible, removable filter screens inserted behind slotted louver inlets. Depending on the location of the heat generating components, louvers and filters may be installed at the top of the cabinet or within cabinet doors. Louvers installed on the sides or back of the cabinet are not acceptable
- Fans may be used within Cabinets to assist in heat removal and cabinet ventilation. If the fans are required to dissipate heat when the HVAC is running, redundant fans shall be provided. If the fan(s) are only required to dissipate heat when the HVAC is not running, a single fan is adequate. In either cases, fan failure or over-temperature detection and alarm are required in the PCS.

2.5.1.4 Packaged - Vendor or OEM supplied with environmental rating to suit the intended application.

2.6 Electrical Systems for Instrumentation

2.6.1 General

2.6.1.1 The objective of this Subsection is to provide the basic criteria for electrical systems for instrumentation and control systems.

2.6.1.2 Electrical distribution panels and motor control centers associated with control building services and the control system UPS shall be located in the electrical equipment room.

2.6.1.3 The electrical equipment room shall be sized to permit top, front, side and back access for operation and maintenance of installed equipment.

2.6.1.4 Where required a separate mechanical equipment room containing air handling equipment, particle filters and chemical filters, shall be included and shall be fire separated from all other rooms.

2.6.2 Electrical Wiring

2.6.2.1 Electrical wiring up to but excluding vendors' standard cabinets shall be designed in accordance with Document Number EPM-KEE-GL-000001: Electrical Design Guidelines

2.6.2.2 Notwithstanding the requirements of Document Number EPM-KEE-GL-000001: Electrical Design Guidelines, the following requirements shall be observed.

- Analog Signals
  - Use TPSH cable for all low level analog signals such as 4-20 mA, 1-5 V DC, 0-10 V DC, pulse type circuits 24 V DC and under, and other signals of a similar nature.
  - Use RTD cable for connections between RTD’s and transmitters.
- Digital Communications Signals
  - Use TPSH cable for all low-level input (24 V and below) and output signals to the plant control system.
  - Use Stranded Copper wire for power to instruments, for 120 VAC signals other than those mentioned above and as otherwise indicated on the drawings. Use stranded wire and cable to supply power to instruments.
- Cable Installation
  - Install instrumentation cables in conduit systems or in cable trays. Use a maximum of 36” length of liquid tight flexible conduit to connect the field sensors to the rigid conduit. Refer to Document Number EPM-KEE-GL-000001: Electrical Design Guidelines for conduit or cable tray requirements.

- Where unarmoured instrumentation cables are installed in cable trays, provide barriers in the tray to separate instrumentation cables from power cables.
- At each end of the run leave sufficient cable length for termination.
- Do not make splices in any of the instrumentation cable runs. Where splices are required, obtain approval. Do not splice cables to gas detection heads.
- Where splices are necessary in instrumentation cables other than coaxial cables, perform such splices on terminal blocks in terminal boxes. Keep splices in instrumentation cable to a minimum and separated physically from power circuits. Cable shields shall be terminated on insulated terminals and carried through to the extent of the cable.
- Where splices are made to coaxial cables, use standard coaxial cable connectors.
- Ground cable shields at one end only. Unless otherwise specified, ground the shields at the marshaling / local control panels.
- Protect all conductors against moisture during and after installation.
- Terminate armoured cables with approved only connector.

2.6.3 Power Supply

2.6.3.1 Two separate, independent, electric circuits shall be supplied to power redundant modules. If a simplex UPS is provided, one of the feed to system redundant power modules shall be supplied from a raw 230 V power feed.

2.6.3.2 Power Supply circuits shall be clearly labeled. Branch circuits or power cords to redundant modules shall be clearly labeled identifying the circuit that they are connected to.

2.6.3.3 Redundant internal power supply modules shall be provided for the following:

- Process controllers
- Input and output modules
- Communication modules

2.6.3.4 Redundant power supply modules shall be provided for critical field instruments.

2.6.4 Power Distribution within PCS Cabinets

2.6.4.1 Power supplies which feed multiple chassis' or baseplates shall have their outputs wired to a power distribution panel within the cabinet.

Commentary Note: The term "power distribution panel" in the above requirement and subsequent requirements of this Subsection refers to a collection of din-rail mounted circuit breakers and/or fused terminal blocks, terminal blocks and wiring used to distribute power to multiple loads from a single source.

2.6.4.2 Branch circuits from power supplies shall be individually fused or protected by a circuit breaker.

2.6.4.3 Terminal blocks in the power distribution panel shall be segregated by voltage level.

2.6.4.4 Power distribution terminal block wiring shall not be daisy-chained using wires or crimp connectors. Jumper bars or preformed jumper combs designed for the specific terminal blocks being used are acceptable methods of distributing power supply wiring.

2.6.4.5 Wiring, terminal blocks, wire tagging and terminal block coding within the power distribution panel shall be as per the requirements defined elsewhere in this document.

2.6.5 Power Supply and Distribution to PCS Consoles and Workstations

2.6.5.1 PCS workstations shall be fed from UPS power sources. This requirement applies to the processor, monitor, and other peripheral devices associated with the workstation.

2.6.5.2 For redundant workstations within an operator console, it is acceptable to supply power to the workstations using either of the configurations described below:

- Each workstation shall be fed from a single UPS power circuit; provided that each workstation is fed from a separate UPS power source.
- Each workstation shall be fed from two separate power circuits utilizing a power switching device to maintain continuous power on loss of a single circuit. One of these circuits shall be fed from UPS power source and the other may be fed from utility power.

2.6.5.3 Workstations which are not supplied in a redundant configuration shall be powered

2.6.5.4 Commercially available multiple outlet power strips (i.e., Tripp-Lite model UL 24CB-15 or similar) may be used to distribute power to multiple components of a workstation (i.e., processor, monitor, and associated peripheral devices) provided that each power strip feeds equipment associated with a single workstation. The power strip must have an integral circuit breaker and switch and must carry a FM or CE marking.

2.6.6 Utility Power

2.6.6.1 One, duplex-type convenience outlet, rated at 230 VAC, 13 amp shall be provided within each cabinet for utility power. Convenience outlets shall be wired to a separate terminal strip which in turn is sourced from a non-UPS AC distribution panel.

2.6.6.2 Two, duplex-type convenience outlets, rated at 230 VAC, 13 amp shall be provided within each console for utility power. Convenience outlets shall be wired to a separate terminal strip which in turn is sourced from a non-UPS AC distribution panel. The outlets shall be placed on opposite sides of the console to enhance availability.

2.6.7 Grounding

2.6.7.1 Grounding design shall be per the provisions of Document Number EPM-KEE-GL-000001: Electrical Design Guidelines

2.6.7.2 Notwithstanding the requirements PCS workstations, computers, I/O cabinets and auxiliary equipment shall be grounded in accordance with PCS vendor's recommendations.

2.6.7.3 PLC based Emergency Shutdown Systems (ESD) shall be grounded in accordance with electrical Subsection and the ESD Programmable Logic Controller (PLC) manufacturer's recommendations.

2.7 Process Automation Network (PAN)

2.7.1 General

Notwithstanding the requirements as set out in Section 1.0: Telecommunications - The objective of this Subsection is to provide the basic criteria for process automation network design selection, and installation.

2.7.2 Process Automation Network Design

The PAN shall be based on IEEE 802.3 CSMA/CD (Ethernet) standard or Vendor proprietary control network standard. The backbone shall be based on Layer 3 multiprotocol switches utilizing 1 Gigabits per second (Gbps) backplane throughput as minimum. Nodes, such as servers/ workstations, shall be connected to 10/100 Mbps ports.

2.7.3 Physical and Logical Separation

2.7.3.1 The network design shall provide physical and logical separation between PAN and all other corporate or utility networks through demilitarized zone and firewall.

2.7.3.2 Logical separation, at minimum, is mandatory for network connections above firewall.

2.7.3.3 Physical separation is mandatory for subsystems such as CCTV, telephone network connections below firewall.

2.7.3.4 Physical separation utilizing dedicated fiber strands of an existing fiber optics cable is permitted and shall include a service level agreement defining area of responsibility for support and maintenance, including agreed response time.

2.7.3.5 A minimum bandwidth of 5 Megabits/s requirements shall always be made available for any given WAN connection.

2.7.3.6 PAN equipment shall be deployed with the latest stable vendor supported operating systems.

2.7.3.7 Network traffic through the firewall shall be limited to server-to-server connections and through selected source/destination IP addresses and TCP/UDP ports and services.

2.7.4 Engineering and Maintenance Network (E&MN)

2.7.4.1 The E&MN shall be connected to the PAN.

2.7.4.2 The E&MN network shall be used to integrate auxiliary systems on a single network such as Emergency shutdown systems, compressor control systems, vibration monitoring systems, etc., for the purpose of centralizing the engineering and maintenance activities for the plant.

2.7.5 Wireless Communications

2.7.5.1 Full Duplex wireless radio communications shall be provided for all new RTUs associated with the Irrigation Control System.

2.7.5.2 Wireless systems will not be utilized for building automation and process automation projects.

2.7.5.3 The Irrigation Central Control shall communicate in real time 2-way communication with the field Remote Terminal Units (RTU) on site via radio communication through a Field Interface Unit (FIU). The RTU shall have the capability to communicate on a bi-directional real time basis with systems above it (RTU-To-Central), parallel to it (RTU-To-RTU) and below it (RTU-To-Slave RTU). This shall include full control and monitoring capabilities.

2.7.6 HART

2.7.6.1 The HART Communications Protocol (Highway Addressable Remote Transducer Protocol) is an early implementation of Fieldbus, a digital industrial automation protocol.

2.7.6.2 It's most notable advantage is that it can communicate over legacy 4-20 mA analog instrumentation wiring, sharing the pair of wires used by the older system. Due to the huge installed base of 4-20 mA systems throughout the world, the HART Protocol is one of the most popular industrial protocols today. HART protocol has made a good transition protocol for users who were comfortable using the legacy 4-20 mA signals, but wanted to implement a "smart" protocol.

2.7.6.3 There are two main operational modes of HART instruments: analog/digital mode, and multidrop mode.

2.7.6.4 In point-to-point mode (analog/digital) the digital signals are overlaid on the 4-20 mA loop current. Both the 4-20 mA current and the digital signal are valid output values from the instrument. The polling address of the instrument is set to "0". Only one instrument can be put on each instrument cable signal pair. One signal, generally specified by the user, is specified to be the 4-20 mA signal. Other signals are sent digitally on top of the 4-20 mA signal. For example, pressure can be sent as 4-20 mA, representing a range of pressures, and temperature can be sent digitally over the same wires. In point-to-point mode, the digital part of the HART protocol can be seen as a kind of digital current loop interface.

2.7.6.5 In multidrop mode (digital) only the digital signals are used. The analog loop current is fixed at 4 mA. In multidrop mode it is possible to have more than one instruments on one signal cable. HART

revisions 3 through 5 allowed polling addresses of the instruments to be in the range 1-15. HART 6 and later allowed address up to 63. Each instrument needs to have a unique address.

