KAHRAMAA كهرماء

المؤسسة العامة القطرية للكهرباء والماء
Qatar General Electricity & Water Corporation

<u>CONTRACT No GTC 626/2014A</u>

CONSTRUCTION OF MEGA RESERVOIR PRPSs (PACKAGE A - UMM BIRKA)

CONTRACT DOCUMENTS (VOLUME 6 OF 19)

CONSOLIDATED CONTRACTORS GROUP S.A.L. (OFFSHORE) (CCC) & TEYSEER CONTRACTING COMPANY W.L.L. JOINT VENTURE

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8 PLANTWIDE SCADA AUTOMATION

8.1 GENERAL SPECIFICATION OVERVIEW

This project is for the provisioning of an IP based 'PLANTWIDE SCADA AUTOMATION' solution for KAHRAMAA MEGA RESERVOIR PRPS and Main Pumping Station. KAHRAMAA requires the incorporation of a SCADA Control system for this Facility. The CONTRACTOR shall treat this part of the Scope of Work as a Procurement, Installation and Construct assignment and shall adhere to the following:

I. Include all the necessary provisions to complete the functional SCADA Control System incorporating the latest technologies and software versions available at the time of installation.

II. In collaboration with one of the proposed sub-CONTRACTORs or any other internationally recognized and credible sub-CONTRACTOR in this field, develop a complete system and submit for KAHRAMAA approval.

III. This specification shall be read in conjunction with the latest edition of Qatar Construction Specifications, all the relevant project drawings and the project particular specifications. In case of contradiction or discrepancy between QCS and the project specifications, the CONTRACTOR shall incorporate whichever is more stringent. Where a question remains on which requirement is the more stringent, CONTRACTOR shall submit the issue to KAHRAMAA representative in writing. The decision of KAHRAMAA representative shall be considered to be final.

8.1.1 Purpose of Specification

The purpose of this Automation Specification is to describe in detail the requirements and selection for provisioning an IP based SMART SCADA solution for KAHRAMAA MEGA RESERVOIR and Main Pumping Station. This specification only covers the Automation in terms of hardware, automation architecture, networking architecture and software and application architecture.

For Programming, Control Strategy and Instrumentation Specifications refer to the MEICA specifications.

The specification is to be read in conjunction with QCS standards for Instrumentation, Control and Automation. The control system is to meet the objectives of KAHRAMAA for lowering carbon emissions and reducing energy, which is to be achieved by optimizing individual systems efficiencies and link them together to share data across a single networking platform.

The proposal calls for the integration of the systems commonly found in KAHRAMAA medium to large pumping stations. This integration will comprise:

I. Building Automation Systems

II. Electrical Energy Management Systems , Low Voltage and High Voltage Power

III. CCTV and Physical Security Intruder Systems

IV. Fire Alarms and Detection Systems

V. Process Plant and associated equipment i.e. pumps, chlorination plant, scrubbers, air blowers etc.

It is a KAHRAMAA requirement that all systems associated with either the pumping stations shall be visualized at Operations and Management level as part of the unified SCADA HMI environment.

8.1.2 Plant Wide Diagram Overview

The following diagrams show the proposed converged Architecture.

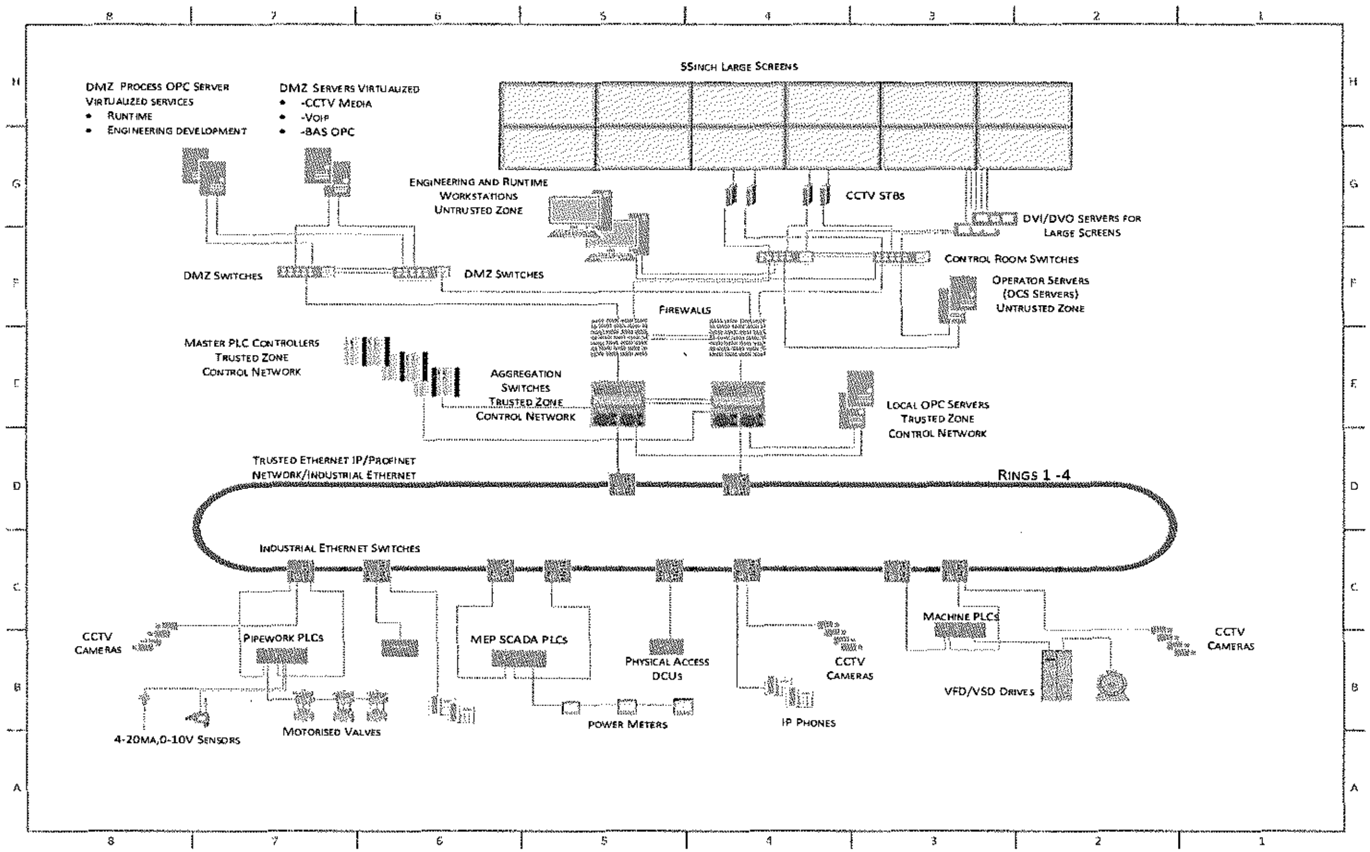


Figure 1 Converged Network Diagram Overview

8.1.3 Technical Synopsis of Functional Requirements

This project calls for a PLANTWIDE machine to machine communications between various automation components comprising pipework PLCs and vendor PLCs commonly referred to as a Distributed Control System (DCS). The functionality of the plant will be that the entire plant can be divided into autonomously operating subsystems. The design and the functions will be identical or in some cases slightly modified form in several systems. Each subsystem is controlled by a number of input signals. Within each autonomous operating subsystem a control program is required to execute the function and pass the corresponding output signals to another controller.

The engineering that is associated with this passing of data is required to be manufacturer-neutral.

The solution to meet these requirements will be either EthernetIP (CIP over Ethernet) or Profinet I Device. This protocol will be configured on all the PLC nodes. Using this protocol there will be no requirement for additional programming of the PLCs so that they can communicate with each other, instead the devices shall be capable of establishing communications using a graphical interface program. The communication protocol will be required to achieve a machine to machine round trip delay not exceeding 100ms, which meets the requirements of this project.

8.1.4 Scope of works

The contractor shall carry out the following tasks as depicted on the drawings and described in this specification which includes the following.

a. Supply, Installation and commissioning of Fiber Optical cabling as depicted on the drawings- excluding ducting and road crossings

b. Supply, installation and commissioning of patch panels and racks as depicted on the drawings – excluding power to the racks

c. Supply, installation of UPS and Power Distribution Modules within each rack as depicted on the drawings

d. Supply, installation and commissioning of CAT 6A cabling to all field devices inclusive of Pipework PLCs and Vendor Supplied PLCs as depicted on the drawings- excluded is all wiring systems to these locations

e. Supply, installation and commissioning of CAT 6A cabling to all field devices comprising HVAC Controllers, CCTV surveillance Cameras, Power Meters, Electrical relays etc as depicted on the drawings- excluded is wiring systems

f. Supply, installation and commissioning of Networking equipment included switches, service modules as depicted on the drawings

g. Supply, installation and commissioning of all Pipework PLCs as depicted on the drawings including all wiring inclusive of Profibus DP and PA wiring, and 0-10v and 4-20mA wiring as depicted in the PLC Diagrams- excluded is wiring systems

h. Supply, Installation and commissioning of all Computer workstations, Software, Servers, Server Software, Licenses etc. as described in this specification and depicted on the drawings

i. End to End configuration of all systems and their process visualization as described in the specification or depicted on the drawings

8.1.5 Tasks

The P&IDs show that the project is a mixture of Vendor Supplied PLCs and Pipework PLCs. For the VENDOR Supplied PLCs the Vendor will be responsible for the signals and cabling back to their PLC and the Programming of their PLC.

For the Pipework PLCs the CONTRACTOR will be responsible for all Pipework Sensors and the Programming of those PLCs. The entire System is controlled by Master PLCs which will communicate with both Pipework PLCs and Vendor PLCs. The CONTRACTOR is responsible for the Master PLCs. The CONTRACTOR will be responsible for Communications between All PLCs. He will achieve this by building the Fiber Optical Network (Comprising of four 1Gbps Rings).

8.1.6 Implementation

In order to successfully carry out the entire conversion measure and to cover the implementation of the individual subprojects according to the schedule, it is recommended that a project coordinator shall be appointed as a link between the sub-assembly sections and the various vendors.

When implementing the individual phases of construction, it must be observed that the individual assembly sections strictly adhere to the overall construction time schedule so that the respective company carrying it out has cleared access to the site.

The manufacturer of the key components of the SCADA/DCS and Automation System for the Pump Station and pipeline control shall be directly responsible for the Design, Supply, Factory Testing, Site Testing and Commissioning of the above systems, including the hardware and project specific engineering and software development and all related integration activities and agents, partners or system integrators shall not be eligible / preferred.

Transit and escape routes must always be kept clear of obstructions. Material storage areas must be coordinated with the site's top management. The same applies to setting up material and construction containers. The use of water, gas, electricity is generally at the expense of the CONTRACTOR and can, if applicable, be provided by the customer after coordination with site management.

As for the materials used, it must be ensured that only tested materials are used. Furthermore, for automation and process control technology, it must be ensured that the product diversity is kept to a minimum in order to later have the least amount of replacement parts in stock as possible. The same applies to the machinery (drives, pumps, etc.).

To ensure operation even during any phase of the project, makeshift solutions must be considered. If these are not explicitly requested in the specifications, the bidder is obligated to point them out in his bid and to specify them with regard to price. If this is not done, later remuneration is ruled out.

For process control technology, The CONTRACTOR must ensure that an integrated control system is used due to the size of the system.

8.1.7 Standards

The following standards apply to this project and are to be followed:

a. Equipment supplied to this specification shall comply with the latest edition of the references listed below, unless otherwise noted.
b. International Electro technical Commission (IEC)
c. IEC 60751 (2008-07) Industrial platinum resistance thermometer sensors
d. IEC 61000-4-2 (2008-12) Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test.
e. IEC 61000-4-3 (2008-04) Electromagnetic compatibility (EMC) - Part 4-3
f. IEC 61000-4-4 2010-01) Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Electrical fast transient/burst immunity test.
g. IEC 61158 (200712) Fieldbus for industrial control systems - Part 2: Physical Layer specification and service definition.
h. IEC 61131-3 (2003-01) Programmable controllers - Part 3: Programming languages
i. IEC 61508: Functional Safety, Safety Related Systems
j. National Fire Protection Association
k. NFPA 70
l. Underwriters Laboratories
m. UL Certificate
n. Canadian Standards Association
o. CSA Certificate
p. ISO-9001
q. The supplier's quality management system fulfills all the specifications of the ISO 9001 standard.
r. GMA-NAMUR
s. The system fulfills the requirements specified by the GMA-NAMUR committee on validation.
t. NA= NAMUR Worksheet
u. NE= NAMUR Recommendation
v. CENELEC / ATEX
w. Guideline 94/9/EG for Explosion Protection
x. NEC (National Electrical Code) Standard 500
y. ISA/ANSI
z. S88.01 – Batch Control Part 1: Models and Terminology
aa. DIN 40 050 / IEC 529 / VDE 0470/ EN 60529
bb. Defines Degrees of Protection
cc. <u>ITU-T K.27, Bonding configurations and earthing inside a telecommunications building.</u>
dd. <u>GR-1089-CORE, Electromagnetic compatibility and electrical safety—generic criteria for network telecommunications equipment.</u>
ee. <u>IEC 60950, Information technology equipment safety</u>

8.1.8 For All Applications

Hardware and software must be for the most part scalable to fulfill the wide-ranging requirements towards a modular and economic expansion of the plant.

I. The system should provide client-server architecture.

II. The system must provide common hardware and development tools for various solutions.

III. The system must be designed for DCS, safety and PLC applications. It must be capable of fulfilling high-speed requirements.

IV. The system must offer integrated fail-safe features in runtime and engineering.

V. The system must support field bus devices from any manufacturer without additional certification.

VI. The vendor system must contain a high-performance display and operator component (DOC) which is owned, developed, manufactured and tested by the vendor.

VII. The controllers of the system must enable fan less operation.

8.1.9 DCS, PLC, Batch and Safety System Combination

The process automation system has been designed to include features traditionally associated with both a programmable logic controller (such as programming in ladder logic, and remote I/O architectures) and a distributed control system (such as continuous and complex control, advanced operator interfaces, sophisticated redundancy).

The successful vendor for the automation must ensure that these capabilities must seamlessly reside in one control system without the use of special gateways or interfaces. In addition, the system shall provide seamless integration of continuous and safety protection control, including common software tools.

8.1.10 Horizontal Integration

The vendor selection is required to provide integration of process control tasks and upstream and downstream discrete control tasks such as raw material handling and has to support the economical plant-wide integration of all operations in any process environment.

8.1.11 Vertical Integration

The vendor shall support vertical integration by utilizing uniform data communication structures to support complete integration from the ERP, MES, control and field levels. The system has to provide adequate interfaces, which enable a functional patency from the MES up to the ERP.

8.1.12 Open System

The vendor selection shall achieve an open system composed of standards-based technology including PC platforms with a Windows operating system, Ethernet communications, TCP/IP, OPC for interconnectivity of multiple systems from different suppliers, field mountable control system, remote IO subsystem, and Industrial Ethernet communication using either CIP over Ethernet commonly referred to as Ethernet IP, Profinet I/O , field devices over PROFIBUS-DP/PA, Foundation Fieldbus H1, HART, AS-I, and Modbus networks.

The system software is resistant to third-party programs. It must be possible to install all system components. The use of virus scanners must be possible.

8.1.13 Decentralized Architecture

The vendor selection shall be based on a decentralized client/server architecture allowing extensive scalability. The system shall be expandable and support at least 10 engineering workstations, 32 operator displays – where each station has access to the entire plant, at least twelve redundant servers, and 50,000 process objects.

8.1.14 Redundancy

The vendor selection shall offer redundancy at all levels to provide a high-level of fault tolerance. Operator stations, servers (including Batch), Historian, the terminal and system buses, controllers, field networks, and I/O modules or channels shall be capable of being made redundant as required.

8.1.15 Fail-safe Controllers

Optional fail-safe control operation shall be available using standard controller hardware and special fail-safe I/O modules, using simplex and/or redundant configurations. Programming of fail-safe applications shall use the same engineering environment as configuration of process applications.

The system shall support modules with high degrees of protection (for example, IP6x).

8.1.16 Licensing

Software licenses for engineering workstations and for operator interface consoles shall be independent of the type and mixture of I/O used (analog vs. discrete, input vs. output).

The software licenses (both runtime and engineering) shall be portable allowing the user to transfer licenses from one PC to another without requiring intervention from the vendor.

8.1.17 Written Explanation of Licensing Practices

To help minimize risk associated with changes in project scope, if software is licensed on a tag-by-tag basis the vendor shall supply in writing details on how the required software license would change under the following circumstances:

I. If the total number of system I/O was increased

II. Modifications to the set-up of I/O modules (e.g. converting 20% of the discrete inputs into analog inputs. This only applies when the vendor cannot fulfill the demands mentioned above. It in no way implies dilution of the requirements described there in)

III. If the user would like to pass real-time variables from his system to a 3rd party OPC Client

8.1.18 License Model

The vendor must offer a clearly delineated licensing model.

The vendor must offer a licensing procedure that is based on the number of process objects (PO) for operator stations (OS) and controller in the application.

The engineering system must control and count the POs.

8.1.19 Use of Standard Products

The system shall be composed of manufacturer's standard hardware, systems software, and firmware that can be configured to meet the stated requirements. The vendor's standard system operating software shall not be modified to meet any of the user's requirements.

Application software shall be designed in a manner that requires no modification to the system operating software.

Software design shall be such that future revisions or updates of the system operating software will not affect the successful operation of the system.

The vendor must offer the same platform for safety and non-safety applications.

8.1.20 Indoor Installations

Equipment installed in air-conditioned buildings shall be designed to operate in the following environmental conditions:

I.	Minimum temperature range:	0 degrees C to 50 degrees C.
II.	Relative humidity:	5% to 95% RH.

8.1.21 Outdoor Environment

It shall be possible to install the I/O system in outdoor enclosures in Class 1 Div 2 (Groups A, B, C, and D) and CENELEC/ATEX Zone 2 hazardous environments.

8.1.22 Storage Environment

It shall be possible to store the equipment before installation for up to 6 months in an air-conditioned building under the following conditions:

I. The equipment shall be packed in a moisture proof container

II. Storage temperature: -40 to 70 degrees C
III. Relative humidity (outside the moisture proof container): 5% to 95%.

8.1.23 Basic System Requirements and Properties

The software-based archiving and logging are to meet the industry-compliant requirements (e.g., in accordance with DWA/GFA H260, ATV M260, ATV A128, Hirthhammer Log, TA Waste, TA Air) with regard to time- and event-dependent process data (measurement values, counter values, laboratory values/manually input values, calculated values, faults and messages).

The software is to offer TCP/IP-based client/server architecture. For very small applications, it is necessary that all software modules (data acquisition, data server, analysis modules) also run on a standard PC. The database is to be designed maintenance-free. The data server stores the process data from the various data sources and continuously compresses it into interval, daily, weekly, monthly and yearly data using different algorithms. The database server continuously calculates the configured operands and also compresses them into interval, daily, weekly, monthly and yearly data. It runs cyclically in the background so that the clients can be supplied immediately with current data. The database server can be set up redundantly.

The software is multi-client-capable and the data storage is document-quality throughout.

The software is to be completely provided with context-sensitive help. All functions are accessible via the menu bar or by clicking the right mouse button.

8.1.24 Data Types

The following basic data types are to be directly supported:

I. 32-bit integer
II. 16-bit integer
III. 1-bit integer
IV. Floating-point with 14 significant digits
V. Floating-point with 7 significant digits
VI. Alphanumeric with 64 characters
VII. Alphanumeric with 16 characters

8.1.25 Measurement Value and Counter Value Processing

The acquisition occurs cyclically (≥1 s) or by delta-event method. In three value ranges, a delta value can be independently defined, at which a recording takes place. A validity range can be defined for each value.

The data is to be compressed into interval values, with at least two adjustable intervals (1, 5, 10, 15, 30 min; 1, 2, 4, 8, 12, 24 h) as daily, weekly (1 or 2 weeks), monthly and yearly values.

For the compression into an interval value, the following functions should be selectable:

I. Difference to the previous value
II. Counter difference with and without overflow
III. Consumption from container capacity or scale
IV. Operating hours from status bits
V. Integral
VI. Weighted sum

For the other compression levels, the following functions should be selectable:

a. Arithmetic average value
b. Logarithmic average value
c. Weighted average value
d. Last value / first value
e. Sum
f. Median
g. Standard deviation

For the respective compression levels, the following analyses are to be provided automatically:

a. Number of the upper and lower limit value violations
b. Average value (5–95 %)
c. Percentile value (5–100 %)
d. Standard deviation
e. Standard deviation from a sample (population-1)
f. Minimum and maximum with timestamp

Normally, the overflow of the counter values is to take place at the "natural" limits (e.g., with an unsigned 16-bit value, the counter overflows at 65535). For individual values, the overflow has to be freely adjustable.

The automatically acquired measurement values are to be checked for plausibility, upper/lower limit value violation, measurement location failure and faulty communication to the PLC.

Corresponding identifiers have to be stored with the measurement value. In the event of a measurement location failure or faulty communication to the PLC, the specification of a replacement value has to be possible.

In telecontrol configurations, the values in the automation system provided with a timestamp have to be likewise read into the control system and be placed chronologically correct in the archive. This data is then available as well for further analyses.

Recorded values can be manually corrected by users with appropriate password authorization. A corrected value is to be marked accordingly in the reports.

8.1.26 Laboratory Values / Manually Input Values

Manually input values do not come online from the PLC, but are manually input, e.g., after being determined in the laboratory. The chronological assignment of these manually input laboratory values is performed by the user. The input of the values has to be convenient. The following options should be available to the user for the input of laboratory values:

a. Input via table
b. Input via various input masks
c. Manual laboratory value import of a file

d. For laboratory values that are automatically written by a laboratory system into a CSV file, an automatic laboratory value import has to be available.

   In principle, manual values can be input for any valid time.
   Via the user administration, manual values can be assigned to individual operators for the input. The retroactive acquisition can be limited in time for each operator.

e. Derived Data (Calculated Values)
f. Derived data – so-called calculated values – shall be provided by the system. The quantity may not be limited. The calculation is to take place in the background as soon as a referenced value changes. The compression into interval, daily, weekly, monthly and yearly values is to be performed analogously in the background. By means of calculated value formulas, arithmetic and logic operations for measurement values, laboratory values, calculated values, constants and system status messages can be created.

The following functions must be implemented:

a. Basic arithmetic operations (addition, subtraction, division, multiplication)
b. Logical functions (AND, OR, NOT)
c. Arithmetic functions (power, root, sine, cosine, tangent, absolute value, percentile, exponential value, natural and common logarithm)
d. Special functions (conditional calculation IF ... THEN, polleni, cosineφ)
e. Comparison (<,>,=, ≤, ≥, ≠)
f. Constants (Euler's number, Pi, configurable constants)
g. Bracketing

h. A calculated value can be manually corrected. A corrected value is to be marked accordingly in the reports.

i. Trend Curve Screens
j. The industry-compliant, archived data – such as measurement values, counter values, laboratory values and calculated values – is displayed on the screen in the form of historical trend curves (load curves).
k.
   Any number of trend curves can be assigned to a trend curve screen.

The following functions are needed to facilitate working with trend curve screens:

a. Online arrangement of trend curves.
b. For each trend curve, a different depiction type (step, marker, line, and bar) is to be selectable.
c. Individual symbol depiction with different markers (circle, triangle, square, hexagon, cross, X) for normal values, replacement values and "changed values". The size of the markers is changeable.
d. Zoom function by making a rectangle with the mouse.

e. The start and end times of the trend curve screen can be changed with the mouse and an input mask.
f. Moving of trend curves in the x-direction (time offset).
g. Trend curves can be freely assigned to a specific value axis.
h. A standardized depiction is to be possible (all measurement values are assigned to a joint 0–100% axis and also depicted with it).
i. Various depiction forms of graphs are to be possible: Time diagrams, frequency diagrams, cumulative frequency diagrams, probability grid in accordance with Dr. Groche, x/y diagrams, overlap diagrams, maximum analyses (e.g., power peaks).
j. The different separation of the vertical axis (y-axis) is to be possible: In the trend curve screen, each trend curve can be different; it can be linear, logarithmic, Gaussian (percentage scaling according to the Gaussian normal distribution) and digital (for values unequal to zero, the line is drawn; for values equal to zero, the line is interrupted; digital values can thus be depicted especially compact).
k. For each trend curve, the upper and lower limit values can be displayed.
l. For each trend curve, the value, sum, maximum, minimum, number of upper/lower limit value violations and standard deviation can be depicted. Each trend curve is to be depicted at least five times in the same trend curve screen.
m. For each trend curve, the relative and absolute time offsets can be individually adjusted.
n. Alarms and messages as well as alarm groups and message groups are to be depicted as trend curve. For the time range depicted, the statistical analyses quantity and duration are to be displayable.
o. For the easy analysis of events (e.g., accumulation in the rainwater overflow basin), a convenient selection of an individual event or of multiple events is to be provided. For a specific week, month or year, or a freely definable time period, the events that have occurred are displayed grouped (e.g., by rainwater overflow basin) and can be selected.
p. Printout of the current trend curve screen at the push of a button.
q. For the depiction, e.g., in the process control system, an ActiveX object with the above described functions for the depiction of archived data in trend curve screens is to be provided.

8.1.27 Reports, Logs, Analyses and Balances

The form of the reports and logs must comply with the instructions ATV-DVWK-M 260 “Acquisition, depiction, analysis and documentation of operating data from wastewater treatment plants with the aid of the real-time data processing”.

This is ensured also without the use of additional software such as MS Excel. The list of required reports can be found in the function catalog.

As a general rule, the following applies: Any number of differently set up daily reports has to be configurable (e.g., abbreviated and long versions). The same applies to weekly, monthly and yearly reports.

The printout, display, archiving on hard drive or sending by e-mail of all reports is initiated manually via the user interface by selecting the desired time period. All reports can also be automatically printed out, displayed, archived or sent by e-mail for a definable time period (e.g., going back one day or month).

8.1.28 Archive Data Storage on external Backup Medium

The data backup program operates parameter-controlled. It is therefore possible to initiate a data backup without dialogs from another program. A dialog window regularly prompts the operator to back up the data (operator-controlled backup). When performing a data backup, its extent can be selected. All configuration data and measurement data can be backed up. A restoring of the data is to be possible analogous to the backup.

8.1.29 Multi-Client Capability

The software must be able to manage clients. For each client, a separate configuration can be assigned. With that, multiple plant sections can be managed from one workstation. Each client has access to the full functionality of the software.

8.1.30 Cross-Plant selective Data Management

The plant-wide selective data management enables the setup of central data storage. With this function, specific data from individual applications can be combined in a central application to, e.g., obtain performance comparisons of individual sections. via TCP/IP connections (e.g., ISDN, LAN), the data from different plants can be ported into a central application. This function has to be executable automatically or manually. It has to be possible to port selected data types into the central application (e.g., raw data, compressed values, hourly values, daily values).

8.1.31 Event Reports

Occurrences that are not cyclic (e.g., rainwater overflow or in case of an accumulation) are depicted in event reports. Statistical analyses are possible in daily, weekly, monthly and yearly reports in order of their occurrence as Sequence of Events (SOE).

An event report is the analysis of data that is not formed over a fixed time period (such as a calendar day), but over a time period determined by external events. An event in turn can consist of multiple partial steps.

By means of the recorded process data, the start and end conditions for such event reports can be searched for and – based on that – analyses be performed.

A report form is assigned to each event.

The analysis of the events consists of a single line, multiple lines or four parts: the start, the end, a data block and a statistic over the time period between the start and the end.

All defined events can be manually corrected and supplemented.

A report page is custom-designed and can result in the output of multiple, physical individual pages.

8.1.32 Alarm and Message Processing

Faults and messages can be displayed in separate windows and be printed out.

It should be possible to interactively define up to 300 alarm windows and simultaneously open up to 8 different alarm windows in the online mode.

For each alarm window,

a. The table size, column number and column width can be set.
b. A distinction can be made between faults and messages.
c. The time period for the depiction can be freely selected.
d. The filter criteria can be specified and thus individual alarms be specifically searched for.
e. The online mode can be activated so that new alarms are automatically displayed.

5 window types are available:

a. For messages only.
b. For faults only.
c. For messages and faults.
d. Fault statistics with quantity, overall duration, average duration, maximum duration and minimum duration as well as the graphical display of the duration.
e. Message statistics with information on the message quantity.

For the depiction, e.g., in the process control system, an ActiveX object with the above described functions for the depiction of archived messages and faults is to be provided.

8.1.33 Maintenance Management

The industry-compliant requirements made on a maintenance monitoring system are to be met. An object to be monitored (unit, drive, machine, motor, structure, etc.) is to be assigned multiple different maintenance jobs. In particular, the following requirements are to be met:

a. Monitoring of the operating times, runtimes and switching cycles.
b. Calculation of the runtimes and switching cycles from binary feedback or counter values (second, minute, hour).
c. Clear depiction in groups and subgroups.
d. Filters that limit the number of maintenance jobs in the dialog.
e. Storing of maintenance documents (routing slips, safety guidelines, repair instructions) per maintenance and unit.
f. Maintenance instructions and list of materials per maintenance.
g. Display and printout of the status reports.
h. Display and printout of the history reports per unit.
i. Logging of unit repairs; does not reset the interval.
j. Performing of maintenance with interval reset and input of notes, duration, costs.
k. Deactivation of individual maintenance jobs.
l. Colored highlighting of the maintenance statuses of the groups and units.
m. A minimum of five dependent partial maintenance jobs can be assigned to a primary maintenance job.

n. The automatic printout, display, archiving on hard drive or sending by e-mail of all maintenance documents (status reports, unit histories, maintenance instructions, list of material) should be easily configurable.
o. By means of OPC, the process control system or other applications are to be supplied with information on the maintenance status of each unit.

8.1.34 ODBC Interface

For the access to the stored data, the industry-compliant software is to provide an ODBC interface, which gives other applications access to the data. The application must employ SQL (Structured Query Language) as the standard language for the data access. Applications offering an ODBC interface – such as MS Excel – can access the data (process/interval/daily/ weekly/monthly/yearly data, messages, faults, maintenance data and event header data) in read mode.

8.1.35 DDE/OPC Server

For the depiction of the industry-compliant, stored measurement and maintenance data, e.g., in the process control system, a DDE/OPC server is to be provided. This interface can be used by all DDE-/OPC-capable systems.

Process, interval, daily, weekly, monthly and yearly data is available as current value and value from the previous period.

The exceeding of the maintenance interval, the reaching (in percent) of the maintenance interval for switching cycles, the runtime, the operating time and the last maintenance time are to be available.

8.2 TECHNICAL OVERVIEW

8.2.1 Application Architecture and Traffic Flow

This section provides a technical overview of the project.

The following diagram shows the proposed traffic flow of data from Operator Client work stations to field controllers for all systems, commonly referred to as HMI Messaging.

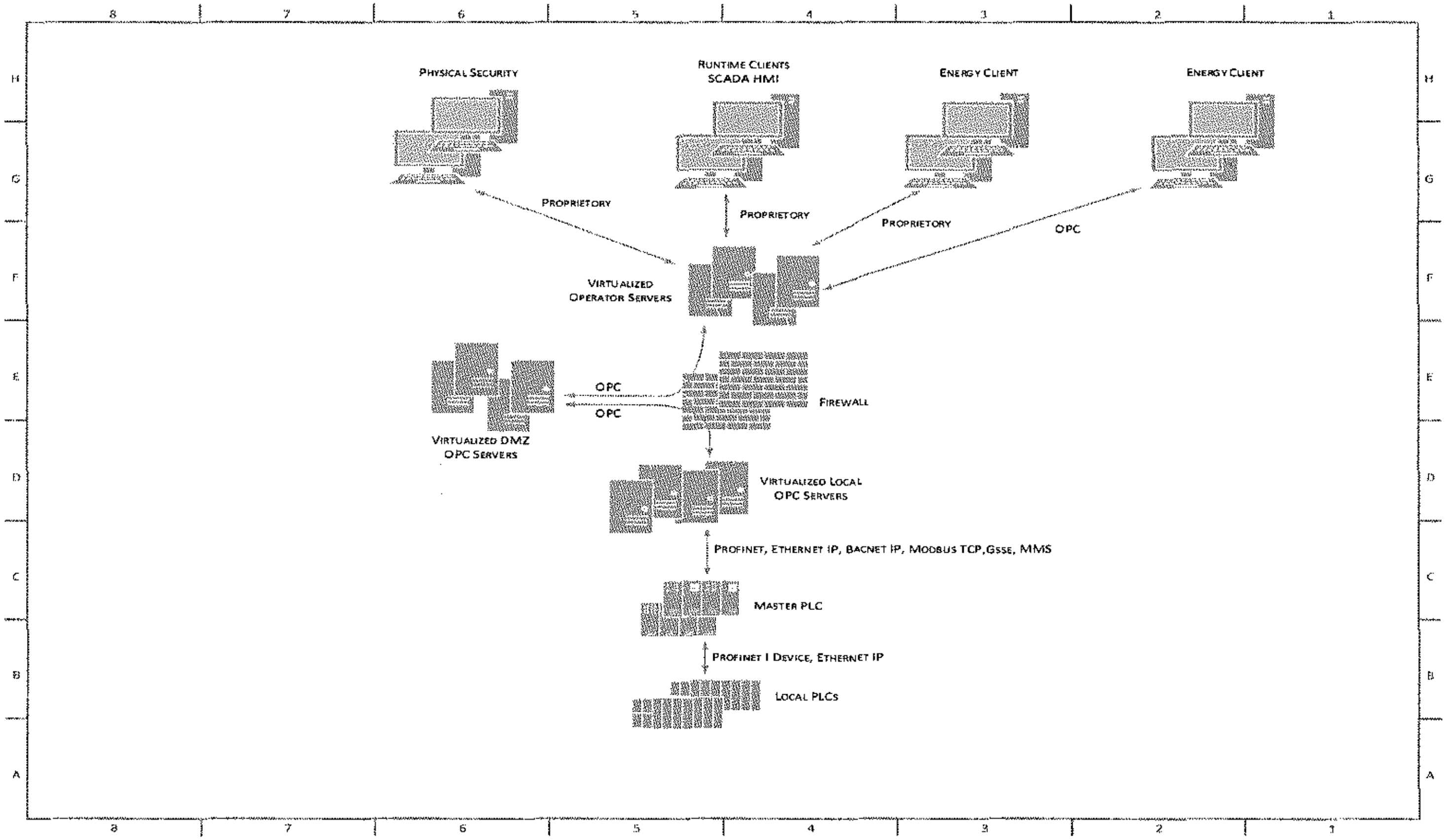


Figure 2 Plantwide HMI Messaging

It is proposed that each client software will either be based on OPC or proprietary software.

The OPC servers features and functionality are described in the following section.

The clients' will communicate either directly with the Operator Servers, which are virtualized except in the case of the process OS which will be a real hardware and operating system.

The OS servers are responsible for data processing which in the case of the process control is described in section 8.6.

8.2.2 Standard Protocols

In this project, the term 'control technology' covers the holistic vertical integration from the control station over the automation level all the way to the instruments. Distributed stations that supply procedural data are also included.

In order to achieve an integrated and uniform system structure, standards and standardized components shall be used. Special developments and special solutions, which are not available commercially, are generally not permitted. Worldwide support must be ensured.

With regard to the components used, it must be ensured that the technical specifications listed in the specifications are complied with.

Structured networking in the field and automation area and the structure of the computer LAN on the control level are to be preferred. Furthermore, standardized equipment must be selected for electrical, measuring and control technology.

Standardization is not limited to devices, it also comprises the hierarchically structured process control, which is the same in all plants, a uniform plant identification system, which is a prerequisite for low-cost, preventive maintenance, as well as uniform and integrated documentation of plant and automation engineering, including processing at the Control Center, with information on storage, alarm processing (e.g. in response matrices), which is the processing of information (limit values, switch points, etc.) and its processing in reports.

This means that standardization in this case includes the following fields:

a. Instrumentation with measuring devices of a manufacturer for defined measurement tasks with fieldbus connection

b. PROFIBUS DP/PA connection as fieldbus Instrumentation standard <u>shall be used only for water quality analyser</u>

c. <u>HART analogue 4-20mA connection as field process instrumentation standard</u>

d. The control network standard shall be PROFINET or CIP OVER ETHERNETIP

e. Industrial ETHERNET for connecting the automation level to the process data servers

f. Automation technology, using hardware that is as uniform as possible and function blocks that can be consistently reused for similar drives and transducers

g. Uniform network structure for the process connection via the various communication channels, no proprietary protocols

h. Uniform system structure and hardware for the Control Centre in all areas; use of a minimum number of consistently reused faceplates for the same aggregates and operator control functions

i. Uniform and integrated operator control and acknowledgement concept

j. Uniform documentation system (this applies to the plant identification and the type of documentation programs used)

k. Selection of uniform components

8.2.3 Control and Field Network Protocols

The currently established standard PROFIBUS DP/PA is to be used process analysers field instrumentation level and HART 4-20mA for all Process Instrumentation as depicted on the drawings and CIP over ETHERNET/IP or PROFINET is to be used for interlinking the PLCs to Master PLCs as the solution for automation systems and for connecting them to the Control Center as depicted on the drawings. Only segment coupler types from the supplier's product range of automation systems shall be used which have been certified in a system test of function and interaction corresponding to the approved module and system components. This ensures a uniform structure between all levels of process control technology, automation and the connected field devices.

Linking distributed stations over WAN is mainly implemented by means of Internet-based procedures based on the TCP/IP protocol. In this case, the OPC protocol is to be used in order to remain within the technological product range. The IPsec security standard must be applied when using OPC protocols and the Internet.

Error messages must be output after coordinating with site management by means of the following mechanisms:

I. Sending text messages direct from the PC

II. Fax and voice

III. The configurability of group services and announcing messages through local loudspeakers

8.2.4 Plant Wide Converged Solution

A Plant Wide Converged solution has been proposed for the following reasons:

a. Provide a holistic approach to site operations, linking process operations with MEP systems for simplified management and trouble shooting

b. Provide a unified approach to process visualization and MEP Engineering systems

c. Provide and holistic approach to Site Security linking CCTV, Process Control and Physical security, and Identity management in order to negate any security vulnerabilities which tend to occur when provisioning disparate networks.

d. Provide equal and standardized approach towards systems redundancy and reliability for control systems for both Process and MEP Engineering systems.

8.2.5 Logical Plant Wide Architecture

The systems shall conform to three logical levels for plant control namely:

I. Management Level

II. Control Level

III. Process Level

The management level or commonly referred to as supervisory level is responsible for the SCADA HMI clients, Domain controllers, Radius Servers, Historians, and Network Management servers. This will also be the location of the Media Servers, DCS servers and Client workstations and Large Screens for process visualization.

The plant level or commonly referred to as control level is responsible for access switch connectivity of Master PLCs, Distributed I/Os and Power meters and Monitors etc This will also include Industrial Ethernet, PROFINET, Fiber Optical Cabling etc.

The process level is responsible for sensors and measuring instrumentation which connect to the plant level devices. This will comprise communications for process area field PLCs and instrumentations for 0-10v, 4-20mA, PROFIBUS and HART signalling.

8.2.6 Engineering Drawings

This specification includes a number of drawings which shows the overall intention for the SCADA Architecture for the Mega Reservoirs and Main Pumping station and Reservoir plant.

There are a number of key process areas; this has been determined by the P&ID diagrams, for example Reservoirs, Main Pumping Station, Chlorination Building etc
In addition to these key process areas there are a number of subsidiary areas for example Tank Filling Station, Leak Detection systems, etc.

All these areas are clearly identified on the site plans and are connected to one of the four Physical fiber optic rings being provided for the site.

8.2.7 Process Areas for Automation Diagrams

The Key process areas each have supporting Automation Engineering Drawings comprising:

I. Fiber Optical Network and Instrumentation Layout Drawings

II. Control Level Network Diagrams

III. Field Level Network Diagrams

IV. Rack Diagrams

It is the intention that all process area MEP systems will also form and integral part of the SCADA Automation and therefore the control of these systems will also be PLC based and share the same Physical Network as the Process Plant.

8.2.8 Networking Diagrams

This specification control level network diagrams for all areas, which includes switches, connectivity of PLCs for both MEP and process equipment and Physical security.

The intention is that the CONTRACTOR shall deem this as the Clients preference on distribution and avoidance of single point of failure, notwithstanding the CONTRACTOR's contribution to value engineering.

The following diagram shows the high level view of the proposed SCADA Architecture and Physical Diagrams.

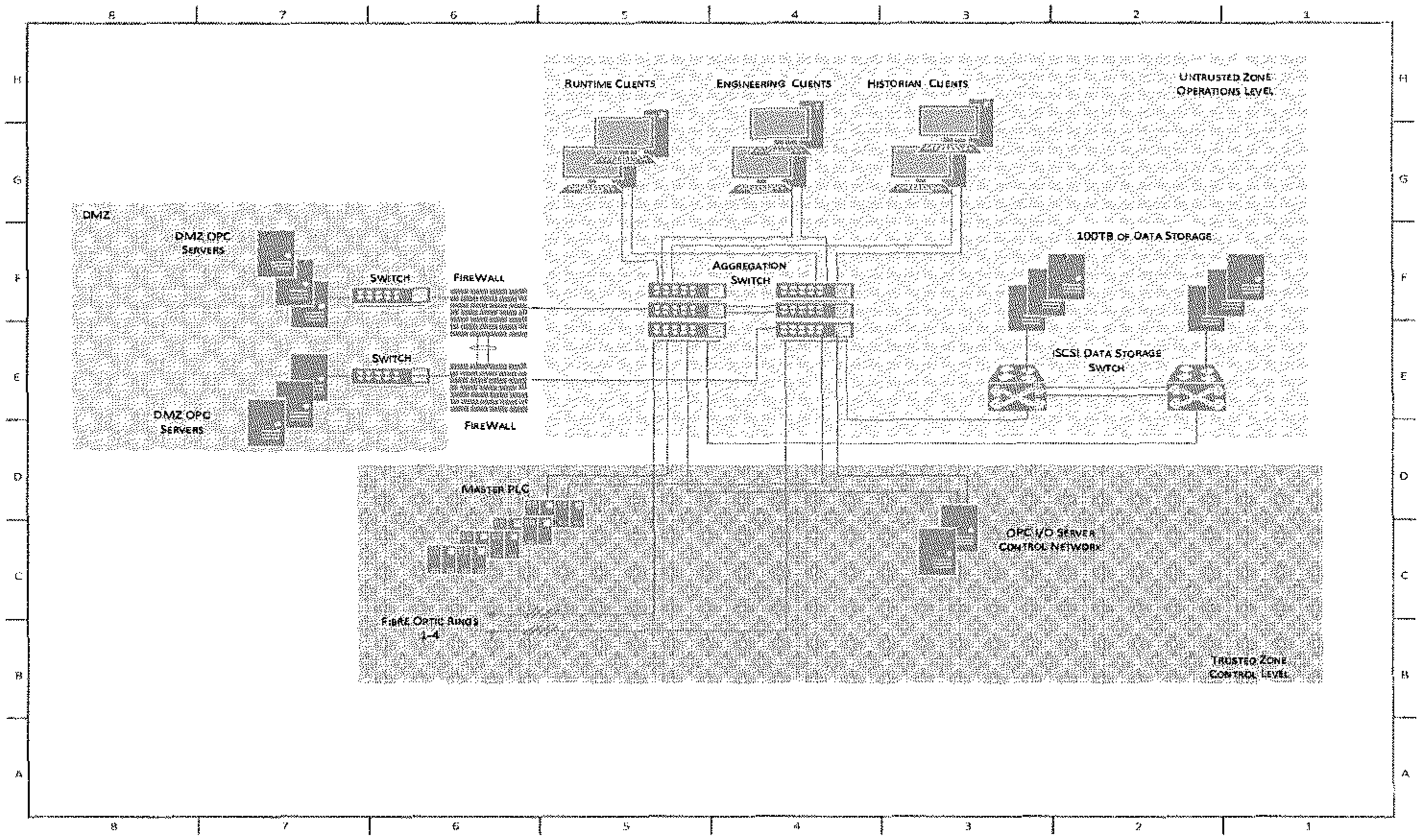


Figure 3 High Level Operators Level Diagram

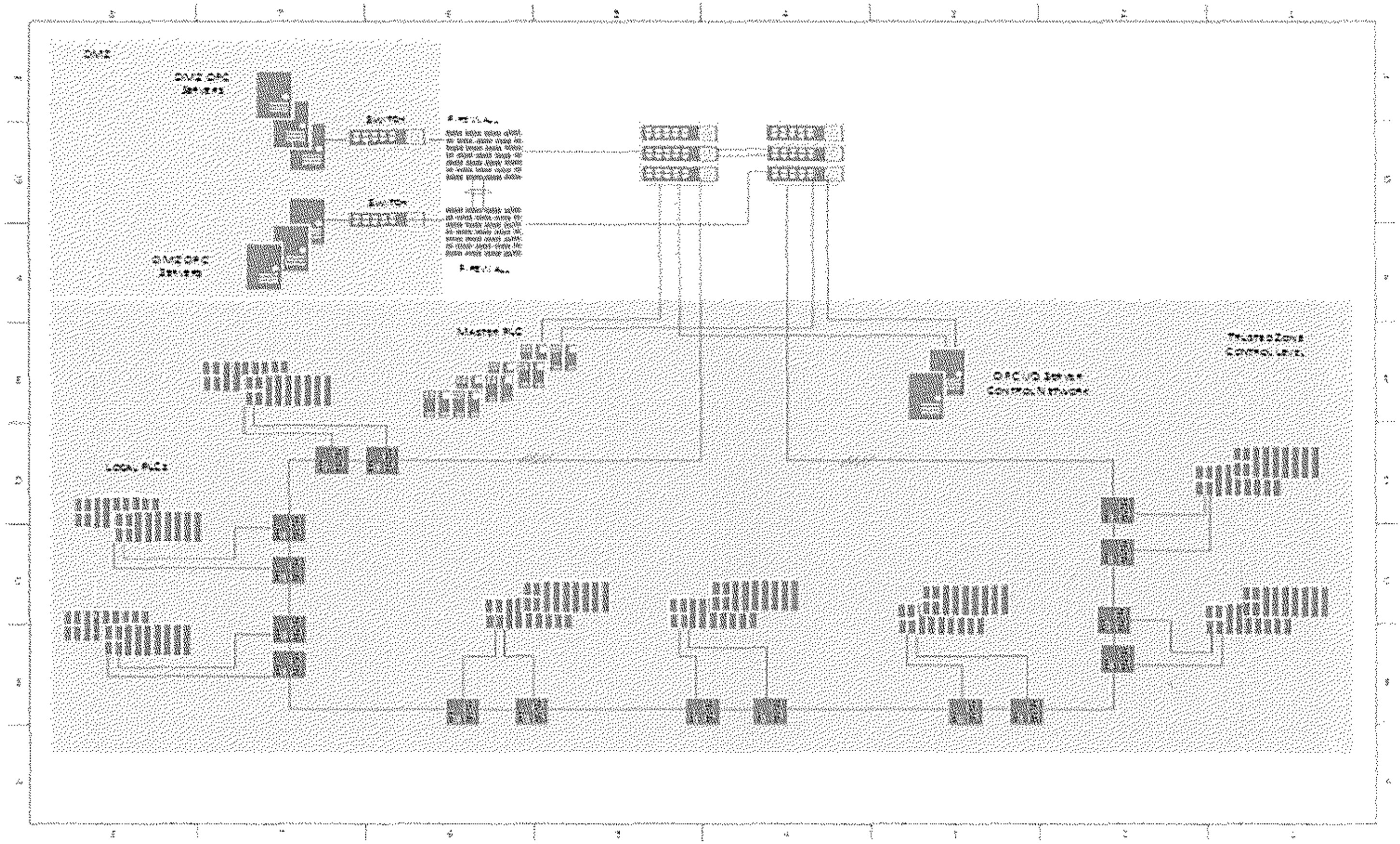


Figure 4 Control Level Network Diagram

8.2.9 Rack Diagrams

This specification includes rack diagrams which show the requirements for distribution networking and automation equipment to avoid single point of failure. The racks are presented both physically and logical, the purpose being that the logical element gives the preferred equipment description.

The rack diagrams show the preferred spacing between the equipment, which is typically 1U. Also it shows the preferred mounting height of the equipment which is typically not more than shoulder height of a 1.77m person. The approach is not to have redundant racks but instead to have redundant equipment in the rack fed from A and B supplies, each supply being sourced from a single UPS, which has a 2 hours Autonomy.

8.2.10 PLC Diagrams

The specification includes PLC Diagrams. The PLC diagrams show the number of instrumentations to be connected, the Power Supply requirements the Communication Processors and the Control Processor Units. Typically the PLCs shall be no more than 9 modules Din Rail or Back Plane Mounted. This is to limit the number of I/Os communications lost due to device failure.

The diagrams show that the PLCs shall have redundant I/O links(either PROFINET or CIP OVER ETHERNETIP) to communicate over the Industrial ETHERNET network and also support PROFIBUS on the Central Processors as well as support of PROFIBUS as a service Module. In addition it shall also support MODBUS and BACNET for MEP SCADA devices. The expectations from the PLC Diagrams are that all Service Modules (SMs) shown on any specific PLC shall be supported on all PLCs, notwithstanding the CONTRACTORs contribution to value engineering.

The CONTRACTOR is to determine which best PLC platform from his product range, in terms of processor and memory and supported service modules, suits the purposes for the pipework instrumentation and MEP SCADA for this project, notwithstanding the required general features and functionality described in the following clauses and appendices.

8.2.11 Fiber Optical Cabling Routing Layout Drawings

This specification also includes Fiber Optical engineering drawings which show the project preference for fiber optical cabling routing, The routes have been selected to avoid going over pipework where reasonably practicable and to avoid single point of failure, notwithstanding the CONTRACTORs contribution to value engineering:

This network comprises four (4) trunk segments:

I. Ring 1 Main Pump House

II. Ring 2 South of the Main Pump House

III. Ring 3 North of the Main Pump House (Reservoirs Area)

IV. Ring 4 West of the Main Pump House (Surge Vessels, Chlorination Bldg, etc.)

These rings are linked together to form a closed ring topology.
Local PLC controllers and field devices of MEP systems with Ethernet ports are connected directly into one of these segments to communicate to the station SCADA/SCADA HMI.

It is proposed that the site will have four Layer 2 Industrial ETHERNET 24 core Fiber Optical Rings to provide connectivity to all the buildings and their PLCs. The proposed cabling specification will be 50 micro meters 1Gbps 850nm Multi Mode Fiber OM3 specifications with reachability of 1kM with 1000BASE –SX Transceivers.

The laying of the fibre optical cabling must be in accordance with the QCS documentation.

8.2.12 Fibre Optical Ring Redundancy

The solution for this project will be the adoption of Carrier ETHERNET which is the creation of large Layer 2 domains. In this instance there will be four Layer 2 domains all of which will share the same logical addressing (IP Subnet). There will be a requirement for a mechanism for resilient failover fast convergence, which supports the proposed ring topology and scaling of VLANs and MAC addresses.

Given these requirements this solution proposes Resilient Ring Path Protection Protocol implemented on ring connected industrial Ethernet switches. These networks have been designed with a maximum of 50 hops per network and a convergence time of 50ms.

The Protocol is a segment protocol which means that each of the rings will run its own instance of the protocol.

A segment is a chain of ports connected to each other and configured with the same segment ID. For this project each end of a segment will terminate at the distribution switches in the computer room, referred to as an edge switch.

A more detailed description of path protection protocol features is given in the Appendix of this document but in general it is reliant on determining Edge Ports and Switches. The general principles depicted on the drawings are that in buildings where there are more than 4 switches, two switches have been identified as Edge switches with edge ports, forming an internal building ring which then connects to a trunk ring.

A. Fiber Optical Cable Installation Requirements

Fusion splicing is to be used for Fiber Optic cabling where required as it provides the lowest loss and least reflectance, as well as providing the strongest and most reliable joint.

B. General Guidelines For Installing Fiber Optic Cable

Outdoor Fiber optic cable with the plant shall be shall be blown into conduit or innerduct. Indoor cables shall be installed in raceways, cable trays hanging from the ceilings. .

C. Bend radius

If no specific recommendations are available from the cable manufacturer, the cable should not be pulled over a bend radius smaller than twenty (20) times the cable diameter.

After completion of the pull, the cable should not have any bend radius smaller than ten (10) times the cable diameter.

D. Cable Construction

Installed cable must be manufactured to meet or exceed the following specifications:

E. Inside Cable

Plenum rated cable shall be used for all interior installations. Installed cable shall meet or exceed the following specifications:

I. Tight buffered 900 um, mechanical strippable Teflon (for plenum applications).
II. EIA/TIA -598 color coding for fiber optic cable.
III. Aramid yarn strength member, capable of supporting a short-term tensile load of 400 lb. without stretching.
IV. Capable of bend radii as small as 20 x outside cable diameter (under installation load) and 10 x outside cable diameter (long term load).
V. Capable of a minimum crush resistance of 850 lb./in.

F. Outside Plant Cable

Outside plant cable shall be used for all applications where cable is to be run in underground conduits. Outside plant cable may not be used for interior applications and shall meet the following specifications:

I. Gel filled buffer tube, 250 um, acrylate.
II. EIA/TIA-598 color coding for fiber optic cable.
III. Flooded core
IV. Capable of bend radii as small as 20 x outside cable diameter (under installation load) and 10 x outside cable diameter (long term load).
V. Capable of a minimum crush resistance of 850 lb./in.

The Contractor is to allow for the splicing machine, OTDR and tools as part of the list of spares required.

8.2.13 Systems Operation Overview - Control Room to Field Network

This specification contains diagrams which show the proposal for communications from the control room to each Ring Master PLCs, which reside in the computer room. There will be a number of workstation clients comprising Runtime, Engineering Historian and Physical Security Clients.

In general terms the Control network is seen as the trusted environment. The Control Room is seen as the untrusted environment. All communications from Control room to the Master PLCs, via the I/O servers, will therefore pass through a firewall. The Workstation Runtime and Engineering Clients in the Control Room will communicate with a Local OPC Client Server computer, which inturn forwards messages using OPC to I/O servers which reside in a demilitarized zone

8.2.14 Wide Area Networking Communications

The requirements for Wide Area Networking for this project are that it must be possible for the site to communicate with the existing Master Control Centre NWCC. The bandwidth requirement for process data is small and can be achieved by a single multimode fibre between sites to the NWCC. The networking solution is designed to accommodate Wide Area Networking Switches connected to the firewall for Wide Area communications. However it may be a consideration to connect Physical Security including CCTV footage to be sent to the NWCC which will require a more robust solution. The computer room has been designed to support both options.

The following diagram shows the proposal for OPC DA Site Wide Communications

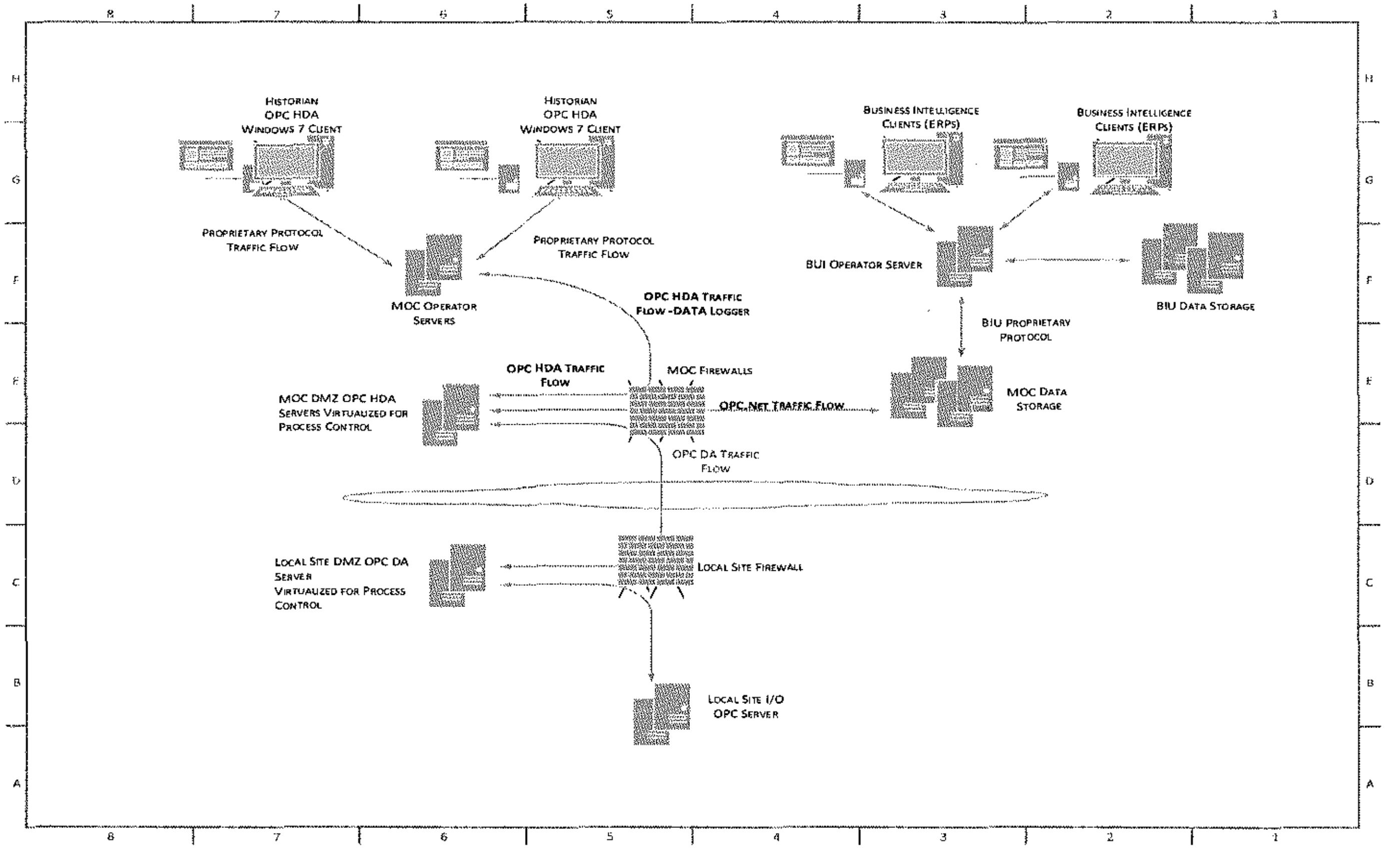


Figure 5 SiteWide HMI Historian Messaging

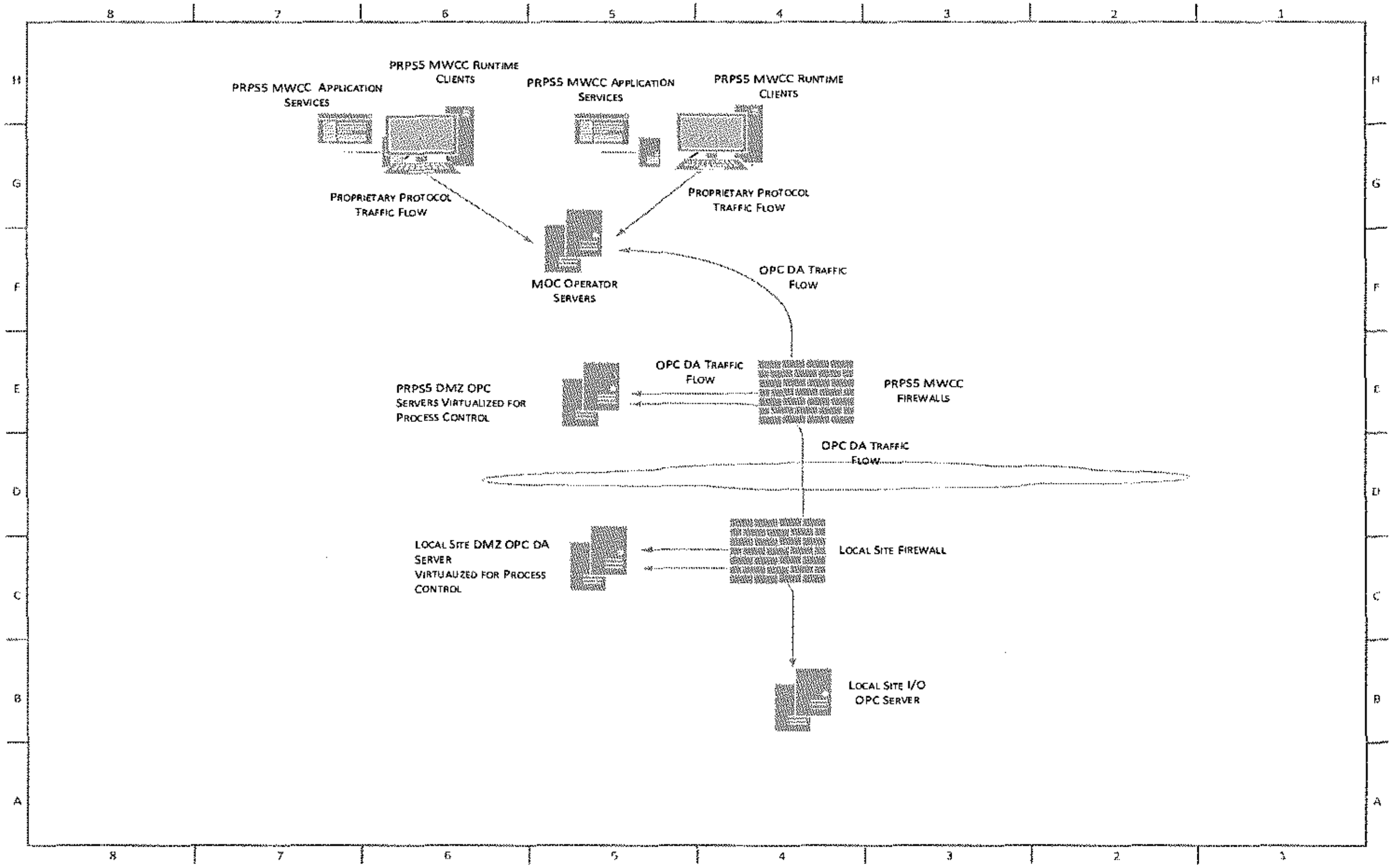


Figure 6 Sitewide HMI Data Acquisition Messaging

8.2.15 LAN Switches

The local network of the process control system is designed as an ETHERNET LAN in accordance with IEEE 802.3 / 802.3u with 1Gbps. The individual network nodes are connected to the LAN through Industrial ETHERNET Switches.

It is proposed that the LAN structure for PRPS will comprise four 1Gbps rings. These rings will be trunk links which will carry multiple VLANs around the site. The rings will start and terminate at the computer room in the main pump room. There will be no routing between the switches the network will be a complete layer 2 network and each VLAN will terminate at the computer room. The design is such that no more than 50 switches will be on a Layer 2 rings.

The switching procedure permits simultaneous parallel communication in different sub segments. The ring protocol shall determine which way data will travel along the VLANS from PLC to PLC or Master PLC to PLC. The design of this network proposes that the ring convergence shall be not more than 50ms.

The Industrial Ethernet switches shall support central network management by means of the SNMP (simple network management protocol). In addition all other network components on the Industrial ETHERNET PROFINET or CIP OVER ETHERNETIP ring shall support SNMP.

8.2.16 Aggregation Layer Switch

It is proposed that all rings within a site will converge on a pair of Aggregation Layer switches, these switches shall support intrusion detection, Quality of Service and network security services. This switch is required to be the point of presence for all pumping stations with the nearby location of the Main pumping stations and will handle all process, MEP, metering and CCTV traffic requirements at this point.

The Aggregation layer switch will be the point of convergence for the four Industrial Ethernet rings. It has been selected for the following reasons:

It is required to converged video, voice and data networks and includes features such as scalability to connect to remote sites along the corridor, operational manageability, integrated wireless, firewall support, dual supervisor, intrusion detection and virtualization and network analysis. It will also be required to provide high switch performance scalable upto 400Mpps.

In addition it is required to provide port density and different multiple connectivity requirements 1Gbps support, 10Gbps support, MMF and SMF.

8.2.17 Multipurpose Controller (PLCs)

The system has been designed with the inclusion of a number Pipework PLCs. These controllers shall be a multipurpose controller capable of executing fast PLC-type programs (discrete) and DCS-style applications (regulatory) allowing process and machinery control to be integrated in one device. Extremely short instruction processing times down to 10 msec, required for programmable logic control, and slower processing times required for process control, shall both be available. A minimum of 6 independent scan rates should be available for optimizing the execution time of the application program.

8.2.18 Large Capacity Controller (PLCs)

The vendor shall provide a large capacity master controller capable of executing a minimum of 1000 standard PID Control loops with a 500 msec. scan rate to reduce the need for partitioning of the user application program. A controller of the upper performance class must at least be offered with the following performance specifications:

I. Execution time: 18ns.

II. Memory: 30 MB.

III. A firmware update must be possible for redundant systems during ongoing operation.

IV. The vendor shall offer a controller in the upper performance range for more than 1000 Process objects.

V. No connected engineering system containing required data in the controller must be necessary for a cold restart.

VI. The vendor system shall not encounter high CPU load or memory requirements for saved texts in the controller. The variable length texts are to be stored in a text database.

8.2.19 Switchover Time with Redundant Systems

In a redundant system, controllers shall operate with a “hot backup” where both CPUs execute the identical step of the user program in parallel. When a CPU error is detected, a bump less switchover shall be initiated between the controllers. The complete switchover shall be completed in approximately 10 msec or less including all I/Os and including no loss of alarms or messages.

Connected redundant I/O components must switchover within 30ms if a fault occurs.

8.2.20 Power Supply

~~There shall be a choice of a 24 VDC or 115/230 VAC 50/60 Hz power supply.~~

8.2.21 Battery Backup

Controller configuration memory shall have a battery backup so that the controller maintains its configuration and state information in the event of an extended power outage. The program execution shall restart where it left off upon power restoration.

8.2.22 Response to Power Failures

In the event of an extended power failure the controller shall not require access to the engineering station to reload or redo any portion of its configuration.
The system must ensure that programs are not deleted if power fails. This should be ensured with battery backup.

8.2.23 Closed-loop-control

Standard software algorithms shall be available to perform regulatory control functions, and these shall have easily configurable parameters.

8.2.24 Control Modes

It shall be possible to put any individual control loop in a manual; automatic, or cascade mode. In cascade, it shall be possible to configure remote set points from other regulatory controllers or from other control blocks.

There shall be bump less, balance less transfer between all control modes, and windup protection shall be provided.

Control blocks shall be able to perform automatic mode switching based on external or internal logic inputs.

8.2.25 Calculations

Algorithm calculations shall be performed in floating-point engineering units or other such equivalent methods that do not require scaling.

8.2.26 Input Functions

The following input functions shall be supplied as standard configurable items:

I. Square root extraction, for flow measurement
II. Linearization of type B, E, N, J, K, L, R, S, T, and U thermocouples
III. Linearization of RTDs
IV. Digital input pulse totalization
V. Pulse input to frequency conversion

8.2.27 Computational Functions

The following computational functions shall be supplied as standard configurable items or simple algebraic instructions.

a. Addition / subtraction
b. Ramp generator

c. Lead lag
d. Integrator / Accumulator
e. Dead time
f. High/low select
g. Multiplication / Division
h. Time averaging
i. Signal selection switch
j. Exponential polynomial
k. Logarithms
l. Square root
m. Absolute value
n. Closing delay
o. Min/Max selection
p. Smoothing function
q. Noise generator
r. Signal smoothing / low pass filter
s. Alarm delay
t. Continuous Control Functions
u. The following control functions shall be configurable items:
v. Proportional Integral Derivative (PID)
w. Auto/manual with bias control
x. Ratio control
y. Step Controller
z. Split Range Controller
aa. Cascade Control
bb. Override control
cc. PID with feed-forward
dd. PID with Smith predictor
ee. PID with safety logic and control loop monitoring
ff. PID with operating point-oriented parameter adaption
gg. Model predictive control

8.2.28 Control Loop Execution Frequency (Scan Rate)

It shall be possible to independently select the execution frequency of each device control strategy in the controller. Controller scan rates as fast as 100 times per second (10 ms) shall be possible.