2.7.6.6 All transmitters shall be high performance type microprocessor based Foundation Fieldbus or 'SMART' type with HART protocol unless stated otherwise.

2.7.6.7 The PCS System shall support communication to HART devices by using Universal and Common practice command sets using HART I/O module as the interface.

2.7.6.8 The system shall be capable of receiving, displaying and storing diagnostic data and device alerts from HART devices by using HART I/O module interface. In case the selected I/O modules are not HART compliance, a multiplexer shall be provided to obtain the HART information.

2.7.6.9 The PCS system shall be capable of displaying configuration data resident in HART devices on the IAMS workstations.

2.7.6.10 FOUNDATION Fieldbus is an all-digital, serial, two-way communications system that serves as the base-level network in a plant or factory automation environment. It is an open architecture, developed and administered by the Fieldbus Foundation.

2.7.6.11 It is targeted for applications using basic and advanced regulatory control, and for much of the discrete control associated with those functions.

2.7.6.12 Two related implementations of foundation fieldbus have been introduced to meet different needs within the process automation environment. These two implementations use different physical media and communication speeds.

- FOUNDATION Fieldbus H1 - Operates at 31.25 Kbit/s and is generally used to connect to field devices and host systems. It provides communication and power over standard stranded twisted-pair wiring in both conventional and intrinsic safety applications. H1 is currently the most common implementation.
- HSE (High-speed Ethernet) - Operates at 100/1000 Mbit/s and generally connects input/output subsystems, host systems, linking devices and gateways. It doesn't currently provide power over the cable, although work is under way to address this using the IEEE802.3af Power on Ethernet (PoE) standard.

2.7.6.13 FOUNDATION Fieldbus was originally intended as a replacement for the 4-20 mA standard.

2.7.6.14 FOUNDATION Fieldbus was developed over a period of many years by the International Society of Automation, or ISA, as SP50.

2.7.6.15 The International Electrotechnical Commission (IEC) standard on field bus, including FOUNDATION Fieldbus, is IEC 61158. Type 1 is FOUNDATION Fieldbus H1, while Type 5 is FOUNDATION Fieldbus HSE.

2.7.6.16 A typical fieldbus segment consists of the following components.

- H1 card - fieldbus interface card (It is common practice to have redundant H1 cards, but ultimately this is application specific)
- PS - Bulk power (Vdc) to Fieldbus Power Supply
- FPS - Fieldbus Power Supply and Signal Conditioner (Integrated power supplies and conditioners have become the standard nowadays)
- T - Terminators (Exactly 2 terminators are used per fieldbus segment. One at the FPS and one at the furthest point of a segment at the device coupler)
- LD - Linking Device, alternatively used with HSE networks to terminate 4-8 H1 segments acting as a gateway to an HSE backbone network.
- And fieldbus devices, (e.g. transmitters, transducers, etc.)

2.7.7 Profibus

There are two variations of PROFIBUS in use today; the most commonly used PROFIBUS DP, and the lesser used, application specific, PROFIBUS PA:

2.7.7.1 PROFIBUS DP (Decentralized Peripherals) is used to operate sensors and actuators via a centralized controller in production (factory) automation applications. The many standard diagnostic options, in particular, are focused on here. Most common application of Profibus DP is in Motor Control Centers

2.7.7.2 PROFIBUS PA (Process Automation) is used to monitor measuring equipment via a process control system in process automation applications. This variant is designed for use in explosion/hazardous areas (Ex-zone 0 and 1). The Physical Layer (i.e. the cable) conforms to IEC 61158-2, which allows power to be delivered over the bus to field instruments, while limiting current flows so that explosive conditions are not created, even if a malfunction occurs. The number of devices attached to a PA segment is limited by this feature. PA has a data transmission rate of 31.25 Kbit/s. However, PA uses the same protocol as DP, and can be linked to a DP network using a coupler device. The much faster DP acts as a backbone network for transmitting process signals to the controller. This means that DP and PA can work tightly together, especially in hybrid applications where process and factory automation networks operate side by side.

2.7.8 BACNET

2.7.8.1 The BACnet protocol defines a number of services that are used to communicate between building devices. The protocol services include Who-Is, I-Am, Who-Has, I-Have, which are used for Device and Object discovery. Services such as Read-Property and Write-Property are used for data sharing. The BACnet protocol defines a number of Objects that are acted upon by the services. The objects include Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Multi-State Input, Multi-State Output, Calendar, Event-Enrollment, File, Notification-Class, Group, Loop, Program, Schedule, Command, and Device.

2.7.8.2 The BACnet protocol defines a number of data link / physical layers, including ARCNET, Ethernet, BACnet/IP, Point-To-Point over RS-232, Master-Slave/Token-Passing over RS-485, and LonTalk.

2.7.9 Control Network Cabling

2.7.9.1 Process Control Network cabling installed indoors shall be placed in ladder, trough or solid bottom cable trays.

2.7.9.2 Redundant network cables installed indoors shall not be installed in the same cable tray.

2.7.9.3 Installation of Fiber Optic process control network cabling shall be in accordance with Section 1.0: Telecommunications, and shall observe the following additional criteria:

- Composite cable of power and fiber optic shall not be used.
- Aerial fiber optic cables shall not be used.
- Multiple fiber optic cables between two locations shall be diversely routed to provide additional reliability and survivability.
- There shall not be more than one fiber hub between a destination location and its originating node.
- Fiber cables shall be sized with at least 50% additional strands above the initial strand requirements. The following minimum strand count shall also be applied:
  - 24 strand count for cable run to a building or a facility that is not a node or hub.
  - 12 strand count for cable run to small or temporary locations.
- Fiber strand count in all fiber cable shall be an even number.

- Spare fiber strands shall be spliced and terminated at the Fiber Distribution Panel (FDP), and marked as spares.

2.8 Control System Access and Security

2.8.1 General

2.8.1.1 The objective of Subsection is to detail the requirements for access control and security of control systems.

2.8.1.2 The ISA99/IEC 62443 standard is the worldwide standard for security of Industrial Control systems and should be referenced during design.

2.8.1.3 Operators of facilities may want to begin sharing information between business and automation systems. However, because automation and control systems equipment connects directly to a process, loss of control and interruption in the flow of information are not the only consequences of a security breach. The potential loss of life, environmental damage, regulatory violation, and compromise to operational safety are far more serious consequences. External threats are not the only concern; knowledgeable insiders with malicious intent or even an innocent unintended act can pose a serious security risk. Personnel from outside the control systems area increasingly performs security testing on the systems, exacerbating the number and consequence of these effects. Combining all these factors, it is easy to see that the potential of someone gaining unauthorized or damaging access to an industrial process is not trivial.

2.8.2 Foundational Requirements

There are several basic or foundational requirements that have been identified for industrial automation security. These are:

2.8.2.1 Access Control (AC) – Control access to selected devices, information or both to protect against unauthorized interrogation of the device or information.

2.8.2.2 Use Control (UC) – Control use of selected devices, information or both to protect against unauthorized operation of the device or use of information.

2.8.2.3 Timely Response to Event (TRE) – Respond to security violations by notifying the proper authority, reporting needed forensic evidence of the violation, and automatically taking timely corrective action in mission critical or safety critical situations.

2.8.2.4 Resource Availability (RA) - Ensure the availability of all network resources to protect against denial of service attacks.

2.8.3 Defense in Depth

2.8.3.1 It is typically not possible to achieve the security objectives through the use of a single countermeasure or technique. A superior approach is to use the concept of defense in depth, which involves applying multiple countermeasures in a layered or stepwise manner. For example, intrusion detection systems can be used to signal the penetration of a firewall.

2.8.3.2 Physical Security - The network hardware used to provide security from offsite intrusion and the SCADA servers used to provide internal security shall be located in a lockable room dedicated to SCADA system. The telephone utility termination point shall be located outside of the lockable room dedicated to SCADA system. Any servers installed in the lockable room not associated with the SCADA system shall be located in a separate rack with their own routers and shall utilize separate telephone lines from the SCADA system.

2.8.3.3 IP address generation and translation - Automatic IP addressing software in the router such as (DHCP) Dynamic Host Configuration Protocol, DNS (Domain Name System) services BIND (Berkeley Internet Name Domain) shall be turned off and routing of unknown networks shall be turned off in the routers at the SCADA zone and process zone. The NAT (Network Address

Translators) shall also be disabled in the routers at the SCADA zone and process zone. This will result in additional effort when adding or removing devices to the network but it will also reduce the possible security leaks in the router software and will prevent casual users from gaining access to the system thought PCs and cell phones.

2.8.3.4 Communications with remote monitoring station along shall be sent with encrypted conduits equivalent to IPsec tunnels and the master station shall be set to block all traffic not using the data polling port in the PLC network and not addressed to SCADA servers.

2.8.3.5 Sites are located outside of the physical security zone of the plant and cannot be made spoof proof. Data from these sites shall be used only for monitoring and shall not be used for control.

2.8.3.6 Software Updates: The simplest and most secure way to make updates to the SCADA software and PLC software is to do so manually on a regular basis. The updates shall be checked with the software writer for authenticity and only then implemented on the SCADA servers and PLCs at the site.

2.8.4 Countermeasures

2.8.4.1 There are several countermeasures that can be used to address external threats to the control system network. These include hardware and software built into the control system network and include:

- IP access controls list.
- Intrusion detection.
- Data conduits that use Cryptographic algorithm, Cryptographic keys, encryption, and digital signature of IP packets with IPsec tunnels.
- Resource isolation or segregation with security zones and conduits within the network through routers and IP access controls list.
- Logging commands and passwords to provide Authentication, Authorization, and Accountability.

2.8.4.2 Countermeasures can also be employed on the workstations and servers and include:

- Virus scanning software that scans the host for malicious software.
- Virus scanning software that will scan the system for unusual activity and log it.
- Physical security of the workstations with password protection that times out and locks inactive workstations from unauthorized visitors.
- Individual passwords to authenticate the user.
- Restrict user access by enforcing variable access privileges.

2.8.5 Security Zones:

2.8.5.1 A security zone is a logical grouping of physical, informational, and application assets sharing common security requirements. This concept applies to the electronic environment where some systems are included in the security zone and all others are outside the zone. There can also be zones within zones, or subzones, that provide layered security, giving defense in depth and addressing multiple levels of security requirements. Defense in depth can also be accomplished by assigning different properties to security zones.

2.8.5.2 A security zone has a border, which is the boundary between included and excluded elements. The concept of a zone also implies the need to access the assets in a zone from both within and without. This defines the communication and access required to allow information and people to move within and between the security zones. Zones may be considered to be trusted or untrusted. Security zones can be defined in either a physical sense such as each pump station or in a logical manner such as the following:

- PLCs, ACPs, and Remote IO in a control system zone.
- Host workstations and servers in a SCADA zone.
- Historical data base in an Enterprise zone.

2.8.5.3 Email servers and other types of typical business software shall not be included inside any of the above zones to prevent Phishing attacks.

2.8.6 Conduits

2.8.6.1 Information must flow into, out of, and within a security zone. To cover the security aspects of communication and to provide a construct to encompass the unique requirements of communications, this standard is defining a special type of security zone: a communications conduit.