8.2.29 Control Loop Output Functions

The following output functions shall be supplied as standard configurable items and shall be the same regardless of execution in the system controller:

a. Linear
b. Linear with clamping (high and low restricted)
c. Non-linear characterization

8.2.30 Set point Clamps

Upper and lower clamps on all set points shall be configurable.

8.2.31 Discrete Control

The following discrete control functions shall be supplied as standard configurable items:

a. Logic functions -- and, or, not, nand, nor, xor.
b. Change of state detects.
c. Set/reset flip-flops.
d. Timers and counters.
e. Comparison elements -- greater than, less than, equal to, not equal to.
f. Multiplexer (selects one of up to 16 signals).
g. Positive, negative, and bi-directional edge trigger.

The vendor system must be able to support wide-ranging technological modules (controllers, positioners, counters etc.).

8.2.32 Sequential Control

Sequential Function Charts (SFC) shall be available. SFC is a structured, IEC 61131-3 compliant, high-level control programming language. The SFC shall include the following features:

a. It shall provide the necessary facilities for real-time control of sequential processes.
b. It shall have access to process control and other database information.
c. It shall be possible to modify the program logic while other sequences are active.
d. It shall support execution of the chart in Manual or Automatic Mode.
e. It shall be possible to configure multiple states within a single SFC container. This allows for effective coordination of sequences which have more than one mode (e.g. Heating and Cooling) or that contain safe-state logic (e.g. Aborting or Holding Logic).
f. The ability to create master SFC elements which can be copied and used throughout the configuration just like a function block. Changes to a single instance of the SFC will result in automatic updates to all other instances in the configuration.
g. The ability to automatically create displays for visualization and control of the SFC directly from the controller configuration.
h. The SFC editor shall include a test/debug mode which does not write to the outputs.
i. Manual adaptation following name changes in charts and their references should not be necessary.
j. Sequential charts in OS: It must be possible to monitor the sequencer of the vendor system and operators must be able to intervene if disturbances occur in the process.
k. It must be possible to perform actions in step transitions.

8.2.33 Sequential Functions

The following sequential functions shall be supplied as standard capabilities:

a) Hold sequence -Manual or preset time.
b) Recycle to prior step.
c) Skip one or more steps.
d) Automatic Restart at beginning upon completion (Cyclic Operation).

e) Configuration of maximum or minimum execution times for steps and transitions.
f) Ability to configure an optional operator confirmation for each individual transition condition.

8.2.34 Step Control Modes

The way in which chart progresses from a transition condition to the next step can be controlled according to the following modes:

a) Transition – Control is governed solely by satisfying the transition condition
b) Confirmation – Control is governed solely by operator confirmation.
c) Transition and Confirmation – Both the transition condition must be satisfied and the operator confirmation must be entered before the sequence will proceed.
d) Transition or Confirmation – Either the transition condition is satisfied or the operator confirmation is entered to allow the sequence to proceed.

8.2.35 Phases of a Step

Each step of a chart shall support the following standard phases of step execution:

a) Initialization – For first-time execution of actions.
b) Execution – For continuous execution of actions until transition condition is met.
c) Termination – For post-processing to allow an action to be executed once after the transition condition has been met.

8.2.36 Supported Operating States

The following 16 SFC operating states (per the ISA S88.01 standard) shall be supported natively by the system:

a) Ready
b) Starting
c) Active
d) Completing
e) Error (Completing)
f) Completed
g) Holding
h) Held
i) Resuming
j) Error
k) Held (error)
l) Resuming (error)
m) Aborting
n) Aborted
o) Stopping
p) Stopped

8.2.37 Supervisory Control

The vendor shall be able to supply standard supervisory control functions fully integrated with the regulatory control functions. The supervisory functions will include the ability to make set point adjustments to selected loops.

It shall be possible for supervisory control applications to be scheduled, run on demand, or triggered by events.

The supervisory system shall have access to the complete database, with privileges to change items such as controller mode and set point.

8.2.38 Auto Tuning

An integrated PID auto tuning facility shall be available from the Engineering Station:

a) Applicable to processes with slow and fast dynamics.
b) Used with self-regulating and integrating processes.
c) Immune to noise and process load disturbances.
d) Can be used for standard and custom libraries.
e) Can be accessed directly from the Engineering Station.

The PID auto tuning facility shall employ an easy-to-use graphical interface with a setup "wizard"(similar to Microsoft Excel®) to assist engineers and technicians who are unfamiliar with the tool.

8.2.39 Fault Handling

Invalid value status shall be generated for inputs and calculated variables.
A value shall be declared invalid if any of the following conditions are true:

a) If a value is out of range.
b) If a value cannot be measured or calculated.
c) If a value is declared invalid by an application program.
d) If a value is declared invalid by the source instrument.

Invalid value status (data quality) shall be propagated through control schemes, and be available at the SCADA HMI.

It shall be possible to inhibit the detection and propagation of an invalid value status. This selection shall be available for every process variable.

It shall be possible for an invalid value status to be used as a logical input to initiate control algorithm changes.

When a control algorithm's input is declared invalid, it shall be possible to configure the output to fail as follows:

a) Hold last good value.
b) Zero output signal.
c) User defined output value.

In the event of communications subsystem failure, regulatory control algorithms shall continue operating with the last valid information.

8.2.40 Variable Scan Rates of Control Functions

The control execution rates for analog functions and discrete functions shall be individually configurable.

The minimum scan rate for discrete and analog control functions shall be 10 msec.

8.2.41 Cabinets

Control cabinets shall conform to CE standards for electromagnetic compatibility with the EMC standard (IEC 61000), and ensure protection against unauthorized access, mechanical influences, contamination, and other environmental influences.

The standard cabinet shall conform to IP40, and a cabinet upgrade to IP55 shall be available.

The controller and I/O modules shall not require the use of cooling fans.

The vendor must offer switches suitable for mounting in switchgear cabinets.

8.2.42 Controller Communication over System Bus

The system bus used for communication between controllers and up to the SCADA HMI Servers shall be capable of running at a minimum of 1Gbps data rate.

Use of fiber optic cables shall be supported, allowing noise free communication between control and operator stations separated by large distances as required by many processing facilities.

ITP cable (Industrial Twisted Pair) are to be used for distances up to 90 m.

The length of the system bus shall be expandable to 150 Km.

The system bus shall support from two to 1024 stations.

For maximum availability, the system bus shall support convergence times of 50ms.

The PID auto tuning facility shall employ an easy-to-use graphical interface with a setup "wizard"(similar to Microsoft Excel®) to assist engineers and technicians who are unfamiliar with the tool.

8.2.43 Reserve CPU Capacity

To reserve CPU capacity for future growth and insure rapid software response to process upsets, CPU execution of the configured software application shall not exceed 50 percent CPU time during the course of normal process monitoring and control.

8.2.44 Inputs and Outputs

The following clauses relate to the service modules in the PLCs as depicted on the PLC diagrams and their support for instrumentation and the protocols used.

8.2.45 General Inputs and Outputs

Common mode rejection ratios of 60 dB or greater from DC to 60 Hz and normal mode rejection ratio of 30 dB or greater at 60 Hz are required.

Analog input and output modules shall provide pass through capability to exchange non-control data, both PROFIBUS and HART, with asset management applications, utilizing the infrastructure of the system.

The following configurable fail-safe options shall be available for output modules:

a) Drive to predetermined analog output, or de-energize for a digital output.
b) Maintain the last good output value for an analog, or hold for a digital output.

The fail-safe actions listed above shall be taken upon a processor halt, or power supply failure, or a communication failure between the controller and the I/O module, if so configured.

It shall be possible to change modules in remote I/O racks while the rack is powered up w/o affecting communication to the other modules in the rack.

8.2.46 Support for Remote I/O Architectures

Remote I/O Capability shall be provided native to the system to minimize wiring costs and to eliminate the need for costly "home run" wiring – The system shall support the following remote I/O families:\

a) Intrinsically Safe (EEx-i) - For installation directly in Hazardous Locations (per NEC Class 1 Div 2, Zone 1 / Zone 2).
b) Support of Fail-safe Applications.
c) Integration of HART field devices.
d) With Integrated Terminal Blocks.
e) With special-purpose modules such as Motor Starters and Weigh scales.
f) With various levels of diagnostics and resolution (number of bits).

To achieve flexibility in the placement of equipment, the vendor's system shall support remote I/O installation whereby conventional I/O modules can be located large distances away (up to 6.0 miles / 9.6 km with copper cable or longer distance when fiber-optics are used) from their associated controller.

8.2.47 Non-proprietary Communication from Controller to I/O

Open standards should be used to communicate between a controller and its I/O modules to facilitate connectivity of 3rd party I/O with the same level of system support (diagnostics and engineering ease of use) as those offered by the vendor. It shall not be acceptable to utilize proprietary communication between the I/O and the controller.

Communication between controller and I/O shall be in accordance with IEC 61158 (Fieldbus communication).

8.2.48 Redundancy

The system shall support the use of I/O Redundancy whereby a single sensor or actuator is connected to two separate I/O modules.

A redundant controller can utilize a mixture of redundant I/O and non-redundant I/O within the same system.

To minimize the potential for common cause failures, redundant I/O Modules must be able to be located in physically separate racks. It is not permissible to share a common backplane.

The system should offer optimal integration of redundant Remote I/O racks (RIOs), redundant I/Os and field bus (PROFIBUS PA and DP), with both redundant and non-redundant models.

It must be possible to create two process PO (process variables) with the same process name and apply integrated redundancy functions without additional programming work.

8.2.49 Analog Inputs

The system shall be capable of supporting the following types of analog process input signals:

a) 4-20 mA DC, 0-20 mA DC, and ±20 mA DC, isolated and non-isolated inputs
b) 1-5 V DC, ±10 V DC, and ±1 V DC isolated and non-isolated inputs
c) Type B, E, J, K, L, R, S, T and U thermocouples
d) Platinum resistance temperature detector (RTD) – Pt100, Pt500, Pt1000, Ni100, Ni1000, Cu10 - per IEC 60751
e) High-speed Pulse input – 1, 10, 20, 100, 250, 500 kHz, @ 24 V

Temperature linearization and thermocouple cold junction compensation shall be provided.

Normal resolution shall be a minimum of 12-bits; special modules with 16-bit resolution shall be available.

Typical analog input modules shall operate at 25 °C with a basic error of no more than ±0.25% of input range.

8.2.50 Digital Inputs

The system shall be capable of supporting the following digital input types:

a) 24 VDC (capable of being time stamped to 1 msec accuracy).
b) 125 VDC.
c) 24-48 VAC/DC, 50/60 Hz.
d) 120 VAC, 50/60 Hz.

e) 230 VAC, 50/60 Hz.

8.2.51 Analog Outputs

The system shall support output types of 0-20 mA, 4-20 mA, ±10 V DC, 0-10 V DC, and 1-5 V DC.
Analog output modules shall operate with an error limit less than the following:

a) Voltage ±0.2% of output.
b) Current ±0.3% of output.

8.2.52 Digital Outputs

The following solid state output ratings shall at least be available:
a) 24 V DC.
b) 120 V AC, 50/60 Hz.
c) 230 V AC, 50/60 Hz.

Relay or solid-state output contacts that are free of voltage and ground shall be available.

Relay outputs with 24 VDC to 120 VDC, 48 VAC to 230 VAC, 5A rating shall be available.

Digital output module with actuator shutoff via low signal or high signal must be available.

8.2.53 HART I/O

The system shall support HART inputs and outputs. The HART interface shall be a module on PROFIBUS, or the HART devices can be connected to conventional analog input/output modules. All components shall have plug and play capability. The engineering system shall be able to read all variables provided by the field device without the need for any additional wiring.

8.2.54 I/O, instrumentation and couplers

The I/O Interfaces and couplers must be integrated in the alarm system of the control system.

The I/O Interfaces and couplers should optionally offer recording of events (SOE Sequence of Events).

The I/O interfaces should support high channel density (i.e. >320 discrete or >80 analog I/O).

The I/O interfaces / couplers shall support HART sensors.

The scan rate for all channels shall not be longer than 120 ms.

A 1 ms time stamp for Digital Input must be available (SOE= Sequence of Event Recording)

The system shall be capable of closed loop scan rates of 10 ms.

8.2.55 Marshaled Termination Assemblies

To reduce installation costs and startup time, the system shall offer a standard set of Marshaled Termination Assemblies (MTA) as a means of providing fast and easy connection to the field level while preventing wiring faults. These termination assemblies shall provide individual blown-fuse indication and redundant power connections. A common MTA shall support connection to a redundant or non-redundant I/O configuration.

8.2.56 Communications and Networking

The system shall utilize Industrial Ethernet on the System Bus for communication between controllers and HMI servers or single stations.

The system shall support the use of standard commercial, off-the-shelf networking components for the terminal bus to communicate between servers and clients.

The system shall support the use of Fiber Optic and Copper (Twisted Pair) media.

The system shall support communication at 10 Mbps and 100 Mbps on the system bus and up to 1000Mbps on the terminal bus network. The system should be able to be configured by GIGABIT Backbone 1000 Mbps.

A project-spanning network view must be available.

Intelligent field devices (PROFIBUS DP, PA, HART, FF) shall be accessible via an integrated configuration tool.

The system shall be able to control and diagnose intelligent drives via the field bus

The system shall support WLAN wireless networks.

The following network sizes shall be supported: Electrical – min. 1.5 km, Fiber Optic – min. 150 km, WAN – worldwide (incl. Web-client).

The vendor system should offer networking options and support hybrid applications and linking of package units.

8.2.57 Supported Architectures

The system shall support the following networking topologies for setup of the System Bus: Linear, Tree, Ring, Star, and Redundant.

8.2.58 Industrialized Smart Switches

Optional smart switches shall be available for use with the system that is designed for use in industrial environments. These switches shall have the following characteristics:

a) Support for Fiber Optic or Copper Media.

b) Built-in Digital Inputs that can be wired into the system to alert users of networking faults.
c) Signaling contacts to alert users of port or power supply failure.
d) Redundant power supplies.
e) Built-in web-based networking management tools.
f) High speed networking fail-over times of 300 msec or less.
g) Fan less design.
h) Extended temperature range - 0 degrees C to 55 degrees C.

8.2.59 Event-Driven Communication

To minimize the communication load on the System Bus, change-based communication shall be used by the system for the communication of alarms and events as well as for the communication of process data from the control system to the Operator Interface.

8.2.60 I/O Bus Redundancy

It must be possible to configure a redundant I/O bus.

The vendor shall provide coupler redundancy.

The vendor must provide a redundant ring structure of the I/O busses.

It must be possible to perform value acquisition from field devices as fail-safe (1 out of 2) and fault-tolerant (2 out of 3), the vendor must ensure this with his bus architecture.

8.2.61 Alarms, Events and Messages

The alarm system shall provide complete alarm and event management with a user definable message structure.

The alarm system shall support definition of up to 16 message sub-classes and 16 message types.
Alarms must be assigned a time stamp based on the execution cycle in the controller.

The vendor system shall support a time stamp resolution of 1 msec for binary inputs.

The alarming system shall support the display up to 1000 alarms per alarm window.

The status bar of the alarm system shall be freely configurable.

The alarm system shall alarm any change of state that the system detects including:

a. Any violation of limits
b. Any change of state of a device connected to the system including all of its peripherals
c. The failure of any communications channel used by the system
d. The failure of system's hardware, which results in an automatic fail-over of the system's functions from the active to standby device.

The alarm system shall display alarm messages in a manner to facilitate easy interpretation of the current alarm status including but not limited to:

a Different text color and background color for those points that are in alarm, those that have been acknowledged, and those that are no longer in alarm
b. Flashing of the current alarm message(s) in the alarm list
c. Alarms that have been automatically hidden by the system or manually by the operator
d. The system shall provide the option of displaying alarms in ascending or descending temporal order.
e. The alarm status and info text shall appear as icons
f. It shall be the possibility to filter the alarms according to different user-specific selections.

The vendor system shall provide a configurable, OS-spanning horn design.

The vendor system shall provide automatic alarm OR'ing in the plant overview, without additional configuration.

The vendor system shall support more than 4 alarm priorities and more than 5 permission levels.

The alarm system shall support the export of selected data in CSV format.

The settings of the alarm system shall be persistent.

8.2.62 Alarm Acknowledgement

The alarm system shall provide capability to acknowledge an alarm message when a data point enters and / or exits alarm state. The system shall permit alarm acknowledgement including but not limited to:

a. For an individual alarm from the overview
b. For a filtered grouping of alarms from a summary list
c. From the device faceplate
d. From a process display (screen acknowledge)

Alarm acknowledgement from one operator station shall be automatically synchronized to other stations to provide global acknowledgement capability.

The operator name shall be saved when alarms are acknowledged.

The system shall offer the option to disable or enable messages via a second set of keys.

The alarm system shall provide filtering to control the behavior of the alarm display screens. The filtering attributes shall include but not be limited to:

a. Date
b. Time
c. Alarm class
d. Alarm type

e. Alarm priority
f. Status (in alarm, out of alarm, or acknowledged)
g. Tag name
h. Area

8.2.63 Alarm Priorities

The alarm system shall provide the ability to condense and present system alarming status in the form of a standard alarm status symbol (i.e. alarm group display). The group display shall be capable of indicating the status of an individual device or of an entire process area. When used to represent the status of a process area, the group display shall form a logical OR'ing together of the alarm states from all devices in the process area.

The group display shall include the following standard alarm categories at minimum, which will each be represented in the symbol with a different color and text representation:

a. Alarm
b. Warning
c. System alarm
d. Operator message (operator action required)
e. Suppressed alarm state

8.2.64 Categorizing Alarms and Messages

Process and designated system alarms shall be annunciated, displayed and stored in history files. Normal plant operator actions, events and normal system actions and events shall not be alarmed; however, they shall be stored in centralized history files.
Alarms and messages shall be grouped to allow the user to readily identify and respond to alarms and conditions (e.g., in priority sequence) in his area of responsibility.
For any process alarm, it shall be possible, by no more than one operator action, for an operator to access a display from which he may take corrective action.
The system shall support the ability to display the highest priority, most recent, alarm at all times.

8.2.65 Operator Actions

The system shall automatically store all operator actions that affect process control parameters or alarm acknowledgment in centralized history files, including:

a. Enable/disable/acknowledge/suppress/lock/shelve alarms
b. Change mode of controllers
c. Change set point of controllers
d. Changes to alarm limits.
e. Changes to tuning parameters

8.2.66 Engineer Actions

The system shall provide the ability for Engineering actions that change the control and monitoring of the process to be stored in a log file along with a comment.

These actions shall include the following:

a. Download of controller configuration
b. Online/Test Mode
c. Download of Batch / Operator Station Configuration

8.2.67 Process Alarm Initiation

It shall be possible to initiate process alarms by configuring alarm attributes of any process I/O point or any calculated point.

For analog tags, the configurable triggers for process alarms shall include:

a. Process variable high limit exceeded
b. Process variable high limit exceeded
c. Process variable low limit exceeded
d. Process variable low limit exceeded
e. Process variable deviation from set point
f. Process variable invalid value (bad quality)

For digital tags, the configurable triggers for process alarms shall include

specific state (0 or 1)

8.2.68 Alarm Suppression / Disablement

The system shall provide the ability to disable or suppress alarms at the following levels:

a. For each individual alarm condition
b. For all alarm conditions associated with a device or point
c. For all alarm conditions associated with an alarm group, process area or displayed on a process graphic

8.2.69 Minimizing Nuisance Alarms

To minimize the occurrence and effect of nuisance alarms on an operator, the system shall provide the following capabilities for identifying, managing and preventing them.

8.2.70 Alarm Dead bands & Chatter Suppression

To minimize analog input chattering (a point going in and out of an alarm condition rapidly) there shall be configurable dead band parameters, on an individual tag basis.

To minimize the occurrence of nuisance alarms during startup / shutdown scenarios the system shall support alarm chatter suppression at the controller level. This feature shall ensure that alarms are not retriggered at the HMI until they have been acknowledged.

8.2.71 Industrial / Cyber Security

In order to protect the process automation system from the danger of hacker attacks, viruses etc., the vendor / system shall provide comprehensive industrial / cyber security capabilities consisting of products and procedures (best practices).

8.2.72 Use of "Defense in Depth" Architectures

The system shall support the use of a "Defense in Depth" strategy as recommended by the US Dept of Homeland Security. "Defense in Depth" advocates the creation of nested security architecture by division of the plant into secure and closed security cells / segments with clearly defined and monitored access points.

8.2.73 Rules for Creation of Security Cells and Segments

The following rules shall be followed to ensure the creation of secure and fully functional security cells and segments:

a. Each segment must form a self-sufficient "zone" that can be operated for a certain amount of time without connection to other segments; thus a segment must be capable of operating autonomously for a period of time.
b. All components contained in a segment and involved in its function should be connected to one another (not through leased lines)
c. Units that cause high network and computer load when connected from the outside via a complex security mechanism should be integrated directly in the segment
d. Access to a security cell should take place only after the user's identity has been verified and logged and only under supervision of authorized persons, for example, physical access by operators.
e. All connections to the Control System LAN should be routed through a firewall, with no connections circumventing it.

8.2.74 Securing network access points

The system shall allow clear demarcation between the protected internal network (control system LAN) and unprotected or untrusted external networks.

8.2.75 Use of Firewalls

The system shall support the use of firewalls to block selective (filter) traffic between network zones (subnets) or from a network to a device. To provide maximum protection, firewalls must allow for rules to be created which allow only necessary access by employing one or more of the following techniques:

a. Packet filtering
b. Circuit level gateways
c. Proxy gateways
d. Stateful inspection

8.2.76 Supported Firewalls

The following firewalls shall be supported at a minimum:

a. Windows XP Personal Firewall
b. Microsoft ISA Server

8.2.77 Security Modules for Industrial Environments

The vendor shall supply rugged, industrial-rated security modules as required, meeting the following characteristics:

a. Integrated firewall capable of Filtering on IP-, MAC addresses and ports.
b. Capable of providing the following additional functions: NAT, DHCP Server, Data encryption.
c. IP 30 protection.
d. Operating Temperature Range: 0°C to +60°C.
e. Capable of accepting Redundant Power input.
f. Can be configured / setup without expert security knowledge.

8.2.78 Creation of Demilitarized Zones (DMZ)

The system shall support the ability to segment the network by use of demilitarized zones (DMZ). DMZs shall be used to provide a secure access point for the following types of control system connections:

a. Data Historian (when it communicates outside the control network)
b. Web servers
c. Security servers
d. Software Update Service (SUS) Servers

8.2.79 User Management and Access Control

The system shall provide the capability of the central management of users within domains or workgroups providing the following specific capabilities:

a. Create, delete, and lock-out users.
b. Ensure IDs are unique.
c. Two-level ID (username + password) or Login Device (e.g. Card Reader).

8.2.80 Password Security

To ensure the security of the passwords used for accessing the system, the following capabilities shall be available:

a. Specification of password properties (min. length ...)
b. Limited time for password validity
c. Expired passwords excluded for the next "n" generations
d. Forced password change after first Log-On
e. Auto – log-off after "n" minutes of inactivity
f. Lock-out of users after "n" failed attempts to log-in.

8.2.81 Role-based Access Control (RBAC)

The system shall provide for user accounts with configurable access and permissions associated with the defined user role. The system shall support the implementation of the principle of minimal rights whereby users and computers can be configured with the minimum set of access rights necessary to perform their function.

8.2.82 Single Sign On

The system shall provide the ability for Single Sign On (SSO) authentication whereby a single login / password allows a user to have access to all programs (PC / Desktop Access, Engineering Tools, HMI, Batch Management) without requiring re-authentication for each application. The Single Sign on capability shall be capable of being used with Role-based Access Control (RBAC).

8.2.83 Software Security Patch Management & Testing

Continuous and immediate testing of new software security patches is critical to maintaining a secure network infrastructure.

8.2.84 Support for Immediate Installation of Microsoft Security Patches

If deemed necessary by the user, it shall be permissible to load the following new MS Security Patches on the system as soon as they are released from Microsoft:

a. Windows operating system
b. Internet Explorer
c. SQL Server

8.2.85 Testing of Microsoft Security Patches

To ensure that the latest Microsoft Security patches have been tested for compatibility with the system, the vendor shall test new Microsoft security patches immediately upon their release. Results of the testing shall be communicated to end users so that they can choose when / if to update.

8.2.86 Software Update Service

The system shall support the use of the Windows Software Update Service (SUS) from Microsoft as a means to quickly and effectively implement automatic deployment of software updates and security patches on all PCs connected to the control network. The SUS Server shall allow viewing of all available updates so that they can be released as required in a procedure determined by the end user.

8.2.87 Use of Virus Scanners & Malware Detection

The system shall support the installation of Virus Scanners on all PCs attached to the control network. The following Virus Scanners shall be supported at minimum:

a. Trend Micro Office Scan

b. Symantec Norton Antivirus
c. McAfee VirusScan

8.2.88 Minimizing Impact on System Performance

To ensure that virus scanners do not have a negative impact on system performance, the vendor shall provide guidance on malware detection settings for use with their system based on the results of system compatibility testing.

8.2.89 Updates and Testing of New Signature Files

To ensure that virus scanners are able to be continuously updated to prevent new malware threats, the vendor shall test new virus signature files immediately upon their release. Results of the testing shall be communicated to end users so that they can choose when / if to update.

8.2.90 Installation and Operation of Virus Scanners

The Installation and Operation of Virus Scanners shall comply with the following:

a. Engineering Stations and all other PCs where engineered data can be introduced to the Control System Network: Virus scanners shall be operated in a real-time mode with continuous scanning of all incoming traffic and shall support manual and periodic scans while offline (Runtime and Engineering)
b. Operator Stations: Virus scanners shall be operated in real-time mode with continuous scanning of all incoming traffic (Runtime)

8.2.91 Auto Configuration of System Security Settings

To minimize the chance of error during the configuration of security settings, the system shall support the automatic configuration of Windows firewalls and registry entries.

8.2.92 Securing Access for Remote Maintenance / Troubleshooting

The system shall be capable of providing a secure connection for remote maintenance and troubleshooting. This access point shall be securable through use of local firewalls and virus scanning software at a minimum. The following methods shall be supported:

a. Authentication and Encryption with IP Security (IPsec)
b. Authentication and Encryption with Secure Sockets Layer (ssl and https)
c. Use of VPN (Virtual Private Network) tunneling and Network Access Quarantine Control for Secure Support Access

8.2.93 Testing for Security Vulnerabilities

The system shall support the end user or designate testing for vulnerabilities using the Microsoft Baseline Security Analyzer (MBSA) or equivalent. Testing shall be able to identify the following conditions at a minimum:

a. Open ports and protocols in use
b. Missing Microsoft security patches

8.3 OPC SERVER DEPLOYMENT AND STANDARDS

The OPC Server deployment should conform to and take advantage of industry standard and de-facto standards.

These should include, but not be limited to:

a) ODBC
b) OLE
c) ActiveX
d) COM/DCOM
e) DDE and Advance DDE
f) C programming language
g) Visual Basic®
h) TCP/IP
i) OPC DA
j) OPC HDA
k) OPC Data Logger
l) OPC Alarm and Events (A&E)
m) OPC UA
n) XML
o) .NET

8.3.1 OPC ARCHITECTURE

The following diagram shows the proposed OPC deployment. OPC will be used as an abstraction layer so as to separate the various SCADA HMIs from the control network. The SCADA HMIs for the process plant will have its own Operator Server(OS) which is more than likely to use its own proprietary protocol, similarly the CCTV clients will use the Media Servers as their Server, finally the Energy and BAS SCADA HMI clients may be built on OPC but do not have to be OPC clients and may also work through OS's. The OPC layer is used to provide all data from all systems in a standard format so that it can be shared between applications.

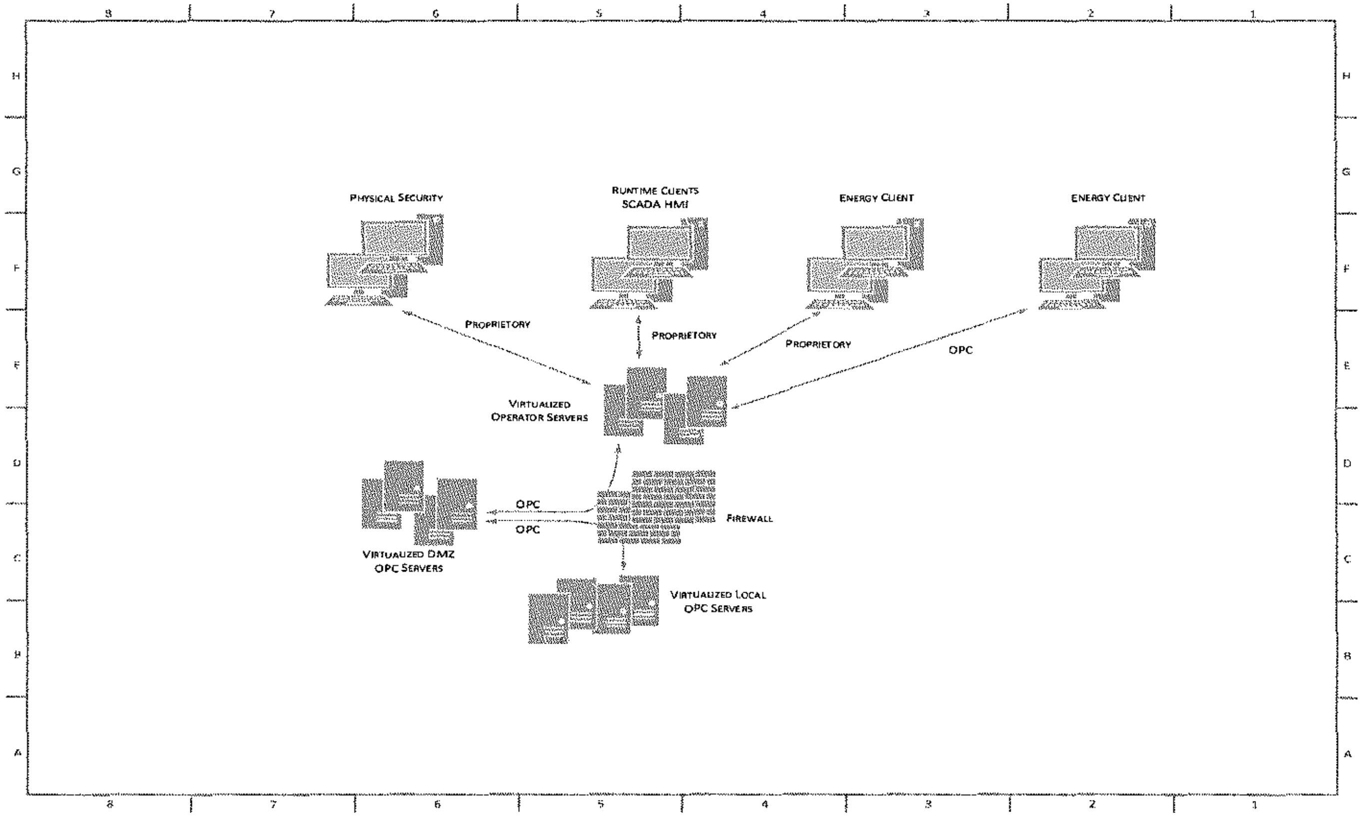


Figure 7 Plantwide OPC Architecture

8.3.2 OPC (OLE for Process Control)

The CONTRACTOR shall provide a true open system based monitoring and control system with its capabilities of acting as an OPC Client as well as an OPC Server. As an OPC Client, the system must be able to collect data from third party OPC data collection servers. As an OPC Server, the software system must be able to share the data and information it manages with other third party programs.

The CONTRACTOR shall provide the following OPC servers for the SCADA:

a) OPC Data Access (DA)
b) OPC Alarm and Events (A&E)
c) OPC Historical Data Access (HDA) <u>the historical servers shall be redundant in both the GCC and ECC</u>
d) OPC XML Data Access
e) OPC Data Logger

For the Historical Data Access server, the Active history for the proposed system shall be at least for 1 year. The Trending history shall also be one (1) year. The sampling rate for historical data shall be at least 1 sample per hour. The required sampling rate shall be agreed with the client. The Database for the historian shall be in Microsoft SQL server and it should support client/server architecture and it shall be open. The CONTRACTOR shall also provide media backup in external HDD format and it should have a high reliability so that the media files could be retrieved in case of controller failure occur.

8.3.3 OPC I/O SERVER Virtualization

The server solution proposes using virtualization of servers wherever reasonably practicable on the sites. Virtualization is the abstraction of hardware through software, separating the Operating System (OS) from its hardware,

In order to achieve efficient disaster recovery, which is considered and important factor for this project it is proposed to run Fault Tolerant Virtualization, by running two virtualized servers simultaneously.

One server will run the applications in the same way single virtualized system would, this server is the active server. The difference is that this active server is connected to a second virtualized server. This second server runs a shadow image of the virtualized instance from the active server. This means that the shadow server has an exact runtime copy of the active server.
When the system is stable, the primary communication to- and from the server is with the active system.

The SCADA system control room will communicate with the active server and with the controllers in the field and conversely with the SCADA HMI's in the control room. When a malfunction occurs, such as a failure of the power supply or CPU in the active server occurs, the primary communication shifts from the active server to the shadow system. Since the shadow server is in sync with the active server it is able to take over the operation of the active server seamlessly. With that, the shadow server becomes the active.

8.3.4 OPC Network and Server Virtualization

It is the intention of this project to run a hosted OPC environment with hosted hypervisors which will run applications with their own Server Operator Systems instances which will differ from the host Operator Systems environment on the native server. Therefore In the unfortunate event of a corrupt environment occurring, the host OS environment is not affected. This environment is ideally suited to the I/O server where downtime in the hosted Operator Systems will not affect the host Operator System environment.

The services to be run on the host Operator Systems environment server hardware platforms as virtual machines are defined as follows:

I. Building Automation Systems –Shared Hardware

II. Process Control- Separated hosted Environment and I/O hardware platform

III. Electrical Systems- Shared Hardware

IV. Fire Security and CCTV-Shared Hardware

V. Other Applications as Virtualized Services, (LDAP,NTP, TACACs +, SIP Proxy) run on Multi Service Platform- Shared Hardware in DMZ

Where there is a requirement for process control between pumping stations the Master PLCs residing at pumping stations shall communicate with each other using OPC DA.

8.3.5 OPC Server Supported protocols

The protocols to supported as an OPC service on the virtualized OPC servers are as follows:

a. BACNET

b. PROFINET

c. MODBUS

d. MODBUS TCP

e. PROFIBUS DP/PA

f. CIP OVER ETHERNETIP

g. OPC

h. SIEMENS H1 protocol (S7 400, S7-300)

i. Rockwell RSLinx,RSView32

j. ABB UNITROL 5000

k. SCHNEIDER TSX 07,TSX17,TS37,47,57

l. OPC GE STRP, SNP,SNP-X , EGD

8.3.6 OPC DA Server Communications

The OPC Data Access Server must support access to all online values according to the OPC specifications OPC DA V1.00, V 2.05a und V3.00. The OPC HDA server function must be able to provide other systems with data from the archive system and should achieve the specifications according to OPC specification OPC HAD V1.20. The OPC-Alarm&Event server must forward messages that can be acknowledged to the subscriber at the corporate management level. Filter mechanisms and subscriptions ensure that only selected data is transmitted at least according to OPC specification OPC A&E V1.10. The OPC-Historical-Alarm&Event server should provide the possibility to read archived alarms and events. An OLE DB access is to ensure that archive data of the MS SQL DB of the OS can be easily accessed. The software is executable at least under Windows 7 or latest on USB data medium; supply and implement ready-to-operate in overall system. *USB access shall be restricted for USB memory devices and allowed for peripherals (keyboard, mouse).*

8.3.7 OPC Server Data Transfer from distributed Systems, 250 process variables

This clause describes the software that transfers data from distributed applications and saves the selected data cyclically or on request to a new database. The software should consist of a Configurator and a Runtime module and should be capable of handling 250 process variables. The collected data should be saved to a separate database. This functionality should enable remote access with all front ends from stations logged on to the network. Moreover, based on the implementation of the optional ODBC driver, access to the data should be enabled by means of any SQL-compatible product. The configuration module must be included. If dial exchange is disabled, the data available on the subsidiary and central systems has to be synchronized whenever access is requested. If the dial exchange is enabled, the data should only be synchronized while a connection to the other system is active. The software should be based on TCP/IP client server architecture. In this context, it must be irrelevant whether access is requested via local network or router. Supply and executable implement on the computer.

8.3.8 Data Storage

There will be a requirement for the project to store large amounts of Data locally comprising CCTV footage and Process Data. We estimate that this will be in the region of a 100TB of data over 2-5 years. The long term objective is for this data to shipped out to a remote storage to be used by KAHRAMAA Financial Systems.

In the short term it is proposed to use an ISCSI fiber channel Storage Area Network solution. The SAN (Storage Area Network) will be a dedicated network which will provide storage to enterprise servers. The SANs will be located in the computer room configured using special switches and storage devices that communicate via Fibre Channel protocol. The Fibre Channel protocol will use block-level SCSI commands which are transmitted over parallel connections. The Servers will connect to the SAN using special Fibre Channel HBAs (Host Bus Adapters) capable of transmitting data at 10Gbps.

8.3.9 Alarm Management System, 8 Users

The Alarm Management System for the KAHRAMAA project calls for the fully automatic transmission of error messages from the higher-level SCADA HMI system to the people responsible. The Transmission of error messages shall be achieved using 4G LTE SMS gateway of the provider and output on local network printer. The following functions must be available: telephone book with at least 8 users, at least 1 simultaneous connection to the process, web configuration and operation, escalation system for unreachable users, delivery and commissioning in complete system.

8.3.10 SMS via GSM for Alarm Management System

Transmission channel for the direct sending of SMS short messages in the GSM network from the alarm management system in water and wastewater treatment plants for the fully automatic transmission of error messages, acknowledgment capability by reply SMS to end running escalation, GSM modem including antenna, ready-to-operate mounting, electrical connection and commissioning in complete system. The CONTRACTOR shall also make the provision of SIM card on site.

8.3.11 Server Redundancy

The system should support Server Redundancy. Server redundancy involves a primary factory monitoring server and a redundant "Hot Standby" server. The redundant server is essentially a mirror image of the primary server, running alternate monitoring/control processes and applications. Data collection is performed via independent or shared network paths to the same devices, depending on the protocol. The characteristics of the selected communications protocol(s) determine the details of the configuration.

Upon detection of failure of the primary server, the secondary server can assume control of data collection, alarm functions, applications, and allow user access with minimal loss of continuity. When the primary server comes back on line, control can be transferred back, and the secondary server will resume its backup role.

8.3.12 Communications Redundancy

The principle of redundancy in automated systems provides for switchover of functionality to a backup component in case of failure of a primary component. The switchover is considered automatic if no operator intervention is required. Redundancy applies to both hardware and software, and implies minimal loss of continuity during the transfer of control between primary (active) and redundant (backup) components. Redundant systems reduce single points of failure, preventing loss of functionality.

The system must support a software based redundancy solution as well as hardware dependent, high availability architectures as well.

For cell control systems, the major levels of redundancy include:

I. PLC

II. PLC LAN or serial connections to server

III. Computer networks

IV. Computer

Each level of redundancy shall provide a failover system that allows continuous system activity with minimal loss of data. The following sections briefly describe each level:

The SCADA HMI clients shall communicate with the Local OPC DA I/O servers that reside in the DMZ. There after the Local OPC DA servers will communicate with masters plcs for retrieving and sending data. The Local OPC DA servers will be virtual machines on a fully redundant hardware platform, comprising to Universal Connectivity Servers (UCS) rack servers or equal and approved. The servers shall be configured so that heartbeat signals operate on both the supervisory and subservient systems. It is proposed that OPC ORB is used at the supervisory level. Loss of communication from primary server shall trigger all requests to automatically be redirected to the standby OPC server.

8.4 HMI FUNCTIONS AND FEATURES

The following clauses describe the functional requirements of the SCADA HMI for process control. All SCADA data processing for visualization is carried out on the Operator Servers.
This section describes the configuration of the Operator servers.

The following diagram shows the proposed SCADA Architecture for process control between clients and OS servers.

8.4.1 Client Workstations

The SCADA HMI workstations are classified as Thick Clients and Thin Clients. Thick Clients include the runtime software and system graphics. Thin Clients receive graphics and process information directly from the Terminal Servers. Thin Client workstations are utilized due to their lower cost. Notebook workstations are also provided for remote access to the SCADA System both in house via wireless access points or off site via standard phone or cellular connections.

Recognizing the requirement for personnel to view the SCADA system SCADA HMI, a Web Portal is used for instances of non-critical applications for personnel requiring a view only interface into the SCADA system with no control capabilities. XLReporter is used in conjunction with the SCADA Historian for producing regulatory and adhoc reports. WIN911 is used for remote alarm notification to pagers and cell phones.

8.4.2 Client Workstations Software License

The predefined user interface of the operator system must have all the features typical of a control system. It should be multilingual, clearly structured, ergonomic and easy to understand. Operators must be able to survey the process extremely easily and rapidly navigate between different views of the plant.

The system must support the operator in the process with hierarchical display structures that can be configured as required. These facilitate the direct selection of lower-level areas during process control. It must be possible to call process displays and process PO by name. An online language selector should permit users to change the language during runtime. A standard view and a server view must be available for the technological representation of a plant, each with variously designed area overviews. Features provided in both views include: Message line for last message received, whose display must be configured in such a manner that either the message with the highest message class or highest priority takes priority, date, time-of-day and name of the operator, area overview with up to 36/49/64 areas (depending on the resolution of the process monitor), working area for plant displays and windows for faceplates, curves, messages, etc. that can be moved as required, system function keys.

In a special message view it must be possible to switch between control message pages such as new list, old list, list of sent messages, operator action list, control element list and message history list. Trends must be displayed as a full-size picture or as a window in the working area, and printed directly. Some trends/trend groups can be predefined already during plant configuration.

At runtime, operators must be able to compose their own trends, select them by process tag name, and save them for reuse. Message priorities must be issued as an additional attribute to the known signal classes to make it easier to view large quantities of signals and to be better able to distinguish important messages from the less important or to hide them. Operators must be able to specifically disable messages (alarms) from individual process PO or from all process PO of a display/area in the event of faults in a sensor/actuator or during startup. Disabling and enabling are recorded in an operator input report. Queued messages must be signalled by group displays representing preconfigured views of message/alarm lists based on signal groups.

The group displays should also indicate whether messages are disabled or not. The last message received - or the message with the highest priority when priorities are assigned - is to be displayed at the top edge of the standard view. A predefined window with further messages can be called up by means of the "Extended message line" button. "Loop-in-alarm" and "Select display using process tag" functions are to support the quick evaluation and clearing of the origin of faults. Using "Loop-in-alarm", the operator must be able to jump directly to the process display with the object which caused the fault and then call up the associated faceplate (loop display) through the process tag whose block symbol is to be colored (cyan). It must be possible to anchor the faceplate window (loop display) so that it remains visible even when the display is changed.

Flexible setting options for audible output and priorities which are to be defined using signal variables must support the signalling of messages/alarms through a sound card or by controlling external signalling devices via a signal module. By means of alarm management, it must be possible to hide and silence alarms that are of lower importance for the safe and fault-free operation of the plant in certain plant states. These alarms must, however, still be logged and archived as before. This is to reduce the amount of work for the operators considerably. Insignificant alarms must be hidden in two ways: dynamically, i.e. depending on preconfigured definitions for up to 32 operating states (Smart Alarm Hiding) and manually, temporary. Central user administration with access control that meets the validation requirements of 21CFR Part11 must be set up.

The administrator must be able to divide the users into groups and assign differently defined access rights (roles) to these groups. The operator obtains the specific rights when logging on within the scope of the access control. It must be possible to use an optional chipcard reader, for example, as logon device in addition to the keyboard. In addition, the central user administration must offer the "electronic signature" function. With the "Sign-of-life monitoring" function, the operator system must be able to monitor the correct operation of all subordinate systems connected to the plant bus. A graphical plant configuration display is to show the status of each monitored bus node. Together with a central timer, the operator system of the process control system is to implement system-wide clock synchronization on the basis of UTC (Universal Time Coordinated). Visual Basic and C must be the scripting languages available for user-specific programming of OS applications.

The visualization function of the operator system is to enable the user to display and operate the sequential controls configured with the SFC tool in the same way as on the engineering system. This must not involve additional configuration overhead. In an overview display it is possible, for example, to open step and transition displays and to present step comments or dynamically supplied step enabling conditions. The software is executable under Windows 7 Documentation on DVD. Supply and implement ready-to-operate in overall system.

8.4.3 Function Block Library

This clause describes the operation of the software required to provide a function block library as a supplement to an existing standard library for a process control system and associated automation system. The software is required to operate in the form of a tested and certified model application for the integration of industry-typical applications from the field level to the automation level to the operations and monitoring level. The library should be implemented in the graphical programming language CFC (Continuous Function Chart) and for sequence control (SFC Sequential Function Chart) according to DIN EN 61131.

The operation shall provide support of components from process instrumentation, energy distribution and drive technology. It shall also provide preparation of faceplates to link process information to a visual depiction with a uniform appearance for operations and maintenance, including the support of an integrated multi-control functionality from local (machine) control up to internet-capable operation over at least eight (8) operations levels of control. The Model solutions for start-up strategies for back-up units; digital value control and monitoring; analog value control and monitoring; volume recording and metered value recording; switching and operation hours counter; split range control; control with analog position feedback signal; cascade control; PID control for actuators; various control functions for valves and motors with fixed speeds, variable speeds and variable directions, each with interfaces for local control panels.

The library should also contain the following function blocks: adjustable polygon progression with at least eight (8) reference points; process signal selection from at least two (2) measured, counted or digital values; addition of two values including factor adjustment; 3-point actuator block; measurement monitoring for up to eight limits; operation mode switch with at least three (3) levels; communication functions with at least 30 measured values and 480 digital values between standard and fault-tolerant automation as well as between standard automation of various performance classes and unit function blocks with automatic switchover based on operating hours or managed control for up to 16 units.

The associated symbols shall be copied into the process diagrams of the process control system and incorporated into the process through a configuration assistant. Further requirements for the faceplates are: enabling; protection; interlocks; operation status; feedback signals; commands; run time, maintenance, limit and gradient parameters; pre-configuration of simulation, manual and substitution parameters; trends, messages, error messages and alarms with associated locking functionality and separate preview information, notepad functions with fixation when changing screens.

Activated process symbols in selected diagrams must be marked with the appropriate colors. The function block library including function block documentation must be delivered, installed on the Engineering Station and executable.

8.4.4 Database system

This clause describes the modular software tool for time-based and event-based recording of process data with the objective of creating reports which are accepted for use as official documents. The tool must meet requirements to the international regulations. The reporting software should run under Microsoft Windows 7 operating systems. The software should support a real client/ server architecture. All software modules (data acquisition, database server, evaluation and front-end modules) must be executable on only one standard PC for small-scale applications.

The database server must be capable of storing the process data from a wide variety of data sources, continuously compress the data in interval, daily, weekly, monthly and annual data overviews based on different algorithms. The software shall also calculate the calculation values in a continuous process and compresses the data in interval, daily, weekly, monthly and annual data. The calculation and compression of the data proceeds cyclically in the background, so that current data is immediately available to the clients.

The data server should also support redundant configurations. This type of data management must be available on up to eight computers with identical databases. The selective cross-plant data management should support central data storage systems. It must be possible to transfer the data from different remote systems to a central application via TCP/IP connections. The system must be capable of simultaneously processing data acquired from different process control systems, PLC components and telecontrol systems.

The drivers for OPC, ODBC, csv-file-import connections must be included. The system should support the automatic import of time-stamped data via CSV-/ dBase interface. Moreover, it should be possible to read in data acquired with handheld devices without problems via file import (CSV- / dBase files). Process values must be recorded cyclically, or by way of delta event recording. In three measuring ranges, users should be able to explicitly define a dead band for recording.

The recording must include cyclic control values additional. The following data compression methods should be used: Mean value 5% to 95%, arithmetical mean value, median, logaritSCADA HMIc mean value, last value, floating maximum / minimum, frequency, total, arithmetical mean value, max./min. hour, percentile (5% to 100%), standard deviation, standard deviation from sample (basic total - 1), 4 maximum values, 4 minimum values. Calculated values are derived from any logic operation with manual, automatic and calculated values. Mathematical, logic and binary functions, date and time operations, as well as conditional statements are available.

The reports generator must facilitate the creation of time-based reports with vertical or horizontal orientation. A comfortable editor should be provided for further report processing. In addition reports must include specific analog values, table objects and graphic presentations. The user-specific configuration of different report types must be supported. The modification reports log all parameter settings of the software, any start and shutdown of the software, all login and logout operations, and all entries or manipulation of values. Reports can be transmitted by e-mail, either displayed on screen or printed out in manual or auto mode. Non-cyclic events (e.g. rain water overflow) must be visualized in event reports. Based on the recorded process data, the start and end conditions for such event reports must be determined and used as a basis for evaluation. The evaluation of events always consists of three parts: the start, the end and statistics relating to the selected time frame.

Some data parts can optionally be used alone. Event reports should present the recorded data in a graphical and tabular way. In daily, weekly, and monthly reports the event reports plus the statistic for the time span also should be presented The following functionality must be available: manual input of values and editing, overwriting automatic recorded values (including input of a comment for each automatic value that is overwritten); viewing, creation and output of process, daily, weekly, monthly and annual reports, including variable time reports; export of data in CSV format (compatible with MS Excel; export of data from graphic views as picture object or value table to the clipboard; automatic data backup; logging of comments for specific process variables; central recording of comments (diary function).

The diagram module must enable the simultaneous opening of up to 64 different diagram windows. Different types of representation of diagrams in particular: time diagrams, frequency diagrams, cumulative frequency diagrams, probabilistic network to Dr. Groche, X/Y diagrams, interleaved diagrams, maximum – evaluation functions (e.g. power peaks) must be integrated directly in the user interface of the process control system. Standard functions to provide for graphic visualization: 2 rulers, zooming of areas selected with the mouse, scrolling of the time range, time offset of specific process variables as relative or absolute parameters.

An Excel AddIn to present the data of any compression level should be included in delivery. User administration should support the explicit assignment of authorizations for the various software functions. It must be possible to explicitly disable or enable selected software modules and corresponding options of user intervention.

Alarm windows can be defined interactively. Five window types should be available. Insertion of background graphic objects should be supported. Colour changes must be configured. With the replay mode it should be possible to play back historical data. Supply as an executable application for one client, including 2 installations of 10000 process variables on the computer mentioned before.

8.4.5 Web Server Software for Control and Monitoring over for 10 Clients

The software must support operator control and monitoring of process control systems over the intranet. The software must be installed on a web server. The web server shall access all subordinate OS servers and makes all project data available. Access to at least 12 lower-level process data servers must be possible. The web-interface shall happen via an internet browser with plug-ins installable via the World Wide Web and via an autarchic integrated browser. A plant must be operated and monitored via the web-interface in the same manner as an OS-client. The process displays must be presentable by the web browser. The simultaneous access of at least 10 web clients must be possible. The software shall provide support of access authorization, user administration, security mechanisms (router, firewall), single license on USB data medium, at least executable under Windows 7.

8.4.6 Client Workstation for upto 10K Process Objects

The PC-based SCADA HMI system for visualization and operation of processes for plant for this project shall support upto 10K Process Objects for signalling and acknowledging events, running on a Windows 7 Platform. In addition it shall support, zooming, DE cluttering, panning in process graphics with multi-monitor operations (at least 4 monitors), prevention of unauthorized operations by user administration, operation and observation of several servers, dynamization of graphic objects, trend controls, setpoint/actual trend display by means of F(x) representation, 25 trend windows/image, able to display several Y-axis, picture-in-picture technology, signaling system, separate display of alarms, warnings, disturbances and faults, audio output of alarms, evaluation of individual bits, individual and group acknowledgement, user-definable evaluations, integration of protocols according to DWA M260 is possible, integration of standard Windows applications such as MS Excel, MS Word, MS.

Access must be possible by means of the standard mechanisms OLE Custom Controls, ODBC/SQL. All configuration and process data is stored centrally in a project directory (process data server) on one or more drives. The client, however, can also have local images and process local actions and thus speed up the image selection and selectively reduce the load on the server(s). Supply the system software with optional update service and implement ready-to-run in the computer system.

8.4.7 Local Multi-Panel for Machines and Plants

The Local SCADA HMI Panels for operating and monitoring of large plants and machines for this project shall be suitable for installations within extreme pollution, qualified for use in corrosive environments (e.g. H_2S, Cl_2, NH_3), condensation, ice formation allowed, aggressive atmosphere according to ISA-S71.04 G1, G2, G3, GX and EN 60721-3-3 chemical (-3C4), mechanical (-3S4) and biological (-3B2) active substances, ATEX/FM-certifications on request.

They shall also support the use as thin client for terminal services, remote maintenance and services via the Internet / Intranet, OPC interfacing to different manufacturers, display of HTML documents, with pixel-graphics 15.1" TFT-touch display with background lighting, 65536 colors, resolution 1024 x 768 pixels, MTBF 50000 h, Windows CE operating system, mouse and keyboard connectable via USB, flash memory with 12288 KB for applications as well as 1228 KB additional memory for options, RS422, RS485 interfaces with 12 Mbit/s, Multi Media card slot, 2xUSB, 2xEthernet interface RJ45, printer terminal, 1xCompact Flash card slot, supply voltage 24 V DC, backed-up hardware clock adapted for synchronization, task scheduler, help system, dynamic positioning of objects, vector graphics, curve functions and bar display, calculation functions, external evaluations with Excel and MS Access, Internet Explorer, input/output fields, configurable control fields with 16 functions simultaneously, online evaluation using characteristics, Visual Basic Scripting, signalling system with different alarm/message classes, message buffer for 1024 entries, 500 process images, 50 archives per project, 50000 entries per archive, recipe memory for 500 recipes, 50 user groups can be set, password protection, 16 online languages, multimedia card data carrier support, time interrupt function for cyclic function processing, display of graphics, bars, predefined texts, buttons. Integrated signalling system with 4000 messages, remote download for configuring USB, MPI, PROFIBUS DP, Ethernet, Modem and CF or SD/Multi Media Card, degree of protection IP65 on the front, according to IEC 60068-x, IEC 6199-4-x, IEC 61131-2, including operating instructions, Compact Flash card, back-up battery; supply and mount ready-to-operate.

8.4.8 Local Touch/Button-Panel Functionality

All Machine –Vendor Supplied PLCs shall have a Operator panel for operating and monitoring plants and machines with pixel-graphics 5.7" STN LC display with CCFL background lighting, 256 colors, resolution 320 x 240 pixels, MTBF 50000 h, membrane keyboard with 32 function keys and 26 LEDs as well as touch functionality, Windows CE operating system, ARM CPU, Flash memory with 2048 KB for applications, RS422, RS485 interfaces with 12 Mbps, USB, Ethernet RJ45, printer terminal, Compact Flash card slot, supply voltage 24 V DC, hardware clock without back-up, task scheduler, help system, dynamic positioning of objects, vector graphics, curve functions and bar display, input/output fields, configurable buttons with up to 16 functions simultaneously, signaling system with different alarm/message classes, message buffer for 256 entries, 500 process images, recipe memory for 100 recipes, 50 user groups can be set, password protection, 16 online languages, multimedia card data carrier support, time interrupt function for cyclic function processing, display of graphics, bars, predefined texts, buttons. Integrated signaling system with 2000 messages, remote download for configuring USB, MPI, PROFIBUS DP, Ethernet, degree of protection IP65 at front, CE, UL, CUL and C-Tick certification, approvals according to EN 55011, EN 60079-0/ -15, EN 61000-6-2/ -4, EN 61241-1, IEC 60721-3-2/-3, IEC 61000-4-2/-3/-4/-5/-6, IEC 61131 and IEC 61241-0, dimensions (W x H x D) 243 mm x 212.5 mm x 45 mm, including operating instructions, user manual, PROFIBUS connecting cable; supply and mount ready-to-operate.

8.4.9 Software for PC Monitoring

This Project calls for Software for monitoring individual PCs in the network via the central server, signalling and reporting of the computers connected in the network, monitoring functions for internal temperature of processors and devices, fans, system state through Watchdog and Heartbeat, function of the hard disk, reporting of operating hours for controlling service intervals, alarms, program interruptions after execution of watchdog, hard disk problems by evaluating diagnostics bytes, communication via OPC client, SNMP, remote via LAN, local with DLL, responds in case of an alarm by starting customer applications or implementing a reset, logging of automatic recording of all messages and operations in a LOG file, measured data of the fans, visualizes the recorded measured data with trend analysis, runs under Windows 7 supply and install ready-to-run in PC system.

8.4.10 Diagnostics of Plant Objects

The SCADA HMI must be capable for running diagnostics of plant objects to enable the system-integrated central diagnostics of all system components for visualizing the maintenance information of the entire automation technology. Starting from the field level/machine to the bus systems and protocols, field modules, PLC all the way to the PC level, all components can be centrally diagnosed. In doing so, the data is automatically adopted from the hardware configuration. A manufacturer-spanning and uniform display of maintenance and diagnostics data is made possible. All diagnostics events are to be logged, likewise all operator actions by the maintenance personnel – thus assuring the traceability of the events and operator actions. They are also the basis for later analyses to optimize the plant

While in operation, the plant management depicts all connected control components (PLC, operator devices), switching devices, drives, networks (e.g., ETHERNETIP, PROFIBUS, and PROFINET), etc. and monitors the current plant status with uniform symbolism. In doing so, the program not only responds after an error has occurred (i.e., corrective maintenance), but also to warnings generated by the components that are to prevent errors before they happen (preventive maintenance). Such condition-based measures have to be scheduled so that the available resources are optimally utilized.

The diagnostics system is to enable a connection to existing systems such as SAP. Likewise, maintenance order management systems are to be connectible. It should be possible to initiate maintenance orders in these systems directly from the diagnostics system.
An optional notification via SMS, e-mail, pager, etc. should be possible.

The diagnostics system is to be seamlessly integrated into the existing operating structure – no separate tool is to be used – to avoid increased training.

The diagnostics system is to be executable together with the process control system on one computer, but also on a separate computer. A diagnostics via the Web is to be possible as well (display of the maintenance and diagnostics information/screens via the Web including operation).
The diagnostics views (including messages, diagnostics/device/maintenance information, navigation) are to be generated automatically by means of the existing configuration to avoid a new, additional and complex configuration.

The diagnostics views are to be integrated into the existing process control and also be usable on a separate diagnostics station.

The overall system is to offer uniform, integrated diagnostics, even when dealing with multiple subordinated systems and processes of various kinds (e.g., process industry and manufacturing industry).

Information from the diagnostics system can be transmitted to and exchanged with other systems through the same interfaces as those of the basic system (example: all devices "undergoing maintenance", all devices with maintenance request "highest priority", all operator actions in the context of the diagnostics, etc.).

In addition, it should be possible to include mechanical, wearing components and component assemblies in the diagnostics, e.g., motors, pumps, gears, etc.

A diagnostics via the Web (Intranet/Internet) is mandatory.

8.4.11 Maintenance Management

In the control system, a module containing maintenance functions is to be fully integrated – thus supporting the plant operator in the inspection, service and maintenance of the plant.
By combining calendar intervals with operating hour meters and switching cycle counters, optimal maintenance dates/maintenance intervals are to be determined. In addition, an order is to be activatable directly through process signals.

For the maintenance reports, it has to be possible to define maintenance objects (e.g., pump, slider) that are linked to an input/output signal. Maintenance orders are assigned to these maintenance objects, whose interval counters count depending on the

a. Runtime

b. Calendar time

c. Number of switching cycles

The performing of maintenance is acknowledged by the user and stored in the system. The intervals for the actual and total times are to be correctable (necessary, e.g., when replacing pumps).

The following overviews are to be retrievable on the screen by the user:

a. Status of all maintenance orders

b. Dates of recommended maintenance

c. Dates of maintenance announcements

d. Dates of planned maintenance

e. Dates for today, tomorrow, past/next month/week

f. Percentage availability or exceeding of the interval

The following must be implemented:

a. Management of all maintenance dates and corresponding documents.

b. Maintenance through combination of performance measurement with calendar and event control.

c. Automatic (one-time/cyclically) or manual maintenance activation.

d. Overview with maintenance orders in tabular form and as object structure.

e. Manual damage assessment and repair orders.

f. Order management and planning.

g. Order feedback with configurable feedback and weak spot codes.

h. Post-processing of order feedback.

i. Long-term archive with filter and export functions.

j. Master data management can be imported and exported, thus creation and modification possible with, e.g., MS Excel.

k. Automatic or manual logging of all maintenance data.

l. Integration of the maintenance data into industry-specific reports.

m. Display of the maintenance data in process screens possible.

8.4.12 Machine Status Monitoring

The system is to offer the possibility of recording the machine status and of depicting the course of the status changes in graphical and tabular form. By means of formulas, specific metrics such as availability are to be determined and depicted in the process control system. Common standard values such as MTBF are to be stored as predefined formulas. Different values are to be comparable with each other and displayable in graphical form, e.g., as bar chart. Immediate analyses are to be possible on the basis of archived values.

8.4.13 Message Forwarding

The system shall be capable of automatically forwarding messages and alarms from the subordinated automation systems to pagers.

The system shall be Web-based, where pages can be directly initiated from the user interface and changed at any time. The following paging services shall be supported:

a. SMS via GSM modem with acknowledgment capability.

b. Voice dialog by telephone.

c. E-mail sending.

d. Output of message on the display of ~~HiPath®/Hicom®~~ telephones.

e. Output of message via paging systems.

The service units defined in advance (e.g., mechanics, electricians) are assigned in a so-called phonebook to the individual persons. Via the shift management, it is defined to which persons at what time in the respective service unit, the messages are to be sent. By using an alternate path strategy, it is made sure that the message is successfully delivered even if individual persons are not reached.

8.4.14 Telecontrol

The DCS system shall be capable of directly connecting to telecontrol remote pumping stations etc., i.e., without a PLC as interface. This means that the central computer operates as telecontrol centre with regard to the data connection. Via 4G LTE, current process values as well as messages from the substations are processed by the control system. Control commands and setpoint values are entered by the operator in the control system and transmitted to remote pumping stations for further processing. Messages and measurement values archived in the control system must be transferred exactly in time, i.e., with timestamp, to the control system, and be chronologically entered there into the archive (pre-processing of the process data in the telecontrol substations).

The status information of the substations is to be displayed in the control system by means of standard screens. The operator must be notified directly at the graphics objects (e.g., actual value fields) about faulty remote pumping. Analog values can be converted via a linear raw value adaptation from the raw value into the physical value and vice versa. Counter values receive an overflow treatment and can be processed with regard to their interval quantities. They are likewise transferred to the control system exactly in time and processed. The transmission paths to the stations are to be designed redundantly. Should one connection path fail, the alternate path is to be automatically used.

8.4.15 Uniform, window-oriented User Interface

The process events are to be transparently controlled and optimized with the control system. Functions are to be available that ensure an efficient and reliable process operation

The design of the user interface is to offer a flexible and task-appropriate depiction of the process dialog. For a better overview, a split – for example – into overview, work and button areas can be performed. This ergonomic and process-oriented arrangement of the process screen as well as the structuring of the process screens in a hierarchy are to be automatically created by wizards. Already configured screens can be placed object-oriented with the mouse at the intended location in the hierarchy tree

All area and detail screens are to be directly selectable via globally valid keyboard shortcuts.
It should be possible to embed other applications into the user interface of the control system to enable a seamless operation (by configuring corresponding OLE containers). Furthermore, it has to be possible to access OCX/ActiveX and .NET objects. With that, the functionality of other programs is to be homogeneously integrated into the user interface of the control system

An overlapping stop is to protect against the overlapping by other screens, i.e., screens are displayed or hidden depending on their size or the configured screen layer (decluttering). This ensures that an operator immediately sees important feedback from the process – e.g., via output fields or message displays – and can respond to it without delay. In runtime, process screens can be enlarged with the mouse (zooming) and screen sections be moved with the mouse wheel (panning).

The control system is to utilize the following input media familiar from the Windows world:

a. Keyboard

b. Mouse

c. Touchscreen or on-screen keyboard

If the standard pointer is positioned over operable objects, it is to change its appearance (I/O field: mouse pointer plus cursor; object operable by mouse: mouse pointer plus arrow). The extra object is freely adjustable.

The control system is to record tag operations.

Recorded are:

a. Date of the event

b. Time of the event

c. Name of the logged on user

d. Name of the object/parameter that was operated

e. Old value prior to the change

f. New value after the change

Operations in critical process situations are thus traceable and reproducible. The display and operating functions are to be supplemented by project-specifically formulated actions. In critical situations, the control system can thus accurately guide the operator in the elimination of the problem and prevent downtimes (automated operator guidance).

The handling of an alarm automatically leads into the screen with the malfunction.

8.4.16 Possibility of integrated Online Parameterization

It is assumed that a comprehensive parameterization system is integrated into the system, with which the user can adapt the function scope and the functionality to changed requirements without programming knowledge.

The system is to allow these parameterizations to be carried out while in runtime. In practice this means that while in operation, the respective editor can run in a second window and the configuration personnel can make specific changes to the application – without having to exit the process operation and without affecting the background activities.

Furthermore, it should be possible to make configuration changes on an operator station.

8.4.17 Object-oriented Data Model

The objects physically present in the plant are to be correspondingly mapped in the system, e.g., a pump with various parameters as structured tag with multiple parameters. A key advantage of the object orientation is that the real world (the technological process) can be closely mapped to the DP world. Thus, all signals and values belonging to a unit (pump, slider, etc.) can be summarized in the form of structured PO and be processed together.

8.4.18 User Administration

Each operation of the process, the archives and the control system is to be lockable against unauthorized access, which includes making changes to setpoint values, the selection of screens or the calling of the configuration software from the process operation.

There shall be different access levels that enable the setup of a hierarchical access protection as well as exclusive authorizations for individual users.

Password and user name determine the access rights of an operator. They can also be newly defined during the process operation. For this, a convenient user administration is to be provided.

It is to be possible to centrally manage the user administration of all computers that are part of the system. In doing so, the system integrates itself into the user administration and security system of Windows. It does not matter whether the Windows security system is implemented on the basis of work groups or via a domain (e.g., corporate network).

In the case of a connection failure to the central user administration, it must be ensured by means of an "emergency operator" that the process operation remains possible, albeit with restrictions.

An automatic logging off after a predefined time is also possible, as is the locking of the access following multiple incorrect password entries. Changes to the access assignment can be performed online – plant-wide and across applications. The operator identification shall optionally be carried out via a smart card.

This mechanism must be integrated into the central user administration.

8.4.19 Open Interfaces for Standard Software

The integration of standard Windows applications such as MS® Excel, MS® Word or MS® Access is to be possible via the standard mechanisms OLE/ActiveX and OLE-DB/SQL. Any application program (e.g., custom data management, analysis, process optimization) is to work together with the control system via the integrated C programming interface, and then be able to use control system data as well as control system functions.

To enable a manufacturer-spanning communication, the control system is to be OPC-capable. Through it, current process data is to be made available to other computers and applications, and also be read from them. Thus, any computer connected to the network is to have access to all data of the control system.

A standard database (e.g., Microsoft SQL) is employed to store (transaction-safe) all list-oriented configuration data such as tag lists and message texts, but also current process data such as messages, measurement values and application data records. The database is accessed via the open programming interface C-API or OLE-DB.

The system is to support the programming language Visual Basic for Applications (VBA) to flexible meet the functional requirements – particularly during the engineering phase.

8.4.20 Open Interfaces for Application Software

It is crucial for the control system to offer options for the homogeneous integration of other applications and application blocks into the user interface for the process operation. It should be possible to integrate application windows as well as OLE Custom Controls (64-bit OCX objects) or ActiveX Controls into the control system application – as if they were objects belonging to the control system.

To make graphics objects dynamic, the use of the scripting languages ANSI-C and Visual Basic should be possible.