2.8.6.2 A conduit is a particular type of security zone that groups communications that can be logically organized into a grouping of information flows within and also external to a zone. It can be a single service (i.e., a single Ethernet network) or can be made up of multiple data carriers (multiple network cables and direct physical accesses). As with zones, it can be made of both physical such as connecting pump stations to remote monitoring sites and logical constructs as connection between the PLCs and SCADA servers.

2.8.6.3 Trusted conduits crossing zone boundaries must use an end-to-end secure process. Due to slow speed of response that is required, several seconds of lag can be tolerated without notice, and the static nature of the network, simple router based IPsec tunnels with a key coded into the router, provide an easy way to build conduits across the a wide area network such as the public telephone networks.

2.8.6.4 The use of IPsec tunnels and IP access control list are mature technologies that shall see little degradation over time. The protection provided through passwords and virus scanning software will require constant maintenance.

2.8.7 Local and Remote Access

2.8.7.1 Local Access

Local access in the form of operator workstations and consoles shall reside on the PAN and shall be below the plant firewall.

2.8.7.2 Remote Access

- Remote access through the plant firewall, for control purposes, is not permitted.
- Remote engineering personnel through the firewall is permitted. The following conditions shall apply:
  - The Engineering station must be in a room with controlled physical access.
  - Remote access nodes shall be placed on the corporate network for server to server communication.
  - A Virtual Private Network shall be used for vendor remote troubleshooting for communication between remote access nodes.

2.8.8 Data Protection and Retention

2.8.8.1 A redundant fixed media storage device shall be provided for the storage of all system and control configuration, graphics, report forms, programs, etc. Automatic/manual copying between redundant media shall be a user selectable parameter. For security, data shall be retained using RAID or equivalent technology, and be capable of permanent archive via CD or DVD.

2.8.8.2 File manipulation on or between any drive in the system shall not be constrained by physical device location.

2.8.8.3 Store data to Disk, Tape etc. and retention shall be as approved by the Entity.

2.8.8.4 Retention and archival of data shall be developed in accordance with the Entity Corporate Data Protection and Retention policy. As a minimum, the following requirement shall be considered:

- The retention period shall be set for 3 months as a minimum.
- Minimum storage capacity for shall be 1 Terra Byte.

2.9 System Integration

2.9.1 General

2.9.1.1 The objective of Subsection is to provide the basic criteria for system integration.

2.9.1.2 Interfaces between the PCS and associated subsystems or auxiliary systems shall use standard hardware and software devices, which are compliant with industry standard protocol; or proprietary protocol, which is offered as a standard product by both the control system vendor and the subsystem vendor.

2.9.1.3 Redundant communication interfaces shall be supplied for:

- Emergency Shutdown Systems.
- Subsystems where loss of communication will result in the significant degradation of control functions.
- Where redundant communications are specified, no single component failure shall result in the loss of communication to any subsystem.

2.9.1.4 Time Synchronization

- Time clocks for all stations which are part of the PCS shall be synchronized to 100 milliseconds or better.
- Time synchronization using GPS and networked time server which supports Simple Networked Time Protocol (SNTP) is the preferred method for synchronization of all servers connected to the PCS.
- Synchronization shall be performed at a minimum of once every 24 hours.

2.9.1.5 Interface to ESD Systems

- Emergency Shutdown Systems, interfaces, bypasses, shutdown and reset functions shall be independent and segregated from the main PCS.
- The interface to ESD systems shall meet the following:
  - Communications between PCS and ESD systems for real-time process data and operator commands shall be via dedicated, redundant communications paths. The PCS shall NOT communicate real-time process data or operator commands to more than one ESD system over the same communications path.
  - "First out" ESD event status, if available, shall be passed via the communications link from the ESD logic solver to the PCS.

2.9.2 DCS, PLC and SCADA (MTU, RTU)

2.9.2.1 The requirements for Distributed Control Systems (DCS) shall comply with the applicable codes and standards

2.9.2.2 The requirements for SCADA Systems shall comply with C37.1-2007, IEEE and applicable codes and standards.

2.9.2.3 The requirements for RTU Systems shall comply with C37.1-2007, IEEE and also refer the relevant applicable codes and standards.

2.9.2.4 The requirements for PLC Systems shall comply with C37.1-2007, IEEE and applicable codes and standards.

2.9.3 Historian

2.9.3.1 All PCS configuration parameters, including tag data, workstation configurations and controller module configurations shall be stored on redundant on-line media.

2.9.3.2 On-line historical data shall be stored for access via history trends, displayed listings, and printed listings.

2.9.3.3 The collection rates, longevity, and scope for historical data are to be specified on a per project basis.

2.9.3.4 Circular files on a FIFO basis shall be implemented such that the latest records are retained when buffer or list overflow occurs.

2.9.4 Instrumentation Asset Management Systems (IAMS)

2.9.4.1 This Subsection deals with the requirements governing the design of IAMS.

2.9.4.2 The Instrument Asset Management System (IAMS) shall automatically and continuously monitor the status, events and operating conditions of the field connected devices to provide an efficient condition-based maintenance solution without interfering with the plant control system

2.9.4.3 Smart field devices Foundation Fieldbus and HART shall be connected to the IAMS system through the PCS.

2.9.4.4 The IAMS system shall be installed, commissioned and put into operation before the pre-commissioning for the field instruments starts.

2.9.4.5 The IAMS database shall be fully populated with the latest device data for every fieldbus and/or HART device on the project.

2.9.5 Condition Monitoring Systems (CMS)

2.9.5.1 This Subsection deals with the requirements governing the design of protective and condition monitoring equipment for rotating machinery.

2.9.5.2 The CMS shall be a single platform software package, capable of integrating various condition monitoring technology modules for rotating machinery and fixed asset condition management. It shall be capable of being configured as either a centralized or distributed database network installation with adequate provision for worst-case real time data transfer requirements.

2.9.5.3 The CMS shall be connected to the plant automation network to allow import and export of data including but not limited to, digital process control servers, computerized maintenance management systems (CMMS), plant historians, plant document management systems and automated reliability based maintenance programs.

2.9.5.4 CMS are independent of electric motor and generator stator temperature monitoring equipment.

2.9.5.5 A typical CMS will be equipped to monitor various bearing temperature and vibration sensors to provide the following diagnostic information from each of the machine sets. The specific requirements will be determined by the mechanical engineer.

- Motor Free-End Thrust Bearing: Three axis of housing vibration velocity (Radial X+Y and Axial Thrust position) two temperature and one oil level measurement.
- Motor Winding Temperatures: 2 per phase - Phase A, Phase B, & Phase C.

- Motor Casing Temperature
- Motor Drive-End Bearing: one temperature and one oil level.
- Pump pedestal: Two axis of housing vibration velocity (Radial X+Y).
- Pump Drive-End Bearing: Three axis of housing vibration velocity (Radial X+Y and Axial Thrust position) and one temperature.
- Motor Shaft: One proximity probe, or Hall Effect speed sensor (key-phasor).
- Motor Shaft: reverse rotation detection.
- Motor Shaft: Tacho RPM measurement.
- Seal Water Pressure and Flow.

2.9.6 Emergency Shutdown and Isolation Systems (ESD)

2.9.6.1 ESD systems are not normally required for building automation and /or water and wastewater facilities. However, depending on the configuration and the power requirements for very high volume pumping stations as with seawater cooling pump stations, it may be necessary to incorporate an ESD system into the design.

2.9.6.2 ESD systems shall be configured using redundant architecture, i.e., Dual Modular Redundant (DMR), 1-out-of-2D (1oo2D) or Triple Modular Redundant (TMR), 2-out of-3 (2oo3) voting architecture.

2.9.7 Control System Overall Integration

2.9.7.1 For Wet Utility Treatment Plant such as Potable Water RO plant, IWTP treatment, SWTP treatment and Sea Water Cooling Pump Station, the PCS is the single window platform for control and monitoring of the process plant operations. The overall integration shall include following minimum requirements

- The PCS shall include distributed field controllers, I/O modules, system and marshalling cabinets, communication modules for interface with other third party control systems, plant automation networks, Data Servers, Operator Workstations, Engineering Workstation, Printers for process operation and control
- The PCS shall also include subsystems such as Instrument Asset Management System (IAMS), Alarm Management System (AMS), Data historian, Cyber security server, time synchronization server, fire wall, web terminal, demilitarized Zone etc. as per individual project requirements.
- If ESD system is required, The ESD system shall be fully integrated with PCS.
- CMS integration with PCS shall be connected through both hardwire and software. For machine protection trip signals such as vibration, bearing temperature etc. shall be hardwired to PCS/ESD for interlock. Other alarms, diagnostics data shall be serial link to PCS through industrial standard protocol such as Modbus TCP/IP, Modbus RTU etc.
- There will be no BAS system for these plants. The HAVC- DDC control panels in each plant building shall provide common alarm signals to be hardwired to PCS for alarm.
- FACP from each plant building shall form the dedicated fire alarm ring network and provide fire alarm workstation to monitor the plant fire alarm status in control room. FACP in each plant building shall also provide Common Alarm and Common Fault signals to be hardwired to PCS to alarm the process operators. In case no centralized fire alarm workstation is available, FACP shall be serial link with PCS through industrial standard protocol such as Modbus TCP/IP, Modbus RTU, etc.

2.9.7.2 For Wet Utility distribution piping network, such as Potable Water Distribution Pump Stations, Valve Chambers, Sea Water Cooling Valve Chambers, lift Stations, etc. the SCADA is the single window platform for control and monitoring of the process plant operations. The overall integration shall include following minimum requirements:

- The local SCADA will be located in Pump Station Control Room include communication gateways, networks, data collection severs, Operator Workstations, Engineering Workstation, Printers for process operation and control.
- The local SCADA system shall uplink with Data Control Center by means of FO cable and radio connection for remote monitoring purpose.
- PLC to be used for pump station local control and monitoring, including controllers, I/O modules, system and marshalling cabinets, communication modules for interface with other third party control systems, networks and gateways for uplink with SCADA system.
- RTU will be used for pump station associated distribution pipeline such as Valve Chamber Instruments control and monitoring. Instruments such as MOVs, Flow Meters, Pressure Transmitters, and Analyzers etc. inside valve chamber will be connected to local RTU which is located inside an instrumentation shelter. All RTUs shall be uplinked to the associated pump station PLC/ SCADA control network through FO cable, and/or Radio Communication for directly uplink with Data Center for remote monitoring by Central SCADA system shall be also provided.
- RTU shall be used for control and monitoring the Sanitary Water Lift Station and odor control unit. RTU shall be linked with Data Control Center through Radio Communication network.
- There will be no centralized BAS system for distribution pump station plant, the HVAC, DDC control panels in each plant building shall provide common alarm signals to be hardwired to PLC for alarm in SCADA system.
- FACP from each distribution pump plant building shall form the dedicated fire alarm ring network and provide fire alarm workstation to monitor the plant fire alarm status in control room. FACP in each plant building shall also provide Common Alarm and Common Fault signals to be hardwired to PLC to alarm the SCADA process operators. In case no centralized fire alarm workstation is available, FACP shall be in serial communication link with PLC through industrial standard protocol such as Modbus TCP/IP, Modbus RTU, etc.

2.9.7.3 For Wet Utility Irrigation distribution piping network, such as Irrigation Water Distribution Pump Stations, Valve Chambers etc. the SCADA is the single window platform for control and monitoring of the process plant operations. The overall integration shall include following minimum requirements

- The SCADA will be located in irrigation Pump Station Control Room include communication gateways, networks, data collection severs, Operator Workstations, Engineering Workstation, Printers for process operation and control.
- The SCADA system shall be uplinked with Landscape and Irrigation O&M Data Control Center by means of FO cable and radio connection for remote monitoring purpose.
- PLC to be used for irrigation pump station local control and monitoring, including controllers, I/O modules, system and marshalling cabinets, communication modules for interface with other third party control systems, networks and gateways for uplink with SCADA system.
- RTU will be used for irrigation pump station associated distribution pipeline such as Valve Chamber Instruments control and monitoring. Instruments such as MOVs, Flow Meters, Pressure Transmitters, and Analyzers etc. inside valve chamber will be connected to local RTU which is located inside an instrumentation shelter. All RTUs shall be uplinked to associated pump station PLC/ SCADA control network through FO cable and Radio Communication for monitoring by pump station SCADA system.
- There will be no centralize BAS system for irrigation distribution pump station plant. The HVAC, DDC control panels in each plant building shall provide common alarm signals to be hardwired to PLC for alarm in SCADA system.
- FACP from each irrigation distribution pump station building shall form the dedicated fire alarm ring network and provide fire alarm workstation to monitor the plant fire alarm status in control room. FACP in each plant building shall also provide Common Alarm and Common Fault signals to be hardwired to PLC to alarm the SCADA process operators. In case no centralized fire alarm workstation is available, FACP shall be in serial communication with PLC through industrial standard protocol such as Modbus TCP/IP, Modbus RTU, etc.

- RTU shall be used for Irrigation Controller, the RTU shall be linked with Landscape and Irrigation O&M Data Control Center by means of radio commination.

2.9.7.4 For Buildings, such as government buildings, schools, colleges, university, hospitals, commercial center, residential compound etc. the Integrated BAS is the single window platform for control and monitoring of the entire camp / compound facilities. The overall integration shall include following minimum requirements

- The centralized BAS shall be provided for entire building/camp/compound, include communication gateways, networks, data collection severs, Operator Workstations, Engineering Workstation, Printers for monitoring the entire camp / compound facilities.
- The BAS shall provide a distributed control system in lieu of Building Management Systems (BMS) - the computer networking of electronic devices designed to monitor and control all HVAC status through BACnet protocol. The BAS shall also provide interface and support all other communication protocol with other widely standalone systems – typically security (access control, CCTV, PA), fire and flood safety, fire pumps, fire suppression, lighting (especially emergency lighting, Energy Efficiency Control system), generators, and mechanical packages such as potable water boost pumps, lift stations, chiller package etc. within a building / Camp / Compound.
- PLC with local monitoring and control functions to be used for potable water boost pump, chilled water pump stations, Chlorination Package, including controllers, I/O modules, system and marshalling cabinets, communication modules for interface with other third party control systems, networks and gateways for uplink with central BAS system. The PLC shall be linked with BAS through Voice / data network in the camp / compound provided by telecom.
- When Sanitary Lift Station are located within the Camps / Compound, RTU will be used for control and monitoring the Sanitary Water Lift Station and odor control unit. The RTU shall be linked with BAS through Voice / data network in the camp / compound provided by telecom.
- All electrical power distributions status such as Substation, MCC, switchgear, main distribution Board, transformer status can be monitored BAS
- Electrical Power Management System (EPMS) – The Electrical Power Management System shall be integrated via Hardwire software to the Medium/Low Voltage Switchgear, Parallel Switchgear, Chillers & Emergency Switchboards the ATS, RMU, UPS, Switchboards & MCC DBs also the Generators and BAS. The EPMS is integrated to the IT LAN via Hardwire Analogue / Digital Signals.
- All Special Gas System within the building shall be monitored by BAS, including Air Compressor, Vacuum Compressor, Gas handling Unit, Gas Detector, Cylinder Pressure Control, etc.
- FACP from each building shall form the dedicated fire alarm ring network and provide fire alarm workstation to monitor the camp / compound fire alarm status in central control room. FACP shall also be integrated with BAS for monitoring and recording from BAS system.

2.10 Control System Software

2.10.1 General

2.10.1.1 The objective of this Subsection is to provide the basic criteria for control system software.

2.10.1.2 It is the intent to have the Contractor furnish the latest generation, standard, field proven, fully debugged and supported PCS software package application with a minimum of additions or changes.

2.10.1.3 Customized or specially written software shall only be furnished if standard software cannot meet all of the functional requirements required. Any custom applications software required shall be fully integrated into the basic software and shall not require unique command structures. No attempt has been made to list all software or list all characteristics of software required by the Instrumentation Supplier – this shall be specified for each specific project.

2.10.1.4 The software package shall provide a system capable of controlling system level activities, and a higher level process control language allowing the operator to monitor and control the process through an interactive human interface. The software environment shall support a multi-programming atmosphere allowing concurrent execution of more than one program in a background/foreground mode or multi-tasking mode.

2.10.1.5 Throughout the execution of all software modules, the operator shall be presented with all of the command or operation choices available at that point in the program using sufficient verbiage or symbols to make the choices self-explanatory and unambiguous.

2.10.2 Standards

Standards are changing from time to time and it is the responsibility of the A/E to get the latest preferred or updated standards at the time of design.

2.10.3 Licensing

2.10.3.1 All software provided shall be installed and used within the terms of the software manufacturer's license agreement. All software purchased by the Instrumentation Supplier shall be registered to the Instrumentation Supplier during the construction phase of this project. During that time, the Instrumentation Supplier shall be responsible for providing and incorporating minor software package updates and patches issued by the software manufacturer. For example, if version 3.1 of a program is purchased, and version 3.2 and 3.3 were released prior to project completion, the Instrumentation Supplier shall be responsible for incorporating these later versions into the final project. The Instrumentation Supplier would not be responsible for incorporating major software revisions such as the release of a version 4.0 or 4.1.

2.10.3.2 Prior to substantial completion of this project, the Instrumentation Supplier shall reregister all provided software packages to the Entity and provide the Entity with written confirmation of having done so. At project completion, all software shall be registered to the Entity and shall include full development a runtime applications

2.10.3.3 A complete list of supported systems and software shall be submitted and approved from the Entity.

2.11 Control Buildings and/or Control Rooms

2.11.1 General

The objective of this Subsection is to provide the basic criteria for design of central control centers.

2.11.1.1 Local Control Buildings - In close proximity to the process facility for which it is designed, a Local Control Building is characterized by its relatively small size. Local Control Buildings are specifically designed to control a single process unit or plant. Field instrumentation will be connected directly to the control building process interface room. The building will be used to provide only the console areas, offices and facilities necessary to support the operation of the plant or process unit.

2.11.1.2 Central Control Buildings - Central Control Buildings are used to control several interconnected process modules or plants. They provide a single focus for plant or multi-plant wide operation and shall be used in conjunction with Process Interface Buildings and Local Control Buildings located at each process module or plant. The building shall be located to minimize the risk of external damage from fires, explosions, or toxic releases and shall provide essential administrative facilities necessary to support the continuous operation of the plant(s).

2.11.1.3 Process Interface Room (Rack Room) - The Process Interface Room is typically a section of the Local Control Building, or Central Control Building (such as in small facilities), used as the termination and internal distribution point for instrumentation wiring. For Local Control Buildings, this will include field instrument wiring terminated in marshaling cabinets for inbound distribution to distributed control system interface modules. For Central Control Buildings incoming wiring will mainly feature electronic or fiber optic highways associated with the Process Control System (PCS) and ancillary control systems.

2.11.1.4 Structural design of these buildings shall follow Document Number EPM-KES-GL-000001: Structural Design Guideline.

2.11.2 Control Room Requirements

2.11.2.1 Local and Central Control Buildings shall be designed to provide administrative and process control facilities to support safe operations and to provide a suitable environment for the operation and maintenance of the process unit or plant PCS.

2.11.2.2 Internal Layout - It is not intended to mandate control building layouts. Floor plans shall be developed on a case by case basis to support local operating practice and facilitate the installation and maintenance of the plant control system.

2.11.2.3 Access

- The main entrance to the control building, which shall face away from the process plant or face the plant considered to have the least risk of fire or explosion, shall be provided with an air lock to sustain building pressurization. Locks are not required for emergency exits and service entrances. Certain emergency exit doors may be restricted from being opened from outside, but personnel shall be able to open them from inside.
- The floor plan shall be designed to minimize casual personnel traffic through the control room. Offices and equipment rooms shall be connected by internal corridors. For Central Control Buildings, the main entrance shall open onto a lobby or corridor from which the control room, offices and other facilities are accessed. For a Local Control Building, the main entrance may open directly through an air lock to the control room area.
- The computer room (when specified), engineering room and process interface room (rack room) shall have their main access through the control room.
- Emergency exits shall provide easy exit routes from each room and from the control building in accordance with building program.
- Double doors shall be installed to provide outside access to the control room, equipment rooms and rack rooms as required. If the control room is elevated above grade then loading platforms with stairways shall be provided to facilitate equipment handling during installation and maintenance. Equipment access doors shall be kept locked during normal operation and shall meet the blast resistance requirements of the structural walls of the building.
- General Requirements
  - The control room shall be designed so that only activities associated with plant control are performed there.
  - The control room shall be engineered to accommodate future planned expansion.
  - Spacing between operator workstations and walls and between workstations must be at least 1.22 m wide to provide adequate access for routine maintenance.
  - The control room and equipment installed therein shall be designed for lowest practical background noise level. Maximum allowable noise levels shall be 40 dBA. Equipment that cannot meet this criterion shall be installed in auxiliary equipment rooms or shall be located in an acoustic cabinet.

2.11.3 Server (Rack) Room Requirements

2.11.3.1 A computer room shall be provided if there are special computers or servers which require either a specially controlled environment or a locked secure area.

2.11.3.2 If specified, computer rooms shall incorporate the following features:

- A computer ID card reader or combination lock shall be fitted to the computer room door to prevent unauthorized access.
- Environmental conditioning shall be provided in accordance with the equipment manufacturer's recommendations.

- The temperature, relative humidity and environmental corrosion rate shall be monitored and alarmed in the control room.

2.11.3.3 All field wiring with the exception of control system communication links shall be terminated inside marshaling cabinets.

2.11.3.4 All incoming cables must be sealed in accordance with Document Number EPM-KEE-GL-000001: Electrical Design Guideline.

2.11.3.5 Power, instrument analog and digital signal cables shall be segregated and run in accordance with Document Number EPM-KEE-GL-000001: Electrical Design Guideline.

2.11.3.6 Workstations for machinery condition diagnostic systems and auxiliary instrumentation systems that do not need to be routinely monitored shall be installed in the server or rack room unless stated otherwise.