8.4.21 System Behaviour during Malfunctions

After a malfunction has been cleared (e.g., restart of a PC), the startup is to automatically proceed in such a way so that the operation of the overall system resumes without requiring operator intervention. In doing so, the process image on the operator stations is to be updated; gaps in the data acquisition are to be marked.

8.4.22 Efficient Configuration

The configuration user interface of the control system is to include wizards, editors and tools that enable an efficient configuration.

It should be possible to manage and modify all texts (graphics objects, messages, etc.) from a central location. By exporting the texts into Microsoft Excel, they can be translated for multilingual projects independent of the system.

When employing PLCs, it should be possible for the symbolic tag designations created there to be directly assumed by the control system. This reduces the configuration work and the susceptibility to errors.

For the mass configuration of the configuration data, the option of influencing the entire database via Microsoft Excel is to be available. In this way, e.g., PO can be created/changed, messages be generated and archives be configured in a very short time.

To test the configuration even without a process connection, a tool is to be provided, with which process values can be simulated. The tool should be able to simulate different curve shapes (sinus, square, random, fixed value, ramp).

In the graphics system itself, frequently used parameterization steps are to be automated by wizards. A variety of wizards for influencing the configuration is to be supplied:

a. System functions (e.g., for assigning system functions to buttons).

b. Standard dynamics (authorizations, set/reset bits, move objects, fill objects with color, etc.)

c. Assignment of screen navigation functions to individual objects.

Furthermore, it should be possible to create own wizards to make the user-defined configuration more effective.

8.4.23 Graphics System

The graphics system of the control system is to process all inputs and outputs on the screen during the process operation. The screens for the visualization and operation of a plant consist of simple as well as complex graphics objects. During the configuration phase, they shall be integrated into the screens with the aid of the graphics editor, which is part of the control system.

For designing and operating an attractive user interface, a number of objects are to be available:

8.4.24 Static objects

a. Line, connector (line element)

b. Polygon, polyline

c. Circle, circular segment, circular arc

d. Ellipse, elliptical segment, elliptical arc

e. Rectangle

f. Rounded rectangle

g. Static text

8.4.25 Ready-made objects

a. Table window, trend curve window, message window, report window and screen window

b. OLE objects

c. OCX (ActiveX) objects (OLE Controls), .NET Controls

d. Input/output field

e. 2D and 3D bars

f. Graphics objects (BMP, WMF, EMF, GIF, JPG, DIB, ICO, PNG)

g. Status displays

h. Text lists, multiline text (with scrollbar)

i. Combo boxes, list boxes

j. Group displays

8.4.26 Windows objects

a. Buttons (rectangular, round, symbolic, with text)

b. Checkboxes

c. Pull-down menus

d. Slider object

8.4.27 Pipe objects

a. Polygon pipe

b. Tee pipe, double-tee pipe

c. Elbow pipe

The appearance of all graphics parts should be dynamically controllable. Parameters on geometry, color, pattern, etc. shall be directly addressed and specified via tag values or from programs.

Thus, for example, a line is to be colored red, green or blue, a circle is to change its size or a group object is to move on the screen. Status displays shall be controlled by means of alternately displaying and hiding individual, superimposed graphics objects.

In this way, the process, the processing in the control system, actions or also standard Windows applications can actively influence the display.

Examples of properties that are to be dynamically changeable:

a. Object color and pattern

b. Background color and pattern

c. Line color, width, type, beginning, end

d. Font

e. Write direction horizontal, vertical

f. National language of label texts (by operation)

g. X and Y coordinates in pixels

h. Display of objects (visible/invisible)

i. Circle radius

j. Start angle, end angle

k. Edge radius

l. User authorization (by operation)

m. Lower limit, upper limit of bars

n. Hysteresis behaviour of bars

o. Scaling and scale graduation for trend curves (by operation)

p. Filling of any polygon (also with patterns)

The control system should also offer the possibility of using already existing graphics or photographic material for the design of the screen. Graphics files with the format BMP, WMF, EMF, GIF, JPG or other shall be imported via OLE. Furthermore, it should be possible to directly integrate AVI and animated GIF files.

With the graphics system, user-defined menus can be created – just like the ones familiar from Windows applications. This menu structure can then either be displayed in all or selected process screens. By means of individual VB scripts, the desired functions are stored at the individual menu items. Thus, screen jumps as well as any action can be realized.

8.4.28 Global Design Templates

The SCADA HMI must support global design templates, in this way the process visualization can be given a uniform "look & feel". The graphics system supplies a wide range of different templates, which can be used or adapted. Through innovative 3D effects, the visualization can be adapted. Each object can be provided with shadows and the "hover effect" can be selected, which changes the depiction of the object as long as the mouse pointer is over the object.

Changes made to the global templates have an effect on all process screens used. For example, by using and centrally modifying the global color palette, a subsequent adaptation is possible at any time without much effort.

It shall also be possible to export the global templates from the projects and to import them.

The system is to offer a type/instance concept for graphical objects, i.e. the user can configure an object, with further changes being made centrally at the type and propagated to all instances.

8.4.29 Measuring Systems (GSD files) -Instrumentation

The configuration tool for cyclic I/O operation must be able to do the following process GSD (device description) files and maintain a hardware catalog of devices to be configured on the bus to allow:

a. the PROFIBUS device address to be specified

b. the specification of the input and output data to be transferred between master and slave

c. certain startup parameters to be selected in order to activate specific operating modes or features of the device

d. selection of the system baud rate generate the database file so it can be used by the controlling PLC

The project calls for all PLCs in the field to be PROFIBUS Masters and all Field Instruments to be PROFIBUS Slaves. The selection of field PLCs must give consideration to the instruments and develop a device description (GSD) file which completely describes the PROFIBUS functionality of the field instrument – for example

a. baud rates supported

b. possible input output data configurations

c. startup parameter

The GSD files for each instrument must be downloaded via the Internet from the vendor's web site.

The GSD file shall be capable of being imported or copied into the PLCs PROFIBUS configuration tool and shall appear in the tool's hardware catalog, which enables it to be configured for bus operation.

Defining the bus configuration shall be a straightforward process by first picking the appropriate master from the master device list in the hardware catalog and assign a PROFIBUS address. Product diversity should be kept as low as possible.

For the parameterization, commissioning, service and maintenance purposes with PROFIBUS DP/PA, the corresponding device master (GSD) files must be stored and retrievable from either a DATABASE server over the PROFINET network or Master PLC on the PROFIBUS network. Remote monitoring shall be possible from the control station system workstation. The remote parameterization and monitoring of the PROFIBUS nodes and their management and support in general will be carried out centrally on the engineering system with the control room. However it must be possible to implement different network gateways, e.g. to EIB bus, ASi bus, and INSTA bus.

8.4.30 Device Diagnostic Reporting

The PROFIBUS protocol for this project will be generally a sub field bus instruments communications to PLCs and will sit below the control network protocol and be responsible for communications between instruments and Field PLCs. For details of the PROFIBUS network refer to the PLC Diagrams.

It is proposed that during a data-exchange cycle, the PROFIBUS slave device (Instruments) will indicate to the master that it has detected a diagnostic condition. In the next data-exchange cycle, the master shall receive the diagnostic information from the slave (instrument). The slave device (instrument) shall be capable of reporting diagnostic information in four different formats: standard diagnostics, device-related diagnostics, module-related diagnostics, and channel-related diagnostics.

The PROFIBUS master must save any diagnostic data from a slave in order for the engineering system to access it.

The standard diagnostics (six bytes) that every slave device is required to report contain information that is generally related to startup problems. For example, if the I/O configuration that was set up in the configuration tool does not match what the slave expects, it will report a "configuration fault."

In this instance if the slave is configured in the configuration file, but the slave actually found on the bus at that address is different, the device shall report a "parameterization fault." The six standard diagnostic bytes are used to report faults that are common across all slave devices .The vendor can use the device-related diagnostics format to report information that may be specific to the particular device or application area, and that cannot be reported using the standard module-related or channel-related diagnostic formats. The format of this type of diagnostic information is defined by the vendor—its detailed structure is not covered in the PROFIBUS standard. In this instance vendor shall provide the device's documentation to determine the exact format for programming.

In general the format used to report diagnostics must follow the PROFIBUS standard.

8.4.31 Acyclic and Cyclic I/O Data Exchange-Component Based Automation

This project calls for communications between Master PLC to Field PLCs and as such will require predominantly for communications based on distributed intelligence using graphic based configuration of communication between modules. .The vendor is permitted to use the CIP OVER ETHERNET/IP which is considered to be and equivalent to PROFINET I Device.

Each Logical Ring within the site has a Master PLC, which serves as a Logical ring Master. Since all Logical ring Master PLCs are on the same VLAN (VLAN 10) all communications between them will real time and deterministic and can therefore also access all PLCs albeit pipework or Vendor Supplied PLCs on any physical ring segment . The Logical Ring Master PLC are responsible for retrieving Cyclic and Acyclic data from specific Pipework PLCs and

In this context the term Master PLC is not used in same way as in a PROFIBUS environment where this means that the slave device cannot initiate communication with the Master.

For information on which data is required to be shared between PLCs refer to the P&ID specifications which form part of the MEICA specifications.

For a more detailed description of PROFINET see Appendices of this Specification

The following diagram describes the Profinet and Profibus Architecture (Analysers Only).

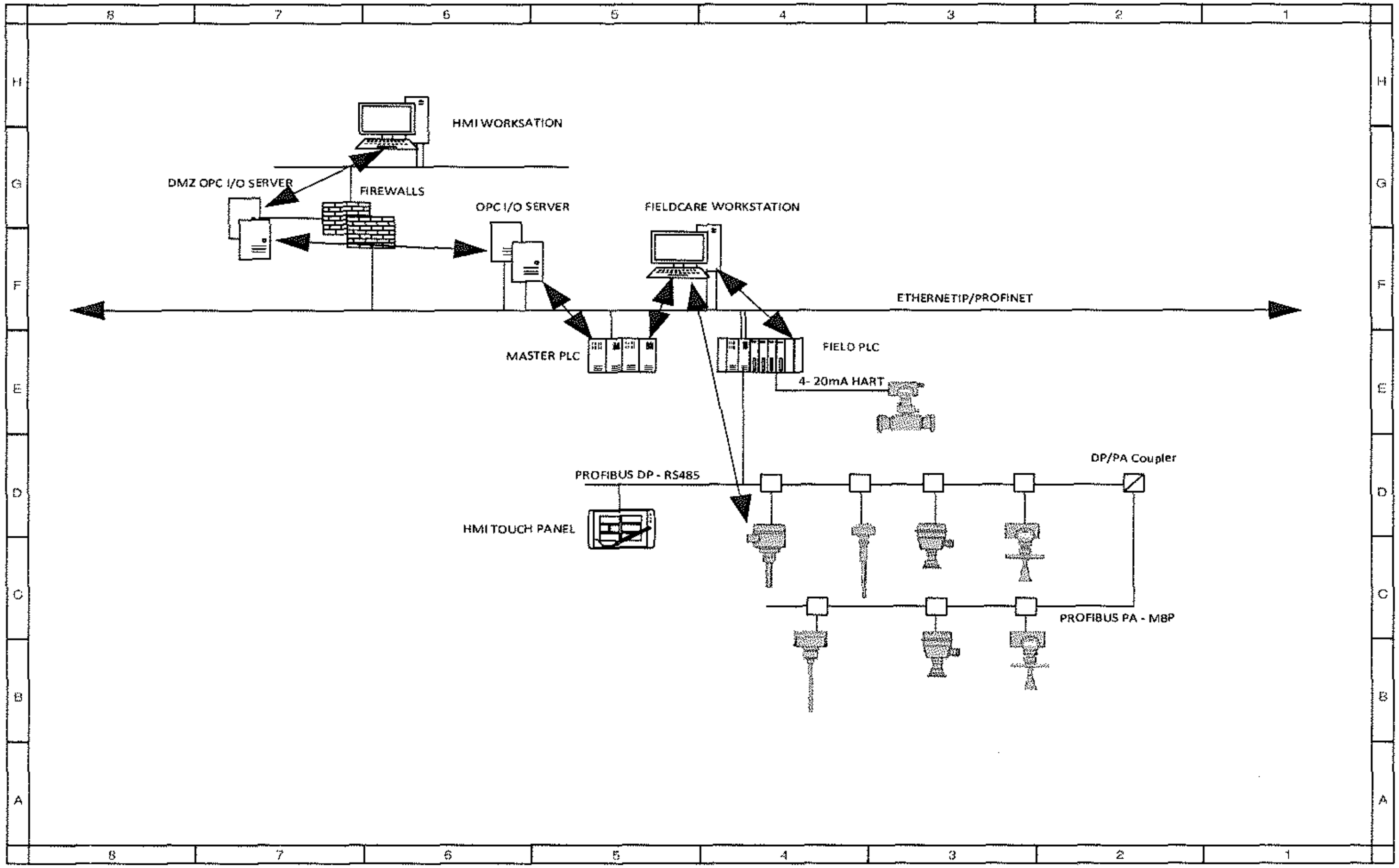


Figure 8 Profinet/Profibus Architecture

8.4.32 Control Centre and Video Wall

The Control Console and Video Wall Frame design is based on the Winsted SIGHT-LINE Architecture and Engineer Specifications.

The Typical Styles and measurements for the consoles and Video Wall Frame are depicted in drawings in the Appendices of this specification.

The system shall be comprised of end frames and/or intermediate frames with horizontal stringers and decorative end panels. The systems will also feature a hinged dual-channel duct cover with integrated aluminium VERSA-TRAK mounting system for LCD monitor arrays.

The following diagram shows the proposed typical layouts of the Control Room for each site. Refer to Contract drawings for exact requirements for each site.

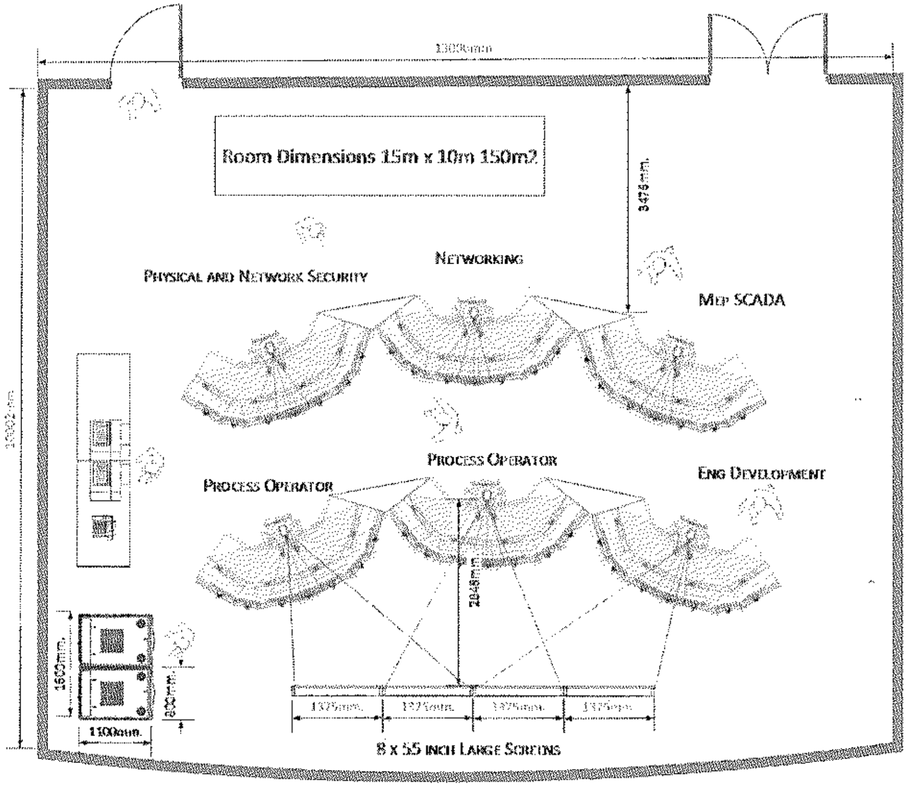


Figure 9 Control Room Operators Layout

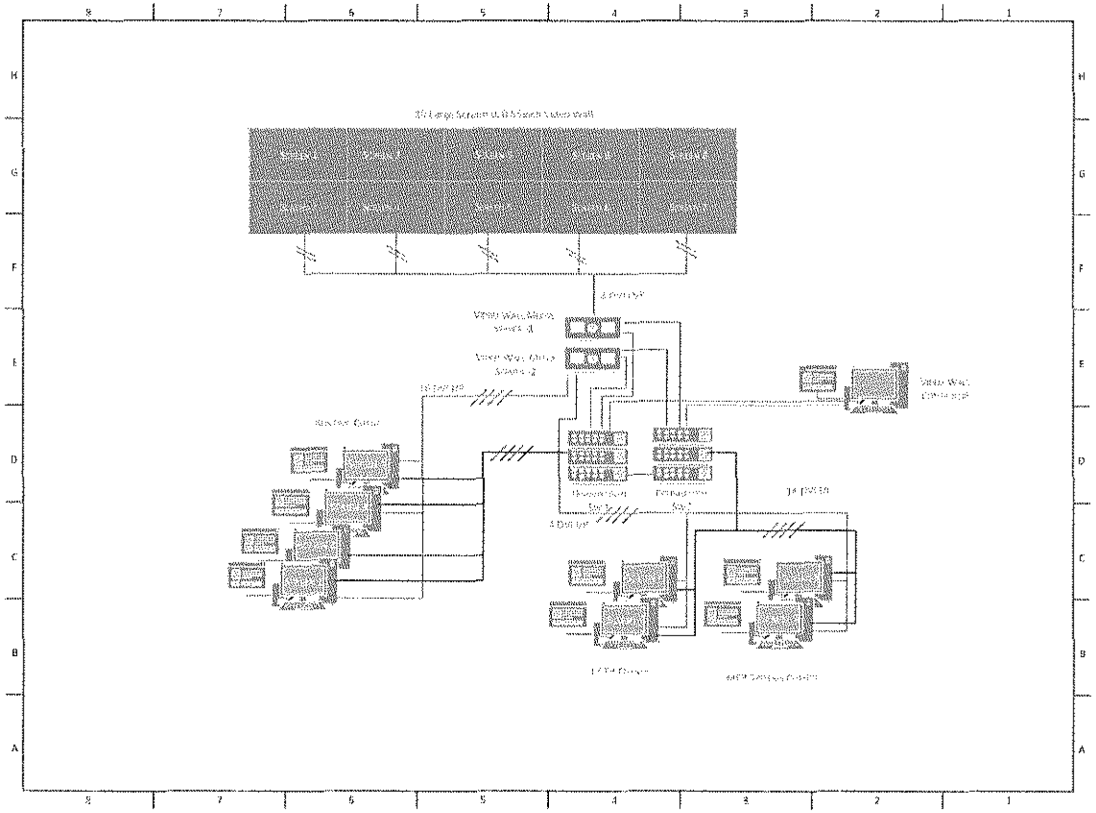


Figure 10 Video Wall Overview

This solution proposes a video screen framing mount constructed of extruded aluminum of an height and length that will support two rows of five 52 inch Plasma monitors. Included with the frame shall be twenty outlet power strips to the rear of the horizontal strip.

The frame shall also be provided with multiple raceway channels for running cables both vertically and horizontally. The wire channels shall have removable covers.

8.4.33 Graphical User Interface/Status Monitoring

The Graphical User Interface should provide a set of tools for graphically representing process status. A graphic editor should be provided to enable creation of graphic screens to represent current process information.

For ease of use, the editor should include cut & paste as well as drag & drop support within a single window and among multiple windows and should include undo/redo support. It should be possible for the user to drag and drop points into a screen from the list of configured points in the system. Support for grouping and ungrouping sets of objects and for readily editing them while grouped are to be included. While editing grouped objects, properties associated with the group shall not be lost during the ungroup/edit process. Object alignment and spacing tools are required so those objects can be properly arranged on the screen.

The editor should include a utility or tool for determining which points are referenced in a screen, which objects reference them, and which points are not currently defined or known to the software. This tool should also include provision to search and replace point names - for both single objects and groups of objects.

A test animation capability should display the screen currently being developed in the runtime environment for rapid prototyping and testing.

The editor software should include the ability to Create/Edit Points from within the Editor. It should also be possible to browse the network to locate computers and projects for available points.

The editing package should include a Wizard / Symbol / Object Library to permit the inclusion of pre-developed or third party graphic objects. Objects contained in the Symbol Library should be objects native to the software solution where appropriate and not simply bitmap representations. The editing package should allow Objects/Wizards to be created with the native graphics and scripting language and added to the Library.

A procedure editor should be included to control set points and to perform window management. The graphic editor should include a scripting expression editor to develop application logic.

Graphic objects on these screens can be linked by name to actual device and virtual data through the distributed point database, direct OPC-DA, and Historical expressions in either a real time or historical sense. Objects on the graphics screens can be configured with animation features, causing them to change color and/or position. Text information can be printed to the screen alerting personnel to current point status. Objects should be dynamically scalable - both horizontally and vertically.

The software should support the following dynamic attributes:

1. Annunciation, movement, blink, rotation, and fill (uni-directional and bi-directional)
2. Gradient fill
3. Object border animation
4. Object visibility
5. Blink fill and blink rate
6. Transfer PO for screen transfer or popup windows
7. Procedure PO to invoke user defined scripts/programs
8. Object and or application help screens
9. Alarm information
10. Trends charts
11. Set point PO for point value changes
12. Animated frames that can include other graphic objects
13. Zoom to Best Fit, Resize Window to Zoom
14. Manual and automated rubber band zoom
15. Automatic font scaling when changing window sizes
16. 1.5 Million Colors
17. Graphic objects should include:
18. Imported metafile objects
19. Embedded OLE, including ActiveX objects, sound, video, clip art, spreadsheets, etc.
20. SPC charts
21. Trend charts
22. Historical Data displays
23. Alarm displays

24. Arcs
25. Lines
26. Circles
27. Ellipses
28. Lines
29. Polylines
30. Polygons
31. Rectangles
32. Text strings
33. Buttons
34. 3 Dimensional Piping creator

Tag types should include:

I. constant - downloads constants to a point
II. variable - allows operator input of desired value
III. ramp - downloads values in configured increments
IV. slide - increment/decrement of point values
V. toggle - sets digital points to opposite state

Graphics screens should support a Visual Basic compliant scripting language. Data items and variables can be manipulated by the screen scripting to provide additional functionality in dynamically controlling screen characteristics.

The graphical editor and viewer should be capable of being an ActiveX container. It should be capable of using ActiveX objects provided with the SCADA HMI package or third party ActiveX controls supplied by others.

The graphical user interface should support ActiveX "methods" to allow the user to interact with ActiveX control objects. Interaction may be through the association of a method to a button or object, which the operator initiates, or methods may be used by the Visual Basic compliant scripting language for advanced functionality and additional control of the ActiveX components.

The graphical interface should have historical playback and review capabilities. Through a PVR type control interface, the user should be able to select a period of time and then replay the graphical screens and watch the process parameters change on the screen in replay mode.

The graphical runtime should be able to optimize the display using anti-aliasing.

The handling of graphic images should be such that they can be scaled without distortion.

The Graphical interface should allow for the creation of large screen sizes that can scale across multiple monitors.

The Graphical UI shall allow the end user to use zoom and pan functions to move around a large screen. The system shall allow for de-cluttering at various zoom levels to increase and decrease graphical detail. These functional shall also be available programmatically to allow for automated zooming and panning as required.

8.4.34 Alarming

The software system must support an Alarm Management module capable of alarm annunciation and routing capabilities. The alarm text associated with each alarm should be user configurable.

I. Alarms are to be applied as follows:

II. Digital Points - the alarm generating condition (0 or 1) should be selectable.

III. Analog Points - the alarm generating conditions should be evaluated based on alarm criteria selected:

Absolute - There should be two levels of high alarming, HI-2 and HI-1, and two levels of low alarming, LO-1 and LO-2. HI-1 and LO-1 are also known as warning alarms. For high alarming, an alarm should be generated when the point value reaches or exceeds the value specified for HI-1 or HI-2. For low alarming, an alarm should be generated when the point value reaches or falls below the value specified for LO-1 or LO-2.

Deviation - Alarm limits for deviation alarms should be given in positive values. The HI-2 and HI-1 alarms should be generated when the difference between the current point value and the Deviation Point value is positive and reaches or exceeds the specified limits. The LO-1 and LO-2 alarms should be generated when the difference between the current point value and the Deviation Point value is negative and the absolute value of the difference reaches or exceeds the specified limits.

a) Rate of Change - Rate of Change alarms should be provided to detect either a faster or slower than expected change in the value of a point.

b) Duration - The Alarm Display should include total time in alarm state.

Alarms should be configurable to be filtered and asynchronously sent to users based on user role and scope of responsibilities. Alarms should be configurable with respective priorities, divided into classes, and color-coded for display. There should be user-defined logging criteria, user-defined acknowledgment and deletion criteria, user-specific textual messages and operator help text. The alarm list can be toggled between dynamic and static display and quickly filtered to limit the current view to a particular alarm set of interest.

The system should support "alarm blocking". Users should be able to define an alarm hierarchy and block the generation of "lower level" alarms if a "higher level" alarm is present. This allows for operators to concentrate on primary causes rather than receive all the resulting secondary problems. For example, if a conveyor stops then all machines feeding it would also stop. The operator needs to determine why the conveyor stopped - the operator does not need to see the other alarms. In this example, fixing the conveyor will fix those alarms as well.

The system should provide for an automatic routing of configured alarm messages to display type pagers. The routing should be configurable as to personnel or pager ID receiving the message. It should be possible to upgrade the paging system to support dual outputs - allowing messages to be sent to local pagers, or to a dial-up paging system.

8.4.35 Command/Scripting Language

The scripting language used by the system must be like VB basic but is not the sourced Microsoft's Visual Basic for Applications product In addition the scripting engine must support .NET scripts to be ran side by side basic scripts as to ensure the customer can choose which scripting language that best applies or a mixture thereof. Scripts can be simple or complex and allow users to automate operator tasks, and create automations solutions. Scripts must be capable of running in either the configure environment ("draw" or "edit") or the run environment ("view"). The .NET scripting language must use Microsoft's IntelliSense feature, exposing all properties, methods and events of graphic objects. This includes 3rd party ActiveX controls. Editing of the basic scripts will be within the SCADA HMI product itself and the .NET scripting is done within or with a 3rd party editor.

8.4.36 Data Logging

Data collected by the software system should be logged via ODBC into a relational database to support historical reporting and analysis. The system should support multiple SQL compatible databases and/or formats. Configurable logging of points, alarms, and events should be supported without forcing the application developer to understanding database internals. Custom application software must not be required to log data. Configuration of the logging characteristics of a point should automatically configure the database that should store the data. A variety of database management systems should be available for use.

The system shall provide an option for integrating Microsoft SQL Server into the application as the standard data-logging database. As an integrated option, it shall have an icon as part of the configuration environment to easily launch the SQL application.

The software system shall support a high-speed data-logging rate to the Microsoft SQL Server database though a "bulk insertion" method. Bulk insertion reduces database overhead by storing information temporarily in memory and writing a larger volume of information to the database at a single time.

The software system must also support high speed / high volume logging and retrieval. This capability is often referred to as a Data Historian.

Point and alarm data is to be logged upon a "trigger" event. The following triggers for logging point and alarm data are required.

Table 1 Triggers for logging Point and Alarm data

Point Data	Alarm Data
At Time of Day	On Generation
On Time Interval	On Reset
On Point Update	On Acknowledgment
On Event	On Deletion
Gated Based on Logical Expression	

Point attributes, which should be available for logging, include

I. Point Value
II. Previous Value
III. Raw Value
IV. Alarm State
V. Resource
VI. Time Last Logged
VII. Engineering units

The logging module should support the logging of multiple point attributes into a single record based on a single trigger. The logging module should also support logging multiple points and their attributes to a single record. The logging module should support the simultaneous logging of multiple tables of data consisting of combinations of single points, multiple points, alarms, and events. This supports the creation of custom database tables unique to an application.

Through configuration alone, the logging utility should support "store and forward" to selected database management products. Data should be buffered on the node collecting it and automatically forwarded to the node where it is to be logged. During a communications outage between the two nodes, the data collection node should continue to buffer data. Upon restoration of communications, the data collection node should automatically forward the buffered data to the logging node for storage.

User configurable database maintenance actions, which are executed automatically, based on database size or number of records should be supported. Examples of these actions include exporting data to a CSV file then purging the records from the database. No custom software should be required to implement this support.

Reports using the logged data may be generated using standard third party database management tools such as spread sheets and report writers.

8.4.37 DDE Client and Server Interface

The software system must support a DDE interface in both client and server modes. In the server mode, DDE aware applications (clients) such as Microsoft Excel™ should be able to access data managed by the Monitoring and Control System. The DDE client interface support the use of third party applications to monitor, analyze, report, and modify point data.

Required Services for the SCADA HMI server support include:

I. Request Point Configuration Data (e.g. alarm limits, engineering units labels)

II. Request Point On-Change (DDE Peek)

III. Request Point Update (DDE Poke)

In the client mode, DDE server applications such as device communications drivers should be able to act as a source of data to the SCADA HMI, for both reading and writing of data down to factory floor devices or external systems. For maximum flexibility in selecting third party servers and for maximum software performance, the SCADA HMI must support both the DDE and AdvanceDDE protocols.

8.4.38 OPC Client and Server Interface

The software system must support an OPC DA and Alarm and Events (A&E) interface in both client and server modes. In the server mode, OPC aware applications (clients) should be able to access data managed by the System. The OPC Client interface should support the use of third party OPC Device Communication Servers. The OPC Server interface should allow for point information collected and maintained by the software system to be sent to OPC applications requesting the data.

The OPC client should allow for browsing of available OPC servers and the published points.

8.4.39 Data Trending

The trending module should be capable of supporting one or more embedded trends within the runtime graphics user interface. The following types of trends should be supported:

I. Trends with Multiple Y Axes

II. Trends with Multiple X Axes

III. Trends with multiple time periods

IV. Reference curves

V. XY Plots

The ability to select any numeric value or values being displayed on a graphic screen and quick trending the values should be provided. There should be no need to have pre-configured graphic screens created to display the quick trends.

The trending option should support display of an unlimited number of pens on a single trend chart. Each pen should display either dynamically updating data or provide seamless access to historical values based on user request. In addition, user should be able to compare data from different time periods.

Trending should support the creation and re-display of files with reference data from the currently displayed trend. This export capability should produce "CSV" format files so as to be compatible with standard office automation tools such as spread sheets and databases.

Users should be able to analyse trend data by scrolling through time, changing the range for point displays, zooming into an area of the trend and selecting a new time period to display.

Printing of trend charts is required.

The trending module should support reading data from "CSV" files for the display of data collected or generated by other applications within the software system framework.

Trend layout should be highly configurable including colors, tick marks, legends, title, and fonts. The update rate for data being displayed from log files should be configurable. The data being trended should be configurable. This configuration must be modifiable at runtime without requiring a development system or license.

Trend data can be supplied from multiple sources including current point data, data from .CSV files, and data logged to a database. Data displayed by the trend manager should support time-based or on-change based sampling.

Trending should support the display of array points. Arrays can be interpreted as independent variables or as a time series of a single variable. The latter case supports buffering of data in high speed sampling applications.

Trending should support rapid retrieval of a large time span of data and be able to aggregate the display of the data into the time axis of the chart. It should also be able to handle aggregating functions such as the min, max, and average display of values over the time period as well.

8.4.40 Statistical Process Control

Data collected though the Monitoring and Control System should be accessible by a Statistical Process Control Module. This includes data from plant floor devices, manual data entry, custom applications, and flat files. SPC Charts/Reports should be provided as ActiveX objects which can be dropped into graphic screens. The software should support an unlimited number of quality characteristics or sub-groups. The quantity of data displayed in SPC charts should be user configurable and should be updated dynamically as new data is collected. SPC ActiveX objects should allow the user to dynamically switch between a chart and report view of the data without the need to reconfigure screens. Users should be able to scroll through data that is not initially displayed on a chart. Standard Charts/Reports should include:

I. Xbar & Range

II. Xbar & Sigma

III. X Individual

IV. Histograms

V. Pareto

VI. U –chart non-conformances per unit within one subgroup

VII. P-chart Fraction nonconforming within one subgroup Independent Attributes Large ($\geq 1.5\sigma$)

VIII. C-chart Number of non-conformances within on subgroup Independent Attributes Large ($\geq 1.5\sigma$)

IX. nP-chart Number of nonconforming within one subgroup subgroup Independent Attributes Large ($\geq 1.5\sigma$)

Software should support the following control checks where "N" is configurable. Each may be separately enabled or disabled.

I. Any one subgroup beyond upper or lower limits

II. N subgroups on the same side of the center line

III. Trend of N consecutive subgroups in a row up or down

IV. N subgroups in a row alternating up and down

V. Sets of Subgroups in a row within one, two or three standard deviation

All SPC Out of Control (OOC) conditions should be capable of being processed by the Monitoring and Control System to:

I. Change the color of a graphic object to red or flashing

II. Sounding an audio alarm

III. Logging the OOC condition to a device or file

IV. Send an alarm message to a user or another process

i. Individual Quality Characteristics are configurable based on the following parameters:

V. Enable or disabled

VI. Subgroup Size and Interval

VII. Center Line, Upper and Lower Control Limits

VIII. Control Limit Recalculation Type (Manual, Automatic)

IX. Control Checks and Alarming

Configuration information should be centralized on a server node and support SPC charts operating on viewer nodes. All nodes displaying an SPC chart must have the same control limits.

Users should be able to dynamically modify control chart configuration parameters through the user interface. In addition, they should be able to delete outliners (points that are out of reasonable range) prior to recalculation of control limits.

SPC charts may be embedded in graphic display screens as ActiveX objects to provide seamless integration among applications.

8.4.41 Classes and Objects based Configuration environment

The screen and database environment should also allow for a structure configuration method using object oriented design. This should allow for the creation od classes from which objects can be derived and various parts of the application created automatically. This would include point definition, alarm configuration, script, graphical mimics and screens. The creation of templates needs be supported to allow for easily re-using configuration across multiple applications.

8.4.42 Production Tracking

The software system should support a configurable Production Tracking application that monitors point values and maintains an accurate image of work-in-process inventory. The Production Tracking module should be configurable with respect to the layout of plant, the type of items being tracked (serialized vs. non-serialized), and the type of plant floor inputs available for tracking. Example inputs include radio frequency (RF) PO, bar codes, type detectors, and limit switches. The tracking system should be auto correcting based on collected data.

Each item should have a set of attributes including location, status, and user-definable fields. Attributes such "product build" options and/or inspection status should be displayable and modifiable through point values.

The Production Tracking application should support manual transactions to add, delete, modify, move, re-sequence, and scrap items.

The Production Tracking module should include a comprehensive set of routing and control functions. These functions should interface to the SCADA HMI's data collection subsystems to exchange data with factory floor devices. The routing and control functions should be support user programming and configuration. The functions should operate based upon the work in process image maintained by the Production Tracking module.

The primary function of the tracking system is to provide tracking data to plant floor users and applications. As such the data maintained by the production tracking module should be accessible through the graphical user interfaces and through a complete set of application interfaces. Additional applications such as dynamic scheduling, material delivery, and assembly broadcast depend on tracking data.

The Production Tracking module should support operation in the distributed software system environment.

8.4.43 Equipment Control

The software system should support an Equipment Control module which includes the capability configure logic and schedule events based on the following criteria:

I. Time of day

II. Time Interval

III. Production event

IV. Point change

V. Alarm Generation

In response to configured events, the system should invoke configurable actions that include:

I. Log Event

II. Acknowledge Alarms

III. Enable / Disable an Alarm

IV. Recipe Upload / Download

V. Execute a Script

VI. Set a Point Value

VII. Copy a Point Value

VIII. Execute a Procedure

Scripts should be modular and re-usable. Scripts should be in a Visual Basic compliant language.

An event editor should be included to permits users to configure, monitor and debug applications. Users should be able to monitor the progress of control programs and dynamically modify their operating characteristics. The event editor should at least support these debug tools:

I. Run in Single Step Mode

II. Start/Stop Scripts

III. Set Break Points

IV. Step into or Over Sub-Scripts

V. Watch variables change

Control programs should have access to all of the application programming interfaces (API's) within other Monitoring and Control applications such as DDE interfaces, equipment/device interfaces, production tracking, and system alarming and logging.

8.4.44 Recipe Management

A module that is capable of monitoring and managing equipment recipes should be available. The Recipe module should support both batch and discrete part processing requirements. The Recipe module should support dynamic configuration of recipe information.

The Recipe management module should support the creation and management of device independent recipe data for production processes. Configuration data should be stored in recipe groups to simplify information management. Within a group, recipe parameters should only have to be entered one time to minimize duplicate data entry.

Parameter values should be supported for each recipe. The module should support the concept of device independence. This should permit the configuration of a recipe a single time yet also permit downloading that same recipe to different devices, i.e. different programmable controller models or manufacturers. This device independent support no longer requires the maintenance of separate recipes for the various pieces of production equipment in the facility.

There should be a dedicated user interface utility. The utility should support the display of recipes, parameters and the mapping of parameters to devices. Ideally, this display should support a spread sheet-like interface for ease of use and to help minimize user training. Like a spread sheet, the information display formatting should be user configurable. The interface should follow the Microsoft Windows look & feel and include tools such as copy/cut/paste.

Overall, the user interface should support the ability to:

I. Create and manage recipe parameters, recipes, and maps side-by-side in a spreadsheet format.

II. Import and export recipe groups from/to CSV format files.

III. Archive recipe groups.

IV. Automatically reconcile recipe groups to accommodate changes in the group's structure and layout.

V. Compare recipes.

VI. Validate recipe information.

VII. Manually upload recipes.

VIII. Manually review/modify parameters and download recipes.

IX. Create recipe parameter files, to support automatic upload and download of recipes.

X. Identify a Batch ID for recipe downloads.

For maximum flexibility, the Recipe management module should also support a graphic user interface. Recipe objects should be implemented as OCX controls that may be embedded in graphic screens. These objects should let a run-time user:

I. Manually upload recipes.

II. Manually review/modify parameters then download recipes.

To support the development of sophisticated applications, the Recipe management module should support an interface to the software system's scripting capabilities. This scripting interface support should include the ability to:

I. Automatically upload and download recipes based on system events, such as point changes from a shop floor device.

II. Import and export recipe groups from/to CSV format files.

The module should support a wide range of data types including:

I. Signed integers

II. Unsigned integers

III. Digital/boolean values

IV. Real numbers

V. Text strings

8.4.45 Calendar Based Control

The software system should provide for calendar based control operations through a self-contained graphic users interface. The software system should allow you to dynamically create, maintain, and execute a calendar schedule of manufacturing events and corresponding actions. For example, a system should allow the user to perform such actions as turn on lights, heat, and equipment based on a schedule which they configure and maintain through simple point and click actions.

Configuration of the calendar-based control should allow the user to define different types of days – production, weekend, holidays, to conform to 4 day or 5 day work weeks, etc. Users should then be able to configure manufacturing control events they want to occur on a particular type of day and the time they should occur. Association of days on the calendar with a particular type of day should be through a point and click interface. The graphic user interface for the calendar-based control should allow the user to dynamically change or override the established schedule.

The graphics interface for the calendar-based control should be available on both Servers and Viewers.

8.4.46 Historical Data Display

The system should provide for tight integration of relational databases through ODBC interfaces. Once data has been logged to the database, open system tools should make the extraction and sharing of the data easy between users and applications.

8.4.47 Integration APIs

The software system should have a set of open interface APIs (Application Program Interfaces). The APIs should include –

I. Point Management API – Allows third party programs to be interfaced to the software system and pass point data to and from the system in real time fashion.

II. Alarm Management API – Should allow alarm information to be passed to and from the API.

III. Logon API – Should allow the user to create their own custom logon dialog boxes.

IV. Device Communication Toolkit – Should allow the user to construct communication modules to third party devices with published protocols.

8.4.48 Marquee Driver

The Software system should have the ability to send alarm information and messages to multi-line marquee display devices. A Marquee module should be available fully configurable. No custom coding should be required to retrieve alarm or message information. It should be possible to determine which set off alarms you want to send to the actual marquee device.

Marquee configuration should include:

a) Marquee Types - All marquee devices that use the same header, footer, message wrap, empty message, and attributes belong to the same Marquee Type.

b) Marquee Ports - The PC communication port or the network communication port to which one or more serial marquee devices are connected. If more than one device is on a port, the header and/or footer information (from the Marquee Type) should indicate which device on which the message is to be displayed.

c) Marquee Devices – The ability to assign a Marquee ID, Marquee Type, Marquee Port, header, footer, empty message, and display time for each marquee device within a project should be provided. The option of associating sets of marquees into Marquee Groups should be provided.

d) Marquee Messages - For each Marquee message, it should be possible to assign a message ID, Alarm ID, alarm state, message header, message footer, message text, the marquees on which to display the message, the attributes associated with the message, and any SCADA HMI point values to be displayed with the message.

8.4.49 Alpha-Numeric Alarm Paging

The Software system should provide advanced communication capabilities such as the ability to send process alarms to standard alphanumeric or numeric pagers carried by a mobile workforce. The paging capabilities should be designed on a client / server architecture of to avoid duplication of configuration information. Paging capabilities should support standard IXO/TAP protocols used by common paging systems.

Paging features should include:

I. On line configuration of users and paging numbers.

II. Enable or disable users from receiving pages.

III. Escalation of pages

IV. Filtering of pages based on point groupings, alarm classes, or alarm IDs.

V. Dynamic on-line configuration changes.

VI. A scripting interface for automatically sending pages, changing a user's pager number, or disabling a page.

VII. Customizable pager messages.

VIII. Configuration templates for fast setups.

IX. Support of distribution lists.

8.4.50 System Monitoring

The software system should provide system monitoring to allow the user to monitor the most important part of the system – the computer. System monitoring should monitor the software system processes as well as key Windows operating system and network parameters. System monitoring should be able to monitor the status of the computer the software system is running on as well as other Windows computers on the network. System monitoring should allow for key system parameters and statistics such as alarm frequency, device communications, data collection and throughput, inter-process communications, data logging, point management, and user registration to be monitored and recorded. System monitored information can be alarmed on.

8.4.51 DGR Screen Playback

The system should provide the capability of playing historical logged data back through the graphic screens so users can review past situations to analyse what might have caused a problem. This feature should provide a wide range of playback speeds with start and stop capabilities so the user can quickly isolate a particular period of time they are interested in. In addition this functionality shall have the ability to affect the entire interface or only specific elements enabling the user to view mixed real time and historical information on a single screen.

8.4.52 Electronic Signatures and Electronic Records

The system should be able to handle the addition of electronic signatures to any point or alarm. Electronic signatures should include one or two signatures per any runtime change including alarm acknowledgement. User accounts should have the ability to be configured within Windows security and a period of continuous use should be configurable were one token (password) would need to be entered. There should be a provision to force 2 tokens even during this period of continuous use. Users should have the ability to enter comments at time of signing and the system should allow for comments to be selected from a predefined list or entered in a free from text box. No changes should occur until the authentication of the user is verified and an electronic record is created about the transactions. This record must contain the time, date, full name of the perform by , full name of the verified by, the original value and new value, the description of the action and any comments entered at time of signing.

Change Management

The system shall have the ability to control and track changes to the SCADA HMI/SCADA applications that are developed.

8.4.53 Client/Server based

The system shall allow applications or projects to be stored on a central server.

8.4.54 Version Control

The system shall provide a check out, and check in mechanism so that no 2 users can modify the application files at a given time. When a check in is performed, the system shall increment the version number of the components that have been modified.

The system shall allow the ability for users to enter comments about the changes that have been made.

The system shall provide the ability to revert to previous version of a project or component in the project.

The system should support the ability to produce version reports on the project and the components with information on the previous version including the date, time, user and comments associated to the change.

8.4.55 Audit Trails

The system shall keep track of changes that are made to the application including the data, time, user making the changes, what files were modified and any comments entered by the user about the changes.

The system shall allow for reports of changes to system as well as the project and its components. These reports should be in a printable format.

8.4.56 Security

The system shall control which users have the ability to access various projects and restrict who can and can't check out various projects.

8.4.57 Scheduled and manual comparisons

The system shall allow the ability to compare the running project files with the master files on the change management server, and provide a report of differences. The report should provide reports of differences at the file level or object level. This functionality should be available both on demand and on a time basis without user intervention.

8.4.58 Notification

The system shall allow the ability to notify administrators or assigned individuals of changes made to the project files. The system shall also provide the ability to notify administrators or individuals of differences detected between the master or server version and the running project.

8.5 ENGINEERING WORKSTATIONS FUNCTIONS AND FEATURES

8.5.1 General

Only one engineering workstation shall be necessary to perform all traditional configuration tasks (Control, SCADA HMI, Batch, and History), Fieldbus configuration (transmitters, drives, analyzers etc), database generation, and editing. However, it shall also be possible to use multiple engineering workstations simultaneously for this work.

The PLC programmer shall be supplied by the contractor, with all assets associated with the device. This shall include all hardware and software items, including (but not limited to):

a) All hardware including communications modules, programming cables, etc.

b) All software including PC based configuration software (to include any "dongle", license or other such software protection device required to utilize the software), fully documented and commented source code files.

c) The intellectual property rights of all application specific software shall be provided to distribute as required for the continual maintenance and operational performance enhancement of the plant.

The central engineering workstation shall be capable of supporting all of the following functions:

a) I/O configuration
b) DCS hardware configuration (controller, operator stations)
c) Configuration of plant and field communication networks
d) Field bus instrument configuration and maintenance
e) Configuration of drives, weighing scales and motor management equipment
f) Configuration of continuous and sequential control operations
g) Configuration of the plant process structure / hierarchy, for example, compliant to S88.
h) Configuration of fail-safe (Safety System) Functions
i) SCADA HMI Graphics display generation and modification
j) Tag logging (archive) configuration
k) Configuration of historical and real-time trends
l) Management of alarm and event configuration
m) Report creation, generation and modification
n) Configuration of user security and access privileges
o) Implementation of the FDA requirements (Food and Drug Administration)
p) Process object view with test mode
q) Data communication with a CAx system
r) The operator shall be able to perform their desired picture assembly online.
s) Batch Configuration & Planning (Recipes, Procedures, Formulas etc)
t) Asset Management configuration
u) Access to external files and programs such as Excel
v) System Diagnostics
w) Servers, Clients and keyboard plant area assignments

x) A controller simulator tool to enable logic debugging and testing w/o requiring any hardware.
y) It should be possible to protect the engineering project via a user specific password.

The following diagram shows the traffic flow diagram for the Engineering Workstation

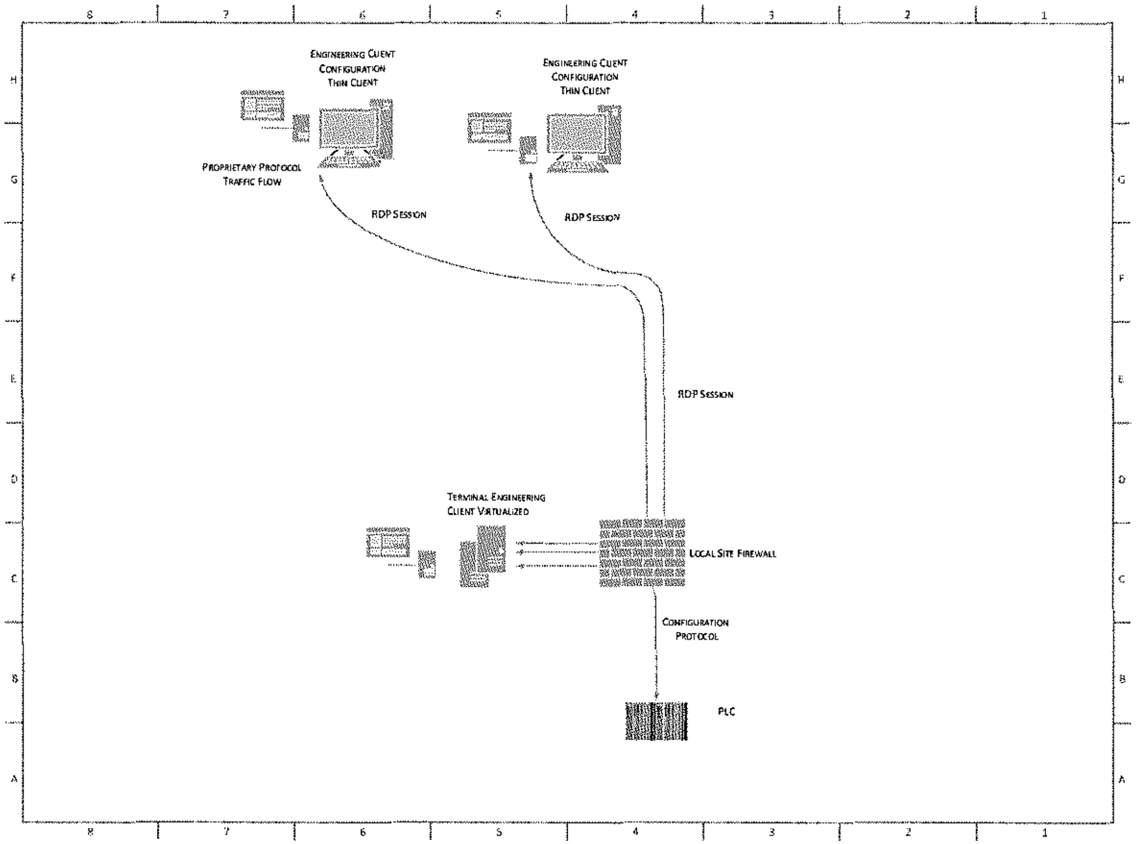


Figure 11 Plantwide Engineering Workstation Messaging Overview

8.5.2 Object Oriented Engineering Tools

Object-oriented configuration tools shall be provided to aid in system configuration. It shall be possible to configure both control and SCADA HMI aspects at the same time from this tool for one or multiple process objects. The tool shall include a spreadsheet style interface for configuration which supports ease-of-use with functions such as copy/paste, search and replace, sort by column, and connection with Excel/Access.

The following parameters shall be configurable from this interface:

a) Control: Loop identifier, Alarm limits, Tuning constants, Descriptors, Engineering Units, I/O assignment.

b) SCADA HMI: Alarm Priorities, Alarm Message Text, SCADA HMI Symbol assignment, tag Archive rates.

The engineering system shall have a uniform database ensuring that data, which has been entered once by the user, shall be available to all tools throughout the system, thus ensuring that there is a single point of entry for the system database.

8.5.3 Optimization of the Run Sequence

The system shall be capable of naming processing cycles or runtime groups for optimization of the run sequence / runtime group.
It must be possible to change the processing sequence of the function blocks.

8.5.4 Bulk Engineering Capabilities

The system shall provide tools for bulk editing of the configuration and to facilitate easy duplication of standard control elements (those provided standard by the system or created custom by the user). The duplication tool shall support generation of instance-specific copies via an export / copy / import routine that utilizes a spread-sheet style tool for configuration. Duplication and instantiation of the following element types shall be supported:

a) Function Blocks
b) Function Block Charts (Control Modules)
c) An entire Unit of Equipment
d) An entire Process Area
e) SFCs

The tool shall support cloning of process control elements through the import of configuration data from an external file.

The tool shall also provide a menu-guided process for defining reproducible elements and for selecting instance-specific attributes (such as tag name or configuration area) of each individual element.

A user interface similar to a spreadsheet shall be provided for cloning elements (such as motors, valves and PID controllers) and for the configuration of their instance-specific properties.

8.5.5 Standard Process Automation Library for Controller and SCADA HMI

A library of standard prebuilt control algorithms for process control shall be available along with their associated SCADA HMI faceplates/symbols. Optional Industry specific libraries shall be available. The standard library shall consist of the following control strategies and pre-engineered symbols/faceplates at minimum:

a) Standard PID Controller
b) CASCADE PID Controller
c) Ratio Controller
d) Split Range Controller
e) Manual Loader
f) Totalizer for Solids and Liquids
g) Digital Value Monitoring with Alarming
h) Analog Value Monitoring with Alarming
i) Motor (Start / Stop) with Interlocks
j) Motor – Two Speed
k) Motor – Forward / Reversing
l) Valve (On/Off) with 1 or 2 Feedback Signals
m) Valve (On/Off) with Interlocks
n) Motorized Valve Control
o) The control function blocks shall feature the following high level functions:
p) PID gain-scheduling
q) Override control
r) Smith-predictor,
s) Lead-Lag Feed forward Control
t) Fuzzy Control,
u) Model predictive control.

8.5.6 Function Block Library for an Industry-Specific Application

As a supplement to the existing standard library for a process control system, a tested and certified industry-specific function block library with a model application shall be created. The supplied model application should integrate industry-typical applications from the field level to the automation level to the operations and monitoring level for the water industry.

The library should be implemented in the graphical programming language CFC (Continuous Function Chart) and for sequence control (SFC Sequential Function Chart) according to DIN EN 61131.

In addition, components from process instrumentation, energy distribution and drive technology shall be supported. The industry-specific function block library must also contain faceplates to link process information to a visual depiction with a uniform appearance for operations and maintenance, including the support of an integrated multi-control functionality from local (machine) control up to internet-capable operation over at least eight (8) operations levels of control.

The supplied model solution must contain start-up strategies for back-up units; digital value control and monitoring; analog value control and monitoring; volume recording and metered value recording; a switching and operation hours counter; split range control; control with analog position feedback signal; cascade control; PID control for actuators; various control functions with feedback for valves and motors with fixed speeds, variable speeds and variable directions, each with interfaces for local control panels.

Further the industry-specific function block library must contain at least the following function block types:

a) 3-point actuator block
b) Operation mode switch with at least three (3) levels
c) Unit function blocks with automatic switchover based on operating hours or managed control for up to 16 units
d) Adjustable polygon progression with at least eight (8) reference points
e) Process signal selection from at least two (2) measured, counted or digital values
f) Addition of two values including factor adjustment
g) Measurement monitoring for up to eight (8) limits
h) Communication function block for the transmission of at least 30 measured values and 480 digital values between standard and fault-tolerant automation as well as between standard automation of various performance classes.

The associated symbols shall be copied into the process diagrams of the process control system and incorporated into the process through a configuration assistant. Further requirements for the faceplates with fixation when changing screens are:
enabling; protection; interlocks; operation status; feedback signals; commands; run time, maintenance, limit and gradient parameters; pre-configuration of simulation, manual and substitution parameters; trends, messages, error messages and alarms with associated locking functionality and separate preview information; notepad functions. The signal identifiers of the function blocks must be consistent and uniform. Activated process symbols in selected diagrams must be marked with the appropriate colors.

8.5.7 Configuration Structure

The application shall be viewable and configurable in a hierarchy which groups configuration elements according to the plant or process structure. This plant hierarchy shall be capable of directly representing the process model and the physical layout of the process. It shall be used to automatically derive the display hierarchy in the operator interface and to generate the dynamic elements of process graphics.

For maximum flexibility in structuring the controller program, the system shall support the creation of a configuration hierarchy that is at least eight levels deep.

8.5.8 Copy / Paste

The system shall support *copy and paste* of all configuration elements contained within the hierarchical configuration structure including:

a) Control Modules (Function Blocks or Charts)
b) SFCs
c) Process Graphics

The system shall support the ability to copy and paste multiple levels of the hierarchy in a single step (Deep Copy) allowing entire process areas or units to be copied and modified with minimal engineering effort.

8.5.9 Concurrent Engineering

The system shall support concurrent engineering practices whereby multiple engineers can work on the same application via a networked environment or via a "check-in / check-out" style for configuration locally on different PCs.

8.5.10 Documenting the Configuration

Tools shall be available for automatically documenting the configuration and project data.

The system shall be able to display the connections between individual charts in the automatic documentation.

8.5.11 Online Configuration Changes

The system shall support making changes to the controller, I/O, SCADA HMI, Batch, and Communication network while online without interrupting operations.

8.5.12 Change Management

The engineering station (ES) shall support versioning.

Configuration additions, changes, and deletions shall automatically update all modules and PO affected by the change.

Configuration changes shall follow a prompt-validation sequence requiring a final acknowledgment step before the change is downloaded to the on-line system. An option shall be provided to allow the user to view a detailed report of changes as part of the download confirmation process.

When configuration data are compiled or downloaded to the system, invalid configuration entries shall be identified and the parameters affected shall be indicated.

It shall be possible to change, delete, and add any independent loop in the controller without affecting the other loops.

In the multi-project mode, the system shall support updating of blocks from the master data library in libraries of the individual projects.

8.5.13 Multilingual Engineering Environment

At least, the English, German, Spanish, Italian and French languages shall be supported by a single version of software. The user shall be able to toggle between the different supported languages in the Engineering and Operator runtime environment without having to recompile the program.

8.5.14 Change tracking of Function Blocks

Each function block or chart shall have a unique Date/Time stamp which indicates when it was last modified. This information shall be displayable as an object property so that it is viewable directly from the engineering tool.

Function blocks / Charts shall support the assignment of a unique version number and author. This information shall be displayable as an object property so that it is viewable directly from the engineering tool.

8.5.15 Comparison Tool (Version Cross Manager)

An optional tool shall be available to perform a detailed comparison of two applications or versions of an application. This tool shall use a MS Windows Explorer-like interface to graphically highlight what elements of a configuration are different (CFCs, SFCs, Function Block types, Scan Rate Order etc). By selecting a "flagged" element, the user can dive deeper to determine exactly what is different (such as an Alarm Limit or Tuning Parameter).

The comparison tool should be able to identify differences in the following elements at minimum:

a) Application Program (Function Blocks, Charts, SFC, hierarchy / layout)
b) Hardware Configuration
c) Communication / Network Configuration
d) Alarms
e) SFC details (Steps, Transitions and Properties)

8.5.16 Project-Specific Libraries

The system shall support creation of a project-specific library which contains only those standard function blocks, charts, and custom function blocks developed by the user that have been approved for use on the project. During configuration all other system libraries can be hidden to ensure that the project team uses only the "project-approved" elements during the application development phase.

8.5.17 Central Management of SFCs

The system shall support central management of SFCs by providing "SFC Types", which allow a single sequential function chart (e.g. Reactor Heat Phase) to be copied and reused throughout an application. Making a change to one instance of the SFC shall result in the automatic update of all other instances in the configuration, thus saving engineering time and minimizing the chance of creating inconsistencies in the application.

8.5.18 Change Log

An optional tool shall be available for use on the Engineering workstation to enforce user access control for execution of protected actions (such as downloading a configuration change to the controller) and to allow recording of comments (detailed reason for change). Information will be recorded in a change log file, which shall be continuously updated with each new change. The change log shall be capable of being reviewed at a later point in time.

8.5.19 Read/Edit Protection of Function Blocks

The system shall support the locking of user-created custom function blocks. This ensures that the contents of the custom block cannot be viewed or edited, allowing users such as OEMs to securely protect their intellectual property.

8.5.20 Integrated FDA Functionalities

The vendor shall offer wide-ranging FDA functionalities in his system, including features listed in the following:

a) System Logon
b) User administration and access control
c) Staged permission levels
d) Change log: recording of all changes during the production
e) Automation system : program download, changes in test mode for CFC/SFC, download of hardware and communication configuration
f) OS: program download
g) Batch and route control: program download
h) Change log: changes in projects and libraries, logons/logoffs, opening and closing projects and libraries, changes to settings
i) Version management (version trail): versioning of projects, libraries, multi-projects, recipes
j) Comparing/updating projects (Version Cross Manager): CFC/SFC, hardware configuration, communication configuration, OS alarms, plant hierarchy, SFC details (step, transitions, properties etc.)

8.5.21 Driver Wizard

A driver wizard shall be available to generate all blocks required for the diagnostics of I/O modules and field devices.

Object naming shall support at least 16 alphanumeric characters, and users shall be able to change an object's tag name without deleting and re-adding the object or any references to it, for example, SFC charts, process pictures or tag logging archives.

Every analog input, output and block needs to be assigned for an Engineering Unit Designation. It shall be possible to show this designation automatically with the value, if the input, output or algorithm.

8.5.22 Global Search Utility

Utilities shall be provided for global searching of the database. These utilities shall be under system access control.

8.5.23 Cross Reference Data Listings

The system shall be capable of generating listings containing the following fields:

a) Tag ID
b) Tag descriptor
c) Point type
d) Hardware address

It shall be possible to perform the following functions on the above list:

a) Sort alphanumerically by any field
b) Filter by any field
c) Print, display and store to media
d) Export Data

The above listings shall be available for all devices in the system.

8.5.24 MONITORING AND CONTROL CHECKLIST

The following list contains the key items that need to be considered when selecting a software system.

Table 2 Monitoring and Control Checklist

Feature	Supported –Required /Yes / No
STANDARDS AND TECHNOLOGY	
Open System Design	Required
True Client / Server Architecture	Required
Enterprise Server Support	Required
Viewers (Without the need to reconfigure point databases)	Required
Web Based Thin Client Viewers – Internet Explorer and Netscape	Required
Web Viewer User and Broadcast mode licensing	Required
Operating Systems Support – Windows 2012 latest	Yes Minimum requirement
Microsoft Technologies Support – (ActiveX, ODBC, OPC, DDE, COM/DCOM, XML)	Required
Industry Standards Support – OPC, TCP/IP	Required
Object Technologies – ActiveX and user created	Required
Web Technologies – Thin client and HTML based	Required
Windows Terminal Services Support	Required
Wireless Technologies for Viewing and Entering Information	Yes
Application Programming Interfaces	No
Multi-threaded scripting	Yes
REAL TIME DATA MANAGEMENT	
Data Sharing without duplicating configurations	Required
Required Data Types – Discrete, float, analog, string, global, arrays, structures	Required
Device Communications – capable of supporting hundreds of devices and protocols.	Required
System Points – Users, Roles, Time, Date, Alarm counts, etc.	Required
Real time tabular display of point values without the need to create screens.	Required

Point Cross Reference indicating where points are used in the system	Required
DIVERSE APPLICATION MODULES	
Graphical user interface with status monitoring	Required
Web Viewer	Required
Thin Client Windows CE Support	Required
Alarming	Required
Data Logging	Required
DDE Client & Server Interface	Required
OPC Client & Server Interface	Required
Data Trending	Required
Statistical Process Control	Required
Production Tracking	Required
Equipment Control	Required
Recipe Management	Required
Calendar Based Control	Required
Historical Data Display	Required
Integration Apis	Required
Marquee Driver	Required
Alpha-Numeric Alarm Paging	Required
Redundancy	Required
System Monitoring	Required

8.6 OPERATOR SERVER (OS) DATA PROCESSING

8.6.1 General

The Operators Server (OS) generally forms part of the SCADA HMI vendor's package. The OS server represents the client work stations and receives data from the OPC I/O server which retrieves data from the PLANT. The acquisition, processing and data management is to be carried out on the OS server. For the functions operator control and monitoring, multiple operator terminals with one dual monitor are provided in the control room.

This server referred to as the OS server in the diagrams has the following tasks:

a. Received commands from the OPC server

b. Real-time data forwarding to the SCADA HMIs.

c. Management of the databases (the databases contain the entire parameterization of the system as well as the long-term archive).

d. Backup/archiving and reimport of data.

e. Editing place functions.

f. Time synchronization of all network-connected computers by means of a central time service (DCF77 or GPS).

The server is to meet the requirements of the process operation (time response, multitasking, and failure safety). A PC with state-of-the-art technology is to be offered (main memory, hard drive capacity). The selection of the PC is to be carried out in such a way so that expansions of the main memory and the hard drive double the required values. The computing performance is to be measured so that during normal operation, the utilization is no greater than 60%. The server computer is to be designed for continuous operation (24/7).

8.6.2 OS Message Processing

The message system processes the results of functions that monitor the events occurring in the process, the automation level and the system. It depicts acquired message events optically and acoustically and archives them electronically and on paper. Direct access to the messages and a sorting in ascending and descending order, as well as supplemental information on the individual messages, ensure a swift error localization and correction.

A hitlist is to provide the operator with easy access to the most frequently occurring messages. Furthermore, it should be possible to display the duration of the individual messages, i.e., the length of time from the occurrence until the clearing and/or acknowledgment.

The message structure is to be freely definable and thus be adaptable to the specific requirements of the plant. A message is composed of message blocks, which can also contain tag values. Per single message,

a. a minimum of 10 tag connections

b. a minimum of 10 user-defined texts

Should be implementable.

A priority is to be assignable to the individual messages to ensure that in the case of multiple simultaneously occurring messages, the message with the highest priority is displayed first. Seventeen message priorities (0–16) shall be provided.

A total of at least 150,000 different messages should be configurable. If there are a large number of messages, it is important to be able to hide messages. This decreases an information overload for the operator of the plant. Messages can be hidden automatically depending on the process status or manually by the operator. It should be possible at any time to display all hidden messages.

All incoming messages are saved by the system, whether they are hidden or visible.

During the commissioning or when expanding or servicing the plant, it should be possible for messages from presently unused modules to be specifically locked by the user while the operation is on-going. If a message event of a locked message occurs, no display and no archiving of the event take place. It should be possible to list the locked messages in runtime and, if necessary, to unlock them.

Through the described option of the message forwarding, the function scope of the message system is to be fundamentally expandable. This should ensure a faster response time in the case of a malfunction.

If a message event occurs, the operator is to be informed about this independent of the selected process screen, and have the option of directly switching to the affected process screen.

If messages are triggered directly by the controller and noted with a timestamp there, they can be integrated into the message system at any time, even retroactively. There, the messages are archived in chronological order and displayed.

The message system is to consist of a revolving archive, where always the latest entries are deleted. The archive can be exported into a long-term archive by shift, day, week or month.

The archive size is to be limited only be the available hard drive space. The system is to automatically notify the operator, if the space on the hard drive is too small.

A continuous load of 10 messages/second (with a central message archiving on a separate server at least 100 messages/second) should be processable. A message surge of at least 2000 messages in 10 seconds every 5 minutes should be possible without a message loss.

8.6.3 Measurement Value Processing

The SCADA system archives measurement values from the automation system. Recorded measurement values are to be processable with definable actions before being saved. The data is to be stored in segments and made available for a specific time period in a kind of revolving buffer. The size or time period of the individual segments and of all segments is to be configurable as needed.

The archived data is to be supplied to the process visualization during this freely definable time period of all segments. Simultaneously, a backup mechanism is to be activatable, which allows individual segments of the archive to be stored in a separate storage location. There, the data remains available even after the revolving time, and can be viewed at any time from the visualization.

The recording of the measurement values is to occur cyclically or event-driven via the Tag Management. With that, process values as well as values from internal PO, values from any application and manual inputs can be recorded. The processing should yield average values, sum values, minimum values, maximum values.

The archiving cycle should be as large as the recording cycle, or be a multiple of it. Average values, sum values, minimum values and maximum values shall be calculated from the recorded values between two storing times. Measurement values recorded are to be immediately written to the hard drive – so that no data loss can occur (instantaneous values). If an error occurs during the measurement value recording, either the last value or a configurable replacement value can be stored.

For a fast recording of values, they also are to be kept as revolving buffer in the main memory (online trend curves).

The control system is to offer different methods for the archiving of measurement values. It archives measurement values cyclically or event-driven, individually or in blocks.

The following methods are to be distinguished:

a. Cyclic-continuous archiving.

b. Cyclic-selective archiving.

c. Acyclic archiving.

d. Archiving only upon a change.

The control system shall offer options for chronologically archiving and displaying process values that are archived by the controller with a timestamp and arrive in blocks in the control system.

8.6.4 Commands/Setpoint Values

Switching operations or the issuing of commands are to be performed by the system user via plant screens (process screens) or other operating masks intended for that. The execution of a command (bit command or setpoint value) is – when configured accordingly – expected by the control system in the form of a feedback and monitored.

The setpoint values configured in the system must be assigned as physical values via an operating mask. The unauthorized issuing of commands and setpoint values is password-protected by the control system. Locked (deactivated) commands and setpoint values are not issued.

8.6.5 Process Operation Control and Process Visualization

This component enables the user to monitor the process, intervene in the process, and define or change system and process parameters; for this, the fully graphical display units with keyboard and mouse are available.

The operator control and monitoring of the process primarily take place by employing

a. Process screens

b. Process information

c. Trend curve screens

d. Message analysis system

8.6.6 Process Screens

To make it easier for the user to operate the control system, the process screens are to be organized in the form of a hierarchically structured operating tree:

a. Plant overview

b. Area overview

c. Plant section screen

d. Detailed object information

The graphics editor of the control system is to offer functions that are customary in powerful Windows graphics programs. Functions for the precise positioning, alignment, rotation, mirroring and passing on of graphical object properties are to be included. Likewise functions for grouping, block generation and the import or embedding of externally edited texts, graphics and videos (BMP, WMF, EMF, GIF [also animated], AVI and JPG formats or via OLE).

Its ability to have multiple pictures (screens) open at the same time allows for a fast copying between different pictures. For this, the clipboard or – to make it easier – drag & drop can be used. Working with the block library and configuring a status display with up to 32 different statuses take place analogous.

With grouped objects, the graphics editor is to permit a direct changing of the properties of the individual objects, without having to break up the grouping beforehand. Likewise, the properties of multiple selected objects are to be changeable simultaneously (e.g., the line color).

The user interface of the graphics editor is to be customizable. The size and position of the individual palettes for colors, zooming, alignment functions, object types and styles are variable; if needed, individual palettes not required can simply be hidden. Frequently used functions are to be available as icons on the toolbar.

The graphics editor is to contain the following:

a. Exact coordinate display.

b. Dimension display.

c. Pixel-precise positioning of objects using cursor and tab keys.

Most objects are to have clear configuration dialogs, which enable the parameterization of the essential properties of an object in a dialog box. This dialog box is to be automatically displayed as soon as the respective object is placed in the screen.

In addition, the graphics editor should provide options to practically manipulate all properties of an object and to also make them dynamic. Dynamic properties are highlighted in bold in the properties box for clear visibility.

The graphics editor should offer multiple options that build on one another for making object properties dynamic. In the simplest case, such properties are connected directly to internal PO of process PO. A dynamic dialog allows simple value conversions to be performed or value ranges for color changes to be defined.

Flexible dynamics are to be possible through the direct integration of scripts – either C scripts in ANSI-C standard or Visual Basic Scripts.

Via a direct connection, control system objects are to be able to influence the properties of other objects, e.g., the position of a slider influencing the rotational angle of a gauge pointer.

A dynamic wizard is to make complex dynamic functions easily accessible to the configuration staff.

The graphics editor is to support a configuration of 32 screen layers. In complex screens with many superimposed objects, individual layers can be hidden to make the depiction clearer.

Common Microsoft aids – such as tooltips for the online project – are of course integrated into the control system and can be configured in a few steps. This configuration as well is to have a multilingual definition.

Once an object has been created, it is to be stored in a library, from where it can be retrieved. This enables company-, technology- or industry-specific standards to be established that contribute to a fast project creation. The control system features a block library – which is subdivided into a global and a project-specific library, and a function library – which is employed in the configuration of actions.

The global library contains ready-made objects sorted by subject, which are part of the control system's delivery scope (valves, motors, conductors, gauges, etc.). This library can be industry-specifically expanded at any time. The project-specific library is intended for the individual project. The objects can be configured in multiple languages.

The blocks in the library shall be listed by name And/Or depicted as icon for the quicker and easier identification of the individual objects. The integration of such an object into a process screen shall be capable of drag & drop.

The global library is to contain the following object classes:

a. Shut-off fittings and gate valves

b. Displays and gauges

c. Control panels, buttons and switches

d. ISA and E symbols based on DIN 30600, ISO 7000

e. Conveyors, motors

f. Conductors, valves and tanks

g. Scales

The user object enables a configuration in block technology. In doing so, any graphical objects can be grouped into a new object, and relevant interface parameters for the process connection be defined. The names used by the configuration staff can be stored multilingual, e.g., "Upper limit" for English and "Obergrenze" for German. Via drag & drop, the user object is to be stored in the library and then be integrated in the control system screens. Only the user-specifically defined parameters are connected to process PO. The global library contains a series of such user objects (e.g., gauges) and, if required, can be expanded during the configuration at any time.

8.6.7 Trend Curve Screens

Archived values (instantaneous values or compressed values) shall be capable of being depicted in trend curves and tables – on the screen and in reports. Colors and patterns, for example, indicate limit value violations, replacement values, faults and time leaps.

The trend curve window is to offer a toolbar for trend curve operations.

By means of this toolbar, the following operations shall be possible:

a. Call of the help

b. Call of the configuration

c. Jump to the first data record

d. Jump to the previous data record

e. Jump to the next data record

f. Jump to the last data record

g. Enlarge section

h. Reduce section
i. Select size of section with the mouse
j. Enlarge/reduce time axis
k. Enlarge/reduce value axis
l. Move trend curve area
m. Move axis area
n. Return to original view
o. Select data connection
p. Select trend curve
q. Select time period
r. Previous/next trend curve
s. Stop/start update
t. Print display
u. Export data as CSV
v. Turn reading ruler on/off
w. Select statistics area
x. Calculate statistics
y. Connect/disconnect backup

A tooltip help is to explain the meaning of the individual icons. If desired, custom-designed buttons can be configured and supplied with corresponding operating functions. For authorized operators, it should also be possible to change the parameterization while in runtime, e.g., apply different colours to trend curves or rearrange groups.

To aid in the analysis, the individual trend curves are to be freely moveable along the time and value axes.

Limit value violations are to be marked by a configurable color change when output in the trend curve window.

From the trend curve depiction, it should be possible to perform statistical analyses. These refer to a freely selectable time period, which can be defined via two rulers. The following calculations are to be possible for the individual trend curves:

a. Minimum

b. Maximum

c. Average value

d. Standard deviation

Furthermore, the number of measurement points and the time period selected are to be displayed.

8.6.8 Message Logging / Analysis / Acknowledgment

The message list shall be displayed via line-oriented message windows. Statuses of messages should be distinguishable by color at any time. Freely definable selection filters specifically direct the view of the message display to individual process or plant sections. It shall be possible for any number of selections to be conveniently saved – to be available again at any time. In the proposed client/server system, the selections are to be centrally managed by the localised DCS server.

Ascending and descending sorting of alarms shall provide for a fast and efficient fault analysis. For example, all messages already cleared shall be automatically removed from the display, if they no longer meet the applicable selection criterion.

In a process screen of the SCADA system, multiple different message windows can be used.

8.6.9 Dynamic Message Window (Process Message Window)

This view shall only contain the arrived, presently still pending and not yet acknowledged messages. Messages that have already been cleared shall be configured for automatic removal from the view.

8.6.10 Message Window with Archive View

In this mode, all messages recorded in the short-term or long-term archive up to that time are displayed – including the already cleared ones. If necessary, newly arriving messages can be displayed in an additional message window.

8.6.11 Message Window with Hitlist

This display shall lists the messages sorted by frequency of their occurrence.

In addition, graphics objects should also be able to display message events by changing their appearance. The message shall be capable of being acknowledged by operating the graphics object.

Message reports shall continuously document the sequence of messages (message sequence report) or specific views in the archive (message archive report). The printout shall take place by page in the case of completely filled pages, or – in the case of a message sequence report assigned exclusively to a line-oriented printer – by line at the arrival of a message. Via open programming interfaces, the messages can be picked up and, for example, acoustically signalled through a sound card.

Any number of analysis actions can utilize this basis. If a message occurs, the application shall be capable of being configure to aim a video camera at the location of the cause and display the situation on the screen.

8.6.12 Process Control Narratives

Process Control Narratives shall be used to describe how each process is to be controlled. These narratives are important for PLC programming, SCADA HMI and Engineering development Client, and facility operation. These narratives should be divided on a process by process basis. Each process narrative identifies all associated equipment within the control scheme for each individual process.

The Process Control Narrative describes how the SCADA system interfaces with the facility and its process system and equipment. It gives details on the process indicators that need to be monitored to ensure that the process is operating correctly. This includes complete listings of all device names, I/O points, control loops, tag names, and control modes.

8.6.13 Process Monitoring

All process parameters such as flows, pressures, levels, etc. are to be displayed as required on the local panels and transmitted through the SCADA system to the SCADA HMI. The status of major process equipment shall be indicated locally and transmitted to the SCADA system. Once the information is in the SCADA system it can be displayed at any SCADA HMI workstation.

The status of auxiliary systems, such as HVAC, Electrical Power Distribution etc. should be monitored as required by the facility operating procedures and requirements.

All process and equipment faults and abnormal situations shall be indicated and alarmed at the at the SCADA HMI workstations. All alarms are generated within the PLCs and transmitted to the SCADA HMI.

Interfaces must provide not only process information but also status information. All pumps, valves, gates, blowers, mixers, and like process equipment shall have signals to the SCADA system which define the equipment's state of readiness, operation status, and control mode.

The following are general guidelines for selection of points to be monitored by the SCADA system:

a. Analog values for all major process variables such as flow, level, and pressure

b. The status of all major process equipment such as pumps, blowers, compressors, etc.

c. The status of all process variables or equipment monitored or controlled by a PLC.

d. The status of all Hand/Off/Remote switches.

e. Limit switches on all computer controlled, two-state valves (both open and closed).

f. Limit switches on all valves and gates used for flow routing, sluice gates and other critical equipment.

g. Motor speed for all variable speed devices that are to be monitored or controlled by the SCADA system.

h. Valve and gate position for all gates and valves which position is adjusted by the SCADA system

i. All safety indicators (e.g., combustible gas detection, fire detection, etc.).

j. Valves used strictly for maintenance such as isolation valves on pump suction and discharge will generally not be monitored.

k. Analogue values for monitoring Vibration, Temperature etc.

Status conditions such as tripped, failure etc. This shall include the reason of trip and failure.

8.6.14 Process Simulation

In the event of a fault in the communication subsystem, continue to process control algorithms with the last valid information.

The system must support different tool levels for simulating processes.

A controller simulation tool for simulating inputs and outputs in the field within the control logic and for facilitating tests and troubleshooting in the controller program must be available. This must be possible without controller or I/O hardware and simulation of batches as well as of continuous processes must be possible. Special modification of the actual controller program in order to permit its execution in simulation mode should not be required.

The system must support the use of PCI cards which must be capable of simulating actual electrical signals and check back signals from remote I/O stations and PROFIBUS field devices to a real controller.

The system must support the utilization of higher-level process simulation programs which can model the process dynamics. These programs must be capable of using the actual controller program to develop the model (maximum reusability) (with export/import of the hardware configuration data). It must be possible to configure the control execution rates for analog and discrete functions individually. The shortest cycle time for discrete and analog control functions must be 10 ms.

8.6.15 Process/Plant Signal Codes

These shall be taken from the listings as detailed and held by the design department. Refer to P&ID diagrams in the appendices of this document.

8.6.16 Process Code Lists

The following are the process code lists for guidance only. Final naming to be agreed with KAHRAMAA Design Department.

Table 3 Project Code list

KEY	DESCRIPTION
W	WATER TREATMENT
S	TREATMENT
G	GENERAL

8.6.17 Report System

The control system is to offer an integrated report system, with which the data can be put on paper. In selectable layouts, it prints data acquired during the process operation via

a. Message sequence reports

b. Message archive reports

c. Archive reports

d. Operating reports

e. System message reports

f. User reports

g. Hardcopies

as well as configuration data (backup documentation, completely or partially). Prior to the direct output on the printer, the reports can also be stored as a file and be previewed on the screen. Via a corresponding operation, the status of all jobs is to be displayed in runtime.

In the configuration, print jobs are to be specified with the layout, the extent (number of pages) and the printer. It is also possible to set cyclic hourly, daily and monthly reports. It should likewise be possible to start the report output time-/event-driven or via a direct operation.

<u>All reports shall support pdf format.</u>

8.6.18 Short-term Archive (Recorder Data)

The short-term archive is used to archive data points acquired by the real-time data processing as quickly as possible. The data stored is primarily used to obtain time curves of measurement values (recorder data).

8.6.19 Long-term Archive

Long-term archiving is the cyclic archiving via the parameterization of selected process data in a database and its further compression in specified time intervals as well as the automatic deletion of archive data after the reaching of a specified age. The data stored in the long-term archive (database) is available for the analysis by the system.

8.6.20 Requirement Specification

The contractor is responsible for the creation of the requirement specification. In the context of the requirement specification, all the details concerning the task definition and the special requirements are clarified and the solution approach is comprehensively described.

If necessary, the requirement specification – in the context of the technical clarification phase – is to be revised in accordance with the requirements and submitted again to the customer.

The scope of the requirement specification essentially includes:

a. Configuration (hardware and software)

b. Function description

c. Information lists of the signals processed

d. Plant screens

8.6.21 Screen Creation

For the creation of screens, the following procedure is assumed:

a. Screen concept utilizing the dynamic industry library elements (on paper or on monitor)

b. Coordination with the customer

c. Incorporation of desired corrections

d. Coordination with the customer again

e. Incorporation of possible required further corrections

f. Completion of the screen creation

An exception to this will be the first plant screen.

In this screen, basic attributes such as the screen arrangement, number and position of message lines, colors, and symbols need to be clarified with the customer. It is therefore assumed that the screen will be changed several times

8.6.22 Documentation

The documentation is to be designed so that the structure and function of the system are clearly and easily identifiable – ensuring an optimum maintenance and repair as well as an easy expansion.

8.6.23 Scope of the Documentation

a. Hardware documentation

b. Standard software and system software documentation

c. Documentation of the data points (PO)

d. User guide

e. Backup documentation of the system parameterization

f. Hardcopies of the plant screens

g. Screen hierarchy (structure of the screen navigation)

h. Group display

i. Program listings of the plant-specifically created application software

All above-mentioned documents are to be clearly put together and organized in DIN A4 folders (two copies), and presented to the customer for inspection no later than at the conclusion of the trial operation. In addition, a copy of the software system on CD/DVD is part of the delivery scope

8.6.24 Local Control

All equipment shall be provided with the means to operate the equipment locally in HAND mode. Such control may be at the device itself or at the associated MCC or local panel. Local control shall be fully independent of PLC control, and is activated by placing the Hand-Off-Auto switch in the HAND position. Indication of the position of all HAND OFF AUTO switches shall be provided on the SCADA System SCADA HMI and LOCAL HMI.

8.6.25 User Interface Control

The Operator should have control of all major equipment and process setpoints from the SCADA HMI or LOCAL HMI. The Operator must be able to respond to process changes or alarms by operating valves, turning on pumps and motors, and changing the setpoints on control loops. Control should be executed primarily through the SCADA HMI in the area control rooms, and as a backup, through the LOCAL HMIs at the PLC control panels.

8.6.26 Process Variable Monitoring (SCADA HMI Trending)

Variables such as flow, level, temperature, speed, and measurements from analytical instruments shall be able to be trended both in real-time and historically. An Operator should have the ability to call up real-time or historical trends that display interdependencies between process variables.

A historical data storage and retrieval system capable of holding a minimum of 5 years of data on-line without requiring installation of archived media should be provided.

8.6.27 Constraint or Interlocks

The SCADA system should provide an Operator with reasons why the command issued failed. Equipment interlocks that inhibit the commanded action need to be included on a SCADA HMI/LOCAL HMI display and in as-built record documentation.

8.6.28 Instrumentation Faults

The SCADA system should have the ability to identify and react to malfunctioning instrumentation. Input signals that are abnormal or out of range should be alarmed. In addition, the SCADA system must be capable of modifying or inhibiting control when signals assume abnormal or out of range values. Equipment control must be automatically placed in a fail safe mode upon instrument failure.

8.6.29 Loop Tuning

An authorized system user should be able to change tuning parameters of control loops through PLC programming software. This function must be password protected (administrator security level) and may be made available through the workstations. PID loops should be contained only in the PLC.

8.6.30 Report Generation

A wide variety of logs and reports are required to aid the Operator's interpretation of events and assist in controlling the process. Reports shall be produced on a fixed schedule and the system shall support ad-hoc reporting to suit Operator needs. The information content of the reports may contain real-time or historical data.

8.6.31 Control Modes

The control strategy for the control modes are identified in the Process Flow Diagrams which are given in the Appendices of this document. In any event the modes of operation are defined as follows:

a. HAND: Changes to process equipment are initiated from the HAND-OFF-AUTO switch. A pump in the HAND position shall be controlled through the local START and STOP buttons. A valve may be opened and closed through the local OPEN and CLOSE buttons or a switch.
b. OFF: All local commands to the device are disabled. A running pump will stop when switched to the OFF position.
c. AUTO: Changes to process equipment are initiated from the PLC, or backup control system. The AUTO control mode has two states, which may be changed from the SCADA HMI or LOCAL HMI. For critical processes having a backup control system, an AUX mode may be available.
d. SCADA-MANUAL: Changes to process equipment are initiated by an Operator. This may be from the LOCAL HMI or the SCADA HMI.

e. SCADA-AUTO: Changes to process equipment are initiated by a control strategy resident within the PLC logic.

8.6.32 Control Strategy

The local AUTO-SCADA HMI state is the executive primary state for Operations Management Level for the local site. Failure of the Local AUTO-SCADA HMI state shall send an alarm to the Master Operations Centre. The Master Operations Centre will only then take control of the local site by Manual intervention, which overrides the AUTO-SCADA HMI state.

The local MANUAL-SCADA HMI state is the secondary state of the site. This state can hand over control of the local site to the Master Operations Centre by manual assignment through the MANUAL-SCADA HMI state. It can also regain control by manual intervention through the same state. The communication between the Local MANUAL SCADA HMI state and Master Operations SCADA HMI is by OPC. The data is encrypted over VPN tunnels.

The dedicated SCADA-MANUAL is the LOCAL HMI or SCADA HMI faceplate graphic which is the primary state for the local control of a single PLC; this is not a networked communication. It can only take control of the device/PLC by Manual Assignment through the MANUAL SCADA HMI state. It is used to switch from AUTO-SCADA HMI at Operations Management level to SCADA-MANUAL state. This state is primarily used for making changes to the current condition of the equipment (e.g., RUNNING or OPEN) to that required by the control strategy.

The SCADA-AUTO state is the normal/running condition of the device/PLC as controlled via the AUTO-SCADA HMI state. Switching from SCADA-AUTO to SCADA-MANUAL does not change the current condition as configured at Operations Management Level.
Switching a device from OFF to AUTO mode will always place the device in SCADA MANUAL. Note that changing the position of the HAND –OFF-AUTO switch from the HAND position will always first STOP a motor. EMERGENCY STOP buttons and important safety interlocks shall be operable independent of the position of any other switches or control modes.

8.6.33 Alarm Monitoring Guidelines

The following are general guidelines for selection of alarms to be monitored by the SCADA system: The alarm color codes shall be provided for segregation the prioritized alarm.

The PLCs will generate alarm signals for all process equipment and process values, equipment status changes, extreme signal levels (value out of range), excessive rates of change, controlled device failure to respond, and system diagnostic signals. The PLCs will generate all analog point limit value alarms.

All emergency or alarm conditions shall be reported to the LOCAL HMI and SCADA HMI for Operator acknowledgement and response as determined by the alarm priority.
Each alarm will be assigned a priority reflecting its severity and importance. Priority 1 alarms are designated as CRITICAL and are considered to be conditions requiring immediate action, such as effluent quality, safety conditions, hazardous chemical leaks, fire, over torque, temperature overloading of motor driven equipment, and critical levels. These alarms will always generate a specific alarm annunciation at the SCADA HMI, with an audible alarm, and requiring acknowledgement by an Operator.

Priority 2 alarms are designated as GENERAL, and are considered conditions of potential problems unless corrective action is asserted on an "as soon as possible" basis. These alarms will always generate a specific alarm annunciation at the SCADA HMI, but can be distinguished from CRITICAL by alarm name, listing, color, and audible alarm tone. These alarms require Operator acknowledgement.
Priority 3 alarms are designated as ALERTS. These are signals that do not require immediate Operator attention or Operator acknowledgement, and will not generate an audible alarm.

8.6.34 Alarm Display

Specific textual alarms or equipment failure conditions are displayed when the alarms conditions occur. The alarming color sequence is as follows:

a.	Normal	Not Visible or White (case by case)
b.	Unacknowledged	Flashing Red
c.	Acknowledged	Static Red
d.	Unacknowledged, Return to Normal	Flashing Black.

8.6.35 Alarm Descriptions

The system shall permit the full text description of the identifiers of this specification. The location codes that would prefix the onsite identifiers are used where it is necessary to relate plant or signals to the site. Location codes will usually be applied by the system at node or SCADA level. The identification standards in this specification shall be sued for all process control systems and documentation.

Where systems permit, they should be the full text description of the identifiers of this specification. Note that the location codes that would prefix the onsite identifiers are only used where it is necessary to relate plant or signals to the site. Location codes will usually be applied by the system at node or SCADA level. The identification standards in this specification shall be used for all process control systems and documentation.

For example:

a) Process and Instrumentation (P&I) diagrams

b) Loop diagrams

c) HAZOP

d) Operational procedures for site quality assurance objectives

e) Manuals

f) Process location of plant items and instruments

g) Site schematic diagrams or schematic maps

h) Data, data analysis, databases and cross referencing

i) PLC names, internal register names or descriptions

j) SCADA systems, local and regional

k) Other user-interface panels

l) SCADA network drawings

m) Outstation wiring and documentation

n) Alarm wiring and documentation

o) Control equipment and signals

8.6.36 System Data and Documentation

The System Data shall include details of all data to be gathered, generated or calculated by the system. The details shall include type of data, range, accuracy/resolution and scaling. All data to be stored shall be detailed including historical trended data, alarms and events etc.

The following items shall be covered:

i. Location of data to be stored - fixed disk, external devices such as external hard disk, flash drives, etc.
ii. Retention period - length of time data is to be maintained
iii. Archiving of data - procedures for back-up to removable medium.
iv. Exporting of data - export facilities to other formats e.g. Excel, Access, Lotus, etc.

8.6.37 Systems Attributes

The section on System Attributes shall be divided into 'Availability', 'Maintainability', 'Installation', and 'Training' as per the following sub clauses:

a) 'Availability' shall state the expected "working" time of the system between failures. Any specialist designs for increasing availability where required, shall be described, such as redundant systems, etc.
b) 'Maintainability'. The CONTRACTOR shall consider and detail issues related to maintainability of the plant. Systems which require regular maintenance to ensure the reliable operation shall be clearly detailed.
c) 'Installation' shall include details of any special requirements for the installation of the equipment, as set out under the following sub clauses:

i. Transport and offloading
ii. Power and services required (Beyond the scope of permanent works)
iii. Connections to existing/3rd party systems
iv. Changes to existing plant or equipment
v. Changes to existing software systems

'Training' shall provide details of formal and informal training to be supplied under the Contract. Where training is not specifically required under the Contract but would nonetheless be beneficial, the CONTRACTOR shall make recommendations for training to be provided, including consideration of management, technicians and operations staff requirements.

The Process Control Narrative shall follow the format described as follows:

8.6.38 Narrative Structure

Each narrative follows a standard format. Items in the standard format that are not relevant or not used for control shall be indicated as such.

The following outlines the basic structure to be followed.

PART 1 – GENERAL

1.1 Introduction

1.2 Common Functions.
PART 2 – PROCESS A (Repeated for each Process)
2.1 Equipment Summary
2.2 System Control Strategy
2.3 Equipment Control Strategy (for each device within process)
PART 3 – CONTROL SYSTEM INTERACTION Input Validation
3.1 Input Validation
3.2 Alarms
3.3 Signal Conditioning.
a) PART 1 – General
The following describes the information to be included in the applicable sections.
Introduction – An overview of the process control area and how it fits into the overall SCADA system. Shall include interfaces to other process control narratives as required. Shall reference drawings and auxiliary information required to interact with the control narrative.
b) PART 2 – Process Sections
The following describes the information to be included in the applicable sections.
Equipment Summary – A description of all equipment within the associated process and integral to the overall control philosophy of the process. Include device tag names.
System Control Strategy – Describes how the process is to be controlled. Includes descriptions of all field selector switches, including all I/O that is part of the process.
Equipment Control Strategy – A detailed description of all I/O associated with each individual device including any calculations that are to be associated with the device (runtime, number of starts, etc.) Describes any hardwired interlocks that may alter equipment operation and all control modes associated with the device. Includes step by step descriptions to how they function in all control modes. This section contains all programmed interlocks and set points that are required to drive the process.
c) PART 3 – Control System Interaction
Input Validation – Addresses all values and I/O that are required to be displayed at the SCADA HMI and LOCAL HMI. Tag names are to be included for labelling these values.
Alarms – Provides specific details for all points that have alarming parameters. Alarm classification (level), display requirements, and alarm messaging are to be included.
Signal Conditioning – If any signal conditioning is required, it will be included under this section.

8.6.39 Naming Standards

Each piece of equipment requires a unique identification number. These numbers will be permanently attached to the associated equipment and used on all documentation including process flow diagrams, O&M manuals, and the SCADA system database. The format of the identification numbers must be carefully followed by all projects dealing with SCADA systems or related instrumentation.

Failing to follow the numbering standards may lead to database configuration problems which will make interfacing, documenting, and troubleshooting SCADA systems, operational data, and report generation erroneous.

8.6.40 Instrumentation and Process Plant Identification

The following is the KAHRAMAA preferred naming convention for constructing formal identifiers process, plant and signal codes and should be used in conjunction with ICA specification and QCS documents.

This code should be used for identification of operational process and plant, signals and associated data.

The identification should therefore be used for all process control systems and documentation.

The identification scheme given here for process plant allows visibility of:

I. Area/Site

II. Main process and number

III. Plant item/Instrument and number

IV. Signal

And will benefit by providing clarity of information at Asset Management Level.

The scheme allows for plant identifiers (for onsite use) of up to a maximum 9 characters in length, comprising process code, process numeric code, plant code and plant numeric code in accordance with the form of specification in this document. The 9-character plant identifier maximum length is compatible with the SCADA hardware and software currently available.

Note that the location codes that would prefix the onsite plant identifiers are only used where it is necessary to relate plant or signals to the site. Location codes will usually be applied by the system at node or SCADA level.

8.7 PLC CONFIGURATION OF CONTROL STRATEGY

8.7.1 Choice of Configuration Languages

Configuration languages shall be offered that are traditionally associated with both a PLC and DCS programming environment. These shall include the following programming languages including those described in standard IEC 61131:

a) Continuous Function Charts (CFC)
b) Sequential Function Charts (SFC)
c) Structured Control Language (SCL)
d) Relay Ladder Logic (LAD)
e) Instruction List (STL)
f) Function Block Diagram (FBD)
g) Safety Matrix (for programming of Safety Systems)

8.7.2 Continuous Function Chart

A continuous function chart (CFC) tool conforming to IEC 61131-3, shall be available for graphical configuration and connection of function blocks. The CFC tool positions, parameterizes, and connects predefined function blocks using an auto routing and integral message configuring function.

It shall be possible to embed a CFC inside another CFC for creation of unit- or equipment-control applications.

It shall be possible to embed CFC charts to a nesting depth of eight. (Support from macro functions)
Connections between function blocks shall require no more than two mouse clicks no matter where they are located, by using auto routing. The auto routing function shall prevent wiring from falling on top of each other.

The tool shall support comprehensive syntax checking during configuration.

Double clicking a connection shall turn the wiring a different color and shall open the destination of the connection, for example, another CFC chart or the I/O module where the signal is connected.

The system shall support trend displays of up to 8 trends in the CFC. It must be possible to export the displayed values.

The vendor system shall enable drag-and-drop across charts in the CFC with tracking of the interconnections.

8.7.3 Sequential Function Chart (SFC)

A sequential function chart (SFC) tool shall be available for graphical configuration of sequential and batch processes per IEC 61131-3. Steps and transitions shall be graphically configured using a convenient editing function. The tool shall support comprehensive syntax checking during configuration.

Connections to continuous control functions shall be available using simple actions such as *Browse, Drag and drop* and *Fill in the blanks.*

The operator's visualization display shall be automatically created, including dynamic step/transition boxes, overview, navigation display, and list boxes.

To minimize configuration time, the system shall automatically connect SFC steps and transitions during configuration, based on their placement in the SFC chart, without requiring the user to manually connect them.

The SFC tool shall provide a standard interface for configuration of the three phases of execution of a step (Initialization, Execution and Termination).

The vendor system must be able to display multiple SFC groups with their current states in a picture in tabular form.

8.7.4 Structured Control Language

A structured control language (SCL) shall be available which utilizes a high-level text-based language whose global language definition conforms to IEC 61131-3. This language, which is similar to PASCAL, shall be capable of being used to program calculations, complex optimization algorithms, define SCADA HMI attributes / behavior and to call other function blocks directly from within the program. It shall support the use of a subroutine style of programming to maximize modularity and reuse. Function Blocks created using SCL can be used throughout the program like standard function blocks in the CFC Editor.

8.7.5 Ladder Logic (LAD)

The system shall support programming in Ladder Logic using syntax similar to a relay ladder logic circuit diagram. The elements of a circuit diagram can include normally open contacts, normally closed contacts, function blocks etc which can be combined to form networks per IEC 61131-3.

8.7.6 Instruction List

The system shall support the use of a Statement List Programming Language (STL) which utilizes a structure similar to machine code. Each statement shall represent a program processing operation of the CPU. Multiple statements shall be capable of being linked to form networks IEC 61131-3.

8.7.7 Function Block

The system shall support configuration using function blocks according to IEC 61131-3.

The user shall be able to modify the appearance and behavior of function blocks by simple modification of an object's property sheet.

Function blocks shall have integrated startup characteristics which govern their behavior during cold start, warm start and hot start conditions.

8.7.8 Safety Matrix

The system shall support the configuration of Safety System programs using a cause and effect matrix, which allows the user to easily relate process events (inputs or causes) to shutdown devices (outputs or effects) by listing all possible causes on one axis and all effects on the other. The relation of causes to effects is defined by marking the appropriate box (intersection) in the matrix. Configuration of matrix should be simple and intuitive by employing familiar Windows point and click, drag and drop, and dialog box style editing.

8.7.9 Custom Function Blocks

The system shall allow users to create their own custom function blocks from scratch using ladder logic, structured control language or other. These custom function blocks should be able to be added to the application library for reuse throughout the project.

Custom function blocks shall be used in the application just like a standard function block (for example they can be embedded in CFCs or connected to standard function blocks) Custom function blocks shall have the capability of being password protected so that access to proprietary intellectual property may be protected in the field.

There shall be no practical limit to the number of custom objects that that a user can create and download is only limited by the memory capacity of the target controller.

8.7.10 Interconnection of Function Blocks and Control Modules

All parameters contained in a control module (composite of multiple function blocks) shall be able to be directly connected to another control module without the need for additional parameter function blocks.

The system shall support auto routing which allows function blocks which are located anywhere in the configuration to be connected quickly by two mouse clicks.

The system shall prevent the user from connecting together function block parameters which have different types (real, Boolean, string etc).

The system shall enable the user to interconnect function blocks above the limitations of an automation system via drag and drop, without the usage of additional communication blocks.

8.7.11 Process and Equipment Interlocks

For ease of use and to minimize engineering costs, it shall be possible to configure device interlocks graphically via simple point and click operations between function blocks. It shall not be acceptable to require the user to program the interlocks using a text-based script-editor.

8.7.12 Testing and Commissioning

All configuration tools shall have test and commissioning functions, for example, it shall be possible to display and modify the value of a function block input or output parameter selective during operation, and with SFCs, to display step conditions and transitions during operation. The manual change of a value has to be marked on the function block on the CFC plan as well as on the faceplate.

From the engineering environment, the user shall be able to create a *Dynamic Display List to* view and manipulate selected real-time input and output values from the control strategy within a table form.

The user shall be able to create Dynamic Trend Displays from the engineering environment to monitor selected real-time input and output values from the control strategy.

It shall be possible to disable the execution of a configured module or force specific values (i.e. hardwired I/O signals) to override the actual signal, all without affecting other modules that may be running in the same controller.

8.8 PLANTWIDE NETWORKING SERVICES

8.8.1 General Specification

The following network standards shall be followed:

The, SCADA system network installations shall be designed using a minimum of 1Gbps FOC uplinks. The communications media to convey signals between network devices shall be fiber optic cables and copper cables. Fiber-optic cabling shall be installed for all backbone network segments that run between process areas. Copper cabling may be used for network segments that are completely within a single room, such as a control room, and between fiber optic network nodes and devices such as PLCs, subject to the maximum allowed distance for CAT6 cable.

8.8.2 Network Performance and Protocol

The network is based on Industrial Ethernet switches in a ring topology. All rings switches are connected using trunk fiber links which will carry multiple VLANs. All switches will be capable of supporting 10/100/1000 Mbps auto-switching communications rates. All devices connected to the ring are connected to dual paths as depicted on the drawings which will provide redundancy to at least two paths.

8.8.3 Operations Level LAN

The operations LAN comprises of the ETHERNET switches interconnecting the Operator workstations and the SCADA Servers. Their type and performance are depicted on the drawings contained in this specification

8.8.4 Field Level LAN

The Field Level LAN server to connect the field and control level devices including but not limited to: PLCs, Distributed I/O's, to the Data Collection Servers. The Field ETHERNET switches shall be of the industrial type, suitable for the plant environment. The Field Level LAN shall be composed of either a redundant Ring having dual ETHERNET ports shall be connected to the Zone ETHERNET Switches.

8.8.5 IP Addressing

The range of IP addresses shall be provided by KAHRAMAA for the configuring the network devices. The CONTRACTOR shall secure all copies of all network IP addresses, network configurations, and project documentation.

All projects related network documentation used by the CONTRACTOR for execution of the work shall be handled as “Confidential” and provided to employees on a “need to know” basis only. Prior to releasing any project related information a nondisclosure agreement must be signed and the CONTRACTOR must request, in writing, permission from KAHRAMAA before providing project documentation to anyone not directly associated with the project.

8.8.6 Virtual Local Area Network (VLAN)

The CONTRACTOR shall configure Virtual Local Area Networks for the Plant Wide Automation System. The following are the recommended VLAN details and the recommended IP Address Range:

Table 4 Virtual LAN Assignments

VLAN ID	Description	Address Range	Number of Hosts
	Network Management System		
	Network Management System		
	SCADA Electrical – Low Voltage		
	SCADA Electrical – Low Voltage		
	SCADA – Process Control		
	SCADA – Process Control		
	SCADA – Operator Workstations		
	SCADA – Building Services HVAC		
	SCADA Electrical – High Voltage		
	SCADA Electrical – High Voltage		
	SCADA Electrical – Low Voltage		
	DC Power Supply Units		
	SCADA Electrical – Medium Voltage		
	SCADA Electrical – Medium Voltage		
	CCTV		
	CCTV		
	Unallocated		
	Unallocated		
	Unallocated		

8.8.7 Quality of Service (QoS)

The CONTRACTOR shall configure Quality of Service policies for the data traffic. The Data traffic shall be classified in order of importance, and these shall be marked with the respective DSCP Value. Four categories are recommended, to minimize the configuration required for the QoS Policy. The Allocated bandwidth per class shall be agreed with the Client. Potential bandwidth constrained links shall be identified, including the Wide Area Network Links.

The recommended traffic classification below shall be a guide for the Quality of service applied to the data traffic.

Table 5 Quality of Service Classes

Traffic Class	Traffic Type	DSCP Value	Match type	Remarks
Premium	Voice OPC SCADA – SCADA - Electrical Engineering Programming traffic,	46	Port Number and Protocol and IP address of machine	Mission Critical
Gold	TACACS, Security	10	Port Number and Protocol and IP address of machine	Preferred
Silver	Telnet CCTV SCADA – Building Management System	18	Port number	Best Effort
	SMTP	20	Port number	
	FTP	22	Port number	
Bronze	HTTP	26	Port number	Scavenger Class

The CONTRACTOR is to use the Templates to configure quality of service on the network in order to provide maximum system usage and balance CPU resources.

The CONTRACTOR shall determine the best Layer 2 parameters—802.1Q class-of-service (CoS) bits for each application on the network.

The layer 2 marking shall be done in the following fields: 802.1Q/p Class of Service (CoS)—Ethernet frames can be marked at Layer 2 with their relative importance by setting the 802.1p User Priority bits of the 802.1Q header. Only three bits are available for 802.1p marking.

It should be noted that only 8 CoS (0-7) can be marked on Layer-2 Ethernet frames.

The following steps to implement the identification and classification of IACS network traffic are recommended:

Step 1 Establish ACLs for each IACS network traffic type. This will allow the industrial Ethernet switch to filter the IACS network traffic based upon key characteristics like transport protocol (UDP or TCP), port type (CIP Explicit messages or Implicit I/O) or existing DSCP value.

Step 2 Setup class-maps to match the acl-filtered traffic with a classification.

Step 3 Setup a policy map that assigns classification to class-maps

Step 4 Assign the service policy to each port that transports IACS network traffic.

The CoS configurations shall be implemented on every ingress port for edge port where defined on the drawings.

This being a converged network the CCTV and MEP SCADA traffic will run on the same network as the Process traffic. The most burgeoning requirement will be CCTV traffic as it travels towards the Media Servers located in the control room. It is imperative that this traffic does not delay the PROCESS control traffic or VOIP traffic.

The switches will automatically be configured to identify these frames and forward this data over and above other Frame Types, particularly in terms of Cyclic Traffic Flow.

However in the event of Acyclic data flow there is a CoS requirement for prioritizing traffic from Client workstations to field devices where CoS will be required to protect this communication.

8.8.8 Process Control Architecture

The Plant Wide Process Control Architecture proposes a Distributed Communications Systems where a number of Master PLCs, depicted on the drawings are required to communicate with field PLCs. The PLCs will be directly wired into Industrial Ethernet Switches.

There will be no requirement for Optical Communication Modules in general terms. However where it is proposed to extend a PROFIBUS network using OCMs, then the following applies.

Optical Communication Modules (OCMs) shall be designed for standalone operation. OCMs shall provide media conversion between copper and fiber optic cable, and support ETHERNET communication between PLCs and SCADA nodes. In addition, they shall support fault tolerant communications over a dual fiber.

OCMs shall provide on-line continuous diagnostics of the optical signals, detecting weak signals and channel faults. Discrete relay outputs shall be energized when a weak signal or a fault is detected on either channel in either direction.

8.8.9 PLC-to-PLC

The requirements for data transfer between PLCs shall be analyzed with respect to the need to initiate messages based on events (such as activation of an alarm condition) or on a regular timed interval. The ETHERNET speed shall enable individual message transactions to be completed in sub-second durations (Typically under 150ms). Nevertheless, the ladder logic shall be designed to not exceed the response time of the process requirements, except by some nominal factor.

The data files shall be organized to easily add new data values to Message instructions.

The data files shall be organized to easily add new data values to Message instructions.

8.8.10 Control Room SCADA HMIs to PLCs

The following guidelines shall be used to implement SCADA communications:

I. Dedicated SCADA polling files shall be assigned in each PLC.

II. The poll files shall be in floating point, integer and status data files as required.

III. Bit files shall not be used; discrete data shall be transferred to integer files.

IV. The data shall be compacted into contiguous memory locations to minimize the size of poll records.

V. The data files shall be organized to easily add new data values to poll records.

VI. The frequency of polling shall not exceed the update rate required by the SCADA system, except by a nominal factor.

8.9 AUTOMATION REQUIREMENTS -GENERAL

8.9.1 Environmental Compliance

The controllers and peripheral devices used in this project must be designed for operating under the following ambient conditions: Temperature range 0 °C to 60 °C and a relative humidity of 5% to 95%. All process areas are deemed hazardous and the I/O system, within these areas, must be capable of being installed in hazardous areas in accordance with Class 1 Div 2 (Groups A, B, C and D) and CENELEC/ATEX Zone 2 in enclosures for use outdoors.

The devices must satisfy all EMC regulations according to the IEC standards 61000-4-2, 61000-4-3 and 61000-4-4.

It must be possible to replace a control module or an input/output module without removing the power or field cables.

8.9.2 Redundant I/O Controllers

The design is based on Redundant Master PLCs (I/O Controllers) located in the computer room which then communicate with Process Plant PLCs in the field over a PROFINET network. It must be possible to integrate upto 64 Process Objects in order to reduce the necessity of distributing the user application programs..

The design allows for the redundant controllers to share the same backplane, which is common practice. The controllers must work with a two-channel (1 out of 2) structure according to the "active redundancy" principle, where both CPUs execute the same step of the user program. If a CPU error is detected, a smooth switchover must be activated, which allows a complete switchover of the controller in the middle of a program sequence without losing any alarms or messages.

All controllers are backed up by a 2 hour UPS as depicted on the drawings however in the event of a longer power outage, it must not be necessary for the controller to access the engineering station to reload a part of its configuration. The load memory of the controller must be protected by means of battery back-up so that the controller retains its configuration and status information in the event of a longer power outage.

The following programming languages must be available (including the ones described in the standard IEC 61131-3): Continuous Function Charts (CFC), Sequential Function Charts (SFC), Structured Control Language (SCL).

8.9.3 Modes of Operation

It must be possible to put each individual closed-loop control circuit into manual, automatic or cascade mode. For a cascade, it must be possible to set remotely activated management variables (setpoint values) from other controllers or control modules.

The switchover between all of the modes of a controller must be designed to be bumpless and without compensation with windup protection.

Control blocks must be able to automatically switch modes based on external binary inputs.

Standard software algorithms must be available for executing regulatory control functions. They must have parameters which can be configured easily.

Algorithm calculations must be carried out on the basis of a real number with a physical unit or other equally valid methods that do not require scaling.

The following input functions must be provided as a standard configuration: Finding the square root for flow measurement, linearization of type B, E, N, J, K, L, R, S, T and U thermocouples, linearization of resistance thermometers (RTDs), pulse summation of digital input, conversion of pulse input to frequency.

The following computing functions must be provided as a standard configuration or simple algebraic instructions: Addition/subtraction, lead-lag, integrator/accumulator, dead time, high/low selection, multiplication/division time averaging, signal selector switch, exponential polynomial, logarithms, square roots, absolute value.

The following control functions must be configurable: Proportional Integral Differential (PID), auto/manual with bias control, ratio control, step controller, controller with split range, cascade control, override, PID with feed forward control action, self-tuning control, fuzzy-logic control, multi-variable control, neural networks.

The following output functions must be provided as a standard configuration and must be equal, independently of the execution in the system controller: Linear, linear with clamping (upper and lower limits), non-linear characteristics.

Upper and lower clamps for all setpoints (setpoint clamps) must be configurable.

8.9.4 Sequence Control in Controllers

The Sequential Function Chart (SFC) function must be available. An SFC (Sequential Function Chart) is a structured, higher-level control programming language in accordance with IEC 61131-3. SFCs must have the following features, for example:

a. Provision of the required equipment for real-time control of sequential processes

b. Access to process control databases and other databases

c. Possibility of changing the program logic while other sequencers are active

d. Support of the execution of the function block diagram in manual or automatic mode

e. Possibility of configuring several operating modes and/or state logics in a single SFC container

f. Possibility of creating master SFC elements which can be copied and used in a configuration such as function blocks. Changes to a single instance of the SFC result in the automatic update of all other instances in the controller configuration

g. Possibility of automatically creating the displays for visualization and control of the SFC in the master SFC direct from the controller configuration

The following standard sequential control functions must be provided: Stop sequence – manually or at a set time, jump back to an earlier step, skipping one or more steps, automatic restart after complete sequence (cyclic operation), configuration of maximum or minimum execution times for steps, capability of configuring an optional operator confirmation for each individual transitional state.

The following modes must be available. They establish how switching from step to step is done: transition, confirmation, transition and confirmation, transition or confirmation.

Each step of a function block diagram must support the following standard phases of the step execution: Initialization, execution and termination.

The following 16 SFC operating states (according to ISA-88) must be supported by the system: Ready, Starting, Active, Completing, Error (Completing), Completed, Holding, Held, Resuming, Error, Held (error), Resuming (error), Aborting, Aborted, Stopping, and Stopped.

8.9.5 Self-Tuning

An integrated PID self-tuning function must be available on the engineering station.

It must be usable for processes with slow and fast dynamic responses, allowing its use in connection with self-regulating and integrating processes and it must be resistant to interference voltages and process load disturbances.

The PID auto-tuning function must provide a user-friendly graphical interface with a setup wizard. The tuner software package expands the PID controller via an additional function block to form a self-tuning PID or PI controller. This allows you to set PID controllers online and to adjust them during operation. Convenient adaptation of the controller to the process in online mode is possible by means of easily understood functions and systematically structured examples.

The PID self-tuner function is responsible for optimizing temperature controllers, level controllers and flow controllers. It can be combined with all controller products and can be used on the hardware platforms of the controllers.

The tool must be suitable for optimizing controlled systems with or without an integral component. Optimization can be carried out in manual or automatic mode. The transient response of the controllers with the determined parameters can be checked by defining jumps. It must be possible to save and recall the derived parameters as required.

8.9.6 Equipment Fault Monitoring –Error Handling

Any time field equipment fails to respond to commands, changes status without Operator or strategy intervention or switches states, the SCADA system shall notify Operations via an alarm.

The "invalid value" status must be generated for input values and calculated variables. A value must be declared invalid if one of the following conditions applies: "Value outside of range", "Value cannot be measured or calculated", "Value is declared invalid by an application", or "Value is declared invalid by the sensor or transducer". The status "invalid value" (data quality) must be distributed by control concepts and must be available at the SCADA HMI. It must be possible to suppress the detection and distribution of an "invalid value" status. This selection must be available by TAG. It must also be possible to use an "invalid value" status as a logical input of changes of the control algorithm. If the input of a control algorithm is declared invalid, it must be possible to configure the output to "error" as follows: Keeping the last correct value, output signal zero or output of a user-defined output value.

8.9.7 System Data and Documentation

The System Data shall include details of all data to be gathered, generated or calculated by the system. The details shall include type of data, range, accuracy/resolution and scaling. All data to be stored shall be detailed including historical trended data, alarms and events etc.

The following items shall be covered:

i. Location of data to be stored - fixed disk, external devices such as external hard disk, flash drives, etc.
ii. Retention period - length of time data is to be maintained
iii. Archiving of data - procedures for back-up to removable medium.
iv. Exporting of data - export facilities to other formats e.g. Excel, Access, Lotus, etc.

8.9.8 Systems Attributes

The section on System Attributes shall be divided into 'Availability', 'Maintainability', 'Installation', and 'Training' as per the following sub clauses:

a) 'Availability' shall state the expected "working" time of the system between failures. Any specialist designs for increasing availability where required, shall be described, such as redundant systems, etc.

b) 'Maintainability'. The CONTRACTOR shall consider and detail issues related to maintainability of the plant. Systems which require regular maintenance to ensure the reliable operation shall be clearly detailed.

c) 'Installation' shall include details of any special requirements for the installation of the equipment, as set out under the following sub clauses:

i. Transport and offloading
ii. Power and services required (Beyond the scope of permanent works)
iii. Connections to existing/3rd party systems
iv. Changes to existing plant or equipment
v. Changes to existing software systems

'Training' shall provide details of formal and informal training to be supplied under the Contract. Where training is not specifically required under the Contract but would nonetheless be beneficial, the CONTRACTOR shall make recommendations for training to be provided, including consideration of management, technicians and operations staff requirements.

The Process Control Narrative shall follow the format described as follows:

8.9.9 Instrumentation and Process Plant Identification

The following is the KAHRAMAA preferred naming convention for constructing formal identifiers process, plant and signal codes and should be used in conjunction with ICA specification and QCS documents.

This code should be used for identification of operational process and plant, signals and associated data.

The identification should therefore be used for all process control systems and documentation.

The identification scheme given here for process plant allows visibility of:

I. Area/Site

II. Main process and number

III. Plant item/Instrument and number

IV. Signal

And will benefit KAHRAMAA by providing clarity of information at Asset Management Level.

The scheme allows for plant identifiers (for onsite use) of up to a maximum 9 characters in length, comprising process code, process numeric code, plant code and plant numeric code in accordance with the form of specification in this document. The 9-character plant identifier maximum length is compatible with the SCADA hardware and software currently available.

Note that the location codes that would prefix the onsite plant identifiers are only used where it is necessary to relate plant or signals to the site. Location codes will usually be applied by the system at node or SCADA level.

8.9.10 Site Local Codes

Sites are each identified by an 8 –character identifier. These are the Corporate ID Location Codes. KAHRAMAA Design Department administers the codes and the list may only be changed at their request. The codes are available at request of the Design Department.

8.9.11 ICA Software Release & System Access

All KAHRAMAA asset delivery schemes, which have a control system element, must complete an software release and systems access procedure.

8.9.12 Creation of New Identifiers

When a project requires a new identifier for process, plant or signal, the proposed identifier will be discussed with the KAHRAMAA design department. New identifiers are only to be introduced unless absolutely necessary.

8.9.13 Rules for Identifying Plant

Plant shall be identified in accordance with the following:

I. All plant shall have a process related unique identifier. Plant identifiers that are not the subject of the CONTRACTORs immediate work shall be taken into account to the approval of the Engineer.

II. The identifier shall comprise location, process and plant/instrument codes selected by, and numeric information allocated by the CONTRACTOR, in accordance with this standard, to the approval of the Engineer.

III. The location code shall be omitted for the use within the location, where ambiguity will not result. This is to avoid unnecessary long string of characters, which will add no value and my not be accepted by many systems.

IV. Main process units shall have identifiers that do not include plant/instrument/signal codes.

V. Signal within SCADA systems shall be derived from the plant/instrument/signal identifier in accordance with this specification. The 9 –character identifier maximum length is compatible with SCADA hardware and software currently available.

VI. Alarm and regional SCADA (Telemetry) signals are text descriptions shall be in accordance with this specification.

VII. The physical location of plant and associated plant shall be logical and shall be such that the individual would naturally choose the correct plant item in the absence of a numbering system. For example, the physical location isolators in relation to plant be such that the individual would naturally choose the correct isolator. The numbering system approach chosen shall be logical and sequential in relation to the physical location of the plant, shall not cause confusion and shall assist the individual in identifying the purpose of plant.

8.9.14 Identifier for Process Plant

Plant associated with main process units shall be given identifiers as follows:

LLLLLLLL-PPP(B)(C)(D)

Main process unit plant shall be given identifiers as follows:

LLLLLLLL-PPP(#)

LLLLLLLL is the 8-character Corporate ID location code(obtained from KAHRAMAA Design Department). The location code shall not be displayed for onsite use. When information or data leaves the site, the location code shall be used.

PPP is the 3 character process code

(B) is a 1 or 2 character process numeric code. Refer to KAHRAMAA Design Team for Code rules for each site

(C) is the 1 or 2 character plant code, or for instruments, the instrument plant code shall be 2 characters and be derived from Table 2

(D) is a 1 or 2, character plant numeric code. Refer to KAHRAMAA Design Team for Code rules for each site

The identifiers PPP(B)(C)(D) above shall be a total of 9 characters or less in length.

Where codes appears to be unsuitable or not available, clarification shall be requested from the KAHRAMAA Design Department.

8.9.15 Delimiters (dash)

The delimiter (-) shall be used to separate the location code from the subsequent codes.

For example ANDOS1ZZ-RAS1P1

8.9.16 Programmable Logic Controller (PLC)

For process common nodes i.e. where control is for several process areas, such as inlet works, and storm tanks, the PO must be intuitively grouped to clearly indicate to which process they relate. i.e. use of available structure within the software, such as subroutines, files etc.

Where platform does not permit alphanumeric PO of sufficient length, other descriptive fields relating to the tag, such as a symbol, to mnemonic' fields must be used to do so.

In cases where field length available for entry of "symbol name" or 'mnemonic" in a PLC type is less than the plant and single identifiers, the full identifier shall be entered in the " description" field, with and agreed suitable abbreviation used in the " symbol/mnemonic" field.

I. The PLC signal code shall be sued as a suffix to the plant or instrument identifier to indicate the signal.

II. Where the tag does not relate directly to a plant item i.e. internal logic tag, it must have a unique identifier of similar structure and brevity. The tag may be formed by a string of more than one of these signal codes

8.9.17 PLC Temperature and hazardous environment hardening:

The Key environmental hardware specifications for the PLCs and Networking Devices include

a. Operating temperature: - 40 ºC to +70 ºC (-40 ºF to 158 ºF)
b. Operating humidity: 5% to 95% RH @ 50 ºC without condensation
c. Mechanical vibrations: Per EIA/TIA 603 Base-station, Sine 0.07 mm @ 10 to 30 Hz, 0.035 mm @ 30-60 Hz
d. Operating altitude: - 400 meter to + 4000 meter (-1312 ft to + 13120 ft)
e. Input isolation: 2.5 kVDC/AC between input and module logic
f. Overload and short circuit protection: Constant current limit with automatic recovery

g. Over-voltage protection

8.9.18 Node Names and Addresses

Where the platform permits the node names should be the text based description of the process area from this specification. This is restricted to differing lengths dependant on Processor/software type. Where limited to less than 8 characters, the specification Process code and plant code should be used e.g. ASL0ZZ for Aeration a Common PLC, or RTU for a PLC controlling a small site of multiple processes. This system will allow a site with multiple PLCs to be logically named for each process area using this specification.

8.9.19 Internal Register (tag) Descriptions, Inputs and Outputs

Where alphanumeric PO of length 6 characters or more are possible, and where the tag relates directly to a plant item i.e. a PLC input or output, the tag must be named using the plant and signal identifiers of the specification. The descriptive fields for the tag should be named with the text based description of the plant and signal codes.

e.g. Tag TK!@HH Description Tank 12 high high

Where platform permits longer tag strings, the plant signal identifiers of the specification will be separated by an underscore or similar distinguishable separating character, to make the tag more intuitive.

E.g. Tag: P11_TD Description: Pump 11 Tripped

8.9.20 Documentation

THE CONTRACTORS Documentation shall include the following:

a) Panel Connection Diagrams

Panel connection diagrams shall show all connections internal to each panel, and specifically power wiring connections, wiring not shown on Instrument Loop Diagrams, network connections, and connections to the LOCAL HMI.

b) Instrument Loop Diagrams

Instrument loop diagrams shall be provided for each loop, and shall conform to ISA S5.4 and these SCADA Standards. Each loop shall be documented such that there are no more than four loops per sheet with each connection point shown.

c) Installation Drawings

Installation drawings shall show installation arrangements for all provided equipment, mounting and anchoring details, conduit entries into cabinets, and SCADA System electrical power supply distribution conduit and wiring. Data sheets and/or catalog cuts for mounting devices, anchors, wire and other incidental installation materials shall be included.

d) Interface Cables

Interface cables diagrams depicting cable pin-out/cable makeup shall be provided as part of the documentation package. This includes all network cables, radio to PLC cables and computer to PLC cables. All cables shall either be standard cables from the manufacturer or custom made without the use of gender changers, 9-25 pin converters, or null modem adapters.

e) Equipment Lists

Additional documentation that shall be furnished, and described elsewhere in these Standards in more detail includes: Wiring Schedules, Cable Schedules, Conduit Schedules, and I/O Lists.

f) Software The software documentation shall provide a comprehensive description of all software necessary for the operation and maintenance of all components of the SCADA system. It shall include a description of any engineered or custom software required.

Documentation shall be furnished for the PLC programming software, LOCAL HMI/SCADA HMI programming software, and any PLC loadable modules or other custom software. This document shall include, as a minimum:

I. A list of the installed characteristics of the PLC programming program, including priority, and access privileges and computer system requirements (Processor, Operating System i.e., Windows 7, Windows 7, etc.) needed to run the program.

II. A list, with descriptions, of any PLC loadable modules used for configuration.

III. A list, with descriptions, of any other custom software used.

IV. Cut sheets or product data sheets for the software provided.

8.9.21 Critical Process Area

In each project document, the critical process areas are to be defined. Separate PLCs (redundancy in CPU, Power supply and communications etc.) for those areas are to be specified. Refer to the P&ID diagrams in the appendices of this document for the presentation of each Process Area.

Based on the capacity of treatment Plant, the design consultant must identify critical process areas (as all Treatment works having same process streams) required for PLCs with redundancy in CPU ,Power supply etc. as per QCS and required number of Works stations , Servers , Historian servers etc. for SCADA system.

The PLC/SCADA system is to be defined based on the process plant systems requirements, which shall comprise , process treatment areas, Building Automation Systems, Electrical Energy management systems, and External PO support.

The following documents are required as part of the project documentation:

I. I/O point identification

II. System Overview includes Process, Control System, Human Interfaces, System Sizing, etc.

III. Functions and operations

IV. Data & Attributes.

V. Design, Development & Test Factors

VI. Quality Plans

VII. Test Factors:

Each stage of testing shall be detailed within the FDS, including the following

i. Module and Integration Testing

ii. Factory Acceptance Testing (FAT) performed at the suppliers premises

iii. Site Acceptance Testing (SAT) on completion of commissioning to demonstrate the system operates pre-handover.

In addition the FDS shall include details of all test documentation and responsibilities for testing both off line and on line.

Functional Design Documentation shall include the following:

a) Product Information

Product information shall include, but not be limited to: catalog cuts, data sheets, performance surveys, test reports, equipment lists, material list, diagrams, pictures, and descriptive material. The product information shall cover all items including mechanical devices, mounting components, wiring, terminal strips, connectors, accessories, and spare parts. The submittal information shall show the standard and optional product features, as well as all performance data and specifications.

b) Equipment Location Plan

Drawings showing the location of all equipment being installed for the project shall be prepared. Drawings shall show, as a minimum, the location of PLC control panels, junction boxes, instruments, conduit or raceway routes, communications patch panels.

c) Panel Fabrication and Layout Drawings

Panel fabrication drawings are scaled drawings that shall show the physical dimensions, materials, and construction of panels, cabinets, terminal boards, or other electrical or mechanical equipment enclosures. These drawings show the physical arrangement and mounting of all components in or on a panel, terminal board, cabinet, or enclosure. These drawings show the physical dimensions, and the space and mounting requirements of mechanical, electrical, control and instrumentation devices or pieces of equipment. Other information provided may include ventilation requirements, locations of connections, weight, and paint color, material and dry film thickness.

As a minimum, panel fabrication and layout drawings shall include a bill of materials: front, back, and section views; the locations of all components to be mounted in or on the panel, cabinet, console, enclosure or assembly; drawing scale; nameplate engraving schedule; and structural materials and supports. All drawings shall be scaled. Overall dimensions and minimum clearances shall be shown. Sufficient detail shall be included to demonstrate material choices, outward appearance, construction methods, and other specific requirements.

8.9.22 Standard Symbols

The CONTRACTOR is to consult with the O&M for 's standard symbols. Within the appendix of this document there are example P&ID and CFD for typical symbols used and recognised by.

8.9.23 Life Expectancy Warranty

Typically expect various Hardware components i.e. PLCs, I/Os, Networking switches to have an equipment life of a minimum 10 years. <u>The overall system availability shall be 99.99%. The contractor shall also provide guarantee of a shelf life of 5 years.</u>

8.10 ELECTRICAL INSTRUMENTATION AND CONTROL

8.10.1 Earthing

Separate Instrumentation Earth Grid shall be provided as per the standards and all analogue and digital signals shielding shall be connected to this earth only.

The grounding system shall be full isolation as described in IEC 61158-2, the cable shield ground is fully isolated from the device grounds. The cable shield is to be grounded at the power supply.

The cables are to be run in metal conduits in order to protect against high frequency interference.

8.10.2 MCC enclosure

All MCC panel enclosures shall be specified as GAMBICA, Form 4 type 7 or Form 4 type 4b as per IEC60439-1

The separation between the individual compartments shall be specified as IP5X to prevent incident in any compartments. Separation shall be with the same sheet steel material used for the panel construction. Panels with IP2X specification are not recommended.

interface; supply, mount ready-to-operate and attach electrical connections.

8.10.3 Rugged Uninterruptible Power Supplies (RUPS)

Rack mounted Ruggedized Uninterruptible Power Supplies (RUPS) shall have the following specifications:

I. Invertor Power Output 6000W

II. Operating Voltage: ~~3~~ single phase 3 wire, ~~415~~ input 240VAC/Output 240VAC 50Hz

III. Double Conversion Online

IV. Dual Incoming Supply

V. Internal Static bypass

VI. Maintenance-free Batteries

VII. Typically 2hr back up time @ 50% duty as depicted on the drawings

In addition to the above the minimum output voltage in Qatar standard voltages are 240/415 VAC ± 6 % with 50 Hz . The CONTRACTOR shall also verify QCS section 21 part18 for RUPS , KAHRAMAA standard for the electrical supply and select accordingly .

A more detailed specification of the RUPS is given in the Appendices of this specification.

It is proposed that all items within the rack are backed by an in line 6000W Output Power UPS, with extendable batteries lasting upto 2hours,

The drawings indicated that typically 10U is reserved for these units which are mounted at the bottom of the rack.

The UPS sizing is based on being able to serve two adjacent racks (A + B supplies) each with a total power consumption not exceeding 2kW (4kW combined load). Under normal mains power failure the battery will support the loads (2kW from each UPS system) for 2 hours. Under single unit UPS failure the remaining UPS will support the loads (upto 4kW) for 1 hour.

8.10.4 Cabling Installation

Power and Instrumentation cabling shall be done in accordance with KAHRAMAA Regulations and Qatar Construction Specifications. Instrumentation cabling is recommended to be installed in perforated metallic cable tray with covers. Instrumentation cabling shall be kept separate from power cabling at all time.

Instrumentation Cable shields shall be earthed as per the manufacturer's recommendations or the protocol specifications. Where no recommendations are made, the shield shall be single point earthed, on the source end.

Standalone processes such as the individual Chemical dosing plants and Motor starters have internal parameters to monitor. While not all the internal parameters are required by the central SCADA control, certain parameters will be required to be interfaced with the central control..

8.10.5 Standalone Control Level Devices

Standalone processes such as the individual Chemical dosing plants and Motor starters have internal parameters to monitor. While not all the internal parameters are required by the central SCADA control, certain parameters will be required to be interfaced with the central control.

8.11 SITE WIDE AREA NETWORKING

This section describes the proposal for provide a site wide area networking solution for the connecting the five PRPS sites together. The Centralized control of the plants will be at PRPS5 which will be referred to as the MWCC.

The following diagram shows the proposed Site Wide Networking solution the rest of the text describes its attributes.

8.11.1 Overview

The site wide network is required to support real time communications between master PLCs at each reservoir site. In addition to this application the network is also required to support CCTV, VOIP and MEP SCADA services to the MWCC. Given these requirements it is proposed to run a fiber optic network between the sites which will support the application requirements.

8.11.2 Carrier Grade Ethernet

Currently Kahramaa's communications between the SRPS's and the NWCC are predominantly using 3G Wireless networks using the ModbusTCP protocol. The adoption of this solution for connecting the Mega Reservoirs (PRPSs) is deemed as impracticable and unsuitable for the following key reasons:

a) 3G wireless has weak security features- weak encryption

b) 3G wireless has limited bandwidth- lack of support for multiple advanced real time applications in terms of jitter and latency

c) Existing solution does not provide a holistic approach to data protection or Cyber Terrorism

d) Modbus TCP has no encryption

Migrating to 4G LTE does not provide sufficient bandwidth for CCTV and MEP SCADA applications alongside the process control data transfer.

It is for this reason it is proposed to provide a Carrier Grade Ethernet solution for the transfer of data from the PRPS's to the Master Water Command Centre (MWCC).

Since the 1970s Ethernet has proven itself to be a technology that can adapt to evolving market needs, which unlike the SDH technology which is currently used by Kahramaa Electricity which has now reached end of life due to bandwidth limitations and lack of support for video services.

Carrier Ethernet by definition is a Fiber Optical Network capable for delivering standardized services at speeds of 10Gbps for a single optical Wavelength over a number of different transport technologies.

The key five attributes required by PRPS's in terms of data transfer that has driven the choice of this technology are:

a. Standardized Services

b. Quality of Services

c. Ability to add Advanced Applications for Process Control and Monitoring as they become available

d. Service Management

e. High Availability and deterministic delivery of data

The site Wide Area Network and choice of Network Hardware and Protocols has been driven by the need to provide point to point services between two User Network Interfaces (UNIs) this being the Firewall at each PRPS site. For the Process control between Master PLCs the UNI will have a separate channel for communications, which is commonly referred to as Ethernet Virtual Private Line (EVPL). There are a number of defined applications within each PRPS site and each application will have its own dedicated channel and Class of Service (CoS) categorized by its importance towards the Water process control.

8.11.3 Service Attributes

As part of the standardized services for each PRPS there will also be a standard service attributes for each service. The attributes will allow the communications between the PRPSs to be customised to meet the Mission Critical Process Applications delivery expectations in terms of:

a) Physical Speed offered at the UNI

b) Bandwidth profile at each UNI terms of Excess Information etc during times of congestion- Data Base Transfer from PRPS to PRPS

c) Bandwidth Profile for each application

d) Control of traffic

8.11.4 Service Delivery Architecture

The proposed DWDM Equipment form part of the Optical Transport Network (OTN) required for the remote overall system operation of KAHRAMAA Mega Reservoir. The OTN will include the following system:

a) Fibre Optic Cabling

b) DWDM Equipment

c) ROADM Modules

The Mega Reservoir plant sites which will be installed with DWDM Equipment are the following:

I. PRPS1

II. PRPS2

III. PRPS3

IV. PRPS4

V. PRPS5 (MWCC)

There shall be a Master Water Control Centre will perform the centralized control for the PRPS.

8.11.5 Ethernet over DWDM

Each water station shall be equipped with optical DWDM Equipment with a Reconfigurable Optical Add and Drop Multiplexer commonly referred to as ROADM. This means that each Channel at the Optical Layer can added and dropped at each PRPS. The purpose of this addition is that each channel is re-usable once it has dropped at its UNI connection adding to the flexibility to add bandwidth in any East or West Direction. For this reason the Add/Drop will be based on a dynamic principle using a ROADM module cards within the DWDM Equipment.
The DWDM equipment shall be configured in 80 channel colours, and each channel has 10 Gb/s capacity.

8.11.6 Ethernet over MPLS

The services provided by DWDM are commonly referred to as Layer 1 services (Physical Services). Ethernet operates at Layer 2 , which is a logical and physical framing services where data transfer is reliant on MAC addresses of the Network Interface Card (NIC) and the intelligence of the switches in the path to learn which ports frames should sent out in order to reach their destination. The switches only know the next hop address in a network path. Since this architecture has multiple hops then End to End reachability of multiple hops requires the determination of the MAC address based upon the resolving the IP address of the destination network device to its MAC address.

This method of address resolution can be improved upon by introducing the technology Multi-Protocol Label Switching commonly referred to as MPLS. This requires connecting each site together logically and each switch in the device will have a table which has labels forwarding data end to end and not just the next hop address.

This will make the network more capable of supporting real time applications, the consequence of which is that additional networking devices are required at each site namely Provide Edge devices.

8.11.7 Fiber Optical Cabling

The water pipe corridor will run from PRPS-1 to PRPS-5. The FO forward cable will be installed alongside the water pipe corridor, and the return FO cable will be run on a different route along road side, from PRPS-1 back to PRPS-5. The ring is completed and terminated in PRPS-5 station.

8.11.8 Service Clients

The solution for Optical Networking considers the following service clients:

a) Process Control SCADA

b) MEP SCADA

c) CCTV

d) OPC Data

e) VOIP

f) Engineering Traffic

The above information shall be assigned each to a dedicated channel in the optical wavelength through ROADM module. There shall be Six (6) dedicated wavelength pre-assigned for the four service clients, and each wavelength shall be rated 10Gb/s bandwidth.
The client wavelength shall be common to all the Station. For example, the MEP SCADA channel wavelength shall be the same from PRPS-1 up to PRPS-5; and the same is true for CCTV, OPC and Process SCADA, with a total of four (4) wavelength channels.