2.11.4 Engineering Room Requirements

2.11.4.1 Engineering workstations shall be installed in the engineering room.

2.11.4.2 Secure fire resistant storage cabinets shall be provided for storage of computer software and documentation. This is not for storing back up system software, manuals and documentation which shall be stored in a secure off-site location.

2.11.4.3 The room shall provide space for desks and filing cabinets.

2.11.5 Electrical - Power, Wiring, Lighting, Grounding Requirements

2.11.5.1 Electrical - Power, Wiring, and Grounding requirements shall be in accordance with Document Number EPM-KEE-GL-000001: Electrical Design Guideline and SBC 401 and IEC standards.

2.11.5.2 Deep parabolic reflector fluorescent tubes shall be used in combination with compact fluorescent or LED spots to provide variable illumination, without glare or shadow, at operator workstations and task lighting for work surfaces. Lighting details shall be in accordance with Document Number EPM-KEE-GL-000001: Electrical Design Guideline.

2.11.5.3 Critical instrument and control systems shall be connected to a UPS system. These systems include:

- Gas Detection System
- Fixed Fire Suppression System
- Emergency Shutdown System
- Process Control System
- Emergency Lighting
- All local and field instrumentation devices
- Other auxiliary protection, monitoring or control systems

2.11.5.4 The UPS system shall be configured and installed in accordance with Document Number: EPM-KEE-GL-00000: Electrical Design Guideline.

2.11.5.5 Wiring

- Under floor power distribution cable systems shall be installed in accordance with SBC 401 and IEC 60364.
- Data highways shall be terminated directly to PCS interface equipment.

- Cables and conduits entering blast resistant control buildings shall be sealed in accordance with Document Number EPM-KEE-GL-000001: Electrical Design Guideline. Multi conductor instrument cables shall be sealed around the outer jacket at the building entry point. Cable end seals shall be applied as required by the SBC 401 and IEC standards.
- Signal and power cables installed in air conditioning plenums shall conform to SCB 401 and IEC standards.

2.11.6 UPS and Battery Room requirements

2.11.6.1 Refer to Document Number EPM-KEE-GL-000001: Electrical Design Guideline, Uninterruptible Power Supply for additional information and details associated with UPS.

2.11.6.2 Batteries shall be located in separate battery rooms and installed in accordance with electrical requirements.

2.11.6.3 Battery rooms shall be ventilated in accordance with HVAC mechanical Section.

2.11.6.4 Safety equipment shall be installed in accordance Document Number EPM-KEE-GL-000001: Electrical Design Guideline.

2.11.6.5 Refer NFPA 111 for additional requirements.

2.11.7 Environmental Requirements

Refer to Document Number EPM-KEE-GL-000001: Electrical Design Guideline

2.12 Fire Alarm and Gas Detection Systems and Fire Suppression Control System

2.12.1 Fire Alarm System

The systems shall include but not be limited to the following:

- Analogue Addressable, fire alarm control panel
- Mimic panel.
- Power supplies, batteries and battery charges.
- Equipment enclosure.
- Analogue Addressable sensors, addressable Manual pull stations, addressable smoke, heat and multi sensor detectors, and etc.
- Repeater panels.
- Audible evacuation signal and control for fire exit doors.
- Wiring and raceway

2.12.1.1 General

- This Subsection applies to the fire alarm and detection systems inside residential, commercial, institutional and industrial facilities.
- Purpose
  - The primary purpose of a fire alarm and detection system is to notify the appropriate personnel and to initiate the appropriate response by these notified personnel.
  - The secondary purpose is to initiate fire safety functions which are building functions intended to increase the level of safety for the building occupants or to control the spread of the harmful effects of fire.
- An approved fire alarm and detection system shall be installed for all facilities in accordance with the latest accepted edition of the SBC 401.

- The system and all associated components shall be designed to address the code requirements for the building and occupancy type assigned to the facility.
- SBC 401 identifies the minimum requirements for fire alarm and detection systems. There may be situations which warrant protection above these minimum requirements. The A/E shall assess the criticality of each facility and submit any recommended system enhancements to the Entity for review and approval.

  For fire alarm and detection provisions in excess of the code requirements to protect special hazards or critical equipment, features and component selection shall be coordinated and shall include consideration for the following:

  - Evaluation of operating characteristics of each detection device as it applies to the specific application
  - Ambient conditions such as temperature, humidity, and corrosion where the devices are to be installed and operate
  - Fuel sources present
  - Ignition sources present
  - Value of the contents of the facility
- The fire alarm and detection system shall be dedicated for that purpose and shall not be combined with other building systems such as building automation, energy management, or security.
- There are requirements for interconnection between the fire alarm and detection system with other building systems for control functions associated with response to a fire alarm condition. The A/E shall coordinate all required interconnections with the manufacturers of the other systems to ensure that the fire alarm system remains independent but has the required interface to facilitate the desired control functions.

- The A/E shall prepare documentation to summarize the recommended approach for the fire alarm and detection system designed for the facility. This documentation shall be submitted to the Entity for review and approval and shall include the following:
  - Floor plans illustrating the locations for all required fire alarm system equipment.
  - The Fire Alarm System Input/output Matrix. Refer to **Table B** for sample.
  - List of fire alarm system enhancements which are recommended above the minimum code requirements in response to specific occupancies or facility characteristics. Include a description of the rationale for these recommendations.
  - Analysis of Fail-Safe Operation. Refer to Document Number EPM-KEE-GL-000001: Electrical Design Guideline.
  - Description summarizing the detection methods selected for the various spaces throughout the facility.
  - List of recommendations for the class and survivability characteristics for the fire alarm and detection system wiring infrastructure.

2.12.1.2 System Description and Requirements

- The fire alarm and detection system shall be a microprocessor based, addressable system comprised of the following components:
  - Fire alarm control panel(s)
  - Auxiliary fire alarm control cabinet(s) required for accommodation of the system control devices, power supplies, etc.
  - Graphic Annunciator(s). Alphanumeric or custom graphic type as determined to be appropriate for the facility
  - Communication devices for transmission of alarms to central and/or remote locations
  - Initiation devices; manual and automatic
  - Notification devices; audible, visual and/or combination
  - Monitoring and control modules
  - Cabling infrastructure

- Fire alarm and detection system shall be specified with the following minimum characteristics and features:
  - Electrically supervised against short, ground and open wiring faults in any of the circuits associated with the fire alarm and detection system.
  - Capable of expansion at any time with no limitations as to the number of automatic or manual initiation devices.
  - Capable of supporting multiple automatic detection devices on the same circuits.
  - Capable to ensure that manual initiation (fire condition) overrides a trouble signal (fault condition).
- Equipment locations for the fire alarm and detection system shall be coordinated with the facility design. The following list provides guidance for locating various fire alarm equipment:
  - Main Fire Alarm Control Panels
    - For small buildings, the fire alarm control panel can be located in a public space and function as the main control panel and the annunciation panel.
    - For larger buildings, the main fire alarm control panels shall be located in rooms accessible by authorized personnel. These rooms could be the Telecom Room or security control room or some other room dedicated for electrical or communications equipment.
    - For buildings where a Fire Command Center is required, the main fire alarm control panel(s) shall be located in the Fire Command Center
  - Auxiliary Fire Alarm Control Cabinets:
    - These cabinets shall be located in electrical or similar utility type rooms which will limit the access to authorized personnel.
    - The location of these cabinets shall be coordinated with the design of the building.
  - Annunciator Panels
    - Annunciator panel(s) shall be located at the building entrance point where the fire response team would enter the building.
    - Additional locations for annunciator panel(s) would be at a designated 24 hour monitored station or other operation center.
  - Voice Communications Cabinets
    - Cabinets housing the equipment associated with the voice communications system for the fire alarm and detection system shall be located at the building entrance point where the fire response team would enter the building.
    - For buildings where a Fire Command Center is required, the voice communications cabinet(s) shall be located in the Fire Command Center.
  - The A/E shall identify the proposed locations for all of the fire alarm and detection system equipment on the preliminary floor plans to solicit review and approval by the Entity.

2.12.1.3 System Operation

- The operation of any automatic or manual initiation device shall trigger various alarm and control functions. These functions shall be in accordance with the applicable codes and shall be summarized as part of the construction documents. The T**able** has been developed to provide a sample Fire Alarm System Input/output Matrix which identifies the operation of the fire alarm and detection system. This matrix will be unique for each facility and shall be developed and submitted to the Entity for review and approval

TABLE - FIRE ALARM SYSTEM INPUT/OUTPUT MATRIX

Input/ Output	Annunciation			Notification					Required Control									
	Trouble Alert (including visual signal & audible signal	Supervisory Alert (Including Visual Signal and Audible Alarm)	Fire Alarm Alert of Location and Type in Initiation	Activate Strobes and Announce Location of the Alarm on Speakers	Immediately Notify Staff at 24-hour Monitoring Locations	Display / Print Changes of Status	Transmit Condition to the Central Monitoring Station	Transmit all Point Status Information to the Building Management System	Notify the Elevator System of Fire in Respective Lobby, Hoistway, or Machine Room	Close Smoke / Fire Dampers	Send Elevator to Primary Recall Floor	Send Elevator to Alternate Recall Floor	Fire Alarm Shall Activate Atrium Smoke Exhaust Fans	Open Smoke Ventilation Windows and Doors	General Alarm Output Notification to the Building Security System	Release Smoke / Fire Door Hold Opens	Fire Alarm System Shall Interrupt Control Circuit to Shut Down Unit	Signal Access Control System to Required Doors
Manual Pull stations - All Locations			□	□	□	□	□	□							□	□		□
All area smoke and Heat Detectors			□	□	□	□	□	□							□	□		□
Door Release Smoke Detectors			□	□	□	□	□	□							□	□		□
Duct Smoke Detectors and Smoke Dampers		□			□	□	□	□		□								
Duct Smoke Detectors and Smoke Dampers		□			□	□	□	□		□							□	
Atrium Area Smoke & Fire Camera Detectors			□	□	□	□	□						□	□		□		□
F.A. Panel Mounted Manual Test Atrium Smoke Exhaust Fan Switch													□	□				
Elevator Lobby Recall Smoke Detector Activated - Primary Floor			□	□	□	□	□	□	□			□			□	□		□
Elevator Lobby Recall Smoke Detector Activated - All But primary floor			□	□	□	□	□	□	□		□				□	□		□
Sprinkler Control Valve - Tamper - All Locations		□			□	□	□											
Sprinkler Waterflow - All Locations			□	□	□	□	□	□							□	□		□
Atrium Area Sprinkler Waterflow			□	□	□	□	□	□					□	□	□	□		□
Fire Pump Waterflow - All Locations			□	□	□	□	□	□										
Fire Alarm AC Power Failure	□				□	□												
Fire Alarm System Low Battery	□				□	□												
Trouble on Signal Line Circuit	□				□	□												
Trouble on Communications Link	□				□	□												
Trouble on Notification Appliance Circuits	□				□	□												
Trouble on Fireman's Communication Circuits	□				□	□												

- Analysis of Fail-Safe Operation
  - An analysis shall be performed for the fire alarm and detection system as well as other interconnected systems including but not limited to building management system, security system, access control system, lighting control systems, smoke control systems, audio/visual systems, etc. This analysis shall evaluate the operation of each system to establish the operation status and condition for each in the event of fire alarm activation. The results of the analysis and the A/E recommendations shall be submitted to the Entity for review and approval.
  - Relays selection and operation for the interconnected systems shall be coordinated with the emergency power supply so that undesirable operations will not occur upon power transfer. For example, in a power failure, it may be acceptable if doors held open by magnetic devices are released, but it would be totally unacceptable if a deluge system was actuated.