To avoid data congestion on the CCTV channel, the CCTV feed shall be regulated to minimized live CCTV video feed to the Master Control Centre. It was estimated that each PRPS Station will require 1.2 Gb/s bandwidth for live broadcast of all CCTV video cameras. Allowing only 50% CCTV live feed to the Master Control Centre, the total CCTV client load will be 0.6Gb/s x 5 = 3Gb/s. It shall be possible on the local PRPS Station to add CCTV live feed, on top of the 3Gb/s, during event related video coverage. CCTV video feed shall be compressed to minimized transmission bandwidth requirement

Physical Access Control System (PACS) remote alarms and high–level supervision of each PRPS Station from the Master Control Station shall be carried through the OPC Data interchange.
The OPC Data is a data interchange using OPC protocol. Data and information in the OPC format shall contain mostly alarms and higher level command/control for the Process SCADA, MEP SCADA, PACS, and BMS of each PRPS Station.

8.11.9 Master Water Control Centre – Service Clients

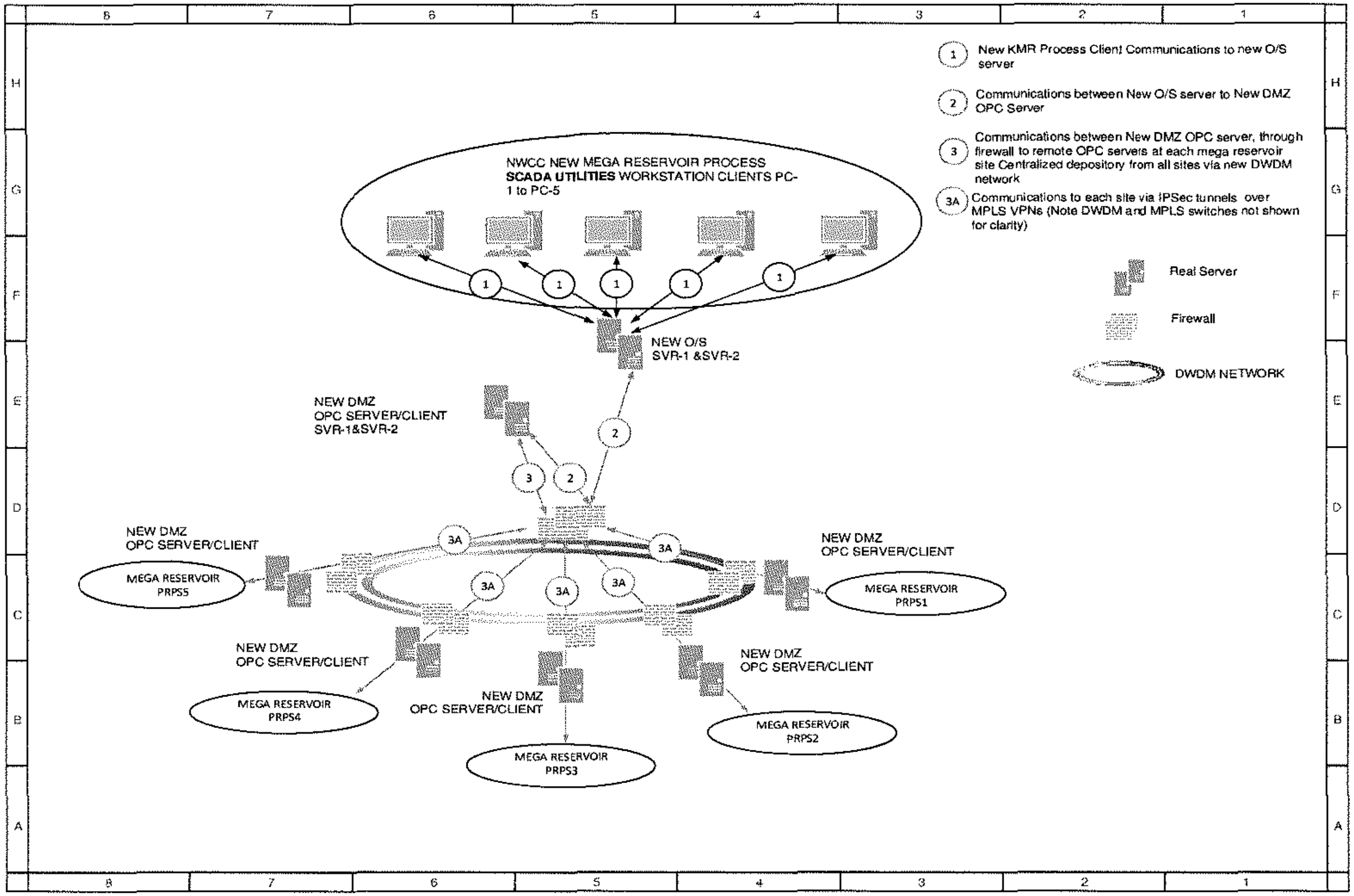
It is proposed that the Master Water Control Center is to be co-located in PRPS-5, in a separate and dedicated control room.
PRPS-5 local control shall be similar to the local control scheme of all the PRPS', and shall be connected to the Optical Transport Network through DWDM Equipment, in the same proposed manner with all the PRPS Stations.

To obtain optimum performance and avoid network congestion, the Master Control Station shall be connected to the system using the same setup with the other PRPS Station using DWDM Equipment with ROADM. The Master Control DWDM ROADM Equipment will also be configured to interface on the same client wavelength, as previously discussed, for the Process SCADA, MEP SCADA, CCTV and OPC Data.

The Master Control Centre shall be capable of capturing and aggregating all the data and information coming from all the PRPS Stations without network congestion.
The Master Control will be equipped with a large-scale Programmable Logic Controller as a Master Station PLC capable of overseeing the dynamic operation of the five (5) PRPS Stations on a supervisory level. In addition, other critical components such as servers, storage, SCADA HMI, system networks and application software shall also be provided to the Master Control Center with features set of a Master SCADA operation. For this reason this UNI shall be deemed mission critical.
All service management and Identity management will be carried out at the Master Operation centre. The MWCC will be responsible for the overall system performance, monitoring of alarms and gathering of data base for corporate-level analysis through the DWDM optical transport network. Data and information extracted from the PRPS Stations shall be stored in the Master Control media storage servers.

The following diagrams show the proposed service traffic flows.

Figure 12 SITE WIDE COMMUNCATIONS TO MWCC


New KMR Process Client Communications to new O/S server
Communications between New O/S server to New DMZ OPC Server
Communications between New DMZ OPC server, through firewall to remote OPC servers at each mega reservoir site Centralized depository from all sites via new DWDM network
Communications to each site via IPSec tunnels over MPLS VPNs (Note DWDM and MPLS switches not shown for clarity)
Real Server
Firewall
DWDM NETWORK
NWCC NEW MEGA RESERVOIR PROCESS SCADA UTILITIES WORKSTATION CLIENTS PC-1 to PC-5
NEW O/S SVR-1 &SVR-2
NEW DMZ OPC SERVER/CLIENT SVR-1&SVR-2
NEW DMZ OPC SERVER/CLIENT
MEGA RESERVOIR PRPS5
NEW DMZ OPC SERVER/CLIENT
MEGA RESERVOIR PRPS1
NEW DMZ OPC SERVER/CLIENT
MEGA RESERVOIR PRPS4
NEW DMZ OPC SERVER/CLIENT
MEGA RESERVOIR PRPS3
NEW DMZ OPC SERVER/CLIENT
MEGA RESERVOIR PRPS2

8.12 IPoDWDM SITE WIDE COMMUNICATIONS

8.12.1 General Requirements

The requirement for the network is the provisioning of a 80 channel Dense Wavelength Division Multiplexing (DWDM) Optical Transport Network (OTN) operating at discrete wavelengths in the C-band centred around 193.1 THz frequency as per ITU-T Rec.G.694.1 grid, at 50GHz channel spacing. The DWDM system shall support transmission comprising of 10Gb/s and 10GE per channel in the C-band based on ROADM technology. The 10GE and 10Gbps shall be supported simultaneously on the same system with no changes to the common equipment at the optical layer.

8.12.2 Spare Channels

Proper termination of the unused channels shall be provided by the manufacturer as part of system design. It shall be possible to utilize the unequipped channels at a later date without affecting the existing traffic.

8.12.3 Interfaces

The following interfaces or combinations thereof shall be supported.

a) STM-1

b) STM-4

c) Fiber Channel 1G

d) Fiber Channel 2G

e) Fiber channel 8G (Optional)

f) Fiber channel 10g (Optional)

g) STM-16

h) STM-64

i) 10G Ethernet LAN and WAN PHY as per IEEE 802.3ae

j) OTU-1 and OTU-2 as per G.709

k) GbE as per IEEE 802.3h for 1000 Base LX-10

l) GbE as per IEE 802.3 for 1000 Base LX

m) 1000 base PX-20 (Optional)

n) 1000 Base ZX (Optional)

o) 10 GBASE-LR & ER optical 10G interface as per 802.3ae (Optional)

p) 10 GBASE-LW & EW (Optional)

q) Interface for 2.5G DWDM (Optional)

8.12.4 Flexible Interface Cards

The system should support multiport high-speed (10 Gb/s) flexible interface cards with SDH ADM and packet cards with switching capabilities in point-to-point and ring topologies. These flexible interfaces should be fully integrated with the DWDM platform and should not be provided by an additional network element, such as an external ADM and external Ethernet Switch. Packet functionality includes aggregation and switching of Ethernet Packets between all ports (client and line).

8.12.5 Client Ports

There should be a minimum of 8 pluggable client ports that are configurable for OC-3/12/48, STM-1/4/16, 1 GbE, Fibre Channel (1Gb/s, 2Gb/s), FICON (1Gb/s).

8.12.6 SAN Support

It should have SAN support for full GFP encapsulation with VCAT

8.12.7 VC-4 Support

It should have VC-4 time slot interchange between all ports and DWDM line-side interfaces ("non-blocking").

8.12.8 Muxponder

Muxponder shall multiplex various combinations of above channels. Certain cases are given below.

a) Multiplexing upto 4 no. STM-16 to a 10G channel

b) Muliplexing upto 4 no. OTU1 to a 10G channel

c) Multiplexing upto 8 no. of GbE interfaces to a 10G channel

d) Multiplexing combinations of STM-16, FC & GbE channels

The above cases are optional and exact requirement shall be given by KAHRAMAA.

8.12.9 ROADM Support

The system shall support Reconfigurable Optical Add Drop Multiplexer (ROADM) in a specific manner as per the requirements of KAHRAMAA.

8.12.10 Network Topology Supported

The following Network topologies shall be supported:

a) Point to point

b) Linear add/drop

c) Mesh Network system with auto recovery feature

d) Closed ring (without 3R generation)

The network protection shall be available both at SDH client level as well as at DWDM optical layer, at various granularities and configurations.

8.12.11 Network Protection

The protection at DWDM layer shall be soft-configurable on per-channel (OCh), for all network topologies from the EMS of the equipment, in accordance with ITU-T Recs.G.808.1.

8.12.12 Direction Mode

The system shall work in unidirectional mode on a pair of fibre for all network topologies using dedicated fibre for Tx and Rx direction.

8.12.13 Network Span

The system shall work in long haul span configuration with or without ILA as per network requirement. However this does not exclude other application codes. Since the number of spans (without the use of 3R regenerator) may vary depending on the type of equipment used, the purchaser may ask vendor to carry out the network planning on the basis of network information provided by the purchaser.

8.12.14 Booster Amplifier

Booster amplifier and pre amplifier shall be integral part of DWDM terminals, ILAs and OADMs/ ROADMs.

8.12.15 Wavelength Reuse

The system will permit wavelength reuse after dropping a particular channel without any restriction on number of reuse of each wavelength. The system should support the capability to pass-through or add/drop 100% of the total system channels via Software control , and be able to scale in increment of one wavelength at a time (from one to full channels) without the need of manual power balancing of individual wavelength and without the restriction of any banded channel architecture.

8.12.16 OTN ITU Requirement

The system shall comply with ITU-T recommendation G709 & G 959.1 for OTN specification.

8.12.17 ODU/OUT Overhead

All client services shall be supervised by processing ODU/OTU overhead bytes in accordance with ITU-T Rec. G.709. At least path monitoring and section monitoring shall be supported.

8.12.18 Out of Band

The system shall support out of band FEC as per ITU-T Rec. G.709.

8.12.19 Super FEC

Super FEC as per ITU-T G.975.1 shall also be supported.

8.12.20 FEC and BER

The system shall be provided with the FEC enable/ disable facility through LCT/EMS. There shall be access point in the system to facilitate BER testing by enabling/ disabling FEC as well.

8.12.21 Optical Fibre Type

The optical fibre shall be ITU-T.G.655 single mode optical fibre.

8.12.22 DCM Support

The equipment shall support Dispersion Compensation Modules (DCM) at the line side equipped for the capacity at the interface rate of 10G. The manufacturer shall provide comprehensive details of such DCMs. If required by the purchaser, link engineering support/ link engineering exercise support shall be provided by the manufacturer using link planning/
design tools or any other method.

8.12.23 Common Hardware

The system shall have entire common hardware including Mux/Demux, DCMs and embedded control & management software etc. for 80 channels @ 10G DWDM system on day one, to be upgraded in field to 80 channels @ 10G through insertion of Transponders/ Muxponder cards only, to reach its full capacity.

8.12.24 Optical Monitoring

Optical monitoring as per ITU-T Rec.G.697 should be supported at all nodes through EMS.

8.12.25 Live Maintenance

It shall be possible to remove or insert any transponders/MUXponders and or multiplexer/D-multiplexer card without affecting the working of other channels.

8.12.26 Network Planning Tool

To accurately simulate the performance of the offered equipment under end of life conditions (i.e. equipment with aged components operating at maximum channels over aged fibre) and ensure successful transmission at 10Gbps per channel over high loss optical fibre, a comprehensive network planning tool shall be supported. The tool may be standalone or may be integrated into EMS. The tool shall, among others, perform the following analysis and recommend the most suitable hardware components as well as settings (i.e. optical power, gain) to mitigate the limiting effects:

a) Attenuation (including optical fibre loss, system component loss and margins),

b) Chromatic dispersion (including required residual dispersion and dispersion compensation),

c) Polarization mode dispersion (including contribution from both optical fibre and system components),

d) Optical signal to noise ratio (OSNR) and

e) Non-linear effects (inc. XPM, SPM, FWM and SRS)

8.12.27 Narrow Wavelength Coloured Interface

The equipment shall support (without using transponders at either of the end points) direct internetworking with narrow wavelength coloured interface (as per ITU-T Rec. G.694.1 DWDM grid) from SDH or MSPP equipment for interfacing STM-64 optical signals. In such cases purchaser opting for coloured SDH wavelengths from 3rd party SDH system to Mux input directly may not be able to avail the benefits of certain quality parameters like FEC.

8.12.28 Optical Supervisory Channel

The system shall support one Optical Supervisory Channel (OSC) as specified by ITU-T Rec.G.692 for the monitoring and configuration of OTM, ILA, OADM and ROADM on the route and shall be manageable from one location for the entire route via the EMS or LCT of the equipment. The OSC transmitter and receiver behaviour at the Inline Amplifier/Booster/Pre-Amp shall be monitored through EMS via suitable alarms.

8.12.29 Variable Optical Attenuators

The system shall provide software controlled Variable Optical Attenuators (VOA). The optical power per channel must be adjusted automatically, without using external measurement equipment. The adjustment arising out of adding/removing channels has to be done without manual adjustment and shall be possible without affecting other channels; it shall either be triggered by a software command or automated.

8.12.30 Optical Amplifiers

The optical amplifiers must implement the following mechanisms to maintain error free system operation under dynamic conditions:
Fast gain control loop: to protect against short term transient conditions such as sudden loss of channels.
Slow output power control loop: to protect against long term conditions such fibre aging.

8.12.31 Performance Monitoring

The equipment shall have the provision for monitoring the performance of individual channel through B1 byte of SDH. Also, in the case Ethernet support, there shall be the provision of analysis of Ethernet frames at GigE Transponders.

8.12.32 Power and Wavelength Monitoring

There shall be the provisioning of power and wavelength monitoring points for external monitoring of power and wavelengths at the input/output points of the Booster Amplifier, ILA and Pre-amplifier. These points shall be suitably connectorized and connecting the measurement devices shall not affect the transmission of the main path. Power splitter modules with a ratio of 95%/5% shall be available to use them where needed.

8.12.33 DWDM Band

The optical window of operation of the DWDM shall be C-Band.
Channel Spacing
The nominal central wavelength spacing shall be 100GHz. Any consecutive 80 wavelengths may be chosen by KAHRAMAA from DWDM grid as specified in ITU-T Rec. G.694.1.

8.12.34 SDH Interfaces

Specifications of SDH Interfaces to be supported:

a) STM-16 AND OTU-1 Interfaces as per ITU-T G.957, G.825 & G.709

b) STM-64 AND OTU-2 interfaces as per ITU-T G.959.1, G.691, G.709, G.783 AND G.8251

8.12.35 Ethernet Interfaces

Specifications of Ethernet Interfaces to be supported:

a) Optical Gigabit Ethernet @ 1.25 Gbps : As per IEEE 802.3, IEEE 802.3ah as applicable for various types of desired and optional interfaces.

b) Optical10 Gigabit Ethernet: As per IEEE 802.3, IEEE 802.3ae as applicable for various types of desired and optional interfaces.

8.12.36 Connector Losses

For the optical connectors used on the equipment side the 'Optical Return Loss' of these connectors shall be better than 50 dB.

8.12.37 Transponder/Muxponder Interface

Transponder/Muxponder shall be provided with tuneable laser for the DWDM line interface covering the complete C-band for 80 discrete wavelengths at 50 GHz spacing for fast provisioning of transparent end-to-end services and spare part reduction.

8.12.38 Laser Shutdown

The equipment shall have the provision of Automatic Laser Shut-Down (ALSD) in the case of fibre-plant breakdown and automatic re-start on restoration of fault in accordance with ITU-T Recs. G.664 . The system shall restore within 0 – 10 sec (programmable) after restoration of fibre plant breakdown or a faulty amplifier.

8.12.39 Mapping Techniques

The equipment shall adopt standard mapping techniques for GFP mapping, Forward Error Correction coding and multiplexing techniques as per ITU-T Rec. G.7041, G.975.1 and G.692 standards respectively. The output of Muxponder/Transponder shall be in a standard ITU-T format.

8.12.40 Migration

The network based on the DWDM System should easily evolve from a point-to-point unprotected system to a DWDM ring or mesh network. Migration and expansion shall not cause any interruption or change of service, nor modify the operational concept or network management.

8.12.41 Expansion

It shall be possible to equip the system progressively, in accordance to the number of channels transmitted, in order to allow real "pay as you grow" configurations.

8.12.42 Protocol Transparency

The system shall be transparent to the protocols of services transmitted through it:

a) The system shall not violate data integrity due to the high sensitivity of SAN protocols to latency.

b) The system shall not add any overhead to the services transmitted through it.

c) The system shall allow disabling Digital Performance Monitoring.

8.12.43 Integrated Ethernet Switching Functionality

The system should support Integrated Ethernet switching functionality, including:

a) E-Line and E-LAN services

b) Ethernet specs – 802.1D, 802.1Q and 802.1ad

c) MEF style traffic management, including CIR, CBS, EIR and EBS

d) 802.3ad link aggregation across ports for protection and multi-link bonding

e) MPLS protection on the line side

8.12.44 Network Configuration

The various network topologies supported are:

a) Point to Point

b) Linear add drop topology

c) Two fibre DWDM ring with true optical ring closure without need for regeneration via Optical and Electro-Optical channel convertors (OEO).

d) Mesh Network System with Embedded Intelligence supporting auto discovery feature to provide automatic protection required for provision of protected "Lambda services and auto restoration across multiple rings.

8.12.45 Parametric Values Support

The system shall fulfil the technical requirements of parametric values, span-budget, dispersion, etc., as per ITU-T.692, G.957, G.959.1 and other relevant ITU-T requirements

8.12.46 Long Haul

Long haul application with per span attenuation 22 dB with number of span without 3R regenerator up to 10 or more using DCM and FEC.

8.12.47 Very Long Haul

(Optional) Very Longhaul application with per span attenuation 33 dB with number of span without 3R regenerator upto 6 or more using DCM and FEC.

8.12.48 Enroute Nodes

Enroute nodes can be OA/OADM/ROADM

8.12.49 Network Protection

OCh-SNCP protection at wavelength level with protection switching getting completed within 50ms (Excluding fault detection and fault propagation time etc.)

8.12.50 Signal Protection

The system shall support service/line signal protection with redundant line interface on a single transponder/muxponder unit for at least the following services: STM-16, OC-3 (Optional), OC-12 (Optional), OC-48 (Optional), FE, GbE, FC (Optional), 2G-FC (Optional) and 10G-FC (Optional).
FICON (optional), FICON express (Optional) and ESCON (Optional).

8.12.51 Service Protection

The system shall support service protection in ring topologies. A mixture of protected and unprotected services shall be possible.

8.12.52 Protection Switching

The system shall support protection switching based on Loss of Signal and Loss of Clock.

8.12.53 Signal Degrade Protection

The system shall also support protection switching based on signal degrade criteria such as:

a) OTH/G.709 criteria such as uncorrected FEC errors, section Monitoring, Path Monitoring.

b) SDH/SONET B1/B2 errors

8.12.54 Line Protection

a) The system shall support line protection with bi-directional switching:

b) The system shall support line protection switching based on fibre break (LOS).

c) The system shall support line protection switching based on fibre degradation.

d) The protection switching shall be only performed in case that the protection path is available and with a power level higher than a user-defined value.

e) The system shall support low priority traffic on the protection path.

f) The system shall support line protection in single fibre working scenarios.

g) Protection switching shall be performed in a sub-50ms time frame.

h) Protection switching at optical layer shall be envisaged as 1+ N switching where N= 0,1,2,3.The Optical Switching solution must handle automatic Service recovery through protection switching to multiple alternative paths via protection or Forced switching as may be required for Maintenance purposes. The switching should be service independent, non-affected by link distances, 3R[O-E-O] Regeneration and service Transparency shall not be affected.

i) Traffic Free Backplane; In order to achieve the highest possible system availability and to avoid a single point of failure the system must have a traffic free backplane. The systems should not carry any payload over the backplane. The system shall perform functions as all wavelengths conversion on single transponders / muxponders which avoid the necessity to carry payload / customer traffic over the backplane.

8.12.55 Equipment Protection

System should have automatically switched equipment protection for:

a) Power Supply protection

b) Optical Line Card protection

c) Channel Card protection

The failure of controller card should either be non-traffic affecting or automatically switched and protected. Total time taken for Fault detection and Switching from active to standby module should be less than 50 ms. There shall be absolutely no interruption to traffic.

8.13 EQUIPMENT PANEL DESIGN STANDARDS

This section describes the types of control panels used by KAHRAMAA as well as general requirements, materials of construction, and construction guidelines.

8.13.1 Panel Types

Panel types shall be specified to be compatible with and suitable for the environment of the installation location, and shall protect enclosed instruments and equipment. The choice of location for panels should attempt to minimize exposure to ambient temperature extremes, moisture, dirt and gaseous contaminants. Panels shall be specified to be designed, manufactured and tested in accordance with the latest applicable standards of NEMA, IEEE, NEC, UL and ANSI. The following is a list of typical NEMA enclosures for SCADA system components:

The following table provides a guide for converting from NEMA Enclosure Type Numbers to IEC Enclosure Classification Designations. The NEMA Types meet or exceed the test requirements for the associated IEC Classifications; for this reason the table should not be used to convert from IEC classifications to NEMA Types and the NEMA to IEC conversion should be verified by test.

Table 6 NEMA References

NEMA ENCLOSURE TYPE NUMBER	IEC ENCLOSURE DESIGNATION
1	IP10
2	IP11
3	IP54
3R	IP14
3S	IP54
4 and 4X	IP56
5	IP52
6 and 6P	IP67
12 and 12K	IP52
13	IP54

a) NEMA Type 1 - General purpose - Indoor enclosures are intended primarily to prevent accidental contact of personnel with the enclosed equipment in indoor applications wherever oil, dust or water is not a problem.

b) NEMA Type 2 - Drip proof - Indoor enclosures are intended for use indoors to protect the enclosed equipment against falling non-corrosive liquids and falling dirt.

c) NEMA Type 3 - Dust tight, Rain tight and Sleet (Ice) Resistant -Outdoor enclosures are intended for use outdoors to protect the enclosed equipment against windblown dust and water.

d) NEMA Type 3R - Rainproof and Sleet (Ice) Resistant - Outdoor enclosures are intended for use outdoors to protect the enclosed equipment against rain and are constructed so the accumulation and melting of sleet (ice) will not damage the enclosure and its external mechanisms.

e) NEMA Type 3S - Dust tight, Rain tight and Sleet (Ice) Proof - Outdoor enclosures are intended for use outdoors to protect the enclosed equipment against windblown dust and water and to provide for its operation when the enclosure is covered by external ice or sleet.

f) NEMA Type 4 - Watertight and Dust tight - Indoor and Outdoor enclosures are intended for use indoors or outdoors to protect the enclosed equipment against splashing water, seepage of water, falling of hose-directed water, and severe external condensation.

g) NEMA Type 4X - Watertight, Dust tight and Corrosion Resistant -Indoor or outdoor enclosures have the same provisions as Type 4 enclosures and, in addition, are corrosion-resistant.

h) NEMA Type 9 - Class II, Group E, F or G - Indoor Hazardous Locations - Air-break equipment enclosures are intended for use indoors, in atmospheres defined as Class II, and Group E, F or G in the "National Electrical Code", to prevent the entrance of explosive amounts of hazardous dust.

i) NEMA Type 12 - Industrial Use - Dust tight and drip tight - Indoor enclosures are intended for use indoors to protect the enclosed equipment against fibers, filings, lint, dust and dirt, and light splashing, seepage, dripping and external condensation of non-corrosive liquids.

j) NEMA Type 13 - Oil tight and Dust tight - Indoor enclosures are intended for use indoors primarily to house pilot devices such as limit switches, foot switches, pushbuttons, selector switches, pilot lights, etc. and to protect these devices against lint and dust, seepage, external condensation, and spraying of water, oil or coolant.

The above enclosure descriptions are not intended to be a complete representation of the National Electrical Manufacturers Association (NEMA) standards for enclosures but to indicate various types of enclosures that may be specified.

Only the following NEMA types are approved for installation in KAHRAMAA facilities:

I. NEMA Type 12
II. NEMA Type 4
III. NEMA Type 4X (stainless steel)
IV. NEMA Type 4X (fiberglass)
V. NEMA Type 9

Use of other NEMA types must be approved by KAHRAMAA.

Local Panels shall never be located in hazardous locations. Local Control Stations consisting of lockout or limited start/stop control may be located in a hazardous area only if all controls and the panel are rated for hazardous locations.

8.13.2 Panel Construction

Panels shall be designed to accommodate all necessary accessories such as instrument air, power supplies, mounting hardware, terminal blocks and any signal conditioning or conversion equipment that may be necessary to make operational all monitored and controlled equipment to be mounted in the panel. Panels shall be designed with sufficient spare space to provide for future expansion of 25% of initial capacity.

Panel layout and equipment spacing should be designed to allow for device removal, calibration and maintenance without disassembly of adjacent devices.

Removable eyebolts must be provided to facilitate sling handling of large enclosures. Eyebolt mounting should be a part of the structural support bracing to distribute stresses and enclosure weight during installation.

All panels shall have sufficient structural reinforcements to ensure a plane surface, limit vibration and to provide rigidity during shipment, installation and operation without distortion or damage to the panel or injury to any mounted instruments. All enclosure seams must be continuously welded and ground smooth to be undetectable after painting.

There are two basic mounting configurations that may be specified for KAHRAMAA facilities; either wall-mounted or free-standing:

8.13.3 Wall-Mounted Panels Single door

Wall-mounted enclosures shall be specified up to a maximum of 48 inches high x 10 inches deep. These panels shall be constructed of a minimum of 14-gauge steel. All two-door panels shall be constructed of a minimum of 12-gauge steel.

8.13.4 Free-Standing Panels

All freestanding Panels shall be specified to be constructed of a minimum of 12-gauge steel.

All panels shall be specified to be primed and finished with two coats of a factory finished ANSI #61 light gray lacquer finish on all exterior surfaces. The panel interior shall be white.

Suitable strip heaters (heat reflector assemblies) shall be specified with thermostat control for condensation and freezing protection in all outdoor enclosures.

An interior incandescent light fixture and a duplex G.F.I. convenience outlet with on/off G.F.I. circuit breaker for maintenance purposes shall be specified for all panel enclosures.

All enclosures shall be specified to be provided with flush hinges and vault-type latch capable of accepting a 3/8-inch shackle padlock. Enclosure doors 36" high and larger shall also require three point latch assemblies.

8.13.5 Maximum Temperature

All panels should have ample cooling to prevent high temperatures from shortening the life of the equipment mounted inside. The specification should prohibit any location within the panel or interior of the equipment mounted inside to reach temperatures higher than 15 degrees F. above the temperature of the location in which the panel is located.

8.13.6 Intake Air Filters

If panels require air exchange for cooling, fans drawing air into the panel must be filtered. The filter surface area should be sized three times larger than the fan intake area for each fan.

8.13.7 Cooling Without Air Exchange

Panels in areas of heavy particulate contamination shall be cooled without air exchange between the interior and the exterior of the panel. Either solid-state cooling equipment or refrigeration must be used to cool the panel. The heat dissipation portion of the cooling unit shall be designed for use in areas with heavy particulate contamination and shall be capable of running extended periods without cleaning.

8.13.8 Panel Wiring and Terminations

The standards and specifications shall be in general applicable to all OEMs available in the market and shall be as per QCS 2010 document relevant clauses.

Control panel wiring shall match current practice followed in KAHRAMAA to avoid confusions during project commissioning/maintenance periods.

All internal panel wiring and terminations shall be designed in accordance with the latest applicable standards of the NEC as well as applicable state and local electrical codes.

Signal wiring shall be segregated from control power wiring, grouped functionally and arranged neatly to facilitate circuit tracing. Low level analog signals of 100 millivolts or less shall not be combined with digital input or control output wiring nor shall they be intermixed within the same bundle, duct, or Panduit within a panel.

Plastic wiring wraps shall be used to bundle wires, except within wiring ducts. The bundles shall be securely fastened to the steel structure at suitable intervals, not exceeding 12 inches.

Where shielding is required, shields shall be continuous foil or metalized plastic providing 100% coverage. A drain wire in continuous contact with the shield shall be included. The drain wire shall not be used as a control signal conductor.

All DC signal wiring shall be segregated from wire conducting AC signals.

Power wiring insulation shall be rated at 600 volts at 90o C and be type MTW. No wire smaller than 12 AWG shall be used for power wiring.

Wiring shall not be spliced. Wire shall be run in continuous lengths from screw terminal to screw terminal. Wire service loops shall be provided to permit device removal.

Design of the terminal layout shall include a grounded barrier to segregate those terminals devoted to current type signals from others. The terminal blocks are to be factory assembled on a mounting channel and the channel bolted to the inside of the panel. Terminals shall accept wire size 12 AWG and smaller.

Terminal blocks shall be rated at least 300 volts for NEMA general industrial control devices; 600 volts NEMA limited power circuits. The terminals shall have a continuous marking strip.

Field wiring terminal blocks shall be provided for interconnections with field instruments and other termination cabinets. It shall not be permitted to connect field wiring directly to PLC I/O module wiring terminals. Field wiring terminal strip shall use spring type terminal blocks, as listed below, and ferrules for multi-strand wires.

Control panel wiring shall be identified at each termination by marking with a number to correspond with the diagrams and shall be color-coded as follows:

Table 7 Colour Coding for Cables

Voltage	Description	Color
	Phase	Red
240 VAC	Neutral	Black
	Ground	Yellow/ Green
	Positive	Blue
24 VDV	Negative	White
	Ground	Green
Analog Input	Positive	Grey
	Negative	White
Analog Output	Positive	Grey
	Negative	White
Digital input		Blue
Digital output	Positive	Blue
	Negative	White
Volt free contact		Orange
		Orange

All wires and cables terminated within control panels, instrumentation panels and termination cabinets shall be provided with identification PO to identify cables according to Section 3.2.

8.13.9 Wiring and Cable Standards

Refer to QCS section 21 part 6 for cables and wiring for relevant General standards. Also refer to O&M Assets Affairs for site specific standards.

8.13.10 Colour Coding Standards

Refer to QCS2010 for relevant clauses

8.13.11 Cable Identification Numbering

Refer to QCS2010 document for relevant clauses

8.13.12 Panel Display Devices

Instruments or devices furnished for front of panel mounting shall be suitable for panel mounting and selected to match each other and present a coordinated aesthetically pleasing functional arrangement. The arrangement of devices on the panel shall be as symmetrical as possible and shall functionally group devices to enable operators to easily locate groups of devices or individual devices to control the process. Panel indication or display devices shall be mounted between 48 and 60 inches above the floor to be easily readable by the operator.

Display devices shall consist of rectangular panel meters, edgewise panel indicators, recorders, annunciators and graphic displays.

All display devices shall have scales that indicate the actual process value with the measured variable reading in engineering units (i.e., 0 to 3000 GPM). It is unacceptable for display devices to indicate the measured value as a percent of maximum (i.e., 0 to 100% full scale) except for those devices displaying position (i.e., percent valve open, percent valve closed).

8.13.13 Analog Controllers

Analog controllers shall be self-contained, stand-alone, microprocessor-based, and completely configurable through the use of internal software. The controller shall be configurable for all analog control applications. The internal programming shall have a minimum of 70 function blocks stored in ROM. The controller shall be designed for interfacing to distributed control systems. Controllers shall also be capable of being tied together through the use of a local instrument link allowing communication between multiple controllers.

The controllers shall be able to be programmed by selection and interconnection of function blocks in order to establish the station type and control strategy. Configuration data shall be stored in non-volatile memory to prevent loss of data during an electrical power interruption. Programming shall be either through the use of controls on the front of the controller or by using a personal computer to download the software configuration to the controller. The software in the PC shall also be capable of uploading programs from the controllers to archive, modify and verify these programs.

8.13.14 Switches, Pushbuttons and Lights

Selector switches and pushbuttons shall be the type that are supplied with the add-on operator mechanisms so that the appropriate number of contact blocks and block type can be attached to the switch. Contact block terminals shall be labeled for identification purposes and contain not less than one single pole, double throw contact.

Contacts shall be specified as heavy-duty type, rated 10 amperes at 120 VAC breaking current.

In the case where the contact blocks are handling low level signal currents, the contacts shall be rated for electronic duty and provide mechanical self-cleaning action for reliable operation on electronic loads where thermal cleaning action is not present. The contacts should be rated at 1 amp at 28 Vdc and be constructed of gold or gold flashing over silver.

All selector switches, pushbuttons and indicating lights shall be oil tight NEMA Type 13. All pushbuttons and indicating lights shall be supplied by one manufacturer, shall be of the same series or model, and shall be heavy duty oil tight, Square D circular type indication lamps are used in KAHRAMAA existing an ongoing project, Allen Bradley, or approved equal. All selector switches shall be Honeywell Microswitch 'CMC' type, or approved equal.

The indication lamps color code shall be as per the QCS section 21, Electrical specification and section 10 , instrumentation specification.

All indicating lights shall be oil tight type operating from either 24 VDC or 120 VAC, 50 Hz power source. Indicating lights operating on 120 VAC shall be transformer type with the indicating lamps operating on 6 to 8 VAC. Indicating lights operating on 24 VDC shall have lamps rated for 28 VDC for longer life. The use of light emitting diodes (LED) is preferred. Removal and replacement shall be accessible through the front of the panel. A push-to-test-feature shall be employed on indicating lights to provide a positive test of light condition. The indicating lights shall be Square D, Allen Bradley, or approved equal.

8.13.15 Relays and Timers for Instrumentation and Control Panels

KAHRAMAA's standard for control logic relays are heavy duty, machine tool industrial type with contacts rated not less than 10 amperes at 240 volts AC, 5 amperes at 24 VDC. Relay coils shall be moulded construction and operate on 24 VDC or 115 VAC 50 Hz +10% as required. If space constraints dictate, miniature relays can be used. However, the electrical ratings of the miniature relay coils and contacts must be carefully matched to the supply voltages and loads. All relays shall be UL recognized. Operating temperature range shall be compatible with the environment in which the relay will be installed.

All relays shall be an eleven-pin base plug-in type furnished with appropriate sockets complete with retention spring.

All auxiliary interposing relays shall be supplied by the same manufacturer to assure similar appearance and uniform operating characteristics. All relays shall have a clear polycarbonate dust cover and internal light indication to show if the relay is energized. Contact material shall be gold or gold flashing over silver and rated 1.0 amperes at 24

VDC in instances where low level signal currents are being switched. Relays shall be Potter & Brumfield or approved equal.

All electrical timing relays, (timers) shall be supplied by the same manufacturer to assure similar appearance and time setting procedures. Timing ranges shall be as required with a range of 10 to 1, minimum. Operating voltage shall be 115 VAC ~~60~~ 50 Hz +10%. Contact rating shall be 10 amperes at 115 VAC and a minimum mechanical life of one million operations. On-delay and/or off-delay shall be supplied as required. Repeat accuracy shall be +5% or better. Reset and recycle time shall be 200 milliseconds maximum. All time delays shall be adjustable via a graduated knob on the timer body. Timing relays shall be DIN-rail mounted, Allen-Bradley or approved equal.

8.13.16 Nameplates and Identification PO

All equipment in KAHRAMAA facilities must be identified as to the function each piece of control equipment provides, its name, and other information as outlined in this section of the SCADA System Control Standards. The equipment nameplate should also conform to the standards as defined in this section.

8.13.17 Equipment Nameplates

Nameplates must identify the function, position, and/or condition indicated for each pushbutton, switch, indicating light or other control device. Nameplates for pushbuttons, switches, indicating lights, and similar control devices shall be the standard type furnished with the device.

Nameplates should be provided for each receptacle, designating the panel board and circuit number that supplies power to that receptacle.

Table 8 PANEL INDICATION LAMP

LEGEND NOMENCLATURE	LENS COLOR
TROUBLE/MALFUNCTION	AMBER
STATUS	WHITE
RUNNING	RED
CONDITION OF DANGER, ACTIVE STATE	RED
CONDITION OF SAFETY, INACTIVE STATE	GREEN
STAND BY /ENERGIZED ON/RUN	GREEN RED
OPEN CLOSED NEITHER OPEN NOR CLOSED (TRAVELLING)	RED GREEN RED AND GREEN LAMPS LIT

Nameplates should be secured to equipment fronts using screws. Rivets or adhesive may be used for securing nameplates to the inside face of recessed panel board doors in finished locations or other type equipment that is enclosed in panels.

Nameplates made of embossed tape should not be permitted for any application, even temporary.

Equipment nameplates shall be made of laminated plastic approximately three thirty-seconds of an inch thick (3/32 inch), beveled edge, white with black engraved lettering, attached with corrosion-resistant machine screws with castellated nuts. Nameplates shall be a minimum size of one and one quarter (1-1/4) inches high by three and one-half (3-1/2) inches wide.

Nameplates for pushbuttons, switches, indicating lights, and similar control devices shall be the standard type furnished with the device.

Nameplates must be provided for the following equipment:

a) All electrical distribution and control equipment and loads served

b) Panel boards, Switchboards and Motor Control Centers with identification of voltage rating and source.

c) Individual Circuit Breakers, Switches, and Motor Starters in Panel boards, Switchboards, and Motor Control Centers, with identification of circuit and load served, including location

d) Individual Circuit Breakers, Enclosed Switches, and Motor Starters, with identification of load served

e) Transformers, identify equipment designation, with identification of primary and secondary voltages, primary source, and secondary load and location

f) Receptacles, with identification of panel board and circuit number.

8.13.18 Instrument Identification

All instrumentation should be identified with equipment and tag numbers in the same way as for equipment described above. However, in many field locations the use of nameplates would be impractical. Equipment PO made of stainless steel ribbon tape is a more practical approach. The stainless steel ribbon tape is embossed with the instrument name. The ribbon has a hole for attaching it with stainless steel wire to the instrument. This type of stainless steel ribbon provides the most indestructible and long lasting nameplate.

Refer to the Electrical Specifications in QCS section 21 for detailed

8.13.19 Panel Wiring and Termination

The standards and specifications shall be in general applicable to all OEMs available in the market and shall be as per QCS 2010 document relevant clauses.

Control panel wiring shall match current practice followed in KAHRAMAA to avoid confusions during project commissioning/maintenance periods.

8.14 CCTV SURVEILLANCE

This section specifies the functional requirement for proposed solution of Security CCTV and Access Control System of Kahramaa Mega Reservoir Sites. It has been designed with consideration being given to the minimum requirement set by Qatar Ministry of Interior (MOI) and BS EN 50132 Standard and recommendations found in the NERC Standard CIP-006-2 Physical Security Program for the Protection of Critical Cyber Assets. The CCTV Surveillance will be used for monitoring Process equipment and Physical Security.

The following diagram shows an overview of the CCTV Systems architecture:

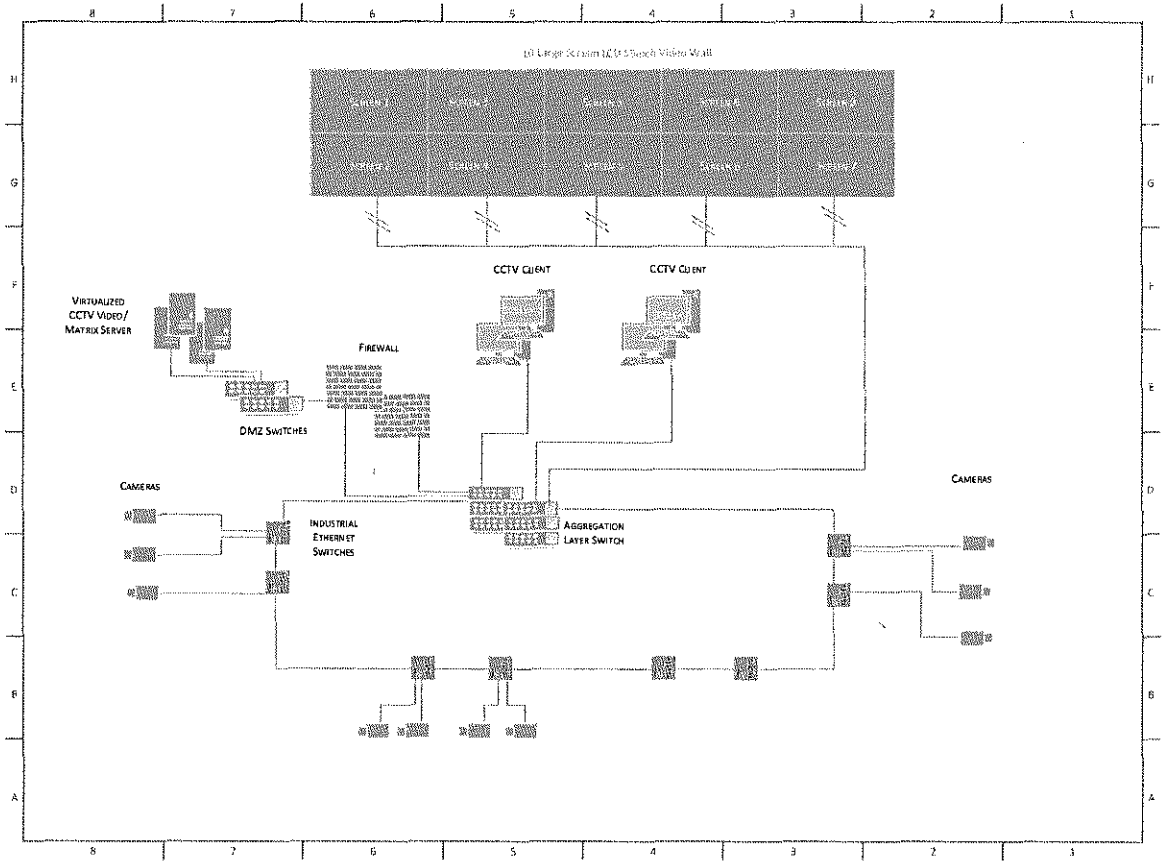


Figure 13 CCTV Physical Diagram

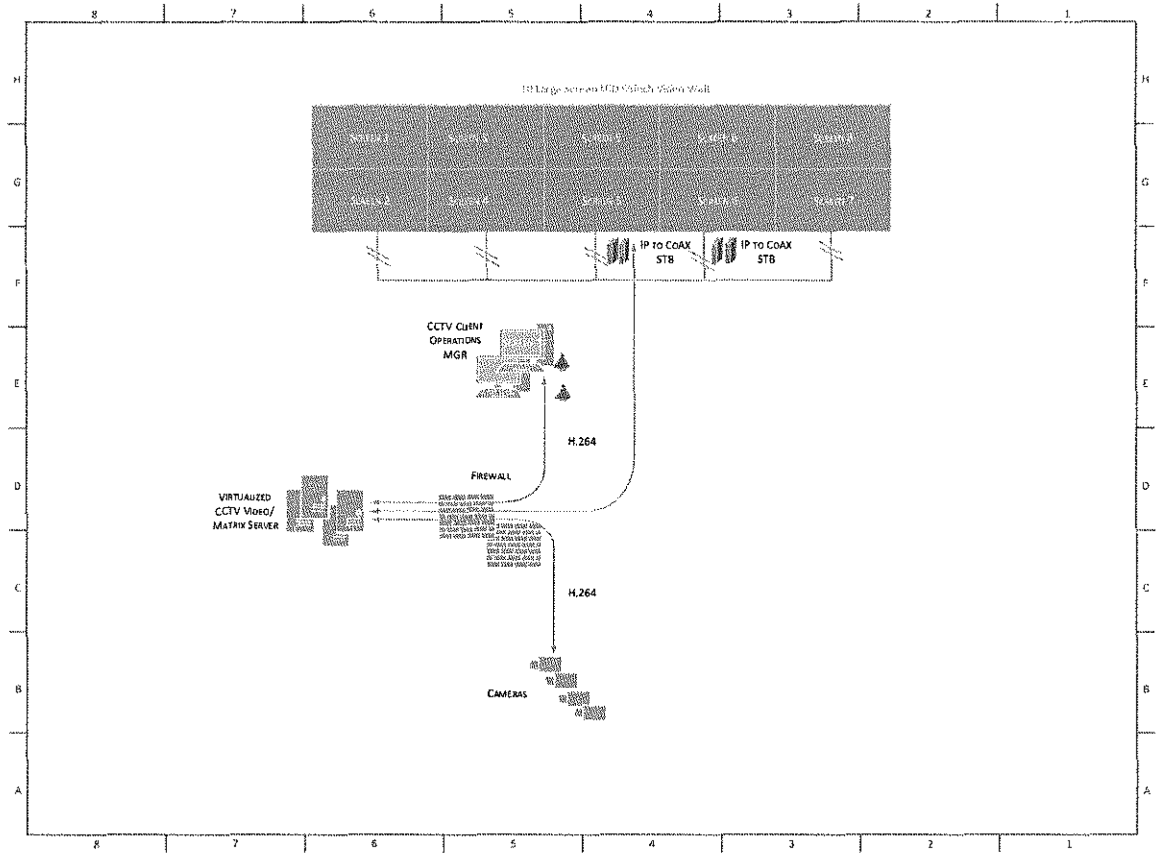


Figure 14 CCTV Logical Diagram

8.14.1 System Design

The Site Security IP CCTV and Access Control System Design has been designed in accordance with the minimum requirements set by Qatar Ministry of Interior (MOI). All Cameras are either POE or POE+. The cameras are connected to the Industrial Ethernet IP network and will send its data to the Media servers located in the computer room. The images are then displayed in the control room on the large 55inch Video Screens.

Refer to Appendix A8D for CCTV Calculations:

The IP CCTV Systems has been designed so as to cover the strategic locations, exit points and sensitive areas of the building as depicted on the security drawings. Also the systems should utilize only industry standard protocol.

The Qatar Ministry of Interior has specified specific guidelines regarding the representation of the objects on monitoring screen as follows:

I. For identification purposes – the figure should cover at least 120% of the screen height

II. For recognition purposes – the figure should cover at least 50% of the screen height

III. For detection purposes – the figure should cover at least 10% of the screen height

IV. For monitoring purposes – the figure should cover at least 5% of the screen height

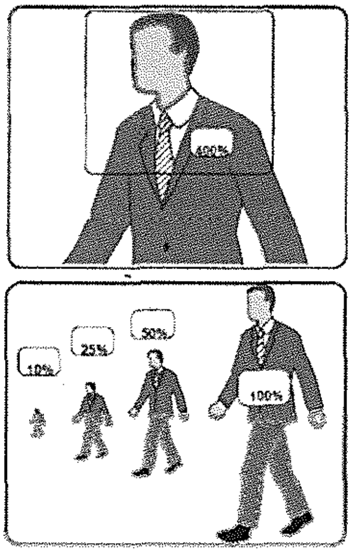


Figure 15- Relative Size of a Person as Viewed From the Screen

The following table shows the level of visual details considered in CCTV design.

Table 9 Camera Allocations

Area	Level of Visual Details	Camera Type
Entrance to the Site	Identification	With Automatic Plate Number Recognition
Site Perimeter	Monitoring (Identification when Fully Zoomed in)	PTZ
Tank Perimeter	Monitoring (Identification when Fully Zoomed in)	PTZ
Site Roadways	Monitoring	PTZ
All Entrances to the Building	Identification	Fixed
Main Pump Room	Identification	PTZ
Main Control Room	Identification	PTZ

8.14.2 Network Topology Design

The network topology design is based on Local Area Network (LAN) infrastructure with highly available, reliable, secured and scalable system. Resilient features such as redundant power supplies, redundant components, and redundant paths should be utilized to provide high network availability. IP CCTVs are connected to localise industrial access switches with PoE /POE+ switch ports to communicate with one another over a shared LAN network Technology – Ethernet

8.14.3 Deployment Model

The IP Video Surveillance deployment is run using Video Surveillance Media Servers and Storage Servers on an Intel-based Linux Enterprise Server operating system (Multi Services servers). Deployment of networked standalone hardware is done for each of the substations.

The Remote Command Center and external site administrator networks consist of Video Surveillance Operations Manager and Video Surveillance Virtual Matrix on an Intel-based Enterprise Server operating system (Multi Services server). Site Administrative tools such as Operations manager workstations, Virtual Matrix Viewers and Operations manager viewers are networked to the tunnel video surveillance system by TCP/IP over Ethernet through Private Fiber Optic Cable connections.

8.14.4 System Programming

The System is to be programmed such that operator's intervention if required shall be minimal and the system should provide features like guard tours, pre-set positions and the pre-set positions will be linked to perimeter protection system/intrusion system in future. The NVR's should allow for recording of events both continuous and motion triggered as per requirement and recordings should be able to create evidences and support post event analysis.

8.14.5 Bandwidth and Storage Requirement

There are estimated approximately 279 cameras (external and internal) identified for each site. The contractor is to refer to the drawings for the exact quantities.

The bandwidth requirement for each CCTV will depend on the camera resolution, compression type, frame rate recording, and the amount of visual activity expected on that particular area. For storage calculation, 120 days retention period was considered. Video compression is

The following parameters are considered.

For Bandwidth and Storage calculation, software called the IP Video System Design Tool version 7.1 by JVSG was used.

Table 10 CAMERA DESIGNATIONS

Area	Estimated Number of Cameras	Resolution	Visual Activity Expected (Motion)	Image Complexity	Recording Duration (% of 24 hours)	Frame Per Second
Site Perimeter	71	1920x1080 (Full HD)	30%- Low	50%- Average	25	5
Tank Perimeter	91	1920x1080 (Full HD)	30%- Low	50%- Average	50	10
Roadways	41	1920x1080 (Full HD)	30%- Low	50%- Average	50	10
Entrances to Building	40	1920x1080 (Full HD)	50%- Average	50%- Average	70	15
Main Pump Room	16	1920x1080 (Full HD)	50%- Average	50%- Average	70	20
Plantrooms (Genset Rooms, UPS Rooms, VFD Rooms)	20	1920x1080 (Full HD)	30%- Low	50%- Average	25	10

Table 11 CCTV STORAGE REQUIREMENTS

Areas	Bandwidth Per Camera (Mbps)	Total Bandwidth (Mbps)	Required Storage (TB)
Site Perimeter	2.3	166	54
Tank Perimeter	4	373	120
Roadways	4	167	109
Entrances to Building	9	374	339
Main Pump Room	9	150	136
Plantrooms (Genset Rooms, UPS Rooms, VFD Rooms)	4	82	26
Total		1311	784

8.14.6 Video Surveillance Media Server

The general features for the Video Surveillance Media Server shall be able to collect and route the video streams from the IP cameras to the viewers or other media servers. For archive viewing, the Media Server receives video from the IP camera continuously (as configured per the archive settings) and only sends video streams to the viewer when requested. The Video Surveillance Media Server shall be able to deliver video requests and video streams to the viewer using HTTP (TCP port 80) and HTTPS (TCP port 443). A full list of features required is defined later in this document

8.14.7 Video Surveillance Operations Manager

The general features of the Viewers are that it shall be able to access the Operations Manager (OM) through their web browser or through the proposed proprietary application software. The Operations Manager shall deliver a list of resource definitions, camera feeds, video archives, and predefined views to the viewer. Once this information is provided to the viewer, the viewer shall be able to communicate with the appropriate device to request and receive video streams.

8.14.8 Video Surveillance Virtual Matrix Switch

The general features of the Virtual Matrix server it shall provide a detailed monitor layout to the Virtual Matrix monitors and the position of each camera feed on the screen. A Virtual Matrix server may support a large number of Virtual Matrix monitors since the communication between the monitors and the server is required only during the initialization or when a new view is pushed to the monitor. Once the monitor layout and views are pushed to the monitors, the monitors shall be able to contact the appropriate device to request video stream.

8.14.9 Video Surveillance Virtual Server Hardware Requirements

Video Surveillance Manager (VSM) shall provide a comprehensive system for video surveillance needs. This system shall enable the network and security teams to collaborate effectively in a highly scalable environment combining both video and network techniques to optimize and support up to 500 of cameras for each site

8.14.10 Video Analytics Software

The Video Analytics software shall run on the same virtual machine as the Video Surveillance Operations Management server and provide tripwire detection as well as the ability to classify objects and detect camera tampering and lLocal HMlering events.

a. Tripwire: Identifies user-defined objects that move in a specified direction as they cross over a line (tripwire) drawn within the camera's field of view.
b. Object classification: Differentiates between a person, vehicle, or other objects.
c. Camera tampering detection: Identifies any event that significantly changes the field of view of the camera.
d. LLocal HMlering: Detects when a person or vehicle remains in a user-defined area of interest for a configurable length of time.
e. Take away events: That Detects when an object has been removed from a user-defined area of interest.
f. Multiline tripwire: Enables the association between two virtual tripwires with respect to crossing one before the other and relative time between crossing both.
g. Leave-behind events: Detects when an object has been left behind or inserted in the full view of a camera.
h. Features
i. Identify intruders moving anywhere in the camera FOV
j. Identify threats in all weather, fog, low light

k. Identify very slow-moving intruders
l. Track intruders with automatic Pan/Tilt/Zoom tracking even after target leaves range of fixed cameras
m. Special treatment for camera vibrations
n. Certificates (from leading agencies like Sandia National Labs)
o. Performs the detection and tracking completely autonomous and can track an intruder that was detected on another camera.
p. Able to classify and inform the operator whether the detected threat in question is a human being or a vehicle of some sort
q. Internal check-up of video quality like No video signal, Bad video signal, Low visibility
r. Map display with variety of visual notifications
s. Integration of different platforms (analog, digital and intelligent systems)
t. Analog Video out with date & time and intrusion track overlay
u. MPEG-4 Video CIF and 4CIF resolutions
v. MPEG-4 Audio
w. Identify intruders crawling, fast running, zigzag, stop and go.
x. Reduce false alarm rates to absolute minimum
y. Track intruders even after they have left the field of view of fixed cameras, and follow their exact path on a map or aerial photo.
z. Track intruders with automatic Pan/Tilt/Zoom tracking even after target leaves range of fixed cameras
aa. Ignore small animals, clouds, camera movement and other visual noise.
bb. Ignore movement in predefined areas (like patrol roads).
cc. Identify and track multiple simultaneous intruders.
dd. Alarm on low visibility, FOV obstruction, video malfunction, weak or no signal.
ee. Camera types: Color, B/W, IR, Thermal; NTSC & PAL.
ff. Track intruder with any PTZ (Pan/Tilt/Zoom) camera automatically.
gg. Keep intruder in center camera through full 360 degrees of movement.
hh. Track all moving objects (Humans, Vehicles).
ii. Manual and automatic modes: track an intruder automatically, or manually select an object of interest to track.
jj. Track intruder even when hiding (the camera will wait until intruder is visible).

Integrated real-time security view: Up to 32 simultaneous video cameras displayed, with aerial photos, site maps and floor plans showing status and physical location of security devices and real-time Moving Target Indicator (MTIs) on a single or dual monitor.

Deployment across a wide area network: cameras, sensor inputs and command centre stations can be distributed geographically. Client/server architecture allows unlimited addition of stationary and PTZ cameras, command stations and users.

Policy-based definition of threat response: automatically activate systems on alarm (automatic door locks, lights, control PTZ cameras, siren, SMS, etc.) and log all alarms for later review.

Server-based database: The database provides the distributed basis for security information, hierarchy and permissions. Each command centre can be personalized per user, based on role and preferences.

Users can define macros, for quick activation of actions, and camera sequences for guard tours.

Integrate sensors from other security systems, including smoke detectors, fences, PIR and more, in order to reduce security desktop overload.

8.14.11 Video Surveillance Virtual Matrix Software

The Video Surveillance Virtual Matrix software, run on the Video Surveillance Operations Management Server, shall use a separate VLAN on the IP network to provide aggregation and transmission of video from cameras and recording platforms much like the function of a classic analog video matrix switch. It shall provide the operators with 24 x 7 monitoring capabilities from any number of available cameras to be displayed on any system monitors within any custom video display patterns. The Virtual Matrix shall easily be integrated with other systems to automatically display video in response to user-defined event triggers. These triggers can include access control and fire systems in buildings, outdoor motion sensors, or even radar systems

This shall include, but not be limited to, the following functions:

a. For Camera numbers between 34 to 64 , it shall be possible to display 16 maximum captured videos between two 42-55 " monitors at any time from a single monitor.
b. System Size – it shall be possible to set parameters for the system size to reduce the amount of time for upload/download of database. Sizing shall be possible for Video Inputs, Video Outputs, Users, Keyboards, Alarm Inputs, Sequences, Groups, and Scenes.
c. Communications – it shall be possible to set the communication port and applicable speed, or to select a network address directly from the configuration window.
d. Video Inputs – it shall be possible to: Select a different logical number for a physical input thus allowing for a different logical order than the arrangement of the physical inputs.
e. Select the type of input – Static Camera, High-speed Dome, or PTZ telemetry receiver.
f. Enable a Video Loss event and associate this with a Sequence.
g. Enable a Video Restore event and associate this with a Sequence. The sequences for the Video Loss and Video Restore events shall be different sequences.
h. Assign a title to the input. The title shall be, at minimum, 24 characters and its position on-screen shall be selectable. Selections for the characters shall include size, brightness, and foreground/background framing.
i. Video Outputs – it shall be possible to:
j. Select a different logical number for a physical output thus allowing for a different logical order than the arrangement of the physical outputs.
k. Scenes – shall consist of four Views. Each View may be configured for a specific camera and/or a specific preset. The Scenes shall be named.
l. Groups – shall be associated with up to 128 Scenes. The Groups shall be named; and this name shall appear on the keyboard LED display when Groups are selected.
m. Alarm Inputs – shall be associated with a physical input. Physical inputs shall be terminations on the main Input/Output terminals or on remotely located I2C Input/Output terminals. There shall be up to 256 Alarm Inputs.

n. It shall be possible to enable/disable the alarm.
o. It shall be possible to enable the alarm to activate on contact opening and associate this event with a Sequence.
p. It shall be possible to enable the alarm to activate on contact closing and associate this event with a Sequence.
q. Users – shall be configured to restrict access and shall be:
r. Assigned a unique password.
s. Individually enabled or disabled.
t. Assigned a date on which the privileges will expire.
u. Assigned to specific functions, which shall include/exclude PTZ control, editing presets, VCR control and controlling

8.14.12 Video Surveillance Storage System

It is a requirement of the deployment that CCTV shall be store for upto 120 days, this will be achieved by provisioning Video Surveillance storage software that when combined with the media server will allow data to be sent to remote storage.

The media server shall support Video Surveillance Storage System(SS) software on the media server that will provide options for storing video and audio using cost-effective, IT-caliber storage devices. It shall combine the Video Surveillance Media Server internal storage with DAS, SAN, and NAS to store the video in multiple locations where it can be secured and accessed most efficiently. Video can be stored in loops, one-time archives, or event clips triggered by external systems. It shall act as a means of providing redundant storage and remote long-term archives.

The Video Surveillance Storage System features shall include:

a. SAN, NAS, ISCSI and DAS configurations
b. Internal storage up to 24 TB (on the Media Server)
c. SAN arrays that support up to 42 TB per array, 420 TB per rack
d. Redundant archives
e. RAID 0/1/5 configuration
f. Optional clustering for failover protection
g. Online access to video at more than 100 times faster than tape
h. Redundant power supplies and RAID controllers
i. Hot swappable fans

8.14.13 Video Surveillance Media Server

The Video Surveillance Media Server shall be run as an independent machine and not on the Operations Management Server previously described. This hardware + software platform will be responsible for configuring the video application through by multiple Web-based consoles to configure, manage, display, and control video throughout the IP network. It shall be capable of managing large number of Media Servers, Virtual Matrixes, cameras, and users.

Video Surveillance Media server shall provide network digital recording and playback with optional built-in analog video encoder cards and Fibre Channel interfaces, the Physical Security Multiservices Platform 2-RU servers shall enable direct connectivity from analog cameras or for IP video directed from the network, and allows remote playback of the recordings over an IP network.

8.14.14 Deployment Requirement Features

The deployment across a wide area network: the cameras, sensor inputs and command centre stations can be distributed geographically. The Client/server architecture shall allow unlimited addition of stationary and PTZ cameras, command stations and users.

Policy-based definition of threat response: automatically activate systems on alarm (automatic door locks, lights, control PTZ cameras, siren, SMS, etc.) and log all alarms for later review.

Server-based database: The database provides the distributed basis for security information, hierarchy and permissions. Each command center can be personalized per user, based on role and preferences.

Users shall be able to define macros, for quick activation of actions, and camera sequences for guard tours.

Integrate sensors from other security systems, including smoke detectors, fences, PIR and more, in order to reduce security desktop overload.

Restricted as to which inputs, outputs, and keyboards they may have access.

Keyboards – each keyboard shall be configured to restrict access.

Security shall be enhanced by implementing the rule that access levels be created for both the User and the Keyboard. Camera access and monitor access shall be set up BOTH for users and keyboard control locations. At the time that a user logs in, the system shall combine the access level (camera and monitor) for the user and the logged-in keyboard location. This combined access level shall limit which matrix switch operations shall be allowed.

Keyboards shall be assigned a priority. Keyboards of a higher priority shall have precedence over keyboards of lower priority.

Keyboards shall be capable of being assigned a dedicated monitor in addition to the monitor selected by the user. Every video switch operation performed on the keyboard will additionally cause the input to be copied to the dedicated monitor.

Keyboards may be assigned to specific functions, which shall include/exclude PTZ control, editing presets, VCR control, and controlling sequences.

Keyboards shall have a minimum of 4 and up to 16 user-defined Keys.

User-Defined Keys – can be programmed to initiate a Sequence or call-up a Group/Sequence.
Time of Day events shall be configured to automatically initiate a Sequence. The event shall be named and shall be:

I. Programmed to operate on any selected day of the week, every day, weekends only, or weekdays only.

II. Initiated at a specific and selectable Time of Day.

III. Prioritized such that an event of higher priority has precedence.

IV. Enabled or disabled without changing the Time of Day parameters.

V. Text Messages of up to 24 characters shall be configured and shall be used for display on keyboards or on-screen displays. It shall be possible to simultaneously display multiple text messages using on-screen displays.

VI. Sequences shall be configured and shall be available for use by the system on Event/Action, Time of Day schedule, or Manual Command.

VII. There shall be a minimum of 1024 sequences available.

VIII. There shall be a minimum 25 steps available in each sequence.

Each step shall consist of a command selected from a list of available commands. The commands shall cover all aspects of system operation and shall include conditional commands. Each step shall consist of multiple parameters.

Downloading – it shall be possible to download parts of, or all, the database from the Configuration Software to the VMS CPU.

Uploading – it shall be possible to upload parts of the database from the VMS CPU to the Configuration PC.

8.15 MEP SCADA HMI

This section of the specification covers the requirements for MEP SCADA. It I proposed that all the MEP Systems are monitored at the control room along with the process control. In addition all alarms from the MEP systems are also monitored at a future Master Operations Control Centre. Currently the existing Master control is termed NWCC.

8.15.1 Coverage and Scope

This document outlines the description of the system basic operation and functional specification for the complete MEP SCADA Energy Monitoring and Control System, or simply referred to as MEP SCADA. The MEP SCADA system includes hardware and software implements for the plant-wide Energy Monitoring and Control of the Mega Reservoir.
In general, the extent of the coverage of this specification covers the following major areas:

I. MV Electrical System
II. LV Electrical System
III. Mechanical System
IV. Fire Alarm System

Each major area is breakdown into more detailed systems, as follows:

I. Main 11kV Switchgear
II. LV Switchgear Mains
III. VFD 11/3.3 kV Transformers
IV. LV Distribution Transformers
V. Generator 11kV Switchgear
VI. Main LV Genset Switchgear
VII. Remote LV and Genset Switchgear, Aux PS
VIII. Remote LV and Genset Switchgear, ACR
IX. Remote LV and Genset Switchgear, Reservoir
X. Chilled Water Pump Station
XI. Main Pump Station BAS
XII. Remote building cooling
XIII. Fire Alarm System

The scope herein includes supply and installation of the following devices and sub-systems, equipment and devices for the MEP SCADA system:

I. Control Relay
II. Energy Metering
III. Transformer Monitoring
IV. Local PLC
V. Main PLC
VI. SCADA/SCADA HMI Software System
VII. Industrial Ethernet Network
VIII. BAS

.3

8.15.2 General Requirements

The plant-wide MEP SCADA monitoring and control covers the electric substation automation, mechanical system control and monitoring, and energy metering. The MEP facilities in the SCADA covers the 11 kV distributions, the VFD 11/3.3 kV transformers, the 11kV generators, the LV generators, the LV main switchgears, the chilled water system, the building cooling distribution, and fire alarm system. The MEP SCADA uses the Distributed Control System approach through the use of industry standard Programmable Logic Controllers (PLC). The identified areas in drawings will be provided with a local PLC for local control and connection point of electrical field devices for overall plant MEP SCADA implementation. The PLC functions as a hardware interface and communication gateway for monitoring and control between the field devices and the station control. The field devices consist of Intelligent Electronic Devices (IED) such as protection relays, generator panel, smart meters, transformer monitoring systems, and cooling controllers, are connected to the PLC through Modbus Serial RS485. The PLC communicates upstream through Industrial Ethernet TCP/IP. A main redundant PLC with substation automation specific SCADA control algorithms are used to process the plant-wide MEP energy supervision and management.

8.15.3 Control Hierarchy

The MEP SCADA monitoring and control systems proposes that the application must be organized in a logical control hierarchy in order to provide a standard format for monitoring/control of the overall facility. This standard approach shall provide operators and maintenance staff a uniform interface on how to monitor and control the MEP systems, and how to override the controls when necessary due to failures or when required for routine maintenance.
For this purpose the control system hierarchy shall be organized and viewed as a pyramid structure with four layers:

IED devices (Protection Relay, Room Controller, etc.) Local PLC (distributed control system).

Centralized PLC (Main MEP PLC) SCADA monitoring/control (automation and energy management application software).

8.15.4 Field Sensors and Specific Control Devices

All electrical and mechanical installation control and monitoring must originate and terminate at this level. All IED components specified at this level should be interfaced with the local PLC. IED's such as Protection Relay are given with absolute control privileges such as short circuit protection whilst providing fault alarm to plant-wide SCADA via PLC.