2.12.1.4 Detector Operation Principle

- The three most common detector devices which are generally used include smoke detectors, heat detectors and flame detectors.
- In addition to these three common detection devices, there are several other specialty detection means that may be considered for application in appropriate facilities. These specialty detection means include optical beam detection, very early smoke detection apparatus (VESDA), and video smoke and flame detection.
- Smoke Detectors

  Smoke detectors detect the visible or invisible smoke particles from combustion. The two main types of detectors are Ionization Detectors and Photoelectric Detectors.
  - Ionization Detectors
    - Ionization detectors contain a small radioactive source that is used to charge the air inside a small chamber. The charged air allows a small current to cross through the chamber and complete an electrical circuit.
    - When smoke enters the chamber, it shields the radiation, which stops the current and triggers an alarm.
    - These detectors respond quickly to very small smoke particles (even those invisible to the naked eye) from flaming or very hot fires, but may respond very slowly to the dense smoke associated with smoldering or low-temperature fires.
  - Photoelectric Detectors
    - Photoelectric smoke detectors contain a light source and light sensor which are arranged so that the rays from the light source do not hit the light sensor. When smoke particles enter the light path, some of the light is scattered and redirected onto the sensor, causing the detector to activate an alarm.
    - These detectors react quickly to visible smoke particles from smoldering fires, but are less sensitive to the smaller particles associated with flaming or very hot fires.
- Heat Detectors
  - The most common heat detectors either react to a broad temperature change or a predetermined fixed temperature.
  - Heat detectors use a set of temperature-sensitive resistors called thermistors that decrease in resistance as the temperature raises. One thermistor is sealed and protected from the surrounding temperature while the other is exposed. A sharp increase in temperature reduces the resistance in the exposed thermistor, which allows a large current to activate the detector's alarm.
- Flame Detectors

- Flame detectors are line-of-sight devices that look for specific types of light (infrared, visible, ultraviolet) emitted by flames during combustion. When the detector recognizes this light from a fire, it sends a signal to activate an alarm.
- The optical sensors used in flame detectors works at specific spectral ranges (usually narrow band) to record the incoming radiation at the selected wavelengths. 30% to 40% of the energy radiated from a fire is electromagnetic radiation that can be read at various spectral ranges (such as UV, IR). The signals are then analyzed using a predetermined technique for flickering frequency, threshold energy signal comparison, mathematical correlation between several signals, correlation to memorized spectral analysis, etc.
- Flame detectors are available in a number of sensor types. The most common sensor types include UV detectors, IR detectors, and UV/IR detectors.
- UV only flame detectors (ultraviolet spectral band detection) work with wavelengths shorter than 300 nm (solar blind spectral band). They detect flames at high speed (3 to 4 milliseconds) due to the UV high-energy radiation emitted by fires and explosions at the instant of their ignition. These devices are quite accurate, although they are subject to interference (false alarms) from random UV sources such as lightning, arc welding, radiation, and solar radiation.
- IR only detectors work within the infrared spectral band. The mass of hot gases emits a specific spectral pattern in the infrared spectral region. They are subject to interference (false alarms) by any other “hot” surface in the area.
- UV and IR spectral band detectors compare the threshold signal in two spectral ranges and their ratio to each other to confirm the reliability of the fire signal. This style minimizes false alarms.

- Specialty Detection Means
  - Optical Beam Detection
    - Optical beam detection utilizes a projected beam of light to monitor for obscuration due to the presence of smoke.
    - Types of beam detection include the following:
      - End-to-End type consists of a separate light transmitter and receiver. The transmitter and receiver are located on either end of the protected area. They include open-area smoke imaging detection in which ultraviolet (UV) and infrared (IR) wavelengths of light are used to detect smoke. The comparative differences between the UV and IR wavelengths help to identify real smoke by comparing reflections and seeing the difference in the profile.
      - Reflective type incorporates the transmitter and receiver in the same enclosure. The light path is created by reflecting light off of a specially designed reflector mounted at the opposite end of the protected area.
  - Very Early Smoke Detection Apparatus (VESDA)
    - VESDA consists of a central detection unit which draws air through a network of purpose built aspirating pipes to detect smoke. The air is passed through a laser sampling chamber that detects the presence of smoke particles suspended in air by detecting the light scattered by them in the chamber.
    - The VESDA system is an aspirating detection system that detects at the incipient stage as opposed to the smoke, flame or intense heat stages.
    - Continuous air sampling associated with the VESDA approach can detect smoke before it is visible to the human eye and provides the earliest possible warning of an impending fire hazard.
  - Video Smoke and Flame Detection
    - Video smoke and flame detection utilizes video image detection (VID) technology to detect flame and smoke. This approach consists of video-based analytical algorithms that allow integration between analog cameras and advanced servers to create a complete flame and smoke detection system.
    - Video-based analytical algorithms include:
      - Flaming fires – looks for specific fire pattern consisting of a bright core of the flame and flickering corona.

  - Smoke plumes – identifies the anomalies that are caused by smoke and analyzes the progression over a period of time to identify a growing smoke plume.
  - Ambient smoke – monitors the light diffusion from light sources and bright objects in the video images to detect the pattern consistent with the slow accumulation of smoke.
- This approach utilizes a network video recorders and management software to support multiple detection cameras to:
  - Record video streams
  - Monitor live videos
  - Maintain an event log for all alarm conditions
  - Dispatch alarms and videos to remote locations
- This detection means provides coverage for large areas such as atriums. The system provides enhancements over conventional flame and smoke detection, such as:
  - Quick detection times
  - Ability to conduct immediate and remote verification
  - Avoids cost associated with regular inspection and maintenance of conventional devices which may be difficult to access
  - Ease of installation and configuration
  - Provides convenience for system integrators

2.12.1.5 Detector Selection

- The type of fire alarm detector must be selected to best suit the characteristics of the facility. Each of the detector types have unique capabilities that must be considered when selecting the appropriate device for a specific application. It is common to utilize several different types of detectors throughout a facility to provide the most effective means of protection. The following paragraphs provide a brief overview of the various detector types along with information regarding appropriate applications. The A/E shall assess the specific applications and provide recommendations regarding detector type selections to the Entity for review and approval.
- Smoke Detectors
  - Smoke detectors are usually more sensitive than heat detectors and usually detect the fire sooner during early flame stages and will meet the needs of most areas containing primarily wood, paper, fabric, and plastic materials. During combustion, these materials produce a mixture of smoke types with detectable levels of both large and small smoke particles.
  - Application
    - Photoelectric smoke detectors shall be used in places where smoldering fires may be expected.
    - Ionization type smoke detectors shall be used where flaming fires would be expected.
    - If both types of fires are possible, both features are available in a single detector.
  - Smoke detectors are suitable for:
    - Residential occupancies, computer rooms and other locations having high values
    - Indoor areas with low ceilings such as offices, closets, and restrooms
    - Relatively clean areas with minimal amounts of dust and dirt
  - Smoke detectors are not suitable for:
    - Open air applications as the detectors require ceilings to direct the smoke from the plume by convection
    - Areas where ceiling heights exceed 10.5 m
    - Rooms where cooking will take place, such as, kitchens, or similar areas where steam and condensation are present
    - Areas where exhaust fumes are present such as, car parks, etc.

- Heat Detectors
  - Heat detectors are normally used in dirty environments or where dense smoke is produced. Heat detectors may be less sensitive, but are more appropriate than a smoke detector in these environments.
  - Heat detectors are ideal for areas where flammable gases and liquids are handled or any area where a fire will quickly cause a large change in the surrounding temperature.
  - Heat detectors are also suitable for:
    - Dirty, dusty or smoky environments
    - Manufacturing areas where large quantities of vapors, gases, or fumes may be present
    - Areas where particles of combustion are normally present, such as in kitchens, furnace rooms, utility rooms, and garages or where ovens, burners or vehicle exhaust gases are present
  - Fixed temperature detectors are suitable for the areas like boiler/plant room, kitchen and furnace/kiln rooms.
  - Rate of rise of temperature detectors are suitable for areas such as car parks, loading bays etc.
- Flame Detectors
  - Flame detectors either ultraviolet or infrared offer the fastest response to a freely burning fire and are well suited for protecting areas involving flammable liquid fires.
  - Flame detectors are best for protecting:
    - Areas with high ceilings and open-spaces, such as warehouses and auditoriums
    - Outdoor or semi-enclosed areas, where winds or draughts can prevent smoke from reaching a heat or smoke detector
    - Areas where rapidly developing flaming fires can occur, such as petrochemical production, fuel storage areas, paint shops, and solvent areas
  - Flame detectors are quite expensive and may be subject to false alarms from radiation such as welding, reflected sunlight, electric sparks and halogen lamps.
  - Flame detectors performance is affected by thick smokes, vapors, grease, and oil deposits on the detector windows resulting in blockage of the line of sight.
- Optical Beam Detection
  - Optical beam detectors are used where the application of standard spot type smoke detectors would be uneconomical or restricted due to the height of the protected area. Where high ceilings are present, beam smoke detectors may be more responsive to slow or smoldering fires than a point smoke detector because they are monitoring the entire smoke field intersecting the beam.
  - Optical beam smoke detectors are line-of-sight devices and are subject to interference from any object or person which may enter the beam path. This limitation makes them impractical for occupied spaces with normal ceiling heights.
  - Several typical applications include:
    - High ceiling areas such as atriums, lobbies, gymnasiums, sports arenas, museums and religious sanctuaries
    - Warehouses
    - Manufacturing areas in factories
  - Features to include for beam detection include:
    - Automatic gain control to compensate for the buildup of dust, dirt and other debris that may lower the detection threshold for the detector
    - Motorized detector which automatically aligns itself to compensate to changes over time due to building movement or other situations
    - Remote test stations to facilitate the periodic electronic testing of the detector
- Very Early Smoke Detection Apparatus (VESDA)

- VESDA systems incorporate more than one level of alarm which is configurable and allows very early warning of an event. The detection and alarm sensitivities can be programmed to levels ranging from more sensitive to less sensitive than conventional detectors. The detectors work best in non-volatile environments.
- VESDA systems are suitable for environments where highly sensitive rapid smoke detection capability is required. Typical applications include:
  - Cleanrooms
  - Areas containing goods easily damaged by fire
  - Telecommunications and Electronic Rooms
- VESDA systems are also suitable for spaces with challenging physical characteristics or aesthetic concerns including:
  - Large spaces with high ceilings such as atriums, lobbies, gymnasiums
  - Mechanical equipment spaces where ductwork, piping and other infrastructure make the installation of spot detectors challenging or ineffective
- VESDA systems can be used in dusty or dirty environments as long as appropriate design, installation and maintenance procedures are followed.

- Video Image Detection (VID)
  - VID is ideally suited for environments where spot or other types of detection would not be efficient including large open or high-volume areas such as atria, shopping malls, religious assembly spaces, hotels, office buildings, airports and warehouses.
  - VID provide monitoring personnel with information regarding the location and extent of the fire which ultimately provides guidance for the activation of the appropriate emergency response.
  - The application of VID must consider the environmental conditions such as lighting, background, foreground and contaminants present in the protected areas.

2.12.1.6 Detector Location

- Detectors shall be located and installed in accordance with the applicable SBC, NFPA Codes and Standards.
- Detector spacing shall be in accordance with the manufacturer's and the listing agency's spacing criteria. The nominal spacing of detectors was developed using a smooth ceiling at a predetermined height. Detector spacing shall be adjusted for other than the standard conditions as identified in the NFPA Codes and Standards.
- Consideration may also be given to architectural symmetry, provided that this does not downgrade detector function to an unacceptable level and location.
- To be most effective, both smoke and heat detectors must be located on or near the ceiling of the space to be protected because that is where smoke or hot gases initially collect.
- Smoke and heat detectors shall not be located near operable windows, air supply vents, or other ventilation sources that would interfere with the natural air currents. The detectors shall not be located in dead air spaces nor near any obstruction that would prevent smoke or heat from reaching the detector.
- All detectors shall be located to avoid localized sources of "false" alarms.
- Heat detectors, though slower to respond to a fire than smoke detectors, are not as prone to false alarms. They are thus often installed in storage rooms and service rooms that are normally unoccupied.
- In case of heating and ventilation system, where smoke detectors are used to initiate signals to shut down fans or to close dampers, they shall be installed in the return air ducts of heating, ventilating and air-conditioning systems, to prevent the circulation of smoke-contaminated air.

2.12.1.7 Fire Alarm Control Panel

- Control panels shall be designed to meet the unique requirements of each building and occupancy.
- Zoning
  - The building area may be divided into zones by floors or as required to allow for accurate and rapid determination of the fire location and the type of systems being activated.
  - Zone configuration shall consider fire zones, means of egress and areas of risk. Maximum area per zone shall not exceed 2000 m².
  - The length of any zone shall not exceed 91 m in any direction.
  - Buildings of 300 m² or less may be considered as a single zone.
- Control panels shall have spare zone capacity. Panels shall have a minimum of two zones, even though the building may be a single alarm zone.
- The control panels shall be a multi-processor based networked system designed specifically for fire and smoke control. The control panels shall include all required hardware, software, and site-specific system programming to provide a complete and operational system.
- The control panel shall be diagnostic type and shall be designed such that interactions between any applications can be configured and modified using software provided by a single supplier.
- When the panel is used with addressable detectors, the panel shall be capable of providing a signal which shall indicate Fire/Fault zone along with the detector which has operated by means of a digital Liquid Crystal Diode (LCD) display.

2.12.1.8 Fire Alarm Annunciators

The requirement for fire alarm annunciation panel depends upon the size and complexity of the system.

- In small buildings, with a single fire department response point, a graphic annunciator panel is unnecessary. The Main Fire Alarm Control Panel can be strategically located to function as the annunciator at the fire department response point.
- For moderate sized buildings, a remote fire alarm annunciator panel shall be provided and shall consist of an alphanumeric screen which has the capability to identify the alarm condition by type and location.
- For large and complicated facilities, a custom, graphic fire alarm annunciator shall be provided to assist the facilities personnel and the fire department responders to quickly determine the cause and location of the fire alarm condition. The graphic annunciator panel shall be provided with the following features:
  - The panel shall show all floor plans of the building and light the floor plan (or part of the plan if so zoned) when that area is in alarm.
  - The annunciator panel shall be graphic type and shall have an audible alarm and provide visual indication of the zone of the building in which the alarm initiating detector is located.
  - The annunciator panel shall be of modular construction, flush mounted with the required number of LEDs for use on 24 V DC. Each LED shall indicate one building zone.
  - The annunciator panel shall have a visible and an audible trouble indicator with silencing switch. The annunciator LEDs shall be electronically supervised. Removal of LED or LED failure shall sound the system trouble signal. LEDs shall be bright enough to be visible in direct sunlight if the annunciator is so located.
  - Graphic annunciator panel shall have capability to bypass audible fire and trouble alarms. These alarms shall be bypassed if Annunciator Panel is located next to Main Fire Alarm Control Panel.

2.12.1.9 Notification Appliances

- The fire alarm and detection system shall be designed with sufficient notification devices to provide ample notification for the building occupants. Notification shall include both audible and visual devices spaced in accordance with all applicable codes.
- Audible
  - Audible devices such as horns, bells and/or speakers, shall be located throughout each facility as required by code to provide audible notification of the fire alarm condition. Audible devices shall be specified with multiple tap settings to facilitate adjustment of the sound intensity to adapt to the final installed conditions.
  - The type of audible device shall be determined from the requirements of the facility. The A/E shall develop a recommendation for the type of audible device and submit to the Entity for review and approval.
  - Audible devices located outdoors shall be specified with a weather-proof enclosure.
- Visual
  - Strobes shall be located throughout each facility as required by code to provide visual notification of the fire alarm condition. Strobes shall be specified with multiple candela ratings to facilitate adjustment of the light intensity to adapt to the final installed conditions.
  - Flashing beacons shall be utilized in place of strobes where insufficient coverage is available from a strobe.
  - Flashing beacons may also be used to supplement the fire alarm strobes where deemed necessary due to the final application.
  - Visual devices located outdoors shall be specified with a weather-proof enclosure.
- Audible/Visual Combination Devices

  The use of combination audible/visual devices is permitted and is the preferred approach.

2.12.1.10 Signal Modules or Interface Modules

These devices are addressable and allow interface with the various types of non-addressable initiating devices such as sprinkler flow switches, sprinkler tamper switches, industrial grade flame detectors, pre-action sprinkler, Zone control valves, fire pumps, clean agent system, etc.

2.12.1.11 Control Modules

These devices are addressable and facilitate integration of control functions between the fire alarm system and other building systems. Several examples include; air handling unit shutdown, release of door hold open devices, opening of automatic doors and gates, Elevators, medical gas, staircase pressurization panel, MCC/AHU's or mechanical system and initiation of fire suppression systems.

2.12.1.12 Power Source(s)

- Power to the control panel must be fed from a reliable source of supply which will not be disconnected for maintenance on other electrical systems. The circuit breaker shall be labeled "Fire Alarm - Do Not Switch Off" and shall be capable of being locked.
- Standby power shall be available to the system in case of failure of the main power source. Integral backup provision with nickel cadmium batteries shall be located in the control panel. The backup batteries shall be sufficient to operate the fire alarm system for a minimum of 24 hours.

- Where the building is furnished with a backup power source such as generator, battery, or UPS the fire alarm and detection system shall be supplied from the life safety emergency power branch in addition to the integral batteries.
- Power supplies for the fire alarm and detection system shall initially be sized with 20% spare capacity to accommodate future system modifications.

2.12.1.13 Wiring Requirements

- General
  - The wiring network for the fire alarm and detection system must be designed in accordance with the applicable codes and must address the criticality of the facility. The extent of redundancy and survivability must be determined to properly specify the appropriate wiring system. The paragraphs below provide an overview of the characteristics for the wiring systems commonly used for fire alarm systems.
  - The A/E shall complete an assessment of the facility and develop the class and survivability recommendations for the fire alarm system wiring including but not limited to the following:
    - Initiating device circuits (IDC)
    - Signaling line circuits (SLC)
    - Notification appliance circuits (NAC)
  - These recommendations shall be submitted to the Entity for review and approval.
- Circuit and Pathway Characteristics
  - Class
    - Class A: Includes a redundant path and its operational capability will continue past a single open. Any conditions that affect the intended operation of the path will be annunciated.
    - Class B: Pathway does not include a redundant path and its operational capability stops at a single open. Any conditions that affect the intended operation of the path will be annunciated.
    - Class C: Includes one or more pathways where end-to-end communications verifies operation integrity. The integrity of individual paths is not monitored, and loss of end-to-end communications is annunciated.
    - Class D: Includes pathways that have a fail-safe operation that performs the intended function when the connection is lost. The pathways do not have supervision of their integrity. An example for Class D is the wiring that provides power to the door holders. Interruption of the power results in the door closing.
    - Class E: Includes pathways that do not require monitoring for integrity or electrical supervision.
    - Class X: Includes a redundant path and its operational capability will continue past a single open or short circuit. Any conditions that affect the intended operation of the path will be annunciated.
  - Levels of Survivability
    - Level 0: Pathways have no required level of survivability.
    - Level 1: Include those pathways installed in buildings which are fully protected by automatic fire protection systems. Any interconnecting conductors, cables or other physical pathways are installed in metal raceways.
    - Level 2: This level consists of one or more of the following:
      - 2-hour, fire-rated circuit integrity (CI) cable
      - 2-hour, fire-rated cable systems [electrical circuit protective system(s)]
      - 2-hour, fire-rated enclosure or protected area
      - 2-hour performance alternatives approved by the authority having jurisdiction
    - Level 3: This is identical to Level 2 except the pathways are installed in buildings which are fully protected by automatic fire protection systems.

- Installation
  - The fire alarm and detection cabling shall be installed in a dedicated raceway system. Under no circumstances shall cables other than fire alarm cables be installed in fire alarm raceways.
  - Minimum size of wire shall be 1.5 mm² stranded copper.
  - Minimum conduit sizes shall be 20 mm.
  - All wiring shall enter panels from the bottom to prevent moisture from entering the panel through the conduit.
  - All wires shall be numbered and labeled.
  - Provide separate circuits for audible and visual devices.