8.15.5 Local PLC

All area coverage as indicated in Section 3 will be provided with local PLC. The main function of the local PLC is to provide communication gateway, converting bus signal from Modbus Serial RS485 to Industrial Ethernet. The PLC's shall also be furnished with digital and analogue I/O's with minimum quantity as specified herein.

In addition, a BAS shall be furnished for the Main Pump Station (to be discussed in a separate document) which provides monitoring and control of lighting and cooling in control room and offices.

8.15.6 Centralized PLC

This PLC shall perform monitoring and control of all the plant-wide MEP SCADA. The PLC shall be furnished completely in a fully redundant configuration as specified herein, programmed and tested providing specified communications, monitoring, display, input/output, annunciation, computational and other requirements for operation of the Substation SCADA system. Any additional components required for the substation automation and energy management operation, whether specifically referenced herein or not, shall be provided by the Contractor.

8.15.7 SCADA Control

The area coverage is as identified in the automation drawings ,shall be monitored, controlled and supervised from one central location, which is the Control Room in the Main Pump Station. There shall be separate software program packages for electrical SCADA consisting of substation automation, energy management, and building automation. Dedicated redundant servers shall be provided for the MEP SCADA operation for the generation of alarm reports, historical data archiving and retrieving, scheduled reports and system maintenance.

8.15.8 Protection Scheme

The protection scheme shall be based on KAHRAMAA 11kV Protection Standard for bus coupler, feeders and transformers. Protection relay can be a single function relay or multi-function relay, as required. Single function relays are legacy devices while the multi-function relays are of the IED type. Both are required to have a Modbus Serial RS485 communication capability for connection to the local PLC for substation monitoring and control.

LV main switchboards shall be link to the SCADA for monitoring and control only of large draw-out type LV mains circuit breaker of the ACB type through the built-in electronic protection control of the ACB.

8.15.9 Transformer Monitoring

There are two types of transformers used in the reservoir, the phase-shift VFD input transformers rated at 3.2 MVA, 11/3.3 kV for large pump motors, and the LV transformers for utilization and small pump motors. All supply transformers are oil-typed. Transformer monitoring shall be provided to include oil pressure, oil temperature, winding spot temperature and core spot temperature. With these implements it shall be possible to monitor the transformer temperature and pressure using data trending through the plant-wide electrical SCADA.

8.15.10 Pressure Sensor

The pressure sensor shall have its own outdoor rated control panel and is connected to the local PLC through its analogue output of 4-20mA signal. The pressure control panel shall have a dry contact relay output for oil high pressure fault signal, and shall be connected to the transformer upstream feeder protection panel and terminated to the 94T ANSI device protection relay. Concurrently, a Buchholz relay shall be provided with output dry contact relays that connects to the 94T ANSI device, and also to the local PLC for direct hardware alarm connection (Buchholz relay fault alarm register).

8.15.11 Temperature Sensor

The temperature sensors shall be of the fibre optic type and are embedded into the windings and core of the transformer. The controller, which is housed in an outdoor rated cabinet, shall accept all the sensors using fibre optic cables and shall also provide connection to the local PLC through Modbus Serial RS485. The temperature controller shall have a dry contact relay output for high temperature fault signal, and shall be connected to the transformer upstream feeder protection panel and terminated to the 94T ANSI device protection relay.

8.15.12 Generator

There are two types of generator used in the reservoir according to operating voltage, the medium voltage type (11kV) and low voltage type (0.415 kV). The main backup generator is the 11kV medium voltage type connected in parallel with factory-fitted synchronizing and control panel, while smaller generators are used for general purpose backup system.

8.15.13 MV Generator Control and Monitoring

Each MV Generators shall be equipped with machine control panel to control the diesel engine governor speed, voltage regulation and frequency control. In addition, the control panel shall have facilities to monitor the various engine parameters and fuel systems. The control panel shall have PLC functionality in terms of features, I/O, SCADA HMI and communications.

The control panel shall be equipped with synchronizing features, which can act as a master or slave synchronizer. When in master mode, it takes control of frequency steering and can synchronize to the incoming utility or generate its own reference 50 Hz waveform (when in stand-alone mode), and sends synchronizing commands to other generator controllers for parallel connection or co-generation application. When in slave mode, it receives synchronizing commands from peer generator controller or from a centralized master controller.

The generator controller shall be fitted with various communication protocols to enable remote monitoring and control. An Ethernet port shall be available, preferably dual port, to directly connect the generator controller to the SCADA/SCADA HMI for remote supervision.

If a master controller is implemented, the master controller shall be furnished also with Ethernet port for direct connection to the SCADA/SCADA HMI for remote supervision.

8.15.14 LV Generator Control and Monitoring

Each LV Generators shall be equipped with machine control panel to control the diesel engine governor speed, voltage regulation and frequency control. In addition, the control panel shall have facilities to monitor the various engine parameters and fuel systems. The control panel shall have PLC functionality in terms of features, I/O, SCADA HMI and communications.

The control panel shall have synchronizing features capable of utility sync for co-generation application.

The generator controller shall be fitted with various communication protocols to enable remote monitoring and control. An Ethernet port shall be available, preferably dual port, to directly connect the generator controller to the SCADA/SCADA HMI for remote supervision.

8.15.15 Generator SCADA HMI Software

The generator systems, MV or LV, shall be provided with SCADA/SCADA HMI class application software capable of supervision and monitoring site-wide. Full SCADA functionality shall be implemented for the generator application software.

8.15.16 Energy Metering

All incoming 11kV feeders in the Secondary 11kV Substation, which is the Pump Station Main 11kV Substation, shall be furnished with energy meters. The energy meters shall be capable of power quality monitoring with embedded smart meter functionality for plant-wide and enterprise-wide SCADA energy management. The energy meters shall have a Modbus Serial RS485 interface for connection to the local PLC.

8.15.17 Chilled Water System

The Main Pump Station is provided with a centralized chilled water system. The primary purpose is to provide cooling mechanics for the large medium voltage (3.3kV) VFD through chilled water circulation. From this same chilled water system are derived the cooling mechanics to provide cooling to office and control rooms.

The chilled water system consisting of compressor motor, valve control and instrumentations, are monitored and controlled using a vendor-supplied local PLC. The discussion of principle of operation and technical specification is provided by others in a separate document.

The local PLC shall be connected to the Control Center through dual Industrial Ethernet. The vendor shall ensure data mapping to be fully compatible with the MEP SCADA, historian and alarm systems.

8.15.18 Building Automation System Client and Server Architecture

The Main Pump Station shall have building automation systems that provide data to a MEP SCADA HMI for lighting and indoor climate control of office and control rooms. Each controlled room will have a temperature thermostat panel and a dedicated room controller. The room controller shall have customized control for each designated room (e.g., CRAC for server room).

Lighting and HVAC controllers and sensors shall all be connected to field controllers that support BACNet/IP which is then connected to the control room through the industrial Industrial Ethernet network. The Building Automation SCADA HMI Server Software shall reside on a OPC/BACnet I/O virtualized server (Software ICONICS's) for centralized supervision, monitoring and control.

The Building Automation Client SCADA HMI Software shall run on a client workstation within the control room. It shall be possible to view the MEP systems from the Control Center station SCADA HMI with associated interactive plant graphics and pictures during runtime operation and alarm.

8.15.19 Fire Alarm System

The main control panel shall be installed in the fire command room. The main control shall have a communication interface for connection into the plant-wide Industrial Ethernet Network using BACNet/IP protocol. The fire alarm main controller shall be capable of correct data mapping, including OPC compatibility, to interface properly into the MEP SCADA for centralized supervision, monitoring and control. It shall be possible to view the fire alarm system from the Control Center station SCADA HMI with associated interactive plant graphics and pictures during runtime operation and alarm.

8.15.20 General System Design

The plant-wide MEP SCADA shall be suitable for operation, control and monitoring of the complete pump station electro-mechanical plant services system, including future extensions. The systems shall be of the state-of-the art suitable for operation in a unique environment present in large water pumping station, follow the latest engineering practice, and ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered MEP SCADA system shall support remote control and monitoring from Remote Control centers via gateways. The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

8.15.21 System Architecture

The MEP SCADA system shall be based on a decentralized architecture and on a concept of distributed intelligence. Functions shall be decentralized, object-oriented and located as close as possible to the process. The main process information of the station shall be stored in distributed databases.

The 11kV substation automation, which constitute the major part of the plant-wide MEP SCADA architecture, shall be structured in two levels, i.e. in a station and a bay level. At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for interposition or transducer. Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station. (Note: A bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer.)

The 11kV Generators' control panel will be connected directly to the Industrial Ethernet system network bus using redundant connection. Likewise, the generator system paralleling and synchronizing main control panel will also be connected to the Industrial Ethernet system network bus.

The data exchange between the electronic devices on bay (LV and MV) and station level shall take place via the communication infrastructure. This shall be realized using shielded RS485 serial cables, thereby guaranteeing disturbance free communication. Data exchange is to be realized using Modbus RTU protocol (RS485 Serial) through a distributed control system local PLC.

The data exchange between BAS field devices and the I/O controller shall take place via the using BACNET. Data exchange between fire alarm intelligent field devices and controller shall be through hard wired cabling, using RS485 signalling protocol.

The communication between the local PLC to the station level main electrical automation PLC is for monitoring purposes only and not for control and shall be through Industrial Ethernet redundant configuration such that failure of one cable shall not affect the normal operation of the substation automation. However any such cable failure shall be alarmed in the SCADA.

At station level, the entire station shall be monitored only from the Control Centre MEP SCADA HMI. Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels

The GPS time synchronizing signal for the synchronization of the entire system shall be provided. Time synchronization shall be based on GPS NTP.

8.15.22 Functional Requirements

The MEP equipment and devices plant-wide shall be operated from different places:
i) Remote control
ii) Station SCADA HMI.
iii) Local controller IED (in the field)
Operation shall be possible by only one operator at a time. The operation shall depend on the conditions of other functions, such as interlocking, synchrocheck, etc.

8.15.23 Select-Before-Execute (SBE)

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

8.15.24 Command Supervision, Interlocking and Blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of MEP systems causing damage and accidents in case of false operation does not take place. In addition to software interlocking hardwired interlocking are to be provided for:

I. Bus Earth switch Interlocking
II. Transfer Bus interlocking (if applicable)
III. Chiller pumps interlocking
IV. Chilled water valve interlocking
V. For software interlocking the bidder shall describe different mode or scenario (e.g., while an IED of another bay is switched off or fails).
VI. A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

8.15.25 Run Time Command Cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

8.15.26 Self-Supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

8.15.27 User Configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.
It shall also be possible to interconnect and derive input and output signals, logic functions, using built-in functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). Multi-activation of these additional functions should be possible.

The Functional requirement shall be divided into following levels:

a. Field Level Functions

b. System Level Functions.

8.15.28 Electrical Bay Level Functions

Each circuit breaker panel, 11kV (MV) or 0.415kV (LV) shall have a built-for-purpose IED's fully integrated inside the cabinet. The cabinet shall be called a "bay" whilst maintaining full process and control functionality. In general, the bay level process shall have minimum functionality:

I. Control mode selection
II. Select-before-execute principle
III. Command supervision: Interlocking, blocking and Double command
IV. Synchrocheck, voltage selection
V. Run Time Command cancellation
VI. Operation counters for circuit breakers
VII. Display of interlocking and blocking
VIII. Breaker position indication per phase
IX. Alarm annunciation
X. Measurement display
XI. Local SCADA HMI (local guided, emergency mode)
XII. Interface to the station SCADA HMI.
XIII. Data storage for at least 200 events
XIV. Extension possibilities with additional I/O's inside the unit

8.15.29 Control Mode Selection

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

a) Emergency Operation- It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED.

b) Remote Mode - Control authority in this mode is given to a higher level (Remote Control Center) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

8.15.30 Synchronism and Energizing Check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

a. Settable voltage, phase angle, and frequency difference.

b. Energizing for dead line - live bus, live line - dead bus or dead line – dead

c. bus with no synchrocheck function.

d. Synchronizing between live line and live bus with synchrocheck function.

8.15.31 Synchronizing Voltage Selection

The voltages relevant for the Synchrocheck functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

8.15.32 Event and Disturbance Recording Function:

Each IED should contain an event recorder capable of storing at least 200 time tagged events. This shall give alarm if 70% memory is full.

8.15.33 Status Supervision

The status of each switchgear, e.g. circuit breaker, earthing switch, etc., shall be supervised continuously. Every detected change of switch or breaker position shall be immediately displayed in the single-line diagram on the station SCADA HMI screen, recorded in the event list and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes. The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit. The electrical SCADA shall also monitor the status of LV switchgears.

8.15.34 Measurements

Process analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated.
The measured values shall be displayed locally on the station SCADA HMI and in the control centre. The abnormal values must be discarded.
The analogue values shall be updated every 2 seconds.
Threshold limit values shall be selectable for alarm indications.
Suitable no. of Transducers shall be provided to facilitate the flow of 4-20mA analogue signals from the bay level equipment to its respective Local PLC and Station level equipment, as per its respective approved drawings for remote control & supervision at Station SCADA HMI's thereof by the successful SCADA supplier.

8.15.35 Event and Alarm Handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station SCADA HMI. Alarms shall be recorded in a separate alarm list and appear on the screen.
All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1ms.

8.15.36 Plant-Wide Electrical SCADA HMI Operation

On the SCADA HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object. Control operation from other places (e.g. Remote Control Center) shall not be possible in this operating mode.

8.15.37 Presentation and Dialogue

The ClientSCADA HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks or keyboard commands. The SCADA HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log. An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.
The following standard pictures shall be available from the SCADA HMI:

a. Single-line diagram showing the switchgear status and measured values

b. Control dialogues with interlocking and blocking details. This control dialogue shall tell the operator whether the device operation is permitted or blocked.

c. Measurement dialogues

d. Alarm list, station / bay-oriented

e. Event list, station / bay-oriented

f. System status

8.15.38 SCADA HMI Design Principles

Consistent design principles shall be adopted with the SCADA HMI concerning labels, colors, dialogues and fonts. Non-valid selections shall be dimmed out. The object status shall be indicated using different status colors for:

a. Selected object under command
b. Selected on the screen
c. Not updated, obsolete values, not in use or not sampled
d. Alarm or faulty state
e. Warning or blocked
f. Update blocked or manually updated

g. Control blocked
h. Normal state

8.15.39 Process Status Displays and Command Procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers (if any) shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select-before-execute (SBE)" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the "execution" of the command the operated switching symbol shall flash until the switch has reached the new position.
The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.
Alarm List

Faults and errors occurring in the substations shall be listed in an alarm list and shall be immediately transmitted to the Control Centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

a. The date and time of the alarm
b. The name of the alarming object
c. A descriptive text
d. The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent). Filters for selection of a certain type or group of alarms shall be available as for events.

8.15.40 Object Picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, the following attributes shall be displayed:

8.15.41 Type of blocking

a. Authority
b. Local / remote control
c. RSCC / SAS control
d. Errors

8.15.42 Control Dialogues:

The operator shall give commands to the system by means of mouse click located on the single-line diagram. It shall also be possible to use the keyboard for command activation. Data entry is performed with the keyboard. Dedicated control dialogues shall be available for the circuit breaker.

8.15.43 User Authority Levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorization group. Each user shall then be given access rights to each group of objects, as follows:

a. Display only
b. Normal operation (e.g. open/close of switchgear)
c. Restricted operation (e.g. by-passed interlocking)
d. System administrator

For maintenance and engineering purposes of the station SCADA HMI, the following authorization levels shall be available:

a. No engineering allowed
b. Engineering/configuration allowed
c. Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

8.15.44 Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise trend and historical reports.

8.15.45 Trend reports:

a. Day (mean, peak)
b. Month (mean, peak)
c. Semi-annual (mean, peak)
d. Year (mean, peak)

8.15.46 Historical reports of selected analogue Values:

a. Day (at 15 minutes interval)
b. Week
c. Month
d. Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory. The following printouts shall be available from the printer and shall be printed on demand:

a. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
b. Weekly trend curves for real and derived analogue values.
c. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24-hr period.
d. Provision shall be made for logging information about breaker status like number of operation with date and time indications.
e. Equipment operation details shift wise and during 24 hours.
f. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as pressure, temperature and status of mechanical services HVAC pumps, fans and valves.
g. Printout on adjustable time period as well as on demand system frequency and average frequency.
h. Reports in specified formats which shall be handed over to successful bidder.

8.15.47 Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided. It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

8.15.48 Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc drive.

8.15.49 Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

8.15.50 IED Parameter Setting

It shall be possible to access all the protection and control IEDs for reading the parameters (settings) from the station SCADA HMI or from a dedicated engineering workstation computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a secured password.

8.15.51 Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate predefined automatic sequences by the operator and also define new automatic sequences.

8.15.52 Communication Interface

The electrical SCADA system shall have the capability to support simultaneous communications with multiple independent remote master stations. The electrical SCADA system shall have communication ports as follows:

a. Two ports for Remote Control Center - <u>IEC 61850 Manufacturing Message Specification (MMS) via OPC Server to be confirmed with Kahramaa Electricity</u>
b. Two ports for Regional System Coordination Center- <u>IEC 61850 Manufacturing Message Specification (MMS) via OPC Server to be confirmed with Kahramaa Electricity</u>

The communication interface to the electrical SCADA system shall allow scanning and control of defined points within the system independently for each control centre. The electrical SCADA system shall simultaneously respond to independent scans and commands from Kahramaa's control centers. The electrical SCADA system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control center's data scan and control commands may be different for different data points within the electrical SCADA system's database.

8.15.53 Remote Control Centre Communication Interface

Kahramaa will supply communication channels between the electrical SCADA system and the remote control centre. The communication channels provided by Kahramaa will consist either of power line carrier, microwave, optical fibre, 4G LTE, VSAT or leased line, the details of which shall be provided during detailed Engineering.

8.15.54 Interface Equipment:

The Contractor shall provide interface equipment for communicating between the electrical SCADA system and Remote control centre and also to the Regional System Coordination Centre.

In case of PLCC (power line) communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem (for both ends) should be standalone type complete in all respects including power supply to interface the electrical SCADA system communication channel.

The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder except the communication link along with communication equipment between substation control room and Remote Control Centre.

8.15.55 Gateway Communication Protocol

The communication protocol for gateways to remote control centre must be open protocol and shall support both the telecommunication protocols i.e. IEC 60870-5-101 (Serial) & IEC 60870-5-104 (TCP/IP), and also IEC 61

8.16 PHYSICAL ACCESS CONTROL SYSTEM (PACS)

8.16.1 General

The Physical Security design will provide basic physical security and control and any illegal or unauthorized intrusion by holistic and total security approach through the concerted workings of the Building Automation system.

8.16.2 Definition of Terms

The following terms used in this document are defined in accordance to the normative accepted definition. However certain terminologies which are unique used in this project maybe defined differently from its customary definition.

ABA Track	Magnetic stripe that is encoded on track 2, at 75-bpi density in binary-coded decimal format; for example, 5-bit, 16-character set.
Access Control List	A list of (identifier, permissions) pairs associated with a resource or an asset. As an expression of security policy, a person may perform an operation on a resource or asset if and only if the person's identifier is present in the access control list (explicitly or implicitly), and the permissions in the (identifier, permissions) pair include the permission to perform the requested operation.
Access Control	A function or a system that restricts access to authorized persons only.
API	Application Programming Interface
Assurance Level (or E-Authentication Assurance Level)	A measure of trust or confidence in an authentication mechanism defined in OMB Memorandum M-04-04 and NIST Special Publication (SP) 800-63, in terms of four levels: [M-04-04] Level 1: LITTLE OR NO confidence Level 2: SOME confidence Level 3: HIGH confidence Level 4: VERY HIGH confidence
Authentication	A process that establishes the origin of information, or determines an entity's identity. In this publication, authentication often means the performance of a PIV authentication mechanism.
Authenticator	: A memory, possession, or quality of a person that can serve as proof of identity, when presented to a verifier of the appropriate kind. For example, passwords, cryptographic keys, and fingerprints are authenticators.
Authorization	A process that associates permission to access a resource or asset with a person and the person's identifier(s).
BIO or BIO-A	A FIPS 201 authentication mechanism that is implemented by using a Fingerprint data object sent from the PIV Card to the PACS. Note that the short-hand "BIO (-A)" is used throughout the

	document to represent both BIO and BIO-A authentication mechanisms.
Biometric	An authenticator produced from measurable qualities of a living person.
CAC EP – CAC	End Point with end point PIV applet
CAC NG – CAC	Next Generation with transitional PIV applet
CAK	Card Authentication Key: A PIV authentication mechanism (or the PIV Card key of the same name) that is implemented by an asymmetric or symmetric key challenge/response protocol. The CAK is an optional mechanism defined in NIST SP 800-73. [SP800-73] NIST strongly recommends that every PIV Card contain an asymmetric CAK and corresponding certificate, and that agencies use the asymmetric CAK protocol, rather than a symmetric CAK protocol, whenever the CAK authentication mechanism is used with PACS.
CCTV	Close Circuit television; this is the video monitoring of the reservoir utilizing high definition digital network PoE cameras.
Central Station	A PC with software designated as the main controlling PC of the PACS. Where this term is presented with initial capital letters, this definition applies.
Controller	An intelligent peripheral control unit that uses a computer for controlling its operation. Where this term is presented with an initial capital letter, this definition applies.
CPU	Central processing unit.
Credential	Data assigned to an entity and used to identify that entity.
DCU	Door Control Unit; a control device acting as a communication gateway between door security elements and Ethernet network
File Server	A PC in a network that stores the programs and data files shared by users.
FRAC	First Responder Authentication Credential
Gateway	This is also known as a DCU device.
I/O	Input/Output.
Identifier	A credential card, keypad personal identification number or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
KB	Kilobyte
kbit/s	Kilobits per second

LAN	Local area network.
LED	Light-emitting diode.
Legacy CAC	Contact only Common Access Card with v1 and v2 applets
Location	A Location on the network having a PC-to-Controller communications link, with additional Controllers at the Location connected to the PC-to-Controller link with Ethernet communications. Where this term is presented with an initial capital letter, this definition applies.
NIST	National Institute of Standards and Technology
PACS	Physical Access Control System
PC	Personal computer. This acronym applies to the Central Station, workstations, and file servers.
PC/SC	Personal Computer / Smart Card
PCI Bus	Peripheral component interconnect; a peripheral bus providing a high-speed data path between the CPU and peripheral devices (such as monitor, disk drive, or network).
PDF	Portable Document Format. The file format used by the Acrobat document exchange system software from Adobe.
PIV	Personal Identification Verification
PIV-I – PIV	Interoperable credential
PPS	Protocol and Parameters Selection
RF	Radio frequency.
ROM	Read-only memory. ROM data are maintained through losses of power.
RS-232	An TIA/EIA standard for asynchronous serial data communications between terminal devices. This standard defines a 25-pin connector and certain signal characteristics for interfacing computer equipment.
RS-485	An TIA/EIA standard for multipoint serial communications.
TCP/IP	Transport control protocol/Internet protocol incorporated into Microsoft Windows.
TPDU	Transport Protocol Data Unit
TWIC	Transportation Worker Identification Credential
UPS	Uninterruptible power supply.
Vcc	Voltage at the Common Collector
WAN	Wide area network.
WAV	The digital audio format used in Microsoft Windows.
Wiegand	Patented magnetic principle that uses specially treated wires embedded in the credential card.

Windows	Operating system by Microsoft Corporation.
Workstation	A PC with software that is configured for specific limited security system functions.

8.16.3 Coverage and Scope

This Section includes a system server, networked workstation computers, operating system and application software, and field-installed Controllers connected by a high-speed electronic data transmission network.

In general, the facilities requiring security access shall be as depicted on the drawings and shall be as follows ~~the following~~:

a) ~~Main~~ Control Room
b) Fire Exit Access
c) Computer Room
d) Electrical Room
e) Mechanical Room
f) VFD Room
g) MCC Room
h) Pump Room
i) Pump Station
j) MV and Generator Bldg.
k) Remote Generator
l) Remote Substation
m) Reservoir Roof Access (Hatches)
n) Outdoor Motorized Valve Access Hatch
o) Chlorination Bldg
p) Maintenance Workshop Bldg
q) Security Room
r) Transformer Pad Access Gate
s) Main Gate
t) Kiosks –All

In describing the functionality of the security access on each building or facility installation, only the typical access door will be considered having similar characteristic and functionality.

In this document, the following types of security access doors and its associated security elements and controllers are included in the functional specification:

a) Steel doors for Fire Exit
b) Steel doors for Facility Room
c) Steel doors access for facility buildings
d) Composite Doors for Control Rooms
e) Outdoor Rooftop Steel Hatch Door for the Concrete Reservoir
f) Transformer Pad Access Gate
g) Main Gate

8.16.4 Operational Requirements

The security access system is a site-wide installation that monitors and supervises all secured areas of the plant and prevents any unauthorized access to it. Access is regulated through the use of secured locally controlled doors. Security is further enhanced with remote control operations of doors and is achieved through the total building management system.

8.16.5 Control Hierarchy

The security access shall follow a distributed control approach. The site-wide physical security access monitoring and supervision will be implemented using a modern access control deployment architecture model based on CIP over EthernetIP. According to the order of network level, the deployment architecture is structured from lowest to highest, thus:

a) Reader, Door Latch, Door Lock, Door Switch
b) Door Control Unit (Gateway)
c) Layer 2 Switch
d) Main System Bus (IP Network)
e) Client PC, Data Base, Physical Access Manager, Admission Control

8.16.6 Local Control

All secured doors shall be equipped with security access devices such as readers and locking mechanism. Both reader and lock are connected to the DCU where it performs communication to the security data servers. The DCU provides local control signal to the door locking mechanism for door locking actuation during normal and emergency condition.

8.16.7 Door Monitoring

Access door such as hatchway in Reservoir and maintenance access in generator rooms shall be provided with door monitoring switch only. Each hatchway and generator maintenance access shall be monitored independently. These access ways shall be equipped with outdoor rated pad lock with common key for ease of security. Door monitoring switch shall be connected to Gateways.

8.16.8 System Communication

The security devices shall be equipped with RS485 to communicate to the Door Control Unit or gateway. The gateways are equipped with Ethernet port and will connect to Ethernet Switch. These switches are then connected to the IP Network system bus for site wide connection.

8.16.9 Event Triggered Security Remote Control

The PACS shall be capable of implementing a site wide access control mechanism during instances of alarms, events, security breach, or scheduled security lock down via the security application software. It shall be possible to synchronize security control with CCTV and life support systems so as to provide either localize or site-wide security protocol in cases of emergencies (e.g., fire protection and life safety).

8.16.10 Remote Operation

The security access shall be provided with application software for offsite remote control such as web enabled remote control and SCADA-style regional-level remote control.

8.16.11 System Design and Function

The physical access control system (PACS) shall be design, manufacture and install suitable and fit for purpose for the water utility industry system operation. As outlined in Section 4, the secured areas within the reservoir will require security access for restriction and control of personnel. Materials and systems used shall meet the installation requirements for indoor and outdoor applications as required.

8.16.12 System Architecture

PACS shall be based on a decentralized architecture and on a concept of distributed intelligence. Each security access doors has a local door control unit or DCU that provides the control and communications. The DCU controls the opening and locking of security access doors in conjunction with the input data from card readers or biometrics input and the stored information from the security server. The DCU is design to communicate upstream to a Layer 2 network switch that provides PoE connectivity. Door elements such as card reader, biometrics and door striker are all supplied from the DCU.

Managing the security information and run time of the security application software are performed using separate hardware components like servers, workstations, and display interfaces. Security database use shall be a common corporate enterprise database.
The PACS shall be fully integrated with security video and camera on the application programming side. The site-wide communication interaction between the CCTV and the security access doors shall take place at the CIP over EthernetIP level through application programs and automation scripts.

8.16.13 Physical Access Control

The physical access control shall have the following features:

a) Regulating access through doors and gates
b) Anti-passback
c) Visitor assignment
d) Tamper protection
e) Secondary alarm annunciator
f) Credential cards and readers
g) Biometric identity verification equipment
h) Push-button switches
i) Terminal interface port
j) Credential creation and credential holder database and management
k) Monitoring of field-installed devices
l) Interface with building management systems.
m) Reporting

8.16.14 Security Control

The security control shall have the following features:

a) Real-time guard tour.
b) Time and attendance.
c) Key tracking.
d) Video and camera control.
e) Monitored Utility Hatch and Doors.
f) PACS Basic Hardware Components

In general, the PACS shall have the following minimum hardware components that make up the physical access and security for the reservoir:

a) Head-End equipment server,
b) Networked PC-based workstations,
c) Physical Access Control System
d) Database Management Software,
e) Credential validation software/hardware,
f) Field installed controllers,
g) PIV Middleware,
h) Card readers,
i) Biometric identification devices,
j) PIV Cards
k) Supportive information system,
l) Door locks and sensors,
m) Power supplies,

8.16.15 PACS System Interface

The PACS shall have the facility to interface with the following facilities and systems within the reservoir:

a) Interfaces facility with Video Surveillance and Assessment System,
b) Interface facility with Gate, turnstile, and traffic arm controls,
c) Interface facility with Automatic door operators,
d) Interface facility with Intrusion Detection System,
e) Intercommunication System
f) Fire Protection System,
g) HVAC,
h) Building Management System,
i) Elevator Controls,

8.16.16 PACS Advance Features

The PACS shall have the capability to support the following features:

a) Multiple credential authentication modes.
b) Bidirectional communication with the reader.
c) Incident response policy implementation capability; system shall have capability to automatically change access privileges for certain user groups to high security areas in case of incident/emergency.
d) Visitor management.

8.16.17 Secure Processing

All security relevant decisions shall be made on "secure side of the door". Secure side processing shall include:

a) Challenge/response management,
b) PKI path discovery and validation,
c) Credential identifier processing,
d) Authorization decisions.

For locations where secure side processing is not applicable the tamper switches and certified cryptographic processing shall be provided.

8.16.18 System Software

Software shall have the following capabilities:

a) Multiuser multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
b) Support authentication and enrolment;
   I. PIV verification,
   II. Expiration date check,
   III. Biometric check,
   IV. Digital photo display/check,
   V. Validate digital signatures of data objects (Objects are signed by the Trusted Authority
   VI. Private key challenge (CAK & PAK to verify private key public key pairs exist and card is not a clone)
c) Support CRL validation via OCSP or SCVP on a scheduled basis and automatically deny access to any revoked credential in the system.
d) Graphical user interface to show pull-down menus and a menu tree format that complies with interface guidelines of Microsoft Windows operating system.
e) System license shall be for the entire system and shall include capability for future additions that are within the indicated system size limits specified in this Section.
f) System shall have open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with <insert operating system> operating system.
g) Operator login and access shall be utilized via integrated smart card reader and password protection.

8.16.19 Security Management System (SMS) Server Redundancy

The SMS shall support multiple levels of fault tolerance and SMS redundancy listed and described below:
a) Hot Standby Servers
b) Clustering
c) Disk Mirroring
d) RAID Level 10
e) Distributed Intelligence

8.16.20 PACS Node Points

The PACS shall be design to have maximum coverage without hardware or system limitations for a totally integrated security system:
a) PACS shall support multiple autonomous regional servers that can connect to a master command and controller server.
b) Unlimited number of access control readers, unlimited number of inputs or outputs, unlimited number of client workstations, unlimited number of cardholders.
c) Total system solution to enable enterprise-wide, networked, multi-user access to all system resources via a wide range of options for connectivity with KAHRAMAA's existing wide area network.

8.16.21 Multiple Authentication Mode

PACS shall provide support for multiple authentication modes and bidirectional communication with the reader. PACS shall provide implementation capability for enterprise security policy and incident response. All processing of authentication information must occur on the "safe side" of a door.

8.16.22 Physical Access

Physical Access Control System shall provide access to following Security Areas:

a) Controlled
b) Limited
c) Exclusion

8.16.23 Authentication Factor

The PACS shall include the following authentication factor:

a) One authentication factor for access to Controlled security areas
b) Two authentication factors for access to Limited security areas
c) Three authentication factors for access to Exclusion security areas

8.16.24 Path Validation Module

The PACS System shall have an Enterprise Path Validation Module (PVM) component that processes X.509 certification paths composed of X.509 v3 certificates and X.509 v2 CRLs. The PVM component MUST support the following features:

a) Name chaining;
b) Signature chaining;
c) Certificate validity;
d) Key usage, basic constraints, and certificate policies certificate extensions;
e) Full CRLs;
f) CRLs segmented on names.

8.16.25 Distributed Processing

System shall be a fully distributed processing system so that information, including time, date, valid codes, access levels, and similar data, is downloaded to Controllers so that each Controller makes access-control decisions for that Location. Intermediate Controllers shall not be used for physical access control. If communications to Central Station are lost, all Controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the Central Station.

8.16.26 System Network Requirements

The PACS shall be provided with a data network system with the following requirements:

a) Interconnect system components and provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
b) Communication shall not require operator initiation or response, and shall return to normal after partial or total network interruption such as power loss or transient upset.
c) System shall automatically annunciate communication failures to the operator and identify the communication link that has experienced a partial or total failure.
d) Communications Controller may be used as an interface between the Central Station display systems and the field device network. Communications Controller shall provide functions required to attain the specified network communications performance.

8.16.27 Central Station

Central Station shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Central Station shall control system networks to interconnect all system components, including workstations and field-installed Controllers.

8.16.28 Field Equipment

Field equipment shall include controllers (Door Control Units), sensors, and controls. Controllers shall serve as an interface between the Central Station and sensors and controls. Data exchange between the Central Station and the Controllers shall include down-line transmission of commands, software, and databases to Controllers. The up-line data exchange from the Controller to the Central Station shall include status data such as intrusion alarms, status reports, and entry-control records. Controllers are classified as alarm-annunciation or entry-control type.

8.16.29 Alarm Response Time

Field device network shall provide a system end-to-end response time of 1 second or less for every device connected to the system. Alarms shall be annunciated at the Central Station within 1 second of the alarm occurring at a Controller or device controlled by a local Controller, and within 100 ms if the alarm occurs at the Central Station. Alarm and status changes shall be displayed within 100 ms after receipt of data by the Central Station. All graphics shall be displayed, including graphics-generated map displays, on the console monitor within 5 seconds of alarm receipt at the security console. This response time shall be maintained during system heavy load.

8.16.30 False Alarm

The design of Central Station and Controllers shall contain features to reduce false alarms. Equipment and software shall comply with ANSI/SIA CP-01-2010.

8.16.31 Error Detection

A cyclic code error detection method shall be used between Controllers and the Central Station, which shall detect single- and double-bit errors, burst errors of eight bits or less, and at least 99 percent of all other multi-bit and burst error conditions. Interactive or product error detection codes alone shall not be acceptable. A message shall be in error if one bit is received incorrectly. System shall retransmit messages with detected errors. A two-digit decimal number shall be operator assignable to each communication link representing the number of retransmission attempts. When the number of consecutive retransmission attempts equals the assigned quantity, the Central Station shall print a communication failure alarm message. System shall monitor the frequency of data transmission failure for display and logging.

8.16.32 Data Line Supervision

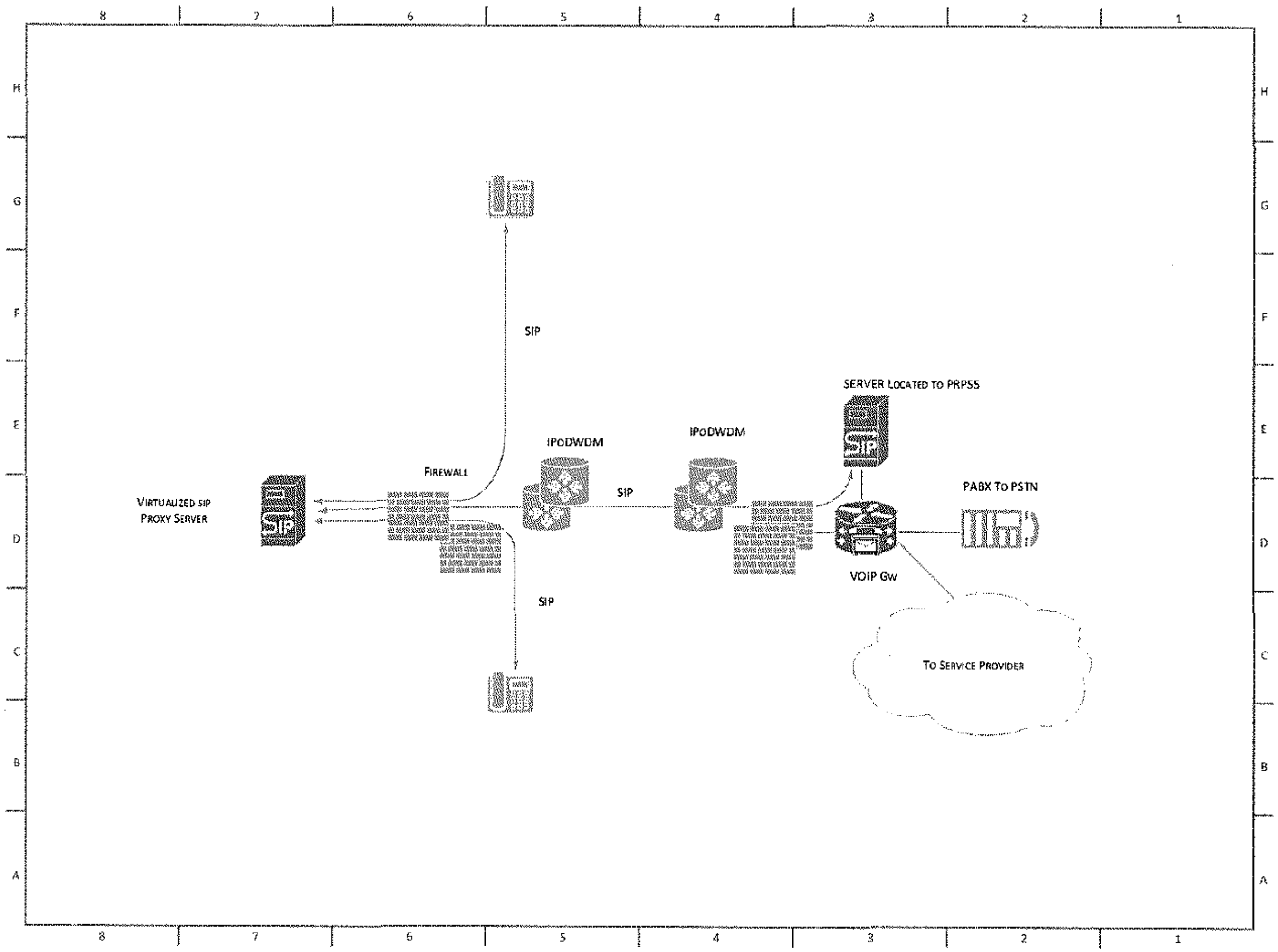
System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.

8.17 VOIP SERVICES

8.17.1 Overview

This section describes the voice services for the site. It is a requirement from Kahramaa that all critical areas have Voice Services. It is proposed that this will be provided by IP using the same network as the Process Control and other applications as part of the converged Ethernet solution.
The following diagrams depict how voice services will be deployed for the KMR reservoirs site to site communications.

Figure 16 VOIP OVERVIEW Traffic Flow


SIP
SERVER LOCATED TO PRPSS
IPoDWDM
IPoDWDM
FIREWALL
SIP
PABX To PSTN
VIRTUALIZED SIP
PROXY SERVER
VOIP Gw
SIP
TO SERVICE PROVIDER

8.17.2 SIP

It is proposed that the messaging protocol for VOIP will be Session Initiation Protocol (SIP) which is the Internet Engineering Task Forces's (IETF's) standard for multimedia conferencing over IP. SIP is an ASCII-based, application layer protocol (defined in RFC 2543) that can be used to establish, maintain, and terminate calls between two or more end points.
For more information on SIP refer to the appendix.

The rest of this section will focus on system architecture specific to this project.

8.17.3 VOIP Architecture

SIP is a peer to peer protocol comprising User Agents (UAs). The user agent functions in one of the following roles:

i. A client application that initiates SIP requests user agent client (UAC) – IP Phone running the SIP application

ii. A server application that contacts the user when a SIP is received and that returns a response on behalf on behalf of the contacted User Agent. A server running the SIP application.

The SIP servers can and will be required to interact with Lightweight Directory Access Protocol (LDAP) servers, locations servers, a database application, Security Servers (RADIUS), and extensible language (XML) application, which will provide back end services such as directory, authentication and financial services.

8.17.4 SIP Clients

The SIP clients (IP Phones) for this project will only act as UACs, all PCs will also have SIP phone capabilities installed.

The SIP clients will also include gateways which will provide call control and setup between SIP clients and other terminal types, which will also, requires translation between transmission formats and communication procedures. Typically the Gateway will be provided by the aggregation layer switch.

8.17.5 SIP Servers

The SIP servers will include a proxy server, it will be located in the computer room as a virtual service on OPC UCS Other, it will be responsible for receiving SIP requests from a client (IP Phone or PC) and then forwarding this request on behalf of the client to a UAC or to the next SIP server located in the Master Operations Control Room (PRPS5). The SIP server for each site will be responsible for authentication, authorization, network access control, routing, reliable request retransmission, and security.

8.17.6 VOIP Call Process

Each phone within each location i.e. substation, Kiosk, Guard House etc will register on the UAS, and given a E.164 number. Once the phone is registered on the UAS, the Caller can then dial the E.164 address of the intended target recipient. The request is sent to the UAS which in turn then sends the call to the targeted recipient UAC.

8.17.7 SHOP DRAWINGS

All shop drawings shall be in accordance with the relevant BSEN standards

8.17.8 SOFTWARE AND TOOLS

The contractor shall allow for field care software tools for documentation, monitoring, diagnostics, recording analysis of the Ethernet and Profibus Plantwide networks.

The tools shall be capable of:

I. Management of all IP and MAC addresses in the network
II. Generation of a network overview map
III. Automatic Scanning of the networks
IV. Monitoring of network nodes for "Failure" , "Newly added" and Not Registered
V. Reading out of data, message frame types and error statistics from the network components
VI. Display of bus load
VII. Recording of message frame traffic
VIII. Recording of PROFINET communications
IX. Recording of PROFIBUS communications
X. Comprehensive trigger, filter and sorting functions

The Application shall be divided into functionality blocks and independent program modules as follows:

a) Configuration of plant through IP and MAC addresses, automatic generation of the plant display, and import and export functions
b) Observer scanning of the networks using various protocols, and displays safety related changes in the network topology both in overview and in a hierarchical display.
c) Plant diagnostics that reads configuration data as well as comprehensive message frame type and error statistics from SNMP- capable network components, and provides information to assist searching for errors in the Ethernet network data such as bus load or online lifelists.
d) Bus Analysis which records message frame traffic on one or more Ethernet busses synchronously, and interprets the message frames throughput at all

levels, including PROFINET. Comprehensive trigger, filter and sorting functions which allows fast localization of errors

e) PROFIBUS Analysis which records the message frame traffic of a PROFIBUS networking and interprets the message frames accordingly. Comprehensive trigger, filter and sorting of functions

8.18 GLOSSARY

Term	Definition
Backbone	The primary communications path on a LAN and on which segments or network devices attach. A backbone is typically fiber optic and can support bandwidth capacities higher than the devices can communicate. A typical example of a network with a ring topology backbone is the segments that create the ring itself.
Control Circuit	Any circuit which principal purpose is the conveyance of information and not the conveyance of energy for the operation of an electrically powered device.
Control Loop	A combination of one or more interconnected instruments arranged to measure or control a process variable, or both. (Source ISA Standards and Practices for Instrumentation)
Control Room	An environmentally controlled room intended for housing digital control equipment, computers, large control panels, etc., and generally intended to be regularly occupied by operators.
Data Sheets	Data sheets as used in this specification shall comply with the requirements of ISA S20.
Electrical Isolation	Pertaining to an electrical node having no direct current path to another electrical node. As used in this specification, electrical isolation refers to a device with electrical inputs and/or outputs which are galvanically or optically isolated from ground, the device case, the process fluid, and any separate power supply terminals, but such inputs and/or outputs are capable of being externally grounded without affecting the characteristics of the device or providing a path for circulation of ground currents.
Fail	Hardwired shut down mode or virtual condition that prevents the equipment from operating in a normal state.
Fast ETHERNET	Common name for the LAN specified by IEEE 802.3 and CCITT 8802.3. A base band, local area network that operates at 100 million bits per second and can be extended up to 1.5 kilometers of cable. It uses a carrier sense multiple access/collision detection protocol.
Four-Wire Transmitter	A transmitter which derives its operating power supply separate from the signal transmission circuit and therefore requires separate power supply connections. As used in this specification, four-wire transmitter refers to a transmitter that provides a 4 to 20 milliampere current regulation of signal with a maximum external circuit resistance of 600 ohms separate from an external power source.

SCADA HMI	Human Machine Interface. The graphical interface in the main control room between the user and the SCADA system. Normally used by an Operator to monitor and control the process.
LAN	Local Area Network. A system of physical cables and associated procedures to allow the exchange of information between two or more personal computers, host computing system and computer terminals. The most common LANs are ETHERNET (IEEE 802.3 and CCITT 8802.3).
HAND	Hand-Off-Auto Switch is set in the LOCAL position and commands to the field device are initiated through the local hardwired buttons. Commands from the PLC are disabled.
Hand-Off-Auto	A Hand-Off-Auto switch, located at the associated field device, a local panel, or the MCC.
Multimode Fiber	Glass fibers, with a common diameter in the 50-to-100 micron range for the light carry component (the most common sizes are 50 and 62.5). Multimode fiber provides high bandwidth at high speeds over medium distances. Light waves are dispersed into numerous paths or modes through the cable's core typically 850 or 1300nm. Typical multimode fiber core diameters are 50, 62.5, and 100 micrometers. However, in long cable runs (greater than 3000 feet [914.4 m), multiple paths of light can cause signal distortion at the receiving end, resulting in an unclear and incomplete data transmission.
OFF	Hand-Off-Auto Switch is set in the OFF position and commands to the field device from the local hardwired controls or buttons are disabled. Commands from the PLC are disabled.
LOCAL HMI	Operator Interface Terminal. The graphical interface at a PLC control panel between the user and the SCADA system.
Operator	The person responsible for running the process operations. Typically interacts with the process through use of an SCADA HMI or LOCAL HMI.
Panel	An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term "panel" in these SCADA System Standards shall be interpreted as a general term that includes flat panels, enclosures, cabinets and consoles.
PCS System	The top-end control system located for treatment facilities that is comprised of redundant hosts, multiple workstations, peripherals, front-end processors, and is the user interface for monitoring and control, trending, report generation, and other functions commonly

	provided in a human-machine interface for plant processes and SCADA.
PLC	Programmable Logic Controller
PLC Panel	Generic name of a panel that contains a PLC and the necessary support devices for operation of the PLC.
Power Circuit	Any circuit which principal purpose is the conveyance of energy for the operation of an electrically powered device.
Ready	Ready is defined as all hardwired conditions, including power, satisfied to permit remote control of the equipment.
Real Time	Pertaining to a system or mode of operations in which computation is performed during the actual time that an external process occurs, in order that the computation results can be used to control, monitor, or respond in a timely manner to the external process.
REMOTE	Hand-Off-Auto Switch is set in the REMOTE position and commands to the field device are initiated through the PLC. Commands from the PLC may be initiated by operator command or a control strategy.
SCADA	Supervisory Control and Data Acquisition. The top-end control system for remote monitored sites comprised of hosts, multiple workstations, peripherals, front-end processors, and is the user interface for monitoring and control, trending, report generation, and other functions commonly provided in a human-machine interface for SCADA
Signal Circuit	Any circuit operating at less than 120 volts AC or DC.
TCP/IP	Transaction Control Protocol/Internet Protocol. A communication protocol that allows multi-vendor systems to participate on a network.
Two-Wire Transmitter	A transmitter that derives its operating power supply from the signal Transmission circuit and therefore requires no separate power supply connections. As used in this specification, two-wire transmitter refers to a transmitter that provides a 4 to 20 milliampere current regulation of signal in a series circuit with an external 24-volt direct current driving potential and a maximum external circuit resistance of 600 ohms.
UPS	Uninterruptible Power Supply.
WAN	Wide Area Network.
Workstation,	A PC-based user interface similar to an Operator Workstation, but with Engineer additional capabilities to modify system database, graphics, reports, control strategies, and other

	programming functions. A PC-based user interface located in the control room.
Workstation, Operator	A PC-based user interface located in the control room.

8.19 DEFINITIONS

This section contains definitions for acronyms, abbreviations, words, and terms as they are used in this document.

8.19.1 ACRONYMS AND ABBREVIATIONS

CPU	Central Processing Unit
COAX	2-pol. cable with a concentric configuration
DOC	Display and Operator Component
DCS	Distributed Control System
FO	Fibre Optics
HART	Highway Addressable Remote Transducer
HMI	Human Machine Interface
IE	Industrial Ethernet
IEC	International Electrotechnical Commission
I/O	Input/Output
ISA	Instrumentation, Systems, and Automation Society
LAD	Ladder Logic
OLE	Object Linking and Embedding
OPC	OLE for Process Control
OS	Operator Station
PC	Personal Computer
PLC	Programmable Logic Controller
PO	Process Object
RTX	Real time extension for Windows
TP	Twisted Pair

8.19.2 WORDS AND TERMS

Archive: Saving measured values and messages in the operator station to history so the data can be called up over a long period of time.

AS-Interface: The Actuator Sensor Interface is a networking system for field mounted binary sensors and actuators.

Audible Alarm Annunciation: Horn, bell, buzzer, or similar device indicating that a new alarm or message has arrived at the operator station.

Availability: The probability that a system will be able to perform its designated function when required.

Blocks: Blocks are separate parts of a user control software configuration distinguished by their function, structure, and purpose.

Bus: A path for electrical signals allowing the exchange of data between various components of a computer or system.

Central Processing Unit (CPU): The central part of the controller in which the user program is stored and processed, and the operating system and communication interfaces are contained.

Continuous Function Chart (CFC): Is a high-level graphical language using function blocks for configuring continuous control systems.

Chart: The document in which the automation functions can be created using the CFC tool or the SFC tool.

Configurable: The capability to select and connect standard hardware modules (blocks) 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.

Configuration: The physical installation of hardware modules to satisfy system requirements; or the selection of software options to satisfy system requirements.

CSV: Comma Separated Values, an ASCII text format in which tabular data are saved.

Cycle: In the controller, the scanning of inputs, execution of algorithms by the controller, and transmission of output values to devices.

Discrete Control: Control where inputs, algorithms, and outputs are based on logical (True or False) values.

Distributed I/O: Field devices or analog and digital modules located at a distance from their central controller.

Engineering Workstation (ES): represents computer equipment that includes a PC, a monitor, a keyboard and an appropriate pointing device, used by technically-trained personnel to configure the control system.

Ethernet: Hardware type standard for data transmission using coax, twisted pair, fiber optic cable, or wireless, usually running at 10 Mbps (see Fast Ethernet).

Faceplate: On the Operator Station screen, a graphic element that represents, for example, an analog controller instrument, a hardwired push-button, or a switch, allowing operator monitoring and control of the device.

Fast Ethernet: A faster version of Ethernet running at 100 Mbps.

Gigabit Ethernet: Ethernet with transmission rates of 1000 Mbps

Foundation Field bus: The ISA/IEC Foundation Fieldbus standard covers a communication system for field mounted measurement and control devices.

Function Block: A control bock as defined in IEC 1131-3. See also Block.

GPS: Global Positioning System, a satellite based system, which provides the exact position anywhere on earth, and the time of day.

Human Machine Interface (HMI): The graphical interface program for allowing an operator to interact with and control a process.

Instance: A copy of a function block, which is used again in the control configuration for a similar application.

Invalid Value: The state of a tag value, which indicates that the quantity being measured or calculated, is out-of-range, not measurable, or not calculable.

Ladder logic (LAD): Graphical representation of the automation task using relay symbols complying with DIN 19239.

Logs: Files or printouts of information in chronological order.

Mode: Control block operational condition, such as manual, automatic, or cascade.

Module: An assembly of interconnected components that constitute an identifiable device, instrument, or piece of equipment. A module can be disconnected, removed as a unit, and replaced with a spare. It has definable performance characteristics that permit it to be tested as a unit.

Object Linking and Embedding for Process Control (OPC): A software application, which allows bi-directional data flow between two separate applications.

Operator Station (OS): Electronic equipment on which the HMI resides, including, at a minimum, PC workstation, a monitor, keyboard, and pointing device used by an operator to monitor and control his assigned process or manufacturing units.

Programmable Logic Controller (PLC): Are used for discrete and continuous control in processing and manufacturing plants.

Process Field Bus (PROFIBUS): A field bus complying with EN 50170 Vol. 2 PROFIBUS (DIN 19245; bus system for industrial application based on PROFIBUS).

Plug and Play: The ability of hardware equipment to automatically identify itself to the system. When the equipment is powered up it is automatically assigned a unique identity without the need to set any dipswitches.

Point: A process variable derived from an input signal or calculated in a process calculation.

Process Object: represents a collection of variables and parameters that performs a control function (e.g. motor, block valve, PID Controller) which may consist of more than one I/O point.

Redundant: A system/subsystem with two modules that provides automatic switchover to a backup in the event of a failure, without loss of a system function.

Regulatory Control: The functions of process measurement, control algorithm execution, and final control device actuator that provide closed loop control of a plant process.

Reliability: The probability that the system or component will perform its intended function for a specified period of time, usually measured as mean time between failures.

Structured Control Language (SCL): represents a high-level language complying with IEC 1131-3 and resembling Pascal for programming complex or custom logic tasks within the controller.

Self-Diagnostic: The capability of an electronic device to monitor its own status and indicate faults that occur within itself.

Security: System access control by key lock, password, electronic card, or other equivalent method.

Sequential Control: A type of discrete control handling sequential processes.

Sequential Function Chart (SFC): Sequential Function Charts are a high-level graphical configuration language for sequential control applications.

Statement List (STL): Statement List is a textual programming language resembling machine code and complying with IEC 1131-3.

System Bus: The network used for communication between controllers and HMI servers.

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.

Terminal Bus: The network used for communication between HMI Clients and HMI servers.

Time synchronization: Time Synch is provided by the operator station to make sure that all PLCs and operator stations on the bus operate with the same time of day.

APPENDIX A8A. VENDOR REQUIREMENTS

A1.1 Development Life Cycle

The vendor must have an established development life cycle that allows for traceability of features and functions throughout that life cycle.
The vendor must have a formal and documented set of quality assurance procedures that are applied to the engineering design, development, and documentation of the software. The presence of a formal quality assurance department shall be required.
The vendor must also demonstrate that its source code for the product is regularly archived both on-site and off-site in facilities suitable to withstand physical harm.
The vendor shall allow for on-site auditing of the development life cycle to ensure good practice.

A1.2 ISO 9001 certified

The vendor must be able to demonstrate that it has established procedures.
Vendor needs to be certified under the ISO 9001-2001 guidelines.

APPENDIX A8B. COMMUNICATIONS BETWEEN CPU

B1.1 PROFINET I DEVICE

This PROJECT proposes to use PROFINET I DEVICE for communications between the CPUs as component is either cyclic or acyclic and with update times up to 10ms and is particularly suitable for data transmission between controllers. At the core of PROFINET I DEVICE is Industrial Ethernet with Real Time Switches with Transmission Speeds of 100Mbps at the Profinet DATA Link Layer and 1Gbps between switches.
PROFINET I DEVICE is an object oriented system where any interface can be connected to any other interface. There is no hard and fast definition of a Client or Server. A device interface can be configured to supply data as a Server or consume data as a Client. Connections are made at system integration time using the connection editor at an object level between device interfaces.

The PROFINET I DEVICE core is designed for Windows that supports files/data under HTML or XML format. PROFINET I DEVICE devices are built by decomposing the functionality of the device into components. Each component is modeled as a set of properties, events and methods. Once these external "interfaces" are designed an eXtensible Meta Language (XML) file is created. The XML file captures the functionality of the device in a text-based, transportable image that can be processed by the PROFINET I DEVICE Connection Editor.

The PROFINET I DEVICE Connection Editor is a device used to do the System Engineering of a network. The Connection Editor provides a graphical tool for choosing the inter-relationships between devices on a PROFINET I DEVICE network. Connections are made between devices at the component layer. An event in one device can trigger a method in another interface. It makes no difference if the method is part of the same interface or a method of a remote device located miles or countries away. Once the inter-relationships are chosen the Connection Editor automatically downloads the connections to each PROFINET I DEVICE device. These connections are stored in non-volatile memory and become the basis of the PROFINET I DEVICE Runtime operation. The connections describe to each device what TCP/IP connections must be made, what Remote Procedure Calls are required and what DCOM interfaces are triggered and when they are triggered.

Active Control Connection Object (ACCO) – The Active Control Connection Object is a software component in the PROFINET I DEVICE Runtime Software core. The ACCO manages cyclic and Change-of-State (COS) data transfer operations. Cyclic data transfer occurs on a timed basis controlled by the ACCO Quality of Service (QoS) method. COS data transfer operations are planned for a future release of PROFINET I DEVICE. ACCOs communicate with ACCOs of other devices to manage data transfer. ACCOs can operate in a local device or in a remote device across a network connection.
PROFINET I DEVICE distinguishes itself from its competitors by the depth of integration in standard Information Technology (IT) functionality. Where its competitors are industrial protocols riding on TCP/IP, PROFINET I DEVICE is all IT with a little of industrial automation.

B1.2 CIP OVER ETHERNETIP

This Project understands that not all vendors support PROFINET or PROFINET I DEVICE, it is therefore proposed that the wider supported protocol CIP OVER ETHERNETIP is an acceptable alternative.
CIP over EthernetIP is an industrial protocol that operates over Ethernet, using the Common Industrial Protocols (ControlNet, DeviceNet). CIP over EthernetIP is an application-layer protocol, and it considers all of the devices on a network to be objects. CIP over EthernetIP is built on the standard TCP/IP stack, making it easy to interface plant floor data from devices such as PLCs and PACs with enterprise servers running Ethernet TCP/IP. This also makes transmitting data over the Internet practical and even makes storage in —cloud computing‖ servers possible. CIP over EthernetIP is designed for those control applications that can accommodate a measure of non-deterministic data transfer, but it is significantly more robust and deterministic than standard Ethernet and TCP/IP are.

a. An CIP over EthernetIP network provides all the benefits of CIP
b. Allows large amounts of information, configuration and I/O data to reside on the same high-speed network
c. Allows the customer to tightly couple the manufacturing operations with the corporate operations
d. Provides a reduction in maintenance cost through the re-use of existing network resources and tools.
e. Allows commercial and industrial technology to exist on the same network.

In addition to the above benefits, an CIP over EthernetIP network provides the added benefits of high-speed data transfers and standard Ethernet network and protocol support, i.e., TCP/IP, HTTP.

Ideal applications for an CIP over EthernetIP network include any application where there is a need to mix industrial and commercial technology on the same network. Also, applications that have very large node counts, applications that need a direct connection to business systems, those that need to be integrated directly to the corporate infrastructure, and applications that need maximum flexibility with respect to performance, topology, and capacity.

At the physical layer Industrial Ethernet (CIP over EthernetIP) supports star, tree and active linear bus. Star topologies are built on generic cabling systems defined for commercial office buildings. This topology is ideal for supporting the many applications necessary for office applications such as telecommunications, data and video over the same cabling infrastructure.
If the vendor choose to use CIP over EthernetIP then all four rings will need to be connected to distribution switches in a star –ring topology for each ring.

B1.3 COMPARISON PROFINET I DEVICE VERSUS CIP OVER ETHERNETIP

	Profinet I Device	**CIP over Ethernet**
Encapsulated Telegram	Profibus over Ethernet	Common Industrial Protocol (CIP)
Supported Topologies	Star Ring Linear	Star Tree Linear/Ring

	Wireless Tree	Wireless Ring
Compatibility	HTML, XML	HTTP,FTP,SNMP,DHCP,DPC
TCP/IP UDP/IP	TCP/IP Special data link	TCP/IP Explicit UDP/Implicit
Supporting interface	DCOM COM	DeviceNet ControlNet OPC
Port Usage	Dynamic	44818 2222 Fixed using OPC tunneller
Speed	10 – 100 Mbps	10,100,1Gbps
Connections	Copper (RJ45) Fiber Optic cable Radio (wireless)	Ethernet cabling any Copper RJ45 M12 or Fiber Optic cable any
Leading Vendors	Siemens GE	Rockwell Automation Cisco Schneider (EIP) Omron Eaton ABB
Standards Body	Profibus Foundation PI	ODVA
Available to Market	Yes	Yes
Security	SCALANCE	IPSEC
Safety	Profisafe	

APPENDIX A8C. HARDWARE SPECIFICTIONS

Section removed please refer to Automation room data sheets

APPENDIX A8D.

1. Surveillance camera calculation
2. Bus cycle time calculation

APPENDIX A8E. PLANTWIDE AUTOMATION DIAGRAMS

The drawings given in Appendix F, for Systems Architecture, PLC Sizing, Network Sizing etc., are for guidance only and depict Kahramaa's preference for solutions based on the P&IDs and Engineering Drawings.

The Contractor is to provide Engineering, Supply and Installation based on these drawings.

APPENDIX A9 – PACKAGE A – PRPS1

GROUND INVESTIGATION FACTUAL REPORT

GEOPHYSICAL REPORT

DOWN HOLE SURVEY

HYDER CONSULTING MIDDLE EAST LIMITED
CONSULTANCY SERVICES FOR WATER SECURITY
MEGA RESERVOIRS

PRPS-01 UMM BIRKA, STATE OF QATAR

REPORT ON GEOTECHNICAL SITE INVESTIGATION

REF: GD/2183/SI/PRPS-01 **NOVEMBER, 2013**

0	23-11-2013	Draft Factual Report	VCS	ARA	AJS
REV	**DATE**	**DETAILS**	**PREPARED**	**CHECKED**	**APPROVED**
			COPY NO.		
			CONTROLLED COPY	**YES☐**	**NO☐**

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APPENDICES

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LIST OF FIGURES

ABBREVIATIONS

ASTM	American Standard for Testing Materials
BS	British Standard
ISRM	International Society for Rock Mechanics
USEPA	US Environmental Protection Agency
SMWW	Standard Methods for the examination of Water and Wastewater
bgl	Below Ground Level
m	Meter
mm	Millimeter
mg/L	Milligram per Litre
MPa	Mega Pascal
MN	Mega Newton
kN	Kilo Newton
mins	Minutes
sec	Second
dia	Diameter
BH	Borehole
TP	Trial Pit
ID/OD	Inner Diameter/Outer Diameter
QNHD	Qatar National Height Datum
QNG	Qatar National Grid
SPT	Standard Penetration Test
RQD	Rock Quality Designation
TCR	Total Core Recovery
SCR	Solid Core Recovery
UCS	Uniaxial Compressive Strength

1.0 INTRODUCTION

Further to instructions received in a letter of award (reference MQ000174.LAR.asc.0540/12) dated 2nd April 2012 from Dr. Luay Al Rifai, Geotechnical Manager for Hyder Consulting Middle East Ltd, Gulf Laboratories Co. have conducted a geotechnical ground investigation for the proposed Water Security-Mega Reservoirs, State of Qatar. This report documents the investigations carried out at Umm Birka (PRPS-01).

The purpose of the investigation was to obtain factual information in the form of borehole and trial pit logs, results of laboratory and field testing, to evaluate the properties of the existing ground conditions of the proposed location.

This report presents the factual field and laboratory data obtained during the investigation.

The report is based upon the assessment of our geological records, the ground conditions encountered during the site work and on results of tests performed in the field and laboratory. There may, however, be ground conditions pertaining to the site which have not been disclosed by this investigation, and which therefore could not be taken into consideration. In particular, it should be noted that groundwater levels vary due to tidal or other effects such as dewatering operations and may at times be significantly different to those reported.

2.0 SITE DESCRIPTION

The site is located in the Umm Birka area, approximately 85 kilometres north of Central Doha and falls on northern side of the Salwa road. (Fig. 2-1).

The project site area was previously used for quarry works. Part of the area was subsequently backfilled. Generally a thin layer of loose sandy material is observed at ground level on the top of the excavated bedrock, deposited due to the transportation of the excavated quarry material.

Access to the proposed site was through undeveloped roads.

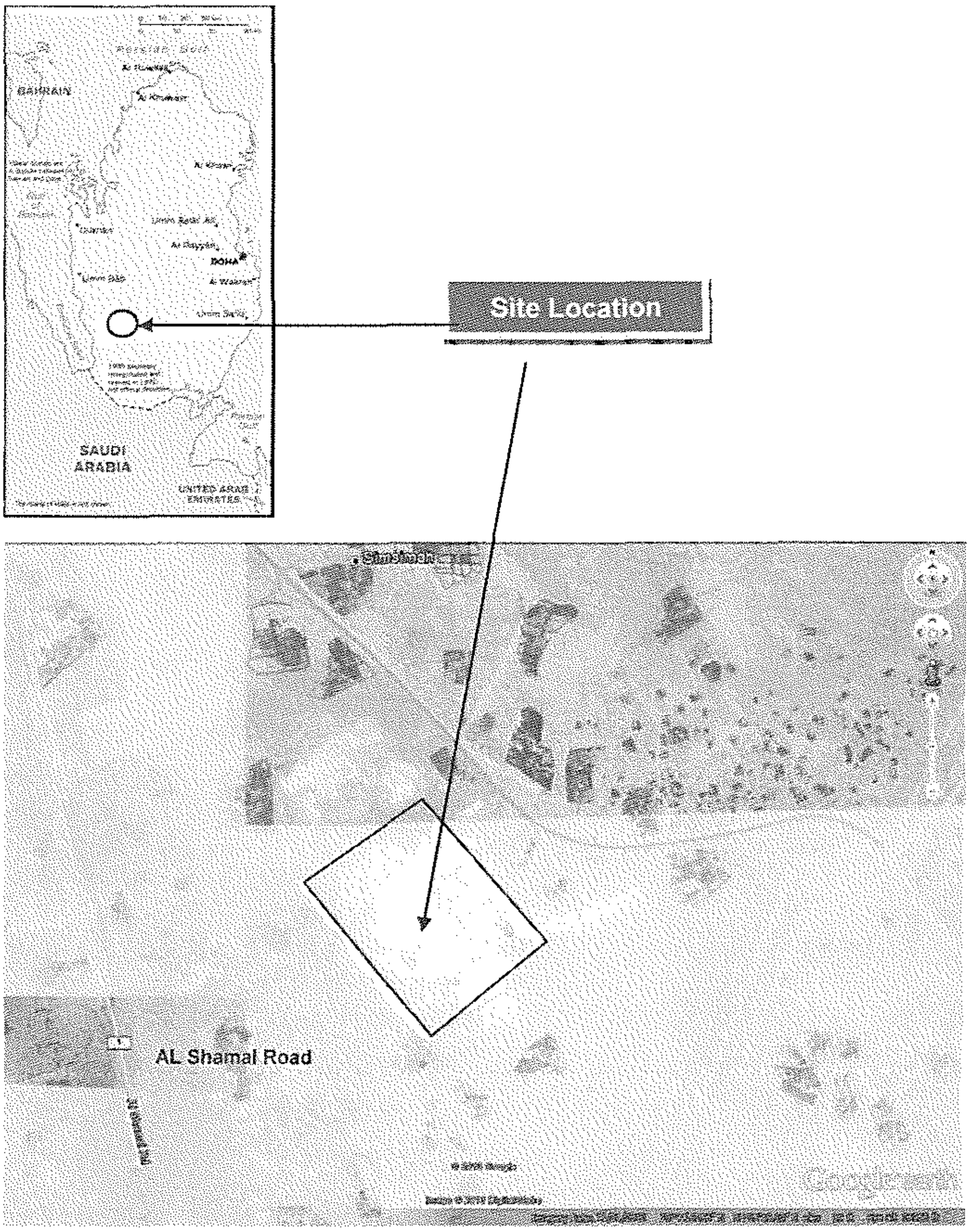

Figure 2-1 Google Earth image of the site

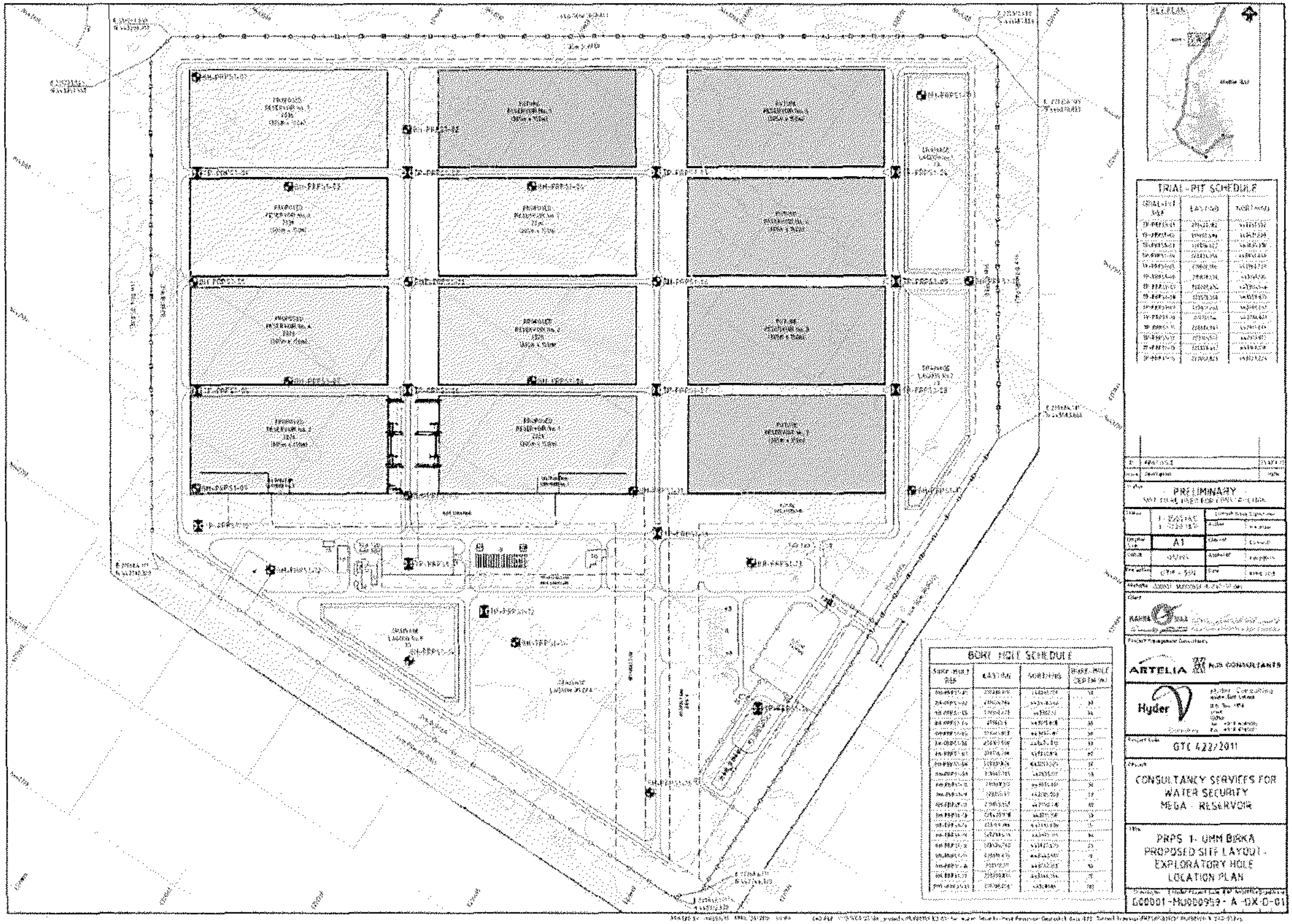

Figure 2-2 Exploratory Location Plan

3.0 GEOLOGY

3.1 Regional Geology

The Qatar peninsula is geologically part of the Arabian Gulf Basin, which has accumulated sediments, with little interruption and has been influenced in only a minor way by tectonic activity, since the Palaeozoic Period. The thickness of sediments overlying basement rocks in Qatar is estimated to be over 10 km. The recent post Cretaceous geological succession of Qatar can be summarized as a rhythmical sequence of shallow water marine limestones along with occasional shales and evaporites. The latter two represent accumulations of material from nearby landmasses and precipitation of anhydrite and gypsum in still, shallow basins respectively. Occasional interruptions to sedimentation have occurred producing minor unconformities.

The formations exposed in the present day Qatar peninsula are all of Tertiary to Quaternary age. The main lithological units which occur at shallow depth in northern, eastern and central Qatar are summarized in Table 3-1.

The geological structure of Qatar can be summarised as comprising a central arch or dome, the axis of which runs south to north through the centre of the country from Shahaniyah to Al Majidah. The dome then flattens only to re-emerge offshore to form the North Dome, which has gained such importance as a trap for a considerable volume of natural gas. The uplift has probably been triggered both by migration of deep-seated salt deposits along with the tectonic movement associated with mountain building elsewhere in the Gulf margins-Zagros (Iran) and the Omani Mountains. In the Central Dome area, uplift and erosion have resulted in the exposure of the oldest rocks occurring in Qatar, belonging to the Rus Formation.

The rocks which make up the Rus Formation in Qatar are generally rather soft, whitish or yellowish chalky dolomitic limestones. Thin beds of greenish to brownish attapulgitic clay are occasionally intercalated. In addition there are several narrow beds of whitish to greyish compact fossiliferous dolomitic limestone, the uppermost of which forms the top of the Rus Formation and is particularly well developed at Al Khor, where it has been used in the past for construction purposes.

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beds of whitish to greyish compact fossiliferous dolomitic limestone, the uppermost of which forms the top of the Rus Formation and is particularly well developed at Al Khor, where it has been used in the past for construction purposes.

A particular feature of the Rus Formation is the occurrence of numerous and extensive beds of evaporites, mainly gypsum and anhydrite. The gypsum beds, which individually can be up to 4m thick, are present beneath ground level throughout southern Qatar and extend northwards to a belt between the Dukhan Anticline, the central arch and south of Al Khor. North of this belt, evaporites are absent from the Rus Formation. This absence is probably result of the arch activity, rising during the Lower Eocene, and thus preventing deposition of evaporites rather than their deposition and subsequent dissolution.

Where present however, the upper beds of gypsum have subsequently been extensively dissolved by circulating ground-waters causing the overlying strata to slump in place giving rise to the many surface collapse structures common in southern and central Qatar.

Over the southern half of Qatar the Rus Formation is overlain by the Lower Dammam sub formation, which comprises the attapulgitic shales of the Midra Shale and Dukhan Alveolina Limestone. The Simsima Limestone is known to be up to 30m thick, the thickest development being in the extreme north of the peninsula, particularly away from the central arch. It is believed that a restricted thickness of Simsima Limestone has been deposited over both the Central and Simsima Arches. Although the Simsima Limestone forms much of the land surface, its detailed stratigraphy and lithology are not well known, since exposures giving a complete cross-section do not exist.

A general description of the Simsima however, as described by Cavalier (1970) and others is fine to medium grained off-white to pale brown and buff, poorly bedded, chalky crystalline calcareous limestone and dolomitic limestone with numerous vugs and irregular joints often filled with weaker siltstone. Thin layers of pale green or red brown attapulgitic clays are occasionally present. Chert bands occur throughout the Simsima but are particularly notable near to the base and at the top.

Table 3-1 Main Lithological Units of Qatar

<table>
<tr><th colspan="2">AGE</th><th>FORMATION</th><th>MEMBER</th><th>APPROXIMATE THICKNESS (M)</th><th>LITHOLOGY</th></tr>
<tr><td colspan="6">QUARTERNARY</td></tr>
<tr><td colspan="2">Holocene</td><td></td><td></td><td></td><td>Mobile sands, bioclastic beach sands, soil.</td></tr>
<tr><td colspan="2">Pleistocene</td><td></td><td></td><td></td><td>Fixed dune sands, sabkha deposits, depression soils, cemented beach rocks.</td></tr>
<tr><td colspan="2">Lower Miocene</td><td>Lower Dam</td><td>--</td><td>0 to 30m</td><td>Fossiliferous marls, clays and thin limestones - outliers only. Occasional green and red clay bands in S.W.</td></tr>
<tr><td colspan="6">TERTIARY</td></tr>
<tr><td rowspan="8">Paleogene</td><td rowspan="5">Middle Eocene</td><td rowspan="2">Upper Dammam</td><td>Abarug Limestone
Abarug Marl</td><td>eroded
eroded</td><td>Grey brown, hard dolomitic limestone.
White to yellow, soft clayey chalky dolomitic Marl</td></tr>
<tr><td>Simsima Limestone and dolomite</td><td>30m</td><td>Buff to pale brown chalky crystalline limestone with siltstone inclusions, variably dolomitic.</td></tr>
<tr><td rowspan="3">Lower Dammam</td><td>Alveolina Limestone</td><td>0 - 1m</td><td>White compact fossiliferous chalky limestone.</td></tr>
<tr><td>Midra Shale</td><td>0 - 10m</td><td>Yellow brown, laminated occasional fissile shale, fossiliferous with limonite and phosphate nodules.</td></tr>
<tr><td>Fahahil Velates Limestone</td><td>0 - 1m</td><td>White, crystalline compact fossiliferous limestone.</td></tr>
<tr><td rowspan="3">Lower Eocene</td><td rowspan="3">Rus</td><td>Khor Limestone</td><td>1m</td><td>Buff to grey brown, massive pitted-vesicular dolomitic limestone.</td></tr>
<tr><td>Carbonate facies</td><td>Up to 20m</td><td>Cyclic deposition of weak carbonate marls siltstones and thin limestones and chalk.</td></tr>
<tr><td>Sulphate facies</td><td>Up to 100m</td><td>Thick deposits of anhydrite and gypsum with marl and thin limestones.</td></tr>
<tr><td colspan="2">Paleocene</td><td colspan="2">Umm er Rhaduma</td><td>>275 ?</td><td>Dolomites/dolomitic limestone of various hardness, often fractured, with bands of chert, and marl and clay intercalations.</td></tr>
</table>

3.2 Local Geological Conditions

Local geological records and archival research indicate that within the Umm Birka area, a thin layer of unconsolidated overburden is underlain by a 15m to 19m thickness of Simsima Limestone which in turn overlie shales of the Midra Shale unit and clays and limestones of the Lower Dammam Formation (Rus Formation). The Rus Formation is underlain by Umm er Radhuma Formation, the upper contact is of which marked by an abrupt lithological change from the near white chalky limestone of the Rus Formation to the brown, vesicular, dolomitic limestone of the Umm er Radhuma.

References used for archival research are given in Appendix E.

3.3 Seismic Characteristics

Seismic activity within the area is low. Recommendations given in BRE Digest (H16) "Earthquake and Seismic Zones in the Middle East", 1983, indicate Qatar to lie within a zone of no influence. Abu Dhabi and Kuwait however, lie within zone B: minor events, equivalent to an earthquake of V to VI (UBC Zone 1).

References used for archival research are given in Appendix E.

4.0 SITE WORKS

The geotechnical fieldwork at the site commenced on the 22nd September 2013 and was completed on 5th November 2013. All investigation works were carried out in accordance with BS 5930: 1999+A2:2010 and the project specifications.

4.1 Extent of Works

The geotechnical fieldwork activities performed were summarised below:

- Drilling of two (2) geotechnical boreholes to depths of 10metres below existing ground level.
- Drilling of one (1) geotechnical borehole to depth of 15meters below existing ground level
- Drilling of one (1) geotechnical borehole to depth of 25meters below existing ground level
- Drilling of eleven (11) geotechnical boreholes to depths of 30metres below existing ground level.
- Drilling of four (4) geotechnical boreholes to depths of 50metres below existing ground level.
- Drilling of one (1) pressuremeter testing borehole to depth of 100metres below existing ground level.
- Excavation of fourteen (14) trial pits to a minimum depth of 3 metres below ground level or to bedrock whichever was shallower.
- Performing standard penetration tests in boreholes.
- Soil and rock core sampling.
- Perform packer permeability testing in four (4) boreholes.
- Installation of standpipe piezometers in four (4) boreholes.
- Performing four (4) Electrical Resistivity tests.
- Performing Pressuremeter tests in Pressuremeter borehole at every 3.0metres depth in rock stratum.
- Environmental soil sampling from three (3) boreholes.
- Laboratory testing of recovered soil and rock core samples.
- Preparation and submission of factual geotechnical report on the findings of the investigation.

All field works were carried out under the fulltime supervision of a qualified engineering geologist.

4.2 Setting-Out

Exploratory locations were set out by MTC Surveys in accordance with coordinates provided by Hyder Consulting. Coordinates are based on Qatar National Grid (QNG) and elevations are referenced to Qatar National Height Datum (QNHD).

Details of the coordinates and elevations of all the exploratory locations are summarised in Table 4-1.

Table 4-1 Coordinates and Termination Depth of Boreholes and Trial Pits

BH/TP No	Easting (m)	Northing (m)	Ground Level (m QNHD)	Termination Depth (m bgl)
BH-PRPS01-01	219336.179	443366.179	9.199	50.00
BH-PRPS01-02	219654.984	443478.542	12.756	30.00
BH-PRPS01-03	219550.273	443302.170	11.151	30.05
BH-PRPS01-04	219865.300	443510.878	13.858	30.10
BH-PRPS01-05	219507.853	443097.581	9.807	30.00
BH-PRPS01-06	220107.599	443494.912	26.738	30.10
BH-PRPS01-07	219716.798	443050.816	11.768	30.00
BH-PRPS01-08	220031.824	443259.525	13.130	30.00
BH-PRPS01-09	219687.705	442833.117	10.123	50.00
BH-PRPS01-10	219968.511	443005.301	6.155	30.00
BH-PRPS01-11	220255.970	443205.003	13.690	50.00
BH-PRPS01-12	219853.952	442790.718	4.026	30.00
BH-PRPS01-13	220470.978	443211.158	15.110	50.00
BH-PRPS01-14	220109.984	442792.036	4.687	15.10
BH-PRPS01-15	220233.476	442907.117	11.317	30.00
BH-PRPS01-16	220534.762	442827.475	11.184	25.00
BH-PRPS01-17	220616.675	443443.917	13.711	10.10
BH-PRPS01-18	220512.111	443762.913	19.528	30.12
BH-PRPS01-19	220290.891	443964.194	20.866	10.10
PMT-PRPS01-01	219786.056	443281.890	12.949	100.00
TP-PRPS01-01	219420.182	443241.502	8.889	0.20
TP-PRPS01-02	219692.494	443421.908	12.247	0.65
TP-PRPS01-03	220014.622	443635.318	16.729	0.70
TP-PRPS01-04	220324.556	443840.649	20.253	0.50
TP-PRPS01-05	219606.194	442960.729	11.400	0.30
TP-PRPS01-06	219878.506	443141.135	11.087	0.20
TP-PRPS01-07	220200.634	443354.544	14.782	0.60
TP-PRPS01-08	220510.568	443559.875	18.143	0.20
TP-PRPS01-09	220417.562	443700.262	19.250	0.95
TP-PRPS01-10	219721.940	442786.021	3.676	0.90
TP-PRPS01-11	220026.987	442917.009	6.658	2.00
TP-PRPS01-12	220165.517	442919.817	5.872	0.50

BH/TP No	Easting (m)	Northing (m)	Ground Level (m QNHD)	Termination Depth (m bgl)
TP-PRPS01-13	220323.467	443169.218	14.967	1.25
TP-PRPS01-14	220602.829	443029.224	12.500	1.00

Geotechnical Boreholes

Prior to commencement of drilling, all exploratory borehole locations were scanned with Cable Avoidance Tool (CAT). Utility / service inspection pits were further hand excavated to rock head level or 1.20m whichever shallower. If rock head was encountered above 1.20m, then the boreholes were progressed by rotary coring methods through rock stratum. Else, from the base of the inspection pit the boreholes were progressed by cable percussion methods using 150 mm diameter casing through unconsolidated overburden to the bedrock and there after rotary coring methods were utilised through rock. Coring was achieved in all boreholes by utilising double tube PQ core barrels yielding cores of 82-83mm diameter. Water was used as flushing medium. Core runs were generally 1.50m long, although runs were frequently shortened in order to maximise core recovery.

Due to the limited thickness of the unconsolidated overburden, and the requirement for hand excavation to check for underground services, standard penetration tests were not performed within the unconsolidated overburden materials except in BH06. However, standard penetration tests using a solid cone (denoted as SPT(c)) were carried out at rock head levels and split spoon sampler within zones of low core recovery during drilling in accordance with BS 1377:1990. SPT test records and corresponding N values are shown in the borehole logs presented in Appendix A2.

Disturbed samples were recovered from the depths shown on the borehole logs and a water sample was recovered from the boreholes in which groundwater was encountered. Following recovery of core samples, cores were placed in purpose-built wooden core boxes. After completion of geotechnical logging on site, all samples and core boxes were subsequently transported to Gulf Laboratories' Doha facilities for photographing and laboratory testing. The cores were photographed prior to sub sampling to preserve a permanent record.

Environmental soil and water samples were collected from boreholes BH-PRPS 01-08, BH-PRPS 01-16 and BH-PRPS 01-18. The collected samples were labelled detailing sample number, date & time of collection and borehole number, kept in ice filled cool boxes and transported to Doha laboratory for testing.

Borehole logs were prepared on the basis of recovered samples, according to BS 5930:1999+A2:2010.

Borehole logs and core photographs are presented in Appendix A2 and D1 respectively.

4.3 Trial Pits

Fourteen (14) trial pits were excavated using JCB 3CX excavator to the top of competent bedrock which was encountered at depths ranging between 0.20m to 2.00m below existing ground level as indicated in the trial pit logs. The trial pits were logged and described on site and all excavated materials were placed back into the pit after logging was completed. Photographs of the trial pits were taken prior to backfilling. Bulk samples were collected from each soil horizon encountered. Soil samples were obtained at the depths indicated on the trial pit logs. All collected samples were transported to Gulf Laboratories' Doha facilities for laboratory testing. Groundwater was not encountered in any of the pits during excavation.

Soil descriptions were prepared according to BS 5930:1999+A2:2010. Trial pit logs are presented in Appendix A3 and trial pit photographs are presented in Appendix D2.

4.4 In-situ Testing

4.4.1 Packer Permeability Testing (Lugeon Test)

A total of four (4) packer or Lugeon tests were performed in r selected boreholes (BH-PRPS 01-01, BH-PRPS 01-04, BH-PRPS 01-06 and BH-PRPS 01-10). The tests were performed in accordance with BS 5930:1999+A2:2010.

One metre long test sections were isolated using a double expandable packer. A water supply line from the packer was connected via a flow meter / pressure gauge group to the water supply pump. A water supply line from the water tanker provided water supply for the test. Water was pumped into the test zone at 3 incremental increasing pressure stages followed by 2 decreasing stages. Each pressure stage was maintained for 15 minutes and water flow into the test sections recorded.

The results of the tests are usually expressed in terms of "Lugeon" units. Permeability of 1 Lugeon is defined as a one metre length of borehole accepting 1 litre of water per minute, under a head of hydraulic pressure equivalent to 10m. BS 5930:1999+A2:2010 states that the Lugeon unit is sometimes simplistically converted to typical permeability units (m/s) by multiplying by 10^{-7}. The permeability was also calculated without conversion from Lugeon units.

The results of the packer testing are presented in Appendix B1.

4.4.2 Soakway Test

Soakaway tests were performed in three Trail pits (TP-PRPS 01-01, TP-PRPS 01-04 and TP-PRPS 01-10).

The test was performed and analysed as per the guidelines of BRE Digest 365. The results are presented in Appendix B2

4.4.3 Pressuremeter Testing

Pressuremeter tests were scheduled in PMT-PRPS 01-01 to a depth of 100 metres, each test performed between every three meters. Twenty One pressure meter test were performed using an OYO Elastmeter 2. The internal displacement calliper and the rubber membrane were calibrated appropriate intervals. The results of Pressure meter testing are presented in Appendix B3.

4.4.4 In-situ CBR

In-situ CBR tests were carried out in two (2) trial pits (TP-PRPS 1-04, TP-PRPS 01-16) at depths ranging from 0.20mbgl to 0.30mbgl.

The tests were conducted in accordance with BS 1377: Part 9: 1990. A mechanical jack having the capacity of 45 kN was used to apply the force. Vertical force was applied to the cylindrical plunger which penetrated the soil at a given rate; the force applied was measured by a calibrated proving ring.

In-situ CBR test results are presented appendix B4.

4.4.5 Electrical Resistivity Tests

Electrical Resistivity tests were performed at four (4) locations. The tests were conducted in accordance with BS 1377: Part 9: 1990 using the Wenner 4 Pin electrode array with inter-electrode spacing's of 1.0, 2.0, 4.0 & 8.0m.

Results of the electrical resistivity tests are presented in Appendix B5.

4.5 Standpipe Piezometers

Standpipe piezometers were installed in four boreholes BH-PRPS 01-05, BH-PRPS 01-08, BH-PRPS 01-16 and BH-PRPS 01-18, to allow subsequent monitoring of the groundwater.

Following completion of drilling, the boreholes were backfilled as necessary to the required installation depth followed by a bentonite seal. The piezometer installation, comprising a 50mm diameter PVC casing with machine cut perforations at the requested filter zone, covered with geotextile was lowered centrally into the boreholes and the annulus around the specified response zone was backfilled with 3 - 5mm pea gravel. The annulus above the gravel filter was then sealed by a bentonite layer, followed by bentonite-cement grout to a depth of 0.50m below ground level.

The upper portion of the piezometers extended approximately 500mm above the surrounding ground level and were protected with a 150mm diameter protective iron casing. The annulus above ground level was filled with concrete. The top of the iron casing was then fitted with a lockable protective cap. No groundwater was observed in the piezometers.

The piezometer installation details are presented in Appendix A4.

5.0 LABORATORY TESTING

Laboratory tests were performed on soil/rock and water including environmental soil/water samples obtained during the investigation. A summary of included laboratory tests, together with standards used is detailed in Table 5-1.

Table 5-1 Summary of Laboratory Test Performed

Type of Test	Test Specifications	Quantity
Particle Size Distribution	BS 1377: Part 2: 1990, Test 9.2-Wet Sieving	9
Atterberg Limits	BS 1377: Part 2: 1990, Test 4 & 5	4
Water Soluble Sulphate, Chloride of Soil/Rock	BS 1377 Part 3:1990, Test 5.3 and Test 7.2	39
pH Value of Soil/Rock	BS 1377 Part 3 :1990, Test 9.5	39
Carbonate Content of Soil/Rock	BS 1377 Part 3 :1990, Test 6.3	39
Acid Soluble Sulphate, Chloride of Soil/Rock	BS 1377 Part 3:1990, Test 5.2 and Test 7.3	7
Aggregate Crushing Value	BS 812 Part 110 : 1990	9
Maximum Dry Density	BS 1377 Part 4:1990, Test 3.4	7
California Bearing Ratio	BS:1377 Part:4: 1990 & CML 10-97	7
Point Load Index	ISRM 1974-(2006)	92
Uniaxial Compressive Strength	ASTM D7012-10 Method C	66
Uniaxial Compressive Strength with Elastic Modulus	ASTM D7012-10	5
Environmental Soil Samples		
Chemical Analysis	SMWW – 21st Edition 2005/BS	3
Heavy Metals	USEPA 3005A/6010 C	3
Total Petroleum Hydrocarbons	USEPA 8015 C – Rev.3 - 2007	3
BTEX	USEPA 5030 B /8260 C	3
Pesticides	USEPA 3550 C/8081B/GCMS	3
Moisture Content	BS 1377 Part: 2: 1990-Test 3	3
Environmental Water Samples		
Chemical Analysis	SMWW – 21st Edition 2005	3
Heavy Metals	USEPA 3005A/6010 C	3
Total Petroleum Hydrocarbons	USEPA 8015 C – Rev.3 - 2007	3
BTEX	USEPA 5030 B /8260 C	3
Pesticides	USEPA 3510 C/8270/8081/GCMS	3

The results of all laboratory tests are presented in Appendix C.

6.0 GROUND CONDITIONS

The exploratory boreholes generally confirm the geology as anticipated and detailed in Section 3.0.

The site comprises a layer of 0.08m to 9.08m thick deposit of unconsolidated overburden overlying the bedrock. The main lithological units encountered at the site summarised as following:

1. Unconsolidated Overburden
   - Madeground
2. Solid Strata
   - Simsima Limestone Member
   - Rus Formation
   - Umm Er Radhuma Formation

General description of each stratum is described in the subsequent sub headings below.

6.1 Unconsolidated Overburden

6.1.1 Made Ground

Generally a thin layer of loose sandy material is observed at ground level on the top of the excavated bedrock, deposited due to the transportation of the excavated quarry material. This material was encountered in all boreholes and trail pits except TP-PRPS 1-02, TP-PRPS 1-04, TP-PRPS 1-05 and TP-PRPS 1-07 with thickness ranging from 0.08 m to 9.08 m.

Table 6-1 details the top and bottom depths of made ground encountered in each borehole and trial pit.

Table 6-1 Top and Bottom Elevations and thickness –Made Ground

BH/TP No	Top Elevation Ground Level (m QNHD)	Bottom Elevation (m QNHD)	Thickness (m)
BH-PRPS 1-01	9.20	8.83	0.37
BH-PRPS 1-02	11.15	10.71	0.44
BH-PRPS 1-03	12.75	12.22	0.53
BH-PRPS 1-04	13.86	13.42	0.44
BH-PRPS 1-05	9.81	9.68	0.13
BH-PRPS 1-06	26.74	17.66	9.08
BH-PRPS 1-07	11.77	10.92	0.85

BH-PRPS 1-08	13.13	12.60	0.53
BH-PRPS 1-09	10.12	9.34	0.78
BH-PRPS 1-10	6.16	5.21	0.95
BH-PRPS 1-11	13.69	12.79	0.90
BH-PRPS 1-12	4.03	3.71	0.32
BH PRPS 1-13	15.11	14.74	0.37
BH PRPS 1-14	4.69	3.80	0.89
BH PRPS 1-15	11.32	11.00	0.32
BH PRPS 1-16	11.18	10.18	1.00
BH-PRPS 1-17	13.71	13.42	0.29
BH-PRPS 1-18	19.53	18.79	0.74
BH-PRPS 1-19	20.87	20.51	0.36
PMT-PRPS 1-01	12.95	12.87	0.08
TP-PRPS 1-01	8.89	8.69	0.20
TP-PRPS 1-03	16.73	16.03	0.70
TP-PRPS 1-06	11.09	10.89	0.20
TP-PRPS 1-08	18.14	17.94	0.20
TP-PRPS 1-09	19.25	18.30	0.95
TP-PRPS 1-10	3.68	2.78	0.90
TP-PRPS 1-11	6.66	5.96	0.70
TP-PRPS 1-12	5.87	5.37	0.50
TP-PRPS 1-13	14.97	14.27	0.70
TP-PRPS 1-14	12.50	11.50	1.00

The encountered material generally comprises light brown silty sandy fine to medium Gravel with some cobbles.

6.2 Solid Strata

6.2.1 Simsima Limestone Member

The Simsima Limestone Member was encountered underlying the unconsolidated overburden in few exploratory locations.

Table 6-2 details the top and bottom depth of Simsima Limestone Member encountered in each borehole.

Table 6-2 Top and Bottom Elevations and thickness –Made Ground

BH/TP No	Top Depth-Existing Ground Level (m QNHD)	Bottom Depth (m QNHD)	Thickness (m)
BH-PRPS 1-06	17.66	13.89	3.77
PMT-PRPS 1-01	12.87	7.85	5.02

TP-PRPS 1-02	12.25	Not Established
TP-PRPS 1-04	20.25	Not Established
TP-PRPS 1-05	11.40	Not Established
TP-PRPS 1-07	14.78	Not Established

The Simsima Limestone Member encountered at the site can generally be described as weak to medium strong and occasionally strong, light brown to greyish brown, light grey to light brownish grey, and off-white to pinkish brown, partially to distinctly weathered, fractured, fine grained crystalline dolomitic limestone. It is also frequently intermixed, or contains pockets of very weak off-white, light greenish grey and reddish/pinkish brown diagenetically derived siltstone. During drilling, the upper layers of limestone was more fractured, generally recovered as angular to sub angular gravel. The basal part of the Simsima Limestone Member generally tends to be more competent in-situ i.e. less broken and less brittle. The Simsima Limestone Member also occasionally contains solution vugs, which are often lined with silty material and occasionally with calcite crystals. Occasional veins and nodules of gypsum were also observed.

Core recovery of the Simsima Limestone member ranges from 95% to 100% (average = 97.6%). Solid core recovery ranges from 0 to 100% (average = 52%). Rock quality designation ranges from 0 to 85% (average = 33%).

6.2.2 Rus Formation

Rus Formation was generally encountered below made ground in most of the exploratory locations. In few locations where Simsima Limestone was encountered, the stratum was encountered beneath Simsima limestone formation.

Table 6-3 details the top and bottom depth of Rus Formation encountered in each borehole.

Table 6-3 Top and Bottom Elevations – Rus Formation

BH/TP	BH/TP No	Top Elevation (m QNHD)	Bottom Elevation (m QNHD)	Thickness (m)
Borehole	BH-PRPS 1-01	9.20	Not established	-
	BH-PRPS 1-02	11.15	Not established	-
	BH-PRPS 1-03	12.75	Not established	-
	BH-PRPS 1-04	13.86	Not established	-
	BH-PRPS 1-05	9.81	Not established	-
	BH-PRPS 1-06	13.89	Not established	-
	BH-PRPS 1-07	11.77	Not established	-

	BH-PRPS 1-08	13.13	Not established	-
	BH-PRPS 1-09	10.12	Not established	-
	BH-PRPS 1-10	6.16	Not established	-
	BH-PRPS 1-11	12.79	Not established	-
	BH-PRPS 1-12	4.03	Not established	-
	BH-PRPS 1-13	15.11	Not established	-
	BH-PRPS 1-14	4.69	Not established	-
	BH-PRPS 1-15	11.32	Not established	
	BH-PRPS 1-16	11.18	Not established	-
	BH-PRPS 1-17	13.42	Not established	-
	BH-PRPS 1-18	18.79	Not established	-
	BH-PRPS 1-19	20.15	Not established	-
	PMT-PRPS 1-01	10.85	-56.55	45.70

The majority of the Rus Formation a layer of weak occasionally pitted limestone underlain by very weak to weak off-white and light brownish grey to grey, partially weathered chalky limestone interbedded with extremely weak to very weak light greenish grey to yellowish brown siltstone/calystone bands. Occasional marl bands were also encountered. The Rus Formation also occasionally contains solution vugs, which are often lined with silty material. Occasional veins and nodules of gypsum and chert were observed.

Total Core Recovery (TCR) ranges from 0% to 100% (average = 71%). Solid Core Recovery (SCR) ranges from 0% to 100% (average = 43%). Rock Quality Designation (RQD) ranges from 0% and 96% (average = 22%).

6.2.3 Umm Er Radhuma

The pressuremeter borehole PMT-PRPS 1-01 was extended below the base of the Rus Formation, into the upper horizons of the Umm Er Rhaduma. The Umm Er Rhaduma Formation was encountered at an elevation of -56.55m QNHD and extends to final drilled depth.

The Umm Er Radhuma Formation is typically weak, light brown fine grained crystalline limestone interbedded with bands and pockets of very weak light brown siltstone. Frequent inclusions of chert bands are also observed.

6.3 <u>Groundwater</u>

Groundwater was encountered in all boreholes except BH-PRPS 1-17 during the drilling. It should be noted that groundwater levels are prone to fluctuations due to seasonal, tidal variations or localized pumping in the area.

Groundwater levels were recorded at the start and end of each shift and are indicated on the borehole logs. The highest recorded water level during drilling is generally varies between 11.81m QNHD and -0.25m QNHD. It is our opinion that, due the low permeability of the chalky limestone formation, the groundwater levels were not stabilized during drilling, hence could be recorded at much higher elevation / depth than the natural level. To establish the groundwater levels, groundwater levels were monitored in all four piezometer between 8th October and 28th October 2013 and the data is presented in Appendix B6. The recorded water level within the piezometers during the monitoring period is varies between 1.29m QNHD and -0.01m QNHD.

During drilling, groundwater samples were also collected from each borehole. Environmental groundwater samples were scheduled for chemical analyses and the results obtained are presented in Appendix C.

ANDREW J. SLATE B.Sc. (Hons), Eur. Geol., C. Geol., FGS

General Manager

APPENDIX A-10

GENERAL SPECIFICATION OF MAIN LAYING MATERIALS FOR WATERMAINS 2005

المؤسسة العامة القطرية للكهرباء والماء
Qatar General Electricity & Water Corporation

General Specification of Main laying Materials For Waterworks

<u>Prepared by:</u>

Material Standards Section
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P.O.BOX: 41 Doha, Qatar

July – 2005

Contents

Section - 1 General

1.1 SUITABILITY OF MATERIALS

1.1.1 All materials to be used with potable water must conform to any current regulations in force of this purpose.

1.1.2 All pipe-laying materials shall be suitable for use with the range of chemical characteristics of the water and complies with W.H.O. guidelines as detailed in Appendix 'A'.

1.1.3 All materials shall be suitable for using and storing in the environmental conditions detailed in Appendix 'B' and normal working water temperature at 50° C.

1.1.4 The Tenderer shall supply materials from KAHRAMAA approved manufacturers and furnish to the Engineer for approval, model type, and signed certificate from the proposed manufacturer confirming the compliance of his materials with clauses 1.1.1. and 1.1.2. and indicating particular conditions, if necessary for compliance.

1.1.5 All the relevant Technical documents of the materials must be Original such as Technical Catalogue or notarized such as certificates and shall be submitted from the Manufacturer for Technical Evaluation.

1.1.6 All materials shall be inspected and tested in full to prove compliance with the requirements of these specifications to satisfaction of KAHRAMAA .The testing shall be carried out according to relevant standards approved by KAHRAMAA.

1.1.7 All materials shall be suitable for the prevailing climatic conditions. All materials and accessories shall not be subject to excessive inherent heating.

1.2 TRANSPORT & STORAGE OF MATERIALS

1.2.1 All materials to be stored strictly in accordance with the KAHRAMAA requirements/Manufacturer storage recommendation.

1.2.2 Upon delivery to the Contractor's stores or site ,the contractor should unpack at all times, open all crates etc., and unload to areas as directed by the Store controller or the concern Engineer. The contractor shall provide all timbers and packing, necessary for the correct stacking of pipes, fittings and etc.

1.2.3 After inspection the contractor shall shift and stack the approved materials to areas as directed by store controller. The contractor will provide all timbers and packing, necessary for correct stacking of pipes, fittings and all other materials.

1.2.4 The rejected materials which inspected and marked by the Engineer, must be removed from the Contractor store or site in accordance with contract specification.

1.2.5 During transport special care shall be taken not to be damage the painting of the materials. Materials shall be cleaned from any foreign matter deposited during transport.

1.3 MANUFACTURER 'S CERTIFICATION

1.3.1 The Applicant must have a valid ISO Certificate.

1.4 STANDARDS

1.4.1 The Tenderer shall follow the latest KAHRAMAA General Specifications of Main laying Materials for Waterworks.

1.4.2 In case of materials were not mentioned in this document, the Tenderer shall follow the standards such as BS, ISO, EN or DIN with all subsequent amendments up to the year of the materials order and with the approval of the Engineer.

1.4.3 Except as provided in the specification all materials, equipment, fabrication and testing shall conform to the latest applicable standard contained in the following list or other equivalent.

1.4.4 The applicable standards are those published by the following organizations: BS, ISO, EN, DIN and etc. Manufacture shall state clearly the standard specifications they have adopted for such items.

1.5 MATERIAL COATING & INTERNAL COMPONENTS

1.5.1 In case of the materials in direct contact with potable water, the applicant must have for the same a health certificate as per requirement of BS6920 "suitability of Non-Metallic Products for use in contact with Water Intended for Human Consumption with regards to their effect on the quality of Water" issued by a International Worldwide Known Quality Body (see Appendix Clause No.V) .Note: Equivalent tests for the test mentioned to be approved by the Concerned Engineer.

1.5.2 If required, clause No.1.5.1 must be submitted in original or notarized copy in English Version

1.5.3 All materials internal coating or internal components shall be tested and approved by WRC, DVGW, KIWA, NSF61, SIRIM, or other World Worldwide Known Quality Body Certifiers (see Appendix Clause No.V) in contact with potable water at 50 degrees centigrade. as per the requirement of BS6920 " suitability of Non-Metallic Products for use in contact with Water Intended for Human Consumption with regards to their effect on the quality of Water" or equivalent.

1.5.4 All casting shall be properly finished, sand blasted and cleaned before coating.

1.5.5 Coating shall be smooth and mirror finish without any hairline cracks.

1.5.6 **Adhesion Test:** Adhesion of coating to metal shall not be less than 12N/mm2 (DIN/ISO - 4624).

1.5.7 **Holiday Test:** Porosity of coating shall be "zero" on 3 kV DC tester.

1.5.8 **Hardness:** Intrinsic Rockwell hardness shall be between 50 - 60.

1.5.9 **Impact resistance:** For applying of impact energy of 5 NM on coating the cracks should not develop, when tested by 3 kV DC tester.

1.6 FASTENERS

1.6.1 If not specified, fasteners shall be of following type:

- Stainless steel grade 316L (For Valves and Fire Hydrants)
- Mild steel with zinc plated, minimum 30 micron thick coating as per WIS 4-52-03
- Mild steel with hot dipped zinc galvanized, minimum 50 micron thick.

1.7 INSPECTION

1.7.1 All material shall be inspected by KAHRAMAA approved Third Party inspection agency before shipping and cost to be paid by the contractor if required in the Tender.

1.7.2 The third party shall inspect the materials in accordance with the latest KAHRAMAA General Specifications and conduct tests. For any clarification, Third Party agency shall contact the Corporation. The Third Party shall submit the detailed inspection report along with observation data sheets directly to the KAHRAMAA.

1.7.3 The Engineer shall hold the final inspection on arrival of the material in "KAHRAMAA" store or site.

1.7.4 KAHRAMAA reserves the right to reject the supplied material during final inspection or at later date, if found not as per the General Specification and will have the right to put the Manufacturer under " ON HOLD " or " BLACK LISTED " until further action.

1.7.5 KAHRAMAA reserves the right to inspect the materials in the factory.

1.7.6 The contractor's quality control departments shall review all contract and specification requirements and ensure that they are understood. They shall review the manufacturing test and inspection and ensure that they are adequate for the production and inspection of material.

1.7.7 The manufacture shall allow access at all times during manufacture and testing to the premises in which the material being manufactured.

1.7.8 Demonstrate to the satisfaction of KAHRAMAA authorized representative that the materials meet requirements of the contract.

1.8 PACKING

1.8.1 Every item shall be packed individually and put into the wooden box, which shall be close and open type. Every layer in wooden box shall be clamped properly to avoid abrasion during transit and damage to coating or as specified elsewhere in the specification.

1.9TECHNICAL CLARIFICATION

1.9.1 For any technical explanation and clarification, the decision of the Engineer shall be final.

Section - 2
Ductile Iron Pipes and Fittings

2.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

2.1.1 All pipes and fittings shall be manufactured from approved grade of ductile iron.

2.1.2 All manufacture and testing shall be in accordance with the latest edition of BSEN-545/ISO 2531, 4179, 8179 including any subsequent amendments and as specified below.

2.2 JOINTS

2.2.1 Spigot & socket pipes & fittings joints shall be provided with approved integrally cast 'push-in' type joints, each joint being supplied with an approved jointing- ring designed by the manufacturer solely for the purpose of sealing the joint.

2.2.2 All flanged pipes & fittings shall be provided with integrally cast flanges drilled to BS4504, PN16.

2.2.3 All flanged pipes & fittings shall be supplied with approved EPDM Gasket which comply the requirement of BS6920 and shall be kept in a sealed sun proof bag with written information of the same.

2.2.4 The manufacture specification of all-joint details, gaskets and jointing rings shall be supplied to the Engineer by the Tenderer for approval.

2.2.5 All jointing materials shall comply to Clause 1.1.1. of this specification.

2.3 LENGTH OF PIPES

2.3.1 All pipes shall be supplied in the lengths of 5.50/6.00 meters or as per Tender Requirements and upon approval and discretion of the Concerned Engineer.

2.4 MARKING.

2.4.1 All pipes & fittings shall be marked in accordance with the latest edition of BSEN-545/ISO-2531.

2.5 CERTIFICATE OF TEST

2.5.1 If requested by the Concerned Engineer, the Tenderer shall provide signed certificates stating the results of all tests as specified in BSEN 545 / ISO 2531, 4179, 8179 from the manufacturer in order to approve the same.

2.5.2 The Concerned Engineer reserves the right to witness tensile tests on bar test pieces selected on the basis of not more than one test piece for every batch of 100 pipes.

2.5.3 Where specified tests are to be witnessed, the tests shall be in accordance with the manufacturer's normal quality control procedure.

2.6 EXTERNAL & INTERNAL COATING OF DUCTILE IRON PIPES & FITTINGS DURING MANUFACTURING.

2.6.1 All materials used for lining of ductile iron pipes and fittings shall conform with the latest edition of BSEN 545 / ISO 2531, 4179, 8179 and meet all the requirements of BS6920.

2.6.2 All ductile iron pipes and fittings shall be internally lined by centrifugal method with Sulphate Resistance Cement mortar lining as per requirement of the latest edition of BSEN 545 or ISO 4179.

2.6.3 D.I. Pipes and fittings shall be cured in curing chambers.

2.6.4 In case D. I. Fittings have seal coat, health certificate of the same shall meet the requirement of BS6920.

2.6.5 The external coating shall be of metallic Zinc coating of 130 gm/m2 (18.5 microns) on pipes and Zinc rich paint coating of 150 gm/m2 (21 microns) on D.I. Fittings as per the latest edition of BSEN 545 or ISO 8179.

2.6.6 The external finishing layer to all pipes & fittings after the application of the Zinc coating shall be of bitumen coating as per the latest edition of BS3416, Type 2.

2.6.7 The internal cement lining shall be uniformed and smooth as possible and shall be within the tolerance limit acceptable by the International standards.

2.6.8 The thickness of internal cement lining in D.I. Pipes & Fittings shall be as follows in accordance with the latest edition of BSEN 545 as follows:-

THICKNESS OF INTERNAL CEMENT LINING

Nominal Size	Thickness
80-300mmØ	4.0mm
350-600mmØ	5.0mm
700-1200mmØ	6.0mm
1400-1600mmØ	9.0mm

2.6.9 The contractor is to supply confirmation from manufacturer that cement lining to be used is suitable for use with the range of chemical characteristics of water detailed in Appendix "A".

2.6.10 The internal section of sockets of pipes and fittings shall not be cement lined and shall be suitably protected during the lining operation.

2.6.11 The internal section of sockets of pipes and fittings shall be painted with a minimum 100-micron thick epoxy or bitumen coating. The coating shall be suitable for use in contact with potable water at 50° C.

2.6.12 The External finishing layer to all pipes and fittings after the application of the Zinc coating shall be of bitumen coating in accordance to BS 3416, Type 2.

2.6.13 FACTORY APPLIED POLYETHYLENE EXTERNAL COATING

2.6.14 The Tenderer may (with the discretion and approval of the Engineer), supply pipes, which is a factory applied polyethylene external coating, applied by extrusion or any other approved method as per DIN 30 674, Part 1.

2.6.15 The factory applied polyethylene external coating shall have minimum thickness for THICKER DESIGN as per DIN 30 674, Clause 4.2.1., Table 1, and Blue color RAL-5000/5001/5005/5010/5017 or Black color RAL-9005/9011 with suitable marking for identification of water as approved by the Concerned Engineer.

2.6.16 The Tenderer is to supply, with his tender, a detailed specification of any proposed factory applied polyethylene external coating for pipes.

2.7 PROTECTION OF ABOVE GROUND & INSIDE CHAMBERS D.I. PIPES & FITTINGS

2.7.1 External coating of ductile iron pipes & fittings to be laid above ground or inside chambers shall be coated with zinc primer as per ISO 8179, then followed by an application of bituminous finish coating.

2.7.2 The bituminous finish coating shall contain aluminum of not less than 20% in the dry film and shall be in silver.

2.7.3 The bituminous finish coating on the spigot portion up to the socket depth shall be black bitumen coating as per BS 3416 , Type 2.

2.7.4 The dry film thickness of the bituminous coating shall be not less than 100microns.

2.8 SPECIAL PROTECTION OF D.I. PIPES & FITTINGS

2.8.1 External coating of ductile iron pipes & fittings to be laid on location of high water table shall be coated with Polyurethane/Epoxy coating with minimum thickness of 300 microns or as prescribed in the Tender requirements and to be approved by the Concerned Engineer.

2.9 PACKING

2.9.1 Pipes of small diameters shall be packed in bundles. Every pipe shall be separated from each other with the help of properly designed wooden spacers. The bundle shall be secured firmly with proper straps and well faced wooden base supports for proper transport, handling and storage. Every bundle shall have only one length of pipe.

2.9.2 For big diameters, it should be supplied separately.

Section - 3
Slip-On Coupling and Flange Adaptors

3.1 GENERAL

These clauses shall be read in continuation of Section 1 of this Specification.

3.1.1 The Tenderer shall price the appropriate items in the Bills of Quantities to include for all rubber jointing rings, gaskets, nuts, bolts and washers.

3.1.2 The Tenderer shall submit full details of all the component materials, which must comply in all respects with the current British, ISO and EN Standards where applicable.

3.2 SLIP-ON COUPLINGS

3.2.1 Slip-on couplings shall be manufactured from either cast iron or rolled steel and shall be suitable for use with ductile iron pipes to BSEN 545 / ISO 2531.

3.2.2 Couplings shall be similar in design to that detailed in BS-8010, Section 2.1, 'Slip-on Couplings'.

3.3 FLANGE ADAPTERS

3.3.1 Flange adapters shall be manufactured from either cast iron or rolled steel and shall be suitable for use with ductile iron pipes to BSEN 545 / ISO 2531.

3.3.2 Flange adapters shall be suitable for jointing the flanges to PN-16, as detailed in BSEN 545 / ISO 2531.

3.3.3 Flange adapters shall be similar in design to that detailed in BS-8010, Section 2.1, 'Flange adapters'.

3.4 STEP COUPLINGS

3.4.1 Step couplings shall be manufactured from either cast iron or rolled steel and shall be suitable for jointing ductile iron pipes to asbestos cement pipes Class 'C'.

3.5 EXTERNAL AND INTERNAL COATING OF SLIP-ON COUPLINGS, STEP COUPLINGS AND FLANGE ADAPTERS DURING MANUFACTURE

3.5.1 All Slip-on couplings, step couplings, flange adapters shall be coated both, internally and externally as per Section 1 of Clause 1.5 of this specification.

3.6 IDENTIFICATION METAL STRIP

3.6.1 All couplings and flange adapters shall be marked by engraving or embossing on a metal strip, the name of manufacturer, individual serial number, tender number and Year of manufacturing.

3.7 PACKING

3.7.1 As per Section 1, Clause 1.9. of this specification.

Section - 4 Corrosion Protection of Ductile Iron Pipes

4.1 PIPE WRAPPING TAPE

4.1.1 The tape shall be supplied 150 mm or 225 mm wide in 15 m or 25 m rolls, or approved by Engineer depending upon the requirements.

4.1.2 Pipe diameters up to 200mm, 150mm width tape shall be used.

4.1.3 Pipe diameters above 200mm, 225mm width tape shall be used.

4.1.4 Note. Wrapping tape dimension selection is Subject to contract Specification.

4.1.5 The adhesive compound shall be of the pressure sensitive type (that is, not requiring a primer in order to achieve bond to the substrata) and shall have thickness between 0.75 to 0.90 mm. Flow coefficient of bitumen viscosity at 200° C and 175° C shall be 5.5 poise and 7.5 poise respectively.

4.1.6 The tape shall be supplied with a wider high quality silicon release paper covering complete tape. Both sides of the tape shall have a minimum of 5mm wider silicon release paper to prevent edge contamination.

4.1.7 During storage at maximum storage temperature of 50° C for six months, the adhesive material shall not flow out of the release paper and there shall not be any end blocking.

4.1.8 Wrapping tape shall be marked with the following information;

- Manufacturers name & logo
- Date of manufacture
- Width of the tape
- Batch Number

Wrapping Procedure

4.1.9 To increase the wrapping protection efficiency, pipe diameters up to 300mmmust be wrapped using semi-Automatic Tape Wrapping Machine and for pipe diameters above 300mm , Fully Automatic Wrapping Machine should be used.

Storage

4.1.10 Wrapping tape should be stored in dry, cool, well ventilated condition , out of direct sunlight.

Packing

4.1.11 Roll shall be placed in a cardboard carton in layers in vertical position. A proper separator for safe storage shall separate each layer. The boxes shall be marked minimum at two places given name and logo of manufacturer, Tender No., Type, Size and quantity of material in black/blue color letters with a minimum height of 50mm.

Wrapping Tape property

4.1.12 The wrapping tape shall also conform to the following specifications given below;

DATA SHEET

S. No.	Property	Test Method	Unit	Data
A.	**Physical**			
1	Color			
1.1	Backing	---	---	Blue RAL 5000/5001/5005/5010/5017
1.2	Adhesive Compound	---	---	Black
1.3	Release Paper	---	---	White/Cream
2	Backing Type	---	---	PVC
3	Backing Thickness Min.	---	mm	0.75
4	Total Thickness Min.	---	mm	1.5
5	Elongation	BS 2782	%	270
6	Tensile Strength Tape	BS 2782	N/mm2	14.8
7	Modulus	BS 2782	N/mm2	50
8	Tear Strength	ASTM D1004	N	50
9	Impact Resistance (Two layers)	DIN 30627	Nm	15
10	Flow coefficient of Bitumen			
10.1	Viscosity at 200° C	Cone & Plate	Poise	5.5
10.2	Viscosity at 175° C	Cone & Plate	Poise	7.5
11	Adhesion to Steel	ASTM D 1000	N/mm	2.75
12	Adhesion to Tape	ASTM D 1000	N/mm	2.75
B.	**Electrical**			
13	Dielectric Strength	BS 2782	kV	30
14	Insulation resistance	ASTM D 257	Ohm/cm2	1012
15	Cathodic disbandment	ASTM G 8	mm2	NIL
C.	**General**			
16	Water vapor permeability	BS 2782	g/m2/24h	0.4
17	Water absorption	ASTM D 570	%	0.1
18	Bacterial growth disbandment	---	---	NIL
D.	**Temperature Range**			
19	For wrapping	---	° C	0 to + 50
20	In service	---	° C	0 to + 50
21	For storage	---	° C	up to + 50

4.2 PRIMER

4.2.1 The primer shall be of fast drying type. It's only purpose shall be to maintain the surface cleanliness condition of the cleaned prepared D.I. pipe surface prior to tape application.

4.2.2 The primer shall be supplied in 20 to 25 Liters drums or as approved by the Engineer.

DATA SHEET

Property	Data
Flash Point, C °	24 - 34
Weight Solid, %	58
Viscosity, cP	200 - 500
Coverage m2/l	6 - 12
Type	Bitumen solution

Packing

4.2.3 Drums shall be put into a wooden box, which shall be close and open type. The boxes shall be marked minimum at two places given name and logo of manufacturer, Tender No., Type, Size and quantity of material in black/blue color letters with a minimum height of 50mm.

4.3 POLYETHYLENE SLEEVING

4.3.1 The polyethylene sleeving shall be manufactured to ISO 8180 and shall have the following additional characteristics: -

A. The film shall be manufactured in tubular form in blue color (RAL-5000/5001/5005/5010/5017) with a nominal thickness of the film shall be 225 microns with tolerance of ± 25 microns.

B. The film shall be manufactured from polyethylene or a blend of polyethylene and/or copolymer of ethylene and higher olefins.

C. No recycled materials shall be used in the manufacture of the sleeving.

4.3.2 Tests

A. Density: between 910-930 Kg/m3 tested as per ISO/R1183.

B. Flow Index: less than 2.5g/600s tested as per ISO/1133.

C. Tensile Strength: both directions not less than 8.3 MPa.

D. Elongation at Fracture: not less than 300%.

E. QA/QC certificate is required.

Marking

4.3.3 Polyethylene sleeving shall be supplied with a center guideline printed on the middle of the tape. The markings consist of the following;

- Manufacturers name & logo
- Date of manufacturing (MM/YY)
- Width & thickness of the sleeving
- Size of the Relevant DI pipe in mm

4.3.4 Lay flat width

The lay flat width of PE sleeving for D.I. pipe shall be as follows:

Sr. No.	Nominal Ø of D.I. pipe in mm	Lay flat width in mm
1	80	280
2	100	320
3	150	435
4	200	540
5	300	755
6	400	980
7	450	1090
8	500	1215
9	600	1440
10	700	1610
11	800	1825
12	900	2025
13	1,000	2255
14	1,200	2685

4.3.5 Packing

Each roll shall be individually packed and placed in a cardboard carton for safe storage. The boxes shall be marked minimum at Two places given name and logo of manufacturer, Tender No., Type, Size and quantity of material in black/blue color letters with a minimum height of 50mm.

4.4 PVC BLACK SELF ADHESIVE TAPE

4.4.1 PVC black self adhesive tape shall be 50 mm/2" wide of length 30 meter/100 ft. in Rolls black in color. The tape shall be good quality and from an approved manufacturer.

4.4.2 The adhesive material shall be suitable when used in water and underground.

4.4.3 Each roll shall be individually packed and placed in a cardboard carton for safe storage.

4.5 JOINT MOLDING PUTTY

4.5.1 The joint molding putty used on all types of pipe joints shall be an inert/non-toxic putty.

4.5.2 The putty shall be suitable for use with the approved PVC/Bituminous tape wrapping materials. The putty shall be that recommended by the tape manufacturer.

4.5.3 The putty shall be supplied in 20-25 Kg. drums or smaller packages as approved by the Engineer.

Typical properties

4.5.4 Putty shall CONSIST of the following properties:

- Color: Black / Beige
- Shrinkage: Nil

- Temperature range: Application: -10 to + 50 C°
  In service : -40 to + 75 C°

4.5.5 Packing

Drums shall be put into the wooden box, which shall be close and open type. The boxes shall be marked minimum at Two places given name and logo of manufacturer, Tender No., Type, Size and quantity of material in black/blue color letters with a minimum height of 50mm.

4.5.6 Storage

Putty should be stored in original containers until required for use. Store in dry, Cool, well ventilated condition, out of direct sunlight and other major sources of heat.

4.6 TRENCH MARKER TAPE.

4.6.1 The tape shall be manufactured from non-biodegradable low-density virgin polyethylene in blue color (RAL-5000/5001/5005/5010/5017).

4.6.2 The tape shall be 150mm wide and 200 micron thick with a tolerance of ± 5%. The rolls shall be of 500-meter long tape.

4.6.3 For PE Pipe, metallic tape (PE tape with continuous 2/3 metallic wires) as approved by Engineer, shall be used.

4.6.4 Marking

The tape shall be inscribed with both Arabic and English in black color with a minimum height of letters 75 mm as follows:

FOR WATER MAINS – with the words

CAUTION POTABLE WATER MAIN BELOW

-------------- احذر خط مياه رئيسى صالح للشرب بالأسفل --------------

FOR SERVICE CONNECTIONS – with the words

CAUTION POTABLE WATER SERVICE CONNECTION BELOW

-------------- احذر! توصيلة خدمات مياه صالحة للشرب بالأسفل --------------

4.6.5 The trench marker tape shall be supplied with the following printed markings:

- Manufacturers name & logo
- Date of manufacturing (MM/YY)
- Width & thickness of the tape
- Batch Number

4.6.6 Packing

Each roll shall be individually packed and placed in a cardboard carton for safe storage. The boxes shall be marked minimum at Two places given name and logo of manufacturer, Tender No., Type, Size and quantity of material in black/blue color letters with a minimum height of 50mm.

4.7 LUBRICANT

4.7.1 The lubricant shall be as per manufacturer's recommendations and conforming to Section 1, Clause 1.1.1. of this specification.

4.7.2 Packing

4.7.3 The lubricant shall be packed in 200 – 500 gram steel containers. These steel containers shall be placed in a cardboard carton for safe storage.

Section - 5
Corrosion Protection to Slip-on Couplings and Flange Adapters during installation

5.1 GENERAL

5.1.1 All wrapping tapes used for the corrosion protection of couplings and flange adapters shall be identical to that detailed in Section 4, Clause 4.1 of this specification.

5.1.2 Moulding putty used for building up the contours on couplings and flange adapters, prior to the application of wrapping tape shall be identical to that detailed in Section 4, Clause 4.5. of this specification.

5.1.3 All polyethylene sleeving used to cover couplings and flange adapters shall be identical to that detailed in Section 4, Clause 4.3. of this specification.

5.1.4 All PVC Black adhesive tape shall be identical to that detailed in Section 4, Clause 4.4. of this specification.

5.2 HEAT SHRINK SLEEVE

5.2.1 Heat shrink sleeve method for corrosion protection on joints, coupling & flange adaptors during installation will depend on Tender Requirements or upon the discretion and approval of the Concerned Engineer.

Section - 6
Gate valves

6.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

6.1.1 All sluice valves shall be manufactured and tested in accordance with BS-5163 Type 'B'/ BSEN 1171 and their amendments.

6.1.2 All sluice valves shall be: -

A. Double flanged drilled according to BSEN 1092-2 PN16.
B. Face –to-face dimensions according to BSEN 558-1; Series 3 and 14.
C. Designed for use with nominal pressure of 16 Bar.
D. with inside screw, solid wedge and shall be of non-rising stem type.
E. Operated by the use of a removable key through a valve cap.
F. Suitable for use in a closed end test.

6.1.3 Gear box shall be of :

- Standard ratio 1.1-10.1 (as specified)
- Torque ranges 400-40,000 Nm.
- Thrust range 4,000-250,000 daN

6.1.4 All sluice valve and gear box shall be suitable for use with water temperature up to 50° C and in climate and soil conditions encountered in the State of Qatar.

6.1.5 All sluice valves shall be of the resilient seat type.

6.1.6 All component parts of the valve body i.e. bonnet and stem seal housing shall be bolted together, where setscrews are used, the socket shall be provided with a PVC cap.

6.1.7 All sluice valves shall be designed for clockwise closing and be marked accordingly.

6.2 TESTING

6.2.1 The sluice valve shall be tested as per BS 5163 as follows:

- Hydraulic test for body - 24 Bar
- Hydraulic test for seat - 17.6 Bar

A factory test certificate shall be issued for each valve giving its serial numbers. This certificate shall be submitted to KAHRAMAA at the time of supply if requested by the engineer.

6.3 HAND-WHEEL

6.3.1 Sluice valves shall be supplied with cast iron hand wheels marked "Open" and "Closed" with arrow in appropriate directions. The design shall be such that it can be removed if necessary.

6.4 MARKING

6.4.1 All valves shall have clearly marked in the casting of the body the following information;

A. Size of valve in mm.
B. Pressure rating in Bars.
C. Manufacturer's name and/or logo.
D. Material type (GGG40/GGG50/SG)
E. Manufacturing Standards Number.
F. Year of manufacture.

6.4.2 All valves shall have individual identification strip which shall be marked by engraving or embossing on a metal strip, the name of manufacturer, individual serial number, tender number and Year of manufacturing.

6.4.3 The metal strip shall be of minimum size of 100mm x 30mm and shall be fixed securely and permanently at appropriate location by industrial type cold welded glue and shall not be screwed or riveted. The glue shall be of industrial grade with a melting point higher than 80 °C.

6.5 MATERIALS

For valve

6.5.1 The valve body, bonnet, gland, yoke and wedge body shall be manufactured of Ductile Iron as per one of the following standards :

- DIN 1693 GGG-50/40
- BS EN 1563:1997 grade EN-GJS-500-7
- ISO 500-7, ISO 400-15

6.5.2 The stem shall be manufactured of acid resistance stainless steel 316L/BS 970 Gr 431 S29 with the threaded portion being formed by rolling process.

6.5.3 Stem nuts shall be gunmetal to BS 1400 LG2 or BS 2874 CZ132.

6.5.4 Dimensions and materials shall conform to those detailed in BS 5163, as applicable for Type "B", and BS EN 1171.

6.5.5 The wedge body/core shall be manufactured from ductile iron.

6.5.6 The wedge shall be completely vulcanized by EPDM and coupled to the valve stem by gunmetal or dezincification resistance brass nut slide into the specifically designed slot hole in wedge or rigidly fastened into the wedge body by forging before rubber vulcanization.

6.5.7 Rubber material shall be of "EPDM EDK-70" and the minimum thickness shall be 1.5 mm, and all sealing surfaces not less than 4.0 mm.

Gear box

6.5.8 Gear box shall be of following materials: -

Body & body cover	Ductile Iron GGG 50/40, SG
Bevel gear-shaft	Steel / Carbon steel
Gear	SG Iron, BS EN 1563 Grade 700-2

	GGG 50 or AISI 1045
▪ Bearing	Steel
▪ Plate & base plate	Carbon steel
▪ Stem nut	Aluminum Bronze / Steel / DZR Brass

6.5.9 Fasteners shall be as per Section 1, Clause 1.6 of this specification.

6.6 FLANGES

6.6.1 All sluice valve flanges shall be drilled to suite ductile iron flanges as detailed in BS EN 1092-2, PN-16 rating.

6.7 SLUICE VALVE STEM SEALS

6.7.1 Sluice valves up to and including 300 mm Ø shall have 'O' ring seals which are to comprise of seal, wiper rings and lip seal. There shall be a minimum of two wiper rings or one wiper ring and one lip seal in addition to the seal rings and shall be made of synthetic rubber material.

6.7.2 Sluice valves above 300mm may have either 'O' ring seals, or stuffing boxes fitted with an approved 'Teflon' or graphite based packing material.

6.7.3 The stem sealing shall be maintenance free.

6.7.4 There shall not be any direct contact with spindle and bonnet to avoid cold welding.

6.8 MATERIAL COATING & INTERNAL COMPONENTS

6.8.1 The entire body of valves shall be coated both internally and externally with either of the following:

- 300 micron Fusion bonded epoxy (Polymeric anticorrosion) coating as per WIS No. 4-52-01.
- 300 micron Electrostatic ally applied epoxy coating.
- 300 micron Fluidized bed epoxy coating.

6.8.2 The color of coating shall be "Blue", Code RAL-5000/5001/5005/5010/5017.

6.8.3 All materials coating shall be WRC, DVGW , SGS , DWI. , KIWA , NSF 61 or other Worldwide Known Quality Body Certifiers in contact with potable water at 50 degrees centigrade .

6.8.4 The concern Department / Section has the right to request any Worldwide Known Quality Body Certifier if require.

6.8.5 All casting shall be properly finished, sand blasted and cleaned before coating.

6.8.6 Coating shall be smooth and mirror finish without any hairline cracks.

6.8.7 **Adhesion Test**: Adhesion of coating to metal shall not be less than 12N/mm2 (DIN/ISO - 4624).

6.8.8 **Holiday Test**: Porosity of coating shall be "zero" on 3 kV DC tester.

6.8.9 **Hardness**: Intrinsic Rockwell hardness shall be between 50 - 60.

6.8.10 **Impact resistance**: For applying of impact energy of 5 NM on coating the cracks should not develop, when tested by 3 kV DC tester.

6.9 VALVE KEY

6.9.1 Valve keys shall be of the heavy duty, lever type, shall be aluminum alloy and to be capable of opening valves against their designed working pressure heads and shall be capable of producing enough torque to close the valve to a drop tight extent.

6.9.2 Valve keys of standard length shall be supplied in the ratio of 1 per 20 sluice valves.

6.10 ACCESSORIES

6.10.1 Each valve shall be supplied with all accessories such as :-

- Bolts, nuts, washers and 3 mm cotton reinforced rubber gasket for each flange.
- Caps.
- The Number of hand wheel to be Supplied:
  - From 1 to 20 valves, 1 hand wheel should be supplied.
  - Up to 40 valves, 2 hand wheels should be supplied.
  - Up to 60 valves, 3 hand wheels should be supplied.
  - Etc.
- Extension spindle of 1.25 m. in length and 40 mm Ø (min.) rod with all accessories such as coupling, cap etc. 1 per 20 sluice valve.

6.11 PACKING

6.11.1 As per Section 1, Clause 1.9. of this specification.

Section - 7
Butterfly Valve

7.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

7.1.1 All butterfly valves shall be manufactured and tested in accordance with BS EN 593 and its amendments or as specified in tender or approved by the Engineer.

7.1.2 Butterfly valves shall be of the following types;

A. Double/Triple Offset or Rubber-lined Concentric type.
B. Double flanged design. Face-to-face dimensions shall be as per BSEN 558-1:
   - series 20 for Replaceable lining valves.
   - series 13 & 14 for Vulcanized and Double/Triple Offset valves.

C. The thickness of the EPDM rubber shall be minimum 3mm.
D. Designed for use with nominal pressure of 16 Bar.
E. Operated by the use of a removable key.
F. Suitable for use in a closed end test.

7.1.3 All butterfly valves and gear boxes shall be suitable for use with water temperature up to 50°C in climate and soil conditions encountered in the State of Qatar.

7.1.4 All component parts of valve body i.e. bonnet and stem seal housing shall be bolted together where setscrews are used. The socket shall be provided with a PVC cap.

7.1.5 All butterfly valves shall be designed for clockwise closing and to be marked accordingly.

7.2 TESTING

7.2.1 All valves shall be individually pressure tested at following hydraulic pressure:

- Body - 24 Bar
- Seat - 17.6 Bar
- Disc - 24 Bar

A factory test certificate shall be issued for each butterfly valve giving its serial number in order to be submitted with the valves, if requested by the concerned Engineer.

7.3 GEAR BOXES & HAND WHEELS

7.3.1 All butterfly valves shall be supplied by acceptably designed gear box with removable type of cast iron hand wheel duly marked open & closed with arrows in the appropriate directions.

7.4 MARKINGS

7.4.1 All valves shall have clearly marked in the casting of the body with the following information:

A. Size of valve in mm.

B. Pressure rating in Bars.
C. Manufacturer's name and/or logo.
D. Material type (GGG40/GGG50/SG)
E. Manufacturing Standards Number.
F. Year of manufacture.

7.4.2 All valves shall have individual identification strip which shall be marked by engraving or embossing on a metal strip, the name of manufacturer, individual serial number, tender number and Year of manufacturing.

7.4.3 The metal strip shall be of minimum size of 10mm x 30mm and shall be fixed securely and permanently at appropriate location by industrial type cold welded glue and shall not be screwed or riveted. The glue shall be of industrial grade with a melting point higher than 80 °C.

7.5 MATERIALS

7.5.1

A. Body - DI GGG-40/50.
B. Disc - DI GGG-40/50, SS 316L, Aluminum bronze ASTM B148 gr.955, or GM. It shall be of solid one piece casting (non-hollow) and coated with 300 micron Relisan/Epoxy.
C. Gasket - Rubber (cotton reinforced)
D. Bearing - PTFE filled line steel bearing(self lubricated)
E. Fasteners - Shall be as per Section 1, Clause 1.6.
F. Shaft - Duplex SS 100% dry shaft design
G. Lining - Must be of the highest grade EPDM rubber.

7.6 FLANGES

7.6.1 All butterfly valve flanges shall be drilled to BSEN 1092-2, PN 16.

7.7 COATINGS

7.7.1 The entire body of valves shall be coated both internally and externally with either of the following:

- 300 micron Fusion bonded epoxy (Polymeric anticorrosion) coating as per WIS No. 4-52-01.
- 300 micron Electrostatic ally applied epoxy coating.
- 300 micron Fluidized bed epoxy coating.

7.7.2 In special cases, Rilisan coating with 300 microns can be approved.

7.7.3 The color of coating shall be "Blue", Code RAL-5000/5001/5005/5010/5017.

7.7.4 All materials coating shall be WRC, DVGW , SGS , DWI. , KIWA , NSF 61 or other Worldwide Known Quality Body Certifiers in contact with potable water at 50 degrees centigrade .