2.12.1.14 Fire Alarm System Overall Integration

- Fire Alarm Network within the Camp / Compound
  - The primary manned response center for the fire alarm shall be central control room within the camp / compound. Centralized reporting of the Fire Alarm shall be via fire alarm network and shall be available at the Central Control room where a dedicated Fire Alarm Workstation with Large Screen HMI / Mimic Panel shall be provided.
  - The secondary manned response center for the fire alarm shall be available at guard house. Repeat mimic panels are used to supervise the entire camps/ compound and shall be installed in all guard houses.
  - The Fire Alarm network shall be a networked system compliant with NFPA 72, style 7, (Class A) supervised communications network requirements. It shall be made up of nodes which consist of interfaces to intelligent Local Fire Alarm Control Panels (FACP) located in all buildings within the camp / compound.
  - Data transfer between locations shall use Highways conforming to NFPA 72, Style 7 wired, (Class A) communications with full network communications supervision and reporting
  - All individual fire alarm will be generated from FACP and shall be graphically displayed at the centralized Fire Alarm Workstation.
  - The FACP shall also be integrated with BAS. Common Fire Alarm and Common Fault Alarm shall be available at BAS for alarm and reporting.
- Confirmed fire alarm in each building shall give following actions:
  - A visual alarm (red LED) on the FACP display panel in the building
  - A general audible alarm in the building
  - An audible and visual alarm at Fire Alarm Workstation in central control room and Mimic panel at guard house
  - General audible and visual alarm in BAS
  - Auto telephone dial with associated Fire Station
  - Interface with HVAC control panel to auto shutdown HVAC and ventilation system. FACP will provide shutdown signal to respective HVAC DDC control panel, but the shutdown logic shall be via DDC control panel relay logic to directly stop the HVAC package, and shall not use the DDC software logic. FACP common shutdown signal will be monitored by BAS, and shall have alarm lamp on HVAC DDC Controller panel.
  - Auto shutdown Fire Dampers
  - Interface with elevator to lock the elevator to safety location. (option)
  - Interface and monitoring auto sprinkler system - Each sprinkler system shall at minimum provide following signals to FACP
    - Tamper Switch for each Zone Area
    - Flow Switch for each Zone Area
    - Sprinkler Pressure SW

- Interface and monitoring clean Agent system. Each clean agent system shall at minimum provide following signals to FACP:
  - Clean Agent Common Alarm
  - Clean Agent Common Fault
  - Clean Agent Confirmed Discharge Alarm

2.12.1.15 Fire and Life Safety Integration

Refer to Document Number - EPM-KE0-GL-000008: Fire and Life Safety Integration Guideline

2.13 Documentation

2.13.1 General

The objective of Subsection is to provide the basic requirements for documentation associated with Instrumentation and Control systems.

2.13.2 Required Instrumentation Documents

2.13.2.1 Following is a complete list of instrumentation documents which are to be prepared, as required, in the design stage of any plant. This list shall be used for the preparation of the “J” section in the drawing control.

- Process Flow Diagram (PFD) - Only one circle symbol shall be used for each control loop, regardless of how many items of equipment eventually are required for the complete control loop.
- Piping and Instrument Diagram (P&ID) - shall be prepared in accordance with Standard Detail Drawing to cover symbols and abbreviations. All instruments and accessory items as well as interconnecting pneumatic and electrical lines shall be shown in accordance with Standard Detail Drawing.
- Control System Design Specifications / Guideless - List of design guidelines / specifications for instrumentation and control system design requirements, installation requirements, standards, quality insurance, assembly stage area, testing procedure, shipment, storage, site support, start up and commissioning, guarantee, etc.
- Instrument installation Schedules - used as the primary instrument index and material control sheet. Each instrument shall be listed and all instruments having the same numerical loop identifier shall be grouped together.
- I/O List
  - I/O List is a document containing a list of instrumentation which serves as an input or output of a control system. Therefore, only the tag number that physically has a cable which connects to the control system appears on I/O List.
  - When there is more than one control system in a plant (e.g. PCS and BAS, FGS, CMS), the I/O list shall clearly indicate which instrument is assigned to which control system or may separate them into different sections of the document.
  - In I/O lists, the following information should be stated as a minimum but not limited to:
    - Tag Number
    - Service Description
    - P&ID Number
    - Type of Instrument
    - Location
    - I/O Type
    - Control System
    - Signal Level
    - Power Supply Requirement

- Calibration Range
- Alarm Set Points

- Instrument Specification Sheets (ISS) or Data Sheets - Each instrument item is to be detailed on a suitable ISS.

  Commentary Note: Packaged unit instruments shall also be specified on standard ISSs.

- Instrument Calculation Sheets and Details. - These are designed to be used as work sheets for the calculations of Pitot tube meters, orifice plates, venture meters, control valves and relief valves. They also serve as a record of the conditions on which the calculation was based.

  Commentary Note: Calculation sheet(s) generated from workstation or vendor software packages are acceptable.

- Control System Architecture Drawing
  - Control system architecture depicts the architecture of the plant control systems and the interfaces amongst the systems required for overall operation of process plant.
  - The required Control System is determined by the level of functionality, complexity and safety of a plant. This may comprise of process control system, safety instrumented system, building automation system, fire alarm system, fire suppression system, SACDA control system.
  - Control system architecture drawings shall also show supervisory level equipment such as operator workstation, engineering workstation, large screen display, Instrument asset management server, historian server, cyber security server, control panel type, interface with other third party systems, fire and gas system and also network equipment.
  - Control system architecture shall clearly define the locations, i.e. main locations, remote I/O locations, indoor/outdoor location, control room/building limit.
  - The major control, Ethernet and communication cables are to be shown and specified.
  - The control system architecture is conceptual in nature and is used for specifying the requirements of the control system to the PCS/SCADA Supplier. This drawing is provided as supporting documentation for the process control system requisition.

- Layout Drawings
  - Control room layout drawings shall show in the plan view, the location of consoles, panels, control racks, computer racks and peripherals, logic racks, termination racks and boxes.
  - Remote building (Process Interface Buildings, Analyzer House, etc.) layout drawings shall show the position of each item of major equipment.
  - Layout of Control Room Console, Panel, Cabinets, and/or Local Panel - Normally these drawings serve only as a guide for the vendor. Therefore, neither construction details nor exact dimensions are required on these drawings. Only the overall dimensions, location of instrument items, shape, graphic layout and general layout are required.

    Commentary Note: In instances where the Local Panel is to be field fabricated, and the instruments to be field mounted, complete lay-out and construction details are required.

  - Front of Control Room Console, Panel and/or Local Panel - Besides the basic information, the layout of the panel board front shall also indicate the cut-out dimensions and mounting details for all instrument items.
  - Back of Control Room Console, Panel and/or Local Panel - In addition to the basic information, the layout of the panel board back shall indicate:
    - Exact location where signal cabling, data highway cabling, and electrical power wiring enters the console or panel board. Instrument air supply and pneumatic tubing must also be shown as applicable to each installation.
    - Panel illumination.
    - Location and designation number of terminal strips or electrical junction boxes.
    - Main air supply header, if required.
    - Schematic layout of pneumatic tubing runs, when applicable.

- Front and Back of Cabinet/Rack Layout - As a minimum shall show dimensions, equipment location, wiring raceway, cable entries and terminal strips.
- The Vendor's final drawings shall be used for record purposes. Drawings which are likely to be changed later, as front of console or panel board, back of console or panel board and terminal layout drawings.

- Cable Block Diagram

  A cable block diagram typically shows all the control equipment and panels and the interconnection between them. Cable number and the number of cores or pairs of cores are usually all that is needed to be shown.

- Cable Schedule

  The cable schedule is developed from the cable block diagram, and will show cable length, core size, construction and type of power/signal as well as the cable number and number of cores/pairs. It will also show if the cable is to be provided by the installer, or whether the cable is supplied by an equipment vendor as well.

- Instrument Interconnection Wiring Diagrams
  - Instrument Interconnection Wiring Diagrams shall be prepared for each of the following enclosures:
    - Field junction box's and field control panels.
    - Marshalling cabinets.
    - All instrument console/panels, cabinet/racks, junction boxes, located in substations, equipment rooms, server rooms, control rooms, etc.
  - The purpose of this drawing is to show the individual wiring between devices (e.g., terminal blocks, indicating lights, switches, I/O modules), and to identify cable numbers, wire tagging, terminal identification, fuse sizes, etc. All spare termination points are to be shown on this drawing.

- Instrument Loop Drawing
  - Instrument Loop diagram is a detailed drawing showing a connection from one point to a control system. It is an important engineering deliverable to be used for checking of a correct installation and connection when testing during pre-commissioning, commissioning and also for trouble shooting during operation.
  - Instrument Loop Drawing shall include connection between:
    - Field instrument to control system (or vice versa)
    - Signal from Local Control Panel to control system (or vice versa)
    - Signal from MCC to control system (or vice versa)
    - Signal form one control system to another system
    - FF Segment allocation to Control System
  - Loop diagram shows instrument (in a symbol) and its terminal numbers which are to be connected, instrument cable number, junction box number, terminal number assigned for the specified instrument, multi-pair cable and pair number, marshaling cabinet number, terminal number in marshaling cabinet, control system details (rack, slot, I/O channel). It also clearly indicates location of each equipment by means of a border line as a limit.
  - Loop Diagram usually shows a single control loop which means it could only contains just one input (sensor to control system), just one output (control system to final element) or combination of both
  - The following is a list of data required along with its source/reference:
    - Instrument Terminal number. Most instrument could be assumed to use (+) and (-). Terminals. Instrument which needs special arrangement such as smoke detector or instrument which in series loop, requires manufacturer connection detail to make the cable is properly connected.
    - Junction box terminal number, this information could be obtained from JB wiring connection

- Marshaling terminal number, this information could be obtained from marshaling wiring connection.
- I/O point detail information. Obtain this information from I/O assignment which is produced by system integrator or control system vendor.

- Control System Sequence of Operation, Control Narrative, C&E or Logic Narrative

  The control narrative, sequence of operation, C&E or Logic Narrative are critical components of design deliverables as they interpret the design intension of control and interlock functional requirements, and provide all information for the system integration supplier to configure the control system.

- List of Nameplates for Instruments - List of Nameplates for Instruments - Separate drawings shall be prepared to cover nameplates required for instruments as follows:
  - Control room panel mounted instruments
  - Rack mounted instruments
  - Local panel mounted instruments
  - Local mounted instruments
  - Annunciator
- Instruments mounted in Control Room Console, Panel, Rack or Local Panel - Panel mounted instruments shall be provided with two nameplates, one on the front and one on the back; rack mounted instruments shall have front mounted nameplates only. The front nameplate shall show service description and tag (mark) number including plant and instrument number. In case of multipoint instruments, this information shall be shown for each point.
- Instrument Piping Details.
- Instrument Mounting Details.
- Field calibration sketches and reports.

2.13.2.2 The following is a list of Instrumentation documents that are to be prepared by the system integration Supplier, in the design / procurement / Construction stage of any plant.

- Specification Compliance Comparison Sheet.
- Non-Compliance Registration.
- Scope of work
- Bill of Quantities

  Panel Equipment Schedule (Bill of Quantities) - This schedule shall be prepared to inform the panel vendor about the types, sources, installation, etc., of the instruments and other miscellaneous equipment that is shown on the different panel drawings.

- Product Catalogues, Selection Details
- Product Operation and Installation Manuals
- Product Certificate
- PCS Functional Design Specification
- SCADA System Functional Specification
- BAS System Functional Specification
- IAMS Functional Design Specification
- Control Panel Layout Drawing
- Control Panel Wiring Diagram
- Control Panel Termination Drawing
- System Architecture Drawing

- Overall System Network Schematic
- I/O Allocation Details
- Factory Acceptance Test Procedure

3.0 COMMISSIONING

3.1.1 References

Refer to Document Number EPM-KT0-GL-000003: Testing & Commissioning Guidelines.

4.0 INTEGRATION OF ELECTRO – MECHANICAL SYSTEM

4.1.1 References

For the integration of the Electromechanical system follow the below documents as guidance

1. EPM-KE0-GL-000007 : ELV System Integration Guidelines
2. EPM-KE0-GL-000008 : Fire and Life Safety Integration Guideline
3. EPM-KE0-GL-000009 : Building Management System (BMS) and Mechanical System integration Guideline