7.7.5 The concern Department / Section has the right to request any Worldwide Known Quality Body Certifier if require.

7.7.6 All casting shall be properly finished, sand blasted and cleaned before coating.

7.7.7 Coating shall be smooth and mirror finish without any hairline cracks.

7.7.8 **Adhesion Test**: Adhesion of coating to metal shall not be less than 12N/mm2 (DIN/ISO - 4624).

7.7.9 **Holiday Test:** Porosity of coating shall be "zero" on 3 kV DC tester.

7.7.10 **Hardness:** Intrinsic Rockwell hardness shall be between 50 - 60.

7.7.11 **Impact resistance:** For applying of impact energy of 5 NM on coating the cracks should not develop, when tested by 3 kV DC tester.

7.8 VALVE KEYS

7.8.1 Valve keys shall be of heavy duty, lever type, and aluminum alloy and to be capable of opening valves against their designed working pressure heads and shall be capable of producing enough torque to close the valve to a drop tight extent.

7.8.2 Valve keys of standard length shall be supplied in the ratio of 1 key per 4 butterfly valves.

7.9 ACCESSORIES

7.9.1 Each valve shall be supplied with all accessories such as :-

- Bolts, nuts, washers and 3 mm cotton reinforced rubber gasket for each flange.
- Caps
- Hand wheel, 1 per 20 valves.
- Extension spindle of 1.25 m in length and 40 mm Ø (min.) rod with all accessories such as a coupling, cap etc., 1 per 20 of butterfly valve.

7.10 PACKING

7.10.1 As per Section 1, Clause 1.9. of this specification.

Section - 8
Air Valves

8.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

8.1.1 All valves shall be suitable for a maximum working pressure of 16 Bar.

8.1.2 All materials shall be suitable for use with potable water at a temperature of 50°C.

8.1.3 The Tenderer shall supply with his Tender, a detailed specification for the valves he intends to supply under the contract.

8.1.4 Air valve heads should be positioned vertically.

8.1.5 The flange shall be either welded type, or rotatable type (with approval of the concerned engineer)

8.2 MATERIALS (FOR GEAR BOX)

8.2.1 Gear Box shall be of following materials:-

Body & body cover	Grey Cast Iron GGG 40/50
Bevel gear-shaft	Steel / Carbon steel
Gear	SG Iron, BS-2789-700/2, GGG 50 or AISI 1045
Bearing	Steel
Plate & base plate	Carbon steel
Stem nuts	Aluminum Bronze / Steel / DZR Brass

8.3 AIR VALVES CONSTRUCTION MATERIALS

8.3.1 The body shall be of ductile Iron, GGG-40/50. The Tenderer shall supply with his Tender, details of all air valve and check valve component parts and the materials from which they are to be manufactured.

8.3.2 Fastener shall be as per Section 1, Clause 1.6 of this specification.

8.3.3 All air valves shall have their entire body coated, both internally and externally as per Section 8, Clause 8.6 of this specification.

8.4 SINGLE AIR VALVE LARGE ORIFICE TYPE

8.4.1 Large orifice air valves are for the bulk removal and inlet of air from and to the mains.

8.4.2 These air valves shall be of BSPT type or flange type to suit the requirement.

8.5 SINGLE AIR VALVE SMALL ORIFICE TYPE

8.5.1 Small orifice air valves are for the removal of air under pressure from the main.

8.5.2 These air valves are installed in the pipeline via a 1" (inch) BSPT tapping.

8.5.3 These air valves shall be supplied with an approved isolating cock on the inlet, threaded to suit the air valve.

8.6 DOUBLE AIR VALVE

8.6.1 Double air valves are a combination of both large and small orifices and are used for bulk removal, inlet of air as well as removal of air under pressure.

8.6.2 These air valves are installed into mains via a standard flange drilled to suit ductile iron flanges to BS EN 1092, PN-16 rating. Inlet sizes are to be as shown in the Bill of Quantities.

8.6.3 Double air valves are to be supplied with an isolating valve and the stem should be positioned vertically with DAV.

8.7 COATINGS

8.7.1 All valves and gear boxes shall have their entire body coated both internally and externally with either of the following:

- 300 micron Fusion bonded epoxy (Polymeric anticorrosion) coating as per WIS No. 4-52-01.
- 300 micron Electrostatic ally applied epoxy coating.
- 300 micron Fluidized bed epoxy coating.

8.7.2 The color of coating shall be "Blue", Code RAL-5000/5001/5005/5010/5017.

8.7.3 All materials coating shall be WRC, DVGW, SGS, DWI, KIWA, NSF 61 or other Worldwide Known Quality Body Certifiers in contact with potable water at 50 degrees centigrade .

8.7.4 The concern Department / Section has the right to request any Worldwide Known Quality Body Certifier if require.

8.7.5 All casting shall be properly finished, sand blasted and cleaned before coating.

8.7.6 Coating shall be smooth and mirror finish without any hairline cracks.

8.7.7 **Adhesion Test:** Adhesion of coating to metal shall not be less than 12N/mm2 (DIN/ISO - 4624).

8.7.8 **Holiday Test:** Porosity of coating shall be "zero" on 3 kV DC tester.

8.7.9 **Hardness:** Intrinsic Rockwell hardness shall be between 50 - 60.

8.7.10 **Impact resistance:** For applying of impact energy of 5 NM on coating the cracks should not develop, when tested by 3 kV DC tester.

8.8 MARKINGS

8.8.1 All air valves shall have clearly marked in the casting of the body with the following information:

A. Size of valve in mm.
B. Pressure rating in Bars.
C. Manufacturer's name and/or logo.
D. Material type (GGG40/GGG50/SG)
E. Manufacturing Standards Number.
F. Year of manufacture.

8.8.2 All valves shall have individual identification strip which shall be marked by engraving or embossing on a metal strip, the name of manufacturer, individual serial number, tender number and Year of manufacturing.

8.8.3 The metal strip shall be of minimum size of 10mm x 30mm and shall be fixed securely and permanently at appropriate location by industrial type cold welded glue and shall not be screwed or riveted. The glue shall be of industrial grade with a melting point higher than 80 °C.

8.9 PACKING

8.9.1 As per Section 1, Clause 1.9. of this specification .

Section - 9
Fire Hydrants

9.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

9.1.1 All fire hydrants shall be manufactured and tested in accordance with latest BS 750, "Type 2", and its amendments.

9.1.2 Fire hydrants shall be screw down type with captive stopper.

9.1.3 Fire hydrants shall be medium, fixed type stopper.. Simple drain plug with needle hole.

9.2 MARKING

9.2.1 All fire hydrants shall have clearly marked in the casting of the body the following information.

A. Number of BS Code i.e. BS 750
B. Manufacturer's name and/or logo.
C. Material designation of body and bonnet i.e. SG.

Model Number and Individual Serial Number of Fire Hydrant, either can be casted on body or marked on Identification Metal Strip along with other information as detailed in Section 1, Clause 1.7. of this specification.

9.2.2 All fire hydrants shall have individual identification strip which shall be marked by engraving or embossing on a metal strip, the name of manufacturer, individual serial number, tender number and Year of manufacturing.

9.2.3 The metal strip shall be of minimum size of 10mm x 30mm and shall be fixed securely and permanently at appropriate location by industrial type cold welded glue and shall not be screwed or riveted. The glue shall be of industrial grade with a melting point higher than 80 °C.

9.3 MATERIALS

9.3.1 All fire hydrant body and bonnet shall be manufactured using ductile iron, GGG 50/40 to BS EN1563, Grade 420-12/500-7.

9.3.2 Fasteners shall be as per Section 1, Clause 1.6 of this specification.

9.3.3 All fire hydrants shall have "O" ring seals which are to comprise of seal and wiper rings and shall be made of synthetic rubber material. Removable gland fire hydrants shall not be accepted.

9.3.4 The stem shall be manufactured of acid resistance SS 316L/BS-970 Gr. 431 S29 with the threaded portion being formed by rolling process.

9.3.5 The wedge body/core shall be manufactured from ductile iron, GGG 50/40 to BS EN1563, Grade 420-12/500-7.

9.3.6 The stopper shall be completely vulcanized by EPDM or a suitable designed EPDM seal fasten with properly design arrangement, suitable for life of the fire hydrant and coupled to the stem by gunmetal or DZR brass nut slides into specifically designed slot hole in stopper or rigidly fastened into the stopper body by forging before rubber vulcanization.

9.3.7 If stopper is completely vulcanized, the rubber material shall be of "EPDM" EDK-70 or equivalent and the minimum thickness shall be 1.5mm and on all sealing surfaces shall not be less than 4.0mm.

9.3.8 The stopper nut shall be made of gunmetal to BS 1400 LG-2 or BS 2874 CZ 132.

9.4 CONNECTIONS

9.4.1 Inlet flanges shall be drilled to suite ductile iron flanges as detailed in BS EN 1092, PN-16 rating.

9.4.2 Fire hydrants shall have a pressure rating of 16 Bar and shall be subject to a working test pressure of 24 Bar.

9.4.3 All materials shall be suitable for use with potable water at a temperature of 50°C.

9.4.4 Outlets shall be 2.5" (inches) male London Round Thread.

9.4.5 Fire hydrants are to be designed for clockwise closing.

9.5 COATINGS

9.5.1 All fire hydrants shall have their entire body coated, both internally and externally with either of the following:

- 300 micron Fusion bonded epoxy (Polymeric anticorrosion) coating as per WIS No. 4-52-01.
- 300 micron Electrostatic ally applied epoxy coating.
- 300 micron Fluidized bed epoxy coating.
- The color of coating shall be "Blue", Code RAL-5000/5001/5005/5010/5017.

9.5.2 All materials coating shall be WRC, DVGW , SGS , DWI. , KIWA , NSF 61 or other Worldwide Known Quality Body Certifiers in contact with potable water at 50 degrees centigrade .

9.5.3 The concern Department / Section has the right to request any Worldwide Known Quality Body Certifier if require.

9.5.4 All casting shall be properly finished, sand blasted and cleaned before coating.

9.5.5 Coating shall be smooth and mirror finish without any hairline cracks.

9.5.6 **Adhesion Test:** Adhesion of coating to metal shall not be less than 12N/mm2 (DIN/ISO - 4624).

9.5.7 **Holiday Test:** Porosity of coating shall be "zero" on 3 kV DC tester.

9.5.8 **Hardness:** Intrinsic Rockwell hardness shall be between 50 - 60.

9.5.9 Impact resistance: For applying of impact energy of 5 NM on coating the cracks should not develop, when tested by 3 kV DC tester.

9.6 TESTING

9.6.1 All fire hydrants shall be tested as per BS 750 as follows: -

- Hydraulic test for body - 24 Bar
- Hydraulic test for seat - 17.6 Bar

A factory test certificate shall be issued for each fire hydrant giving its serial number. This certificate shall be submitted to KAHRAMAA at the time of supply.

9.7 STAND PIPES

9.7.1 Stand pipes shall be of revolving head type, the heads to be fitted with chained blanking plugs with a minimum height of 950mm and manufactured from aluminum alloy or equivalent.

9.7.2 Inlet shall be 2.5" (inch) female London Round Thread to fit fire hydrants to BS 750 and outlet shall be 2.5" instantaneous male to BS 336.

9.8 ACCESSORIES

9.8.1 Each fire hydrant shall be supplied with following :

- Bolts, nuts, washers and 3 mm cotton reinforced rubber gasket for each flange.
- Hand-wheel, 1 per 20 fire hydrants.
- Extension spindle of 1.25 m. In length and 40 mm Ø (min.) rod with all accessories such as coupling, cap etc. 1 per 20 fire hydrants.
- Stand pipe, 1 per 20 fire hydrants.

9.9 PACKING

9.9.1 As per Section 1, Clause 1.9. of this specification.

Section - 10
Check Valve

10.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

10.1.1 All valves shall be suitable for a maximum working pressure of 16 Bar.

10.1.2 All material shall be suitable for use with potable water at a temperature of 50° C

10.2 CHECK VALVES CONSTRUCTION MATERIALS

10.2.1 The body shall be of ductile iron, GGG – 40/50.

10.2.2 Fasteners shall be as per Section 1, Clause 1.6. of this specification.

10.3 MARKINGS

10.3.1 All check valves shall have clearly marked in the casting of the body with the following information:

A. Size of valve in mm.
B. Pressure rating in Bars.
C. Manufacturer's name and/or logo.
D. Material type (GGG40/GGG50/SG)
E. Manufacturing Standards Number.
F. Year of manufacture.

10.3.2 All check valves shall have individual identification strip which shall be marked by engraving or embossing on a metal strip, the name of manufacturer, individual serial number, tender number and Year of manufacturing.

10.3.3 The metal strip shall be of minimum size of 10mm x 30mm and shall be fixed securely and permanently at appropriate location by industrial type cold welded glue and shall not be screwed or riveted. The glue shall be of industrial grade with a melting point higher than 80 °C.

10.4 PACKING

10.4.1 As per Section 1, Clause 1.9. of this specification.

Section - 11
Surface Boxes, Marker Posts & Indicator Plates

11.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

11.1.1 Surface boxes for sluice valves, single air valves and stopcocks shall be manufactured in accordance with BS-5834, Part 2 Grade A or EN 124, Class D-400 or equivalent as specified.

11.1.2 Surface boxes for double air valves shall be manufactured in accordance with BS-5834, Part 3 Grade A or EN 124, Class D-400 or equivalent as specified.

11.1.3 Surface boxes for fire hydrants shall be manufactured in accordance with BS-5834, Part 3.

11.1.4 All surface boxes shall be manufactured from ductile iron, Grade A or D-400 heavy duty as specified.

11.1.5 All surface boxes shall be coated with a cold applied black bitumen solution to BS-3416.

11.1.6 All surface boxes shall be kite marked or a BIS Certificate of compliance with the relative standard must be supplied with all deliveries.

11.1.7 Lifting keys, of malleable cast iron with loop handles or "T" handle as appropriate suitable for shall be supplied One (1) set per Twenty (20) surface boxes.

11.2 SLUICE VALVE SURFACE BOXES (UP TO 300MM Ø VALVES)

11.2.1 The SV surface boxes shall be of the double triangular loose coupled type, with a nominal 150mm x 150mm clear opening to BS 5834, Part 2 Grade A or equivalent.

11.2.2 The covers of the SV surface boxes shall have open keyways.

11.2.3 The covers of SV surface boxes are to have in the casting the letters 'SV' and Water/W with a minimum height of 25mm.

11.2.4 The covers of the SV surface boxes are to be fitted with security chains.

11.3 SLUICE VALVE SURFACE BOXES (400MM Ø VALVES AND ABOVE)

11.3.1 The SV surface boxes shall be of the rectangular type with a minimum 600mm x 450mm clear opening and shall conform to BS-5834, Part 3 or EN-124, Class D-400 or equivalent as specified.

11.3.2 The covers of SV surface boxes shall have closed keyways.

11.3.3 The covers of SV surface boxes are to have in the casting, the letters 'SV' and Water/W with a minimum height of 25mm.

11.4 SINGLE AIR VALVE SURFACE BOX

11.4.1 The SAV surface box shall be of the double triangular loose-coupled type with a nominal 300mm x 300mm clear opening and shall conform to BS-5834, Part 2, Grade A or EN 124, Class D-400 or equivalent.

11.4.2 The covers of SAV surface boxes shall have open keyways.

11.4.3 The covers of SAV surface box are to have in the casting the letters 'AV' and Water/W with a minimum height of 25mm.

11.5 DOUBLE ACTION AIR VALVE SURFACE BOX

11.5.1 The DAV surface box shall be of the double triangular loose-coupled type with a nominal 750mm x 600mm clear opening and shall conform to BS-5834, Part 3 or EN 124, Class D-400 or equivalent.

11.5.2 The covers of DAV surface box shall have closed keyways.

11.5.3 The covers of DAV surface boxes are to have in the casting, the letters 'AV' and Water/W with a minimum height of 25mm.

11.6 STOPCOCK SURFACE BOX

11.6.1 The stopcock surface box shall be of double triangle loose-coupled type, fitted with a safety chain having a nominal 150 mm x 150 mm maximum clear opening to BS-5834, Part 2 Grade A or EN 124, Class D-400 or equivalent.

11.6.2 The frame and cover of the stopcock surface box shall have a lever recess cast in at the opposite end to the hinge.

11.6.3 The cover of the stopcock surface box shall have in the casting the word 'stopcock' and Water/W with a minimum height of 12mm.

11.7 FIRE HYDRANT SURFACE BOX

11.7.1 Fire hydrant surface box shall be suitable for use with screw down hydrants and shall comply with the requirements of BS-750 or BS 5834, Part 3 or equivalent with clear opening of size 380 mm x 230 mm.

11.7.2 The frame of the fire hydrant surface box is to have a level recess at each end and a minimum of one open keyway.

11.7.3 The cover of the fire hydrant surface box is to be one piece, supplied with a security chain.

11.7.4 A valve opening direction indicator plate is to be fixed to or cast onto the underside of the fire hydrant surface box cover.

11.7.5 The cover of the fire hydrant surface box shall have in the casting either the words 'Fire Hydrant', in letters 25mm minimum in height or the letters 'FH' and Water/W with a minimum height of 50mm.

11.8 MARKER POST

11.8.1 Marker post shall be manufactured from steel channel as detailed in the standard drawing No. 1/49/C.

11.8.2 Each post will be supplied with a steel backing plate use for SV, AV and FH,

11.8.3 Each post will be supplied with:-

11.8.4 a) Six (6) Nos. of M-8 x 30mm long counter sunk bolts with hexagon drive.

11.8.5 b) Four (4) Nos. of M-6 x 30mm long slotted round head bolts with nuts and spring washers.

11.8.6 All posts and backing plates are to be grit blasted prior to the application of a suitable three stages epoxy paint system. The color shall be light aircraft gray color Code RAL 7035.

11.9 INDICATOR PLATE

11.9.1 Indicator plates and tiles will be from the 'F' range. The Engineer will notify Numbers and letters in Arabic and English to be shown on the tiles.

11.9.2 Fire hydrant plates will have the letter 'H' cross and commas be empty of tiles and have a plastic backing plate.

11.9.3 Sluice valve and air valve plates will have the Arabic 'Water' 'T' cross and commas, be empty of tiles and have a plastic backing plate.

Section - 12
Copper Tubes

12.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

12.1.1 The copper tubes shall be manufactured to BS-2871, Part 1, Table 'Y'/ EN 1057 R 220-250 and marking shall be engraved as per relevant standard.

12.1.2 The tubes shall be suitable for underground use for the transmission of potable water.

12.1.3 The tubes shall be supplied in the following forms:

12.1.4 15mm to 28mm Ø - soft coils of 20 meters length.

12.1.5 42mm & 54mm Ø - half-hard 5.8 meters straight length.

12.1.6 Tube samples and test results including 'Drift Test' results shall be provided at the client's request.

12.1.7 The coiled tubing is to be secured against uncoiling during transit, the straight lengths to be supplied in wooden boxes and are to be fitted with end caps to prevent damage during transit.

12.1.8 All tubes are to be new and factory fresh, tubes which have developed thick 'patina' through standing in stockyards etc. will not be accepted.

12.2 SHEATHING

12.2.1 The copper tubes shall be externally coated over their entire length with continuous seamless polyethylene sheathing. The color of this sheathing shall be Green/Blue.

12.3 TUBE SIZES

12.3.1 The copper tubes shall comply with the following specification with regard to size:

Tube Nominal size	Outside dia (mm)		Nominal wall	Thickness
(mm)	Max.	Min.	Thickness(mm)	sheathing (mm)
15	15.045	14.965	1.0	1.0
22	22.055	21.975	1.2	1.0
28	28.055	27.975	1.2	1.0
42	42.07	41.99	1.5	1.6
54	54.07	53.99	2.0	1.6

Section - 13
Copper Fittings, Ferrules, Stopcocks & Poly Adapters

13.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

13.1.1 The compression fittings shall be manufactured to BS-864, Part 2, Type 'B', and shall be the 'manipulative' type with 2 locking rings and marked as BS 864.2.

13.1.2 The capillary fittings shall be manufactured to BS-864, Part 2, and shall be of the 'integral' solder ring type and marked as BS 864.

13.1.3 All the above fittings as referred in Clause 13.1.1 & 13.1.2, shall be suitable for use with copper tube to BS-2871, Part 1, Table 'Y'/ EN 1057 R-220-250, shall also be suitable for underground use with potable water and shall be wrapped by lubricated tape.

13.1.4 All poly fittings shall be compression type and shall be manufactured to BS 864, Part 3, Type A marked as BS 864.3 and shall also be suitable for use with potable water.

13.1.5 All nuts on these fittings shall be hexagonal or octagonal.

13.1.6 All fittings must be new, clean and recent manufactured.

13.2 MARKING

13.2.1 All fittings shall have engraved and/or casted the following:-

A. The manufacturer's name and identification mark.
B. British Standard Number:
C. Compression Fittings - BS-864.2 or BS-864.3
D. Capillary Fittings - BS-864
E. Poly Adapters - BS-864.5
F. The size of the fitting in mm.

N.B. In the case of universal swivel ferrule, these will not have the BS number on them. However, ferrules may have their size indicated in "imperial" measurement. In addition to the above, an arrow indicating the "direction of flow" engraved and/or cast into them.

13.3 MATERIALS

13.3.1 All fittings including nuts & bolts, unions, etc., are to be manufactured from 'gunmetal' to BS-1400 LG2 or DZR Brass except material specified else where in the specifications. Samples with complete material specifications shall be supplied at the time of tendering.

13.3.2 Universal swivel ferrules, saddles and Poly Adapters must be manufactured from 'gunmetal', no other material will be accepted.

13.3.3 Stopcock, material option will depends on the application type:

- **For Above ground application:** Stopcock are to be manufactured from gunmetal to BS-1400 LG2 or DZR brass.

- **For under ground application:** If the Stopcock will be in direct contact with soil then it must be manufactured from gunmetal to BS-1400 LG2. If not (inside chamber with wrapping protection) either DZR brass/ gunmetal.

Note. Specifications of both applications will depend in the tender requirements.

13.3.4 Gaskets to be supplied with fittings in this section must be suitable for use with potable water and the type of gasket to be set out in the offer.

13.4 UNIVERSAL SWIVEL FERRULE

13.4.1 The ferrule shall be suitable for connecting copper service pipes, (copper tubes to BS-2871, Part 1, Table 'Y'/ EN 1057 R 220-250), to cement lined ductile iron distribution mains to, (BS-4772/ISO 2531/EN545), and shall be ductile iron distribution pattern. Screws down type ferrules with crutch heads are not acceptable.

13.4.2 The ferrules shall be suitable for insertion under-pressure by the use of a normal under-pressure-tapping machine, as well as for normal dry installation.

13.4.3 The ferrules shall be manufactured throughout in 'gunmetal' to BS-1400 LG2 including the inner plug, the top plug may be of PVC.

13.4.4 The following inlet/outlet connection will be required: -

Size of ferrule	Type of outlet connection
½" x 15mm	Copper compression , BS 864-2, Type 'B'
¾" x 22mm	Copper compression , BS 864-2, Type 'B
1" x 28mm	Copper compression , BS 864-2, Type 'B
1½" x 42mm	Copper compression , BS 864-2, Type 'B
2" x 54mm	Copper compression , BS 864-2, Type 'B

N.B. See also under 13.2.1. for details of connections and markings for the above ferrules.

13.5 STOPCOCKS

13.5.1 Stopcocks are to be manufactured to BS-1010, with crutch heads and loose jumpers. The stopcock shall be manufactured from gunmetal to BS-1400 LG2 or DZR according to the type of the application as mentioned in clause 13.3.3.

13.5.2 Stopcock washers are to be suitable for use with potable water at a normal temperature of 50° C.

13.5.3 Stopcocks will be required with the following types of connection: -

Size of stopcock	Type of connection
15mm	Copper compression Type 'B'
22mm	Copper compression Type 'B'
28mm	Copper compression Type 'B'
42mm	Copper compression Type 'B'
54mm	Copper compression Type 'B'

N.B. See clause13.2.1 for details of connections, markings and materials for the above stopcocks.

13.6 SADDLES

13.6.1 Saddle strap shall be manufactured from 'gunmetal' to BS-1400 LG2 with bolts size suitable for ferrule connections up to 54mm, (2 inches).

13.6.2 All bolts and nuts shall be stainless steel.

13.6.3 The saddles shall be suitable for use with ductile iron pipes to BSEN 545 / ISO 2531.

13.7 POLY ADAPTERS

13.7.1 The poly adapters shall be manufactured to BS-864, Part 3, Type A, shall be marked as BS 864.5 and shall be made of gunmetal to BS 1400 LG2.

13.7.2 The fittings shall be suitable for Polyethylene pipes. The PE pipe shall comply to the requirements of BS 1972, 1973, 3284 & 3796.

13.7.3 The fittings shall meet performance requirements for joints and compression fittings for use with PE pipe as per BS 5114.

13.7.4 The fittings shall be suitable for working pressure of 12 Bar at 20° C.

13.7.5 Minimum length of threaded engagement excluding chamfer shall be as follows:

S. No.	NOMINAL SIZE	MINIMUM LENGTH OF THREADED ENGAGEMENT
	inch	mm
1	3/8	5.5
2	½	5.5
3	¾	7.0
4	1¼	7.0
5	1½	7.0
6	2	8.0

13.7.6 Internal Support

The internal support shall be Class "C" or it shall be color coded BLUE in accordance with pipe specifications to BS 1972 & 3284.

13.7.7 Testing

13.7.7.1 Internal Pressure

The fitting when assembled shall be capable to withstand internal hydrostatic pressure of 36 Bar for One Hour, when tested with PE pipe, complied with the requirement of BS 3284 or BS 3796 Class "D".

13.7.7.2 External Pressure

The fittings when assembled shall be capable to withstand external hydrostatic pressure of 0.1 Bar and 0.8 Bar with open-end test for One Hour.

13.7.7.3 Pull out Test

The axial moment of the pipe from the socket of the fitting shall not exceed1.0mm when longitudinal force is applied as per table below for a minimum period of One Hour:

Nominal Size	LONGITUDINAL FORCE IN NEWTON					
	Class Type 32 Pipe BS-1972, BS-1973			Class Type 50 Pipe BS-3284, BS-3796		
	B	C	D	B	C	D
3/8	-	470	580	-	-	690
½	-	725	870	-	850	1070
¾	810	1140	1380	-	1370	1660
1¼	1320	1760	2180	1600	2080	2650
1½	2710	3700	4530	3080	4350	5660
2	4370	5780	-	44830	6760	8520

Section - 14
Electronic Flow meter-Domestic Type ½"(15mm)-1½"(40mm)

14.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

14.1.1 The specification set out below, covers water meters in the size range 15 mm (½") to 40 mm (1½"). These meters are to be designed and manufactured for use with potable water, but must have the capability of allowing particulate up to 2.5 mm in diameter and air to pass through them without damage to the meters. Items to be supplied must conform to each and every part of this specification, and any deviation must have the prior approval in writing of KAHRAMAA.

14.1.2 A pair of meter end connections, comprising of a nut and a union, along with a washer and non-return valve fitted at outlet end if necessary and as per the discretion of the Engineer, shall be included with each water meter..

14.1.3 A pair of meter end connections, comprising of a nut and a union, along with a washer and non-return valve fitted at outlet end if necessary and as per the discretion of the Engineer, shall be included with each water meter. A Strainer suitable for stopping particulate greater than 3 mm shall also be supplied at the inlet end of each meter

14.1.4 The Electronic water meter shall be of the "Non-Moving Parts" type, Electromagnetic, Ultrasonic or other to be approved by Engineer as the means to determine the water flow rate or any other equivalent principles approved by the Engineer. Water meters shall comply with requirements of ISO 4064 Part 01, BS 5728 Part 01 (for electromagnetic) and be Metrological Class C. For Ultrasonic type, Technical codes, Standards, Data sheet to be revised and approved by concern Engineer.

14.1.5 The water meter manufacturer shall be ISO 9001 certified and the offer must include the ISO certificate The meter shall be designed and manufactured under the ISO 9000 series of quality standards.

14.1.6 Water meters shall be of dry type and Meter Register shall be 'Digital'.

14.1.7 In addition to 'Direct Read from its register' the meter shall have Remote Communication facility, such as provision of a socket to insert a data retrieval port to monitor readings through an 'Automatic Meter Reading (AMR)' system in the future.

14.1.8 Remote Communication: Meter shall have facility for remote communication such as; meter reading, flow rate, pressure etc and the manufacturer shall specify in his offer that which parameters can be transferred remotely from the meter.

A. By the term 'remote communication' it is envisaged that the meter can be communicated with by both the following options:

- **From just outside the premises of the customer where the meter is installed, using a hand-held unit**. The water meter and the hand-held unit for remote communication shall be compatible to each other.
- **From the Control Centre** – The meter and the communication unit in the Control Centre shall be compatible to each other.

B. Protocol for Remote Reading shall be elaborated in details in Technical & Commercial offers. Options are GSM, PLC (Programmable Logic Controllers or Power Line Carrier communication), Smart Reader etc. all compatible to KAHRAMAA IT networks/Personal Computers of relevant Operating Systems & Software.

C. Flow meter shall have an integrated data logging facility / communication port (RS232 or RS485) for data upload & download using portable handheld device or PC.

D. **Power Supply**: The water meter shall recive power from a Built-in battery with an operational life of atleat 10 years.

14.2 METER SIZE AND LENGTH OF METER BODY.

14.2.1 The length of water meter body with respect to different size of meter shall be in compliance with BS ISO 13359 or equivalent as per discretion of the Engineer, as follows.

Meter size	Length of meter body
15mm (½")	200 mm
20mm (¾")	200 mm
25mm (1")	200 mm
40mm (1 ½")	200 mm

14.3 SECURITY

14.3.1 Security against tampering is a very important aspect regarding meter. Manufacturer shall provide details of facility for sealing the meter for the approval of Kahramaa.

14.3.2 The water meter's built-in battery shall not be visible and shall be completely secured inside the water meter.

14.4 IP CODE (INGRESS PROTECTION AGAINST DUST AND WATER)

14.4.1 For Integral or Combined version where the sensor (primary device) and transmitter (secondary device) are combined together, the water meter shall be of IP 68 (NEMA 6) rated. For Remote or Separate versions, where the sensor and transmitter are of two components, the sensor and transmitter shall be of IP 68 (NEMA 6) rated.

14.5 METER BODY CONSTRUCTION

Item	Characteristics	Description
1	**Meter Body**	DZR Brass, high quality Brass or Industrial Grade Plastic, suitable for use in aggressive water conditions and capable to withstand against harsh weather conditions.
2	**Internal Materials**	Metal and or Plastic, suitable for use in aggressive water conditions, noting that no moving parts.
3	**Meter Register**	Digital
4	**Power**	If powered with a high capacity built-in battery, then minimum operational life shall be at least 10 years. Manufacturer to state type/category of battery and its maximum life span.
5	**Method of Measurement**	Volumetric Solid State
6	**Error Measurement**	+ 2%, at least Metrological Class C
7	**Unit of Measurement (nos. of digits shown on flow meter's display to read the volume)**	Simple straight reading (Minimum 7 digits), the cubic meter display to consist of minimum 5 Nos. digits in 'Black' and the fraction display to consist of minimum 2 Nos. digits in 'Red' border or better, approved by the Engineer.
8	**Working Pressure**	16 Bar (as per discretion of the Engineer)
9	**Minimum Test Pressure**	20 Bar (as per discretion of the Engineer)
10	**Fixing Positions**	Meters must be suitable for fixing in any orientation in vertical, without loss of accuracy, i.e. Class C.
11	**Meter Connections**	Meters to be supplied with brass (DZR or high quality) union type (cap and lining) tailpieces all threaded on major pipe connections and are to be BSP or as approved by the Engineer.
12	**Working Temperature**	Meter to be suitable for use with water temperature up to and including 50 °C and ambient temperature up to 70 °C.
13	**Additional Requirements**	a) Meters to be supplied must incorporate, in the design, both a strainer and non-return valve, contained within the meter body, as per discretion of the Engineer. b) The meter must not require accuracy adjustment over a ten years period. If this requirement is not met, manufacturer shall highlight the specified duration. c) The meter must not loose accuracy with water borne particulate passing through meter. d) The meter must not suffer wear damage due to airflow passing through the meter. e) The water meter shall be 100% Maintenance Free with no moving parts within the measuring chamber. f) In case of accidental damage to the meter or its components due to external sources, the manufacturer shall clearly state on his offer / submittal the list of spares for replacing the damaged components, i.e. display or totalizer.

14.6 MATERIALS APPROVAL

14.6.1 All material and associated componenets intended to be used for this project must be approved by the Materials Stanadards Section of Kahramaa, prior to place firm order for purchasing.

Section - 15
Electronic Flow meters [Bulk & District]

15.1 CHARACTERIZATION

These clauses shall be read in continuation of Section 1 of this specification.

15.1.1 The flow meter should be a new technology Microprocessor based, Electronic flow meter to measure & monitor a Bi-directional volumetric flow rate (Actual Flow rate, Totalizer & sum Totalizers), for full filled pipe and/or partially filled pipelines flow conditions.

15.1.2 The flow meter shall have the facility to link any future monitoring & data-acquisition systems such AMR (Automatic Meter Reading), SCADA etc...

15.1.3 The Electronic flow meter shall be Electromagnetic type, Ultrasonic or other with an optimum accuracy, long-term stability, automatic zero error averaging and low power consumption to be approved by the project Engineer.

15.1.4 Each flow metering system (Electromagnetic type) shall comply with EN ISO 6817, 1995 and/or ISO 4064 Part 1 or equivalent and comprise a flow sensor (primary device) mounted in the flow line and a separate Signal Converter or Electronic Display Unit (EDU) (secondary device).

15.1.5 For Ultrasonic type, Technical codes, Standards, Data sheet to be revised and approved by the project Engineer.

15.1.6 The meters shall be suitable for use with water temperatures of 50 C° at pressure up to 16 bars. End connection for sensor shall be drilled to BS 4504, PN 16, or equivalent ISO/DIN standards

15.1.7 The flow meter shall be carefully sited on live water main in accordance with EN ISO 6817 and the flow meter manufacturer's recommendation. Particular attention should be paid to the provision of the correct velocity range, Earthing rings, Electrodes and the correct In-and-Outlet straight section of upstream and downstream.

15.1.8 Flow meters shall be of 'Remote/separate type' (primary and secondary devices are connected by a cable) or 'Integral/compact type' (primary and secondary devices are mounted together without a cable) as suitable for installation at various site conditions.

15.1.9 Flow meters located within flow chambers of areas subject to flooding shall be rated to IP68. Signal converters or EDU (secondary device) shall not be located in these areas and be kept aboveground service cabinet.

15.1.10 The system accuracy shall be a maximum at normal operating flow with an error of not more than + 0.5% of the reading for AC powered, battery powered or solar powered meters. The flow meter shall measure with such accuracy even at very low-flow rates and manufacturer's catalogues & data sheets to specify the minimum velocity, which the flow meter can measure.

For partially filled pipelines flow meter with a duty filling level range 10-100 % of the pipe cross section, The system accuracy shall be a maximum at normal operating flow with an error of not more than + 1-5 % (at different flow velocities) of the reading for AC powered, battery powered or solar powered meters. The flowmeter shall measure with such accuracy even at very low-level of water in the pipe line (filling ≥10 % of inside tube diameter). Manufacturer's catalogues and data sheets to specify the minimum velocity, fill level and related accuracies.

15.2 PRIMARY DEVICE (SENSOR):

15.2.1 Flow sensors shall comprise of a meter tube assembly containing all necessary electrodes, housing and terminations suitable for operation without loss of accuracy when totally submerged to a depth of 3 meters. The flow sensor shall be rated to IP68 (NEMA 6) according to IEC529/EN 60529 and be suitable to indefinite submergence of above depth.

15.2.2 The sensor shall be made from a non-magnetic material lined with an inert material as per requirement of EN ISO 6817, 1995 suitable for potable water at 50 C° and fitted with flanges as specified. The lining material shall extend from the bore of the tube to fully cover the face of the tube flanges.

15.2.3 The sensor's liner shall be certified by an internationally recognized body such as WRc, NSF-61 or equivalent worldwide known body certifier. Acceptable electrode material is stainless steel or other to be approved by project Engineer.

15.2.4 Any taper pieces necessary to give the correct velocity range through the flow meter shall be installed at upstream and downstream of sensors, as necessary and instructed by the project Engineer.

15.3 SECONDARY DEVICE (SIGNAL CONVERTER)

15.3.1 This will be kept aboveground within a service cabinet or inside covered meter room and shall be of IP65 (NEMA 4) rated. In case of underground installation inside a flow chamber of areas subject to flooding, then it shall be of IP68 (NEMA 6) rated.

15.3.2 The flow meter's signal converter shall be suitable for 240V or 110V AC operation (92 to 255 volt AC 48 to 63 Hz supply) without the need for link setting or voltage selection. The nominal voltage used in the State of Qatar is 240V/415VAC + 6% with nominal mains frequency of 50 Hz + 0.1 Hz. In addition, automatic battery backup system must be available to ensure no loss of metering during AC power down periods as per the discretion of the project Engineer.

15.3.3 Alternatively, where in places AC power supply is not available, the meter shall be suitable for operation from long life lithium batteries or solar power supply module with backup batteries that provide an operating life of at least 3 years. It shall be possible to change the batteries onsite and shall incorporate a battery management system to ensure there is no interruption to flow measurement during battery change-over. The lithium batteries shall have a minimum shelf life of at least 10 years.

15.3.4 High contrast, illuminated graphics LCD screen, temperature compensated and excellent readability which shall indicate the flow direction, actual flow rate and forward, reverse & sum flow totalizers in user-defined standard engineering units, and status & Error messages, with the date & time. Menu selection facility allowing parameters configuration such range, units, settings.

15.3.5 The flow sensor shall be intelligent such that any associated signal converter or electronic display unit can be connected to it without subsequent programming or configuration, with capability to store data in a non-volatile memory for a minimum retention of 5 years.

15.3.6 Flow meter preferable to have features for alarm during empty pipe, maximum and minimum flow rates and meter status, with a configurable low-flow cut-off.

15.3.7 The meter software shall incorporate password protection to prevent inadvertent or fraudulent programming or units of measurement changes. The totalisers function shall be user selectable by means of software programming.

15.3.8 Input & output (current, pulse, alarms) signals shall be galvanically isolated from input & output circuits, with a software management system allow all data to be configurable.

15.3.9 The secondary device (Transmitter) shall have an extensive self diagnostic mechanism & error tracking capability (function) in such forms (alphanumerical messages, signal over an output contacts)

15.3.10 Meter shall havc provision for remote communication through GSM or radio transmitters or any other modes facilitating continues monitoring & remote on-line diagnostics, configuration and data retrieval

15.3.11 Flow meter preferable to have an integrated data logging facility, and communication port (RS232 or RS485) for data upload & download using portable handheld device or PC.

15.4 FLOW METER SENSOR-TRANSMITTER CABLING:

15.4.1 For remote/separate type flow meters, the Contractor shall supply the flow meter standard pre-cabled with appropriate length as per various site conditions in line with Engineer's instruction. Type of cable shall be armoured or others to be approved by the project Engineer. The cable connection box shall be potted and/or sealed in accordance with the IP rating. Where necessary the cables shall be terminated adjacent to the flow head in an IP68 rated polycarbonate enclosure or equivalent. The manufacturers' recommendations regarding the cable screening and earthing requirements must be strictly adhered to.

15.5 TESTING & COMMISSIONING

15.5.1 Nominal pressure 16 bar, Test pressure 20 bar. A factory test certificate shall be issued for each meter giving its serial number. This certificate shall be submitted to KAHRAMAA at the time of supply, if necessary.

15.5.2 Carry out the required site testing of flow meters after installation and operation, which guarantee that the flow meters & other accessories are functioning properly.

15.6 MATERIAL CONSTRUCTION

15.6.1 Sensor (primary device) and electrode shall be manufactured as per the requirements of EN ISO 6817, 1995 for electromagnetic type. For Ultrasonic type, material construction, data sheet and all necessary technical documents to be submitted for the approval of the project Engineer.

15.6.2 Fasteners shall be as per Section 1, Clause 1.6 of Kahramaa General Specification for Main laying Materials for Waterworks – January 2003 or any update

15.7 CERTIFICATES AND STANDARDS

15.7.1 30. Calibration Certificate: The manufacturer shall submit calibration certificates with every single flow meter by which the Serial Number/Part No. of the water meter shall match the calibration certificate.

15.7.2 The meter performance shall have been verified on a fully traceable test facility that is internationally accepted. Laboratory traceability packs shall be available on request of Kahramaa.

15.7.3 The water meter manufacturer shall be ISO 9001 certified and the offer must include the ISO certificate. The meter shall be designed and manufactured under the ISO 9000 series of quality standards. It shall also have flange-to-flange length (lay length) to ISO 13359 standard for electromagnetic meters up to 400 mm dia and for bigger sizes to be approved by the project engineer to facilitate interchangeability of product. For Ultrasonic type, relevant Technical codes & Standards, to be revised and approved by the project Engineer.

15.8 DOCUMENTATION AND TRAINING

15.8.1 The contractor shall supply the original installation, operation, and service manuals in both hardcopy & softcopy format.

15.8.2 Factory official training program should cover the following flow meter aspects: Calibration, Installation, Operation, Configuration and Maintenance.

15.9 SPARE PARTS AND TOOLS

15.9.1 Contractor should include a separate offer (in addition to his original offer) detailing all necessary flow meter's spare parts with its unit price.

15.9.2 The above offer should include all necessary equipments, tools, software's and portable handheld devices and PCs for testing, configuration and data downloading.

15.10 EQUIPMENT MARKING

15.10.1 Electromagnetic type:

A. **Primary Device Mandatory Data,** The following data shall be impressed either on the primary device or on a name plate:
   - Instrument type, model and serial number.
   - Nominal diameter, rated pressure and temperature.
   - Protection class IP, and sensor calibration factors.
   - Ordering information (order part no.).

B. **Secondary device Mandatory Data,** The following data shall be impressed on a name plate:
   - Instrument type, model and serial number.
   - Power supply: voltage, frequency and power rate.
   - Output signals, Limiting load impedance.
   - Ordering information (order part no.).
   - Protection class IP.

15.10.2 For Ultrasonic type:

For Ultrasonic or any other technology, The Standard marking of the same shall be checked by the concern Engineer for approval.

Section - 16
S.S. Repair clamps & Under pressure Drilling Tees

16.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

16.1.1 The repair clamps and under pressure drilling tees shall be suitable for use with Ductile Iron pipes manufactured to BSEN 545/ISO 2531. All pipe diameters being metric.

16.1.2 All units shall be supplied complete and ready for use.

16.1.3 All units are to be supplied in minimum of Two (02) bands segments for easy handling during installation.

16.1.4 All units are to have 'Finger' lugs to ensure bolt guidance and alignments of units during installation.

16.1.5 All units are to have a suitable method of jointing between the stainless steel band of the clamp body and the lugs containing the bolts etc.. The preferred method of jointing is by 'pinning'; the Tenderer shall specify the method of jointing at the time of tendering.

16.1.6 In the case of under pressure drilling tees, the method of jointing the branch to the main clamp body shall also be set out in the offer. In the case of welded joints, the method and standards of welding and preparation shall be set out.

16.1.7 The packing of all units shall provide protection from damage during transit and be suitable for storage once delivered.

16.1.8 The inner diameter of S.S. Repair clamps shall be suitable to the outer diameter of the D.I. Pipes as per ISO 2531 / BSEN 545.

16.2 MARKING

16.2.1 Repair camps and under pressure tees are to be supplied with each unit marked with the following information: -

- Manufacturer's name.
- Size of pipe for which the unit is manufactured for.
- Direction of rotation.
- Size of branch
- Grade of stainless steel.

16.3 MATERIALS

16.3.1 The repair clamps and under pressure drilling tees shall be manufactured from high grade Stainless Steel to BS-1449, Para 2 - 316L/S12 or similar approved.

16.3.2 'Finger' lugs may be manufactured from cast or malleable iron, ductile iron, steel or stainless steel. In all cases, other than the lugs manufactured from stainless steel, the lugs must be protected from corrosion by a suitable coating; this is to be specified at the item of tendering.

16.3.3 Fasteners shall be manufactured from stainless steel.

16.3.4 The gaskets used in all units shall be of EPDM (EDK-70), suitable for use with potable water and full details of the same shall be included with the tender offer.

16.4 LENGTHS OF THE CLAMP

16.4.1 Lengths of the repair clamp must fall within the ranges set below;

Type	Minimum Length	Maximum Length
A	300 mm	450 mm
B	500 mm	600 mm
C	750 mm	1000 mm

16.4.2 The Tenderer shall specify at the time of tendering the exact length of the clamp he is to offer to comply with each of the above ranges.

16.5 FLANGES

16.5.1 The flanges fitted to the branch outlet of the under pressure drilling tees are to be drilled to BS 4504, PN-16.

16.5.2 The branch must be of stainless steel.

Section - 17
Concrete and Ancillary Items

17.1 CONCRETE

17.1.1 All concrete shall be made using the sulphate resisting cement and shall comply fully with the specification set by the Ministry of Municipal Affairs & Agriculture in the QNBS.

17.2 PRE-CAST CONCRETE CHAMBER SECTIONS

17.2.1 Pre-cast concrete chamber sections shall be of grade SRC-30/20, concrete made with sulphate resisting cement.

17.2.2 Pre-cast concrete chamber sections shall be of the size and shape as detailed in standard drawings in Appendix C .

17.3 IMPREGNATED FIBER BOARD

17.3.1 Pipelines that are surrounded with concrete are to have expansion joints as specified. These joints are to be formed by the use of bitumen impregnated fiber board.

17.3.2 The fiber board shall be bitumen impregnated 19mm thick and generally conform to ASTM-1751 standard.

17.3.3 The contractor is to supply details of fiber board to the Engineer for approval.

Section - 18 Polyethylene Pipes & Fittings For Service Connections (MDPE)

18.1 GENERAL

18.1.1 Polyethylene Pipes & Fittings used for conveyance of potable water shall be manufactured in accordance with DIN-8074, BS 6730, BS 6572, ISO 4427 or equivalent and shall be manufactured by ISO Certified Company.

18.1.2 Polyethylene Pipes shall be MDPE, PE-80, SDR 11, PN-12.5 bar at 20°C.

18.1.3 Polyethylene Pipes shall be blue in colour of either solid wall or multi-layer construction

18.1.4 Hydrostatic Test Pressure shall be 1.5 times the working pressure at 20°C.

18.1.5 Polyethylene Pipes & fittings shall be Kite Marked certifying it complies with ISO 4427 or equivalent DIN, BS Standard.

18.1.6 Pipe manufacturers must furnish test certificate in accordance with EN 10204-3.1 for batches of MDPE supplied.

18.1.7 Polyethylene Pipe shall be protected with GRP duct when laid aboveground along customer wall premises. Two sizes are allowed; 2" duct for 20mm ($^1/_2$"), 25mm ($^3/_4$") & 32mm (1") and 3"duct for 50mm (1$^1/_2$") & 63mm (2"). The GRP duct shall be of semi-circular shape and be firmly fixed to the wall with brackets.

18.1.8 Polyethylene Pipe shall have trench marker tape of 100mm wide with aluminum stripe at its centre to detect the pipe through metal detector.

18.2 POLYETHYLENE PIPES (MATERIAL)

18.2.1 The polymer used for the manufacturing or the products must be approved by World wide Known Quality Body Certifier such as WRc , DVGW, etc. in contact with potable water at 50° C.

18.2.2 The Pipes & Fittings used for conveying potable water or likely to come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth and shall not give rise to unpleasant taste, or odor, cloudiness or discoloration of water.

18.2.3 Polyethylene shall be manufactured from virgin polyethylene resin of a single or bi-modal process of manufacture. Master batching and/or re-grind material is not permitted.

18.2.4 Polyethylene pipes installed in the water meter service cabinet between stop cock and water meter or in direct sunlight shall be black in colour, UV resistant, of solid wall construction to ISO 4427, all as per discretion of the Engineer.

18.2.5 The polyethylene pipe shall meet the following specification:-

Specification	Value
Min density measured according to	949 Kg/m^3

ISO 1872	
Melt flow rate measured according to ISO 1133	@ 2.16 Kg. Load= 0.18g/10min. @ 5 Kg. Load = 0.18/10min.
Tensile Strength at yield	18 Mpa
Elongation at break	600 %
Elongation	10 %
Thermal conductivity	0.32 W/m° K
Vicat Softening point at 1 kg. load	122°C
Flexural Modulus- ASTM D790	900 MPa
Tensile strength ASTM D638	30 MPa
HDT @ 0.46 MPa – ASTM D648	90°C
HDT @ 1.82 MPa – ASTM D648	58°C

18.3 LENGTH AND SIZE

18.3.1 PE pipes are normally supplied in in coils as per the table below (or in bundles of straight lengths of 6 or 12m as per the discretion of the Concerned Engineer):

MDPE Pipe sizes (in mm) and coils (in meters).

Nom. Ø	Min. Ø	Max. Ø	Min. Wall Thickness	Max. Wall Thickness	Max. Coil Length
20	20	20.30	2.30	2.80	500
25	25	25.30	2.30	2.80	400
32	32	32.30	3.00	3.50	300
40	40	40.30	3.70	4.30	300
50	50	50.30	4.60	5.30	300
63	63	63.40	5.80	6.70	200

18.3.2 The ovality of the pipe in coils as manufactured shall not exceed the value of 0.06 of the nominal size of the pipe.

18.3.3 The ovality of the pipe in coils after relaxation and straight pipe shall not exceed the value of "1 + (0.008 of the nominal size of the pipe).

18.4 FITTINGS

18.4.1 Fitting shall be compression type (either PP-R or Gunmetal) to suit MDPE Pipe and must be UV resistant.

18.4.2 Fittings for use with MDPE SDR11 pipe shall have a pressure rating of PN16 @ 20 deg C for standard fittings and PN 12.5 for universal transition couplings (PE to copper, PVC-U, steel)

18.4.3 Fittings shall be manufactured under a Quality Assurance System assessed and approved to ISO 9002.

18.4.4 Fittings for polyethylene shall be approved to ISO9080 (Plastic piping and ducting systems- determination of the long term hydrostatic strength of thermoplastic materials in pipe form by extrapolation) or equivalent.

18.4.5 Fitting bodies and nuts shall be made from polypropylene using at least 90% virgin raw material so to comply with the following performance.

Properties	Test Method	Value
Flexural Modulus	ASTM D790	900 MPa
Tensile Strength	ASTM D638	30 MPa
Elongation	ASTM D638	10 %
HDT @ 0.46 MPa	ASTM D648	90°C
HDT @ 0.46 MPa	ASTM D648	58°C
Density	ASTM D792	0.9g/cc
Chemical Resistance		Excellent
Water absorption		None

18.4.6 Fittings for PE connection shall be supplied complete with pre-assembled and captivated grip ring and "O" ring.

18.4.7 Fitting color shall be black so as to minimize potential light transmission and/or UV degradation.

18.4.8 Fittings shall comprise an internal positive stop to ensure perfect installation.

18.4.9 The compression fittings must conform with the following relevant internationally standards performance requirements:-

Test Criteria	Standard
Dimensions of the threads	ISO 7/1, BS 21
Pressure testing- tightness of the joints	ISO 3458
Internal Pressure resistance of the joints when subjected to bending stress	ISO 3503
Resistance to pull-out of test assemblies @ 20°C	ISO 3501
Internal under-pressure test	ISO 3459
Long term pressure test	ISO/DIS 14236

18.5 STOP VALVE:

For underground installation - Stop Valve shall be made of Gunmetal BS 5433 crutch head with gunmetal ended compression couplings to fit MDPE pipe both sides for all size range from 20mm up to 63mm.

For aboveground installation inside/outside service cabinet before water meter – Stop valve shall be of Brass tamper proof lockable type as per discretion of the concerned Engineer. Suitable size of gunmetal or polypropylene (PPR) compression couplings at both sides shall be used in connecting MDPE Pipe of all size range from 20mm up to 63mm.

18.6 FLANGED FITTINGS:

Flange Adaptor to join MDPE pipe to flanged equipments (63mm OD MDPE pipe to 2" dia flange to BS 4504/ISO 7005, BS EN 1092-2 with PN 16 rating), material: black coated Steel or SG Iron to BS EN 1563:1997 Grade EN-GJS-450-10, Gasket: EPDM compound Grade 'E'.

18.7 SADDLE STRAPS

18.7.1 Saddle straps for service connections shall be flat boss type suitable for tapping from ½" up to 2" diameter ferrule. The strap shall be suitable for making service connections under pressure or dry using approved tapping machine into DI, AC Steel or PVC pipes. The saddle shall be of two parts fitted with EPDM sealing gasket in a groove on the underside of the flat boss.

18.7.2 The flat boss shall be cast with a hole or marking through the boss to facilitate the drilling and tapping process. The straps shall be supplied un-drilled.

18.7.3 The saddle strap shall be of gunmetal to BS 1400-LG2 with stainless steel nuts, bolts and washer to ISO 3506 and shall be suitable for a working pressure of up to 16 bar.

18.7.4 The name of manufacturer, patent number, pipe diameter to which the strap is suitable, and pipe material shall be engraved on the saddle strap.

18.7.5 The saddle strap shall be accompanied by manufacturer's certificate stating date of manufacture, material specification.

18.8 FERRULE

18.8.1 Ferrule shall be of gunmetal BS1400 LG2 body with gunmetal compression coupling outlet suitable to fit directly with MDPE service pipe of all size from 20mm to 63mm, for Underground application. Gunmetal with PE compression coupling outlet is unacceptable.

18.8.2 Ferrules shall be the screw down valve type allowing for the shut off of the flow by means of Ω" square head spindle extending from the top cap for opening and closing. The valve shall close clockwise.

18.8.3 The ferrule stem, banjo, spindle, inner plug and top cap shall be of gunmetal to BS 1400-LG2. The washers shall be of EPDM and shall provide the sealing between the outer body and the ferrule stem. A polyethylene top plug shall prohibit the ingression of dirt.

18.8.4 The ferrule shall be designed as a main stem with a 360° swivel outlet at 90° with control of water flow via the threaded inner plug. The inlet shall be male taper thread to BS 21.

18.8.5 The ferrule shall be suitable for drinking water at a temperature of up to 50°C and capable to sustain a working pressure of up to 16 bar without leakage.

18.8.6 The ferrule shall permit the installation of service connection using under pressure tapping through flat boss saddle straps.

18.9 JOINTS

18.9.1 Fittings shall be of the slide and tighten type using a dynamic sealing method and positive grip.

18.10 MARKING

18.10.1 Pipes shall be marked as follows:-

1. Manufacturer's name
2. Standard
3. Nominal size of pipe in mm [nominal outside diameter x nominal wall thickness]
4. SDR

5. Pressure rating in Bar
6. Month & year of manufacture.
7. Body of the fittings should have Manufacturer's name/ logo.

18.11 PACKAGING

18.11.1 All compression fittings must be individually packed in transparent protective bags indicating its type and size.

18.11.2 All compression fittings must be packed in cartoon boxes.

18.11.3 If only one type of product is packed all cartoon boxes shall have a label showing the manufacturer identification, the description of the product, the drawing of the product, the relevant size and the quantity.

18.12 HANDLING & STORAGE

18.12.1 Pipes and Fittings shall be handled and stored carefully as per manufacturer's recommendation.

18.12.2 From manufacturer to laying stage, Pipes & Fittings shall be stored and transported in covered area to avoid direct sunlight.

18.12.3 All damaged Pipe & Fitting due to mishandling shall be rejected.

18.12.4 The height of stack of pipes shall be as per manufacturer's recommendation.

Section - 19
uPVC Duct

19.1 GENERAL

These clauses shall be read in continuation of Section 1 of this specification.

19.1.1 All uPVC Duct should be manufactured, and test according to BS EN 1401-1.

19.1.2 uPVC Duct Color should be orange-brown (approximately RAL 8023) or dusty grey (approximately RAL 7037) in color.

19.1.3 Dimensions of the Ducts:

Nominal Size (DN/OD)	Nominal Outside Diameter (dn)	Mean Outside Diameter		Wall Thickness SN2 SDR 41	
		dem,min	dem,max.	emin	emax.
110	110	110.0	110.3	3.2	3.8
160	160	160.0	160.4	4.0	4.6

All Dimension in millimeters

19.1.4 All Ducts should be supplied in 4 meters or 6 meters in length.

19.1.5 The external and the internal surface of the pipe shall be smooth, clean, and free from grooving, blistering, impurities and any other surface irregularity.

19.1.6 Pipe ends shall be cleanly cut and the ends of the pipes shall be square to their axis.

19.2 MARKING

19.2.1 uPVC Duct should be supplied with a center guideline printed on the middle of the duct, where the marking consists of the following:

- Number of Standard. (e.g. EN 1401)
- Manufacturer name and/or trade mark.
- Nominal Size.
- Minimum wall thickness.

19.3 PACKING

19.3.1 As per Section 1, Clause 1.9. of this specification.

APPENDIXES

I. Typical Drinking Water Quality

II. Site Environmental Conditions

III. Drawings

1. Water Meter Service Cabinet

2. Precast Concrete Chamber Slab Construction Details

3. Marker Post, Backing Plates, and Plate

I. Typical Drinking Water Quality

W.H.O. & E.U. GUIDELINES

Sr. No.	Parameter	Unit	Guide Level	Maximum Permissible Level
1	pH	Number	6.5 – 8.5	9.5
2	Total Dissolved Solid (TDS)	mg/L	200 – 600	1,000
3	Alkalinity	HCO3 mg/L	30 Minimum	--
4	Chloride	CL mg/L	25	250
5	Total Hardness	CaCO3	60 Minimum	500
6	Chlorine Residual	CL2 mg/L	0.2	0.5
7	Floride	F mg/L	0.7	1.5
8	Sulphate	SO4 mg/L	25	250
9	Calcium	Ca mg/L	100	--
10	Copper	Cu mg/L	1.0	2.0
11	Sodium	Na mg/L	20	200
12	Iron	Fe mg/L	0.30	2.0
13	Manganese	Mg mg/L	0.1	0.50
14	Magnesium	Mg mg/L	30	50
15	Aluminum	Al mg/L	0.05	0.2
16	Nitrate	NO3 mg/L	25	50

- Bacteriological Quality of drinking water.

Organisms	Guideline value
All water intended for drinking E. coilthermo tolerant coliform bacteria	Must not be detectable in 100-ml sample
Treated water entering the distribution system E coil thermotolerant coliform bacteria Total coliform bacteria	Must not be detectable in 100-ml sample Must not be detectable in 100-ml sample. In the case of large supplies, where sufficient sample are examined, must not be present in 95% of samples taken throughout any 12-month period.

*****

II. Site Environmental Conditions

State of Qatar is classified as being among the worlds most arid and desert regions. The rainfall is concentrated in the Winter & Spring period (December to March) with an average of 50 – 80mm per annum. No discernible pattern in rainfall occurrence is apparent, but there is a tendency of rainfall to occur more often during February & March. Rainfall can be heavy with poor natural drainage resulting in surface flooding.

Month	Temperature Degrees Centigrade			Humidity %	
	Mean Max.	Mean Min.	Mean Daily	Mean Max.	Mean Min.
January	22.3	13.1	17.5	90.7	51.9
February	22.7	12.7	17.5	82.8	38.7
March	27.5	16.8	21.8	85.3	40.9
April	31.3	20.0	25.3	80.9	37.3
May	37.6	24.3	30.7	67.6	20.8
June	41.0	26.0	33.6	64.2	20.1
July	41.5	28.3	34.6	71.0	24.6
August	40.7	28.3	34.1	77.7	30.7
September	38.3	25.9	32.0	86.5	38.9
October	35.2	23.0	29.0	83.7	37.0
November	29.8	19.5	24.5	89.9	37.6
December	24.8	14.5	19.4	86.1	46.5

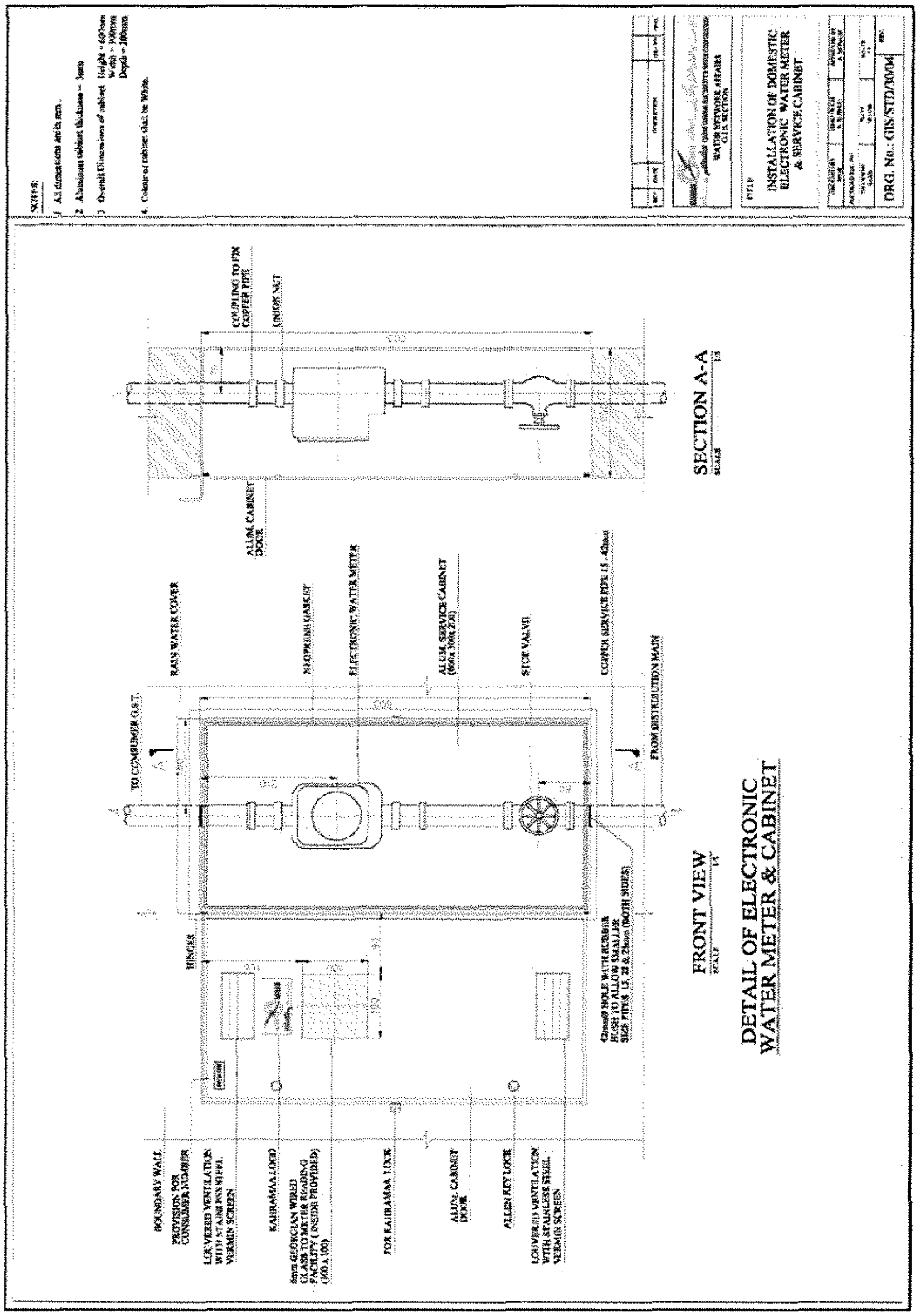
- Minimum-recorded related humidity is 100 %.
- Maximum recorded direct sunlight temperature is 75° C.
- Maximum recorded ambient shade temperature is 51° C.
- Minimum recorded ambient shade temperature is 0° C.
- Site elevation is 2 – 20 M AOD (State of Qatar).
- Prevailing winds are mainly Northerly occasionally with Southeasterly gusts up to 140 Km/h.
- Sandstorms though not severe, do occur and can persist for several days.
- The site is not subject to Industrial pollution, but due to being near the coast; the air can be salt laden with occasional fog. During the winter and spring periods, sever electrical storms with sheet and forked lightning can occur.

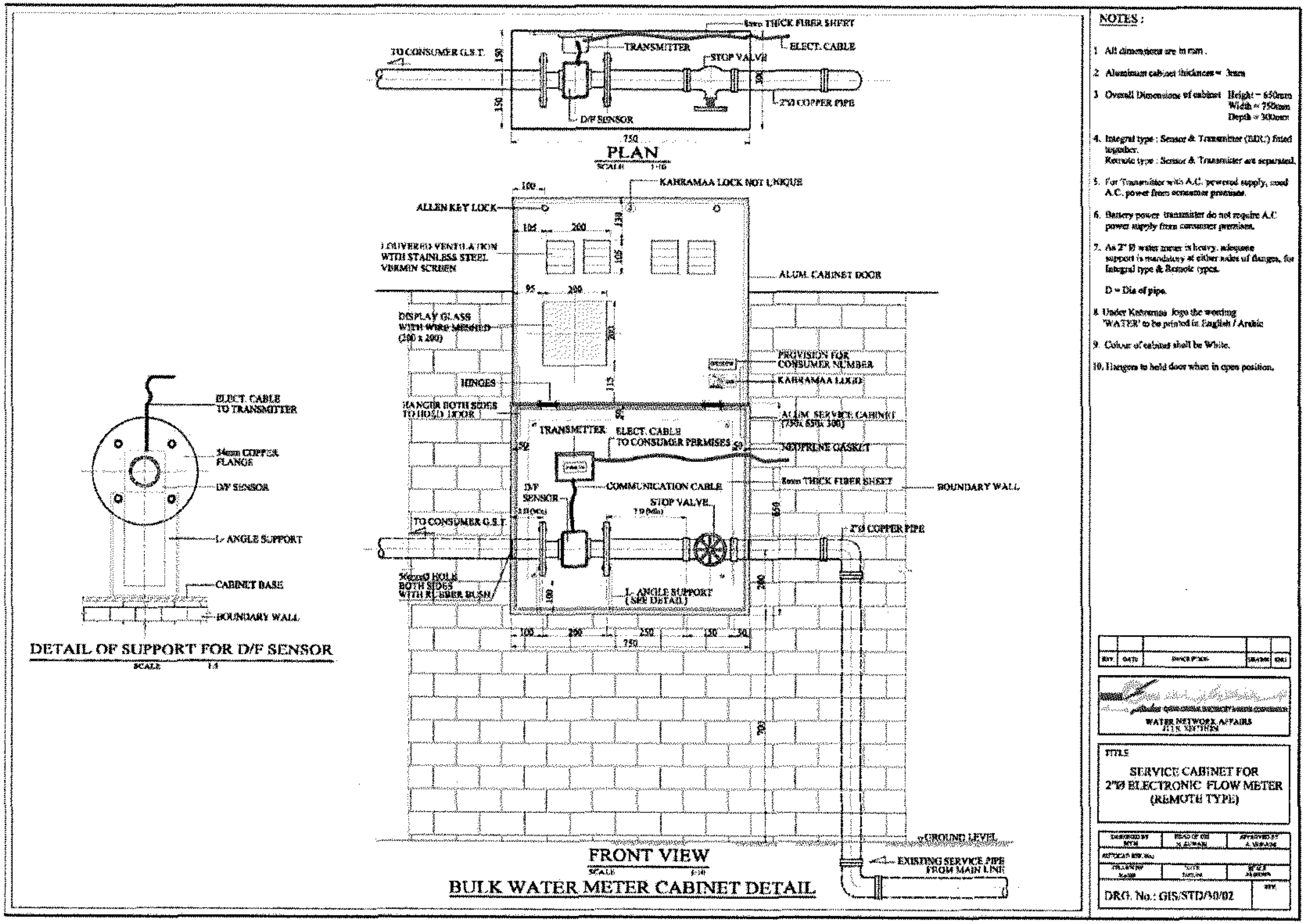
☆☆☆☆☆

III. DRAWINGS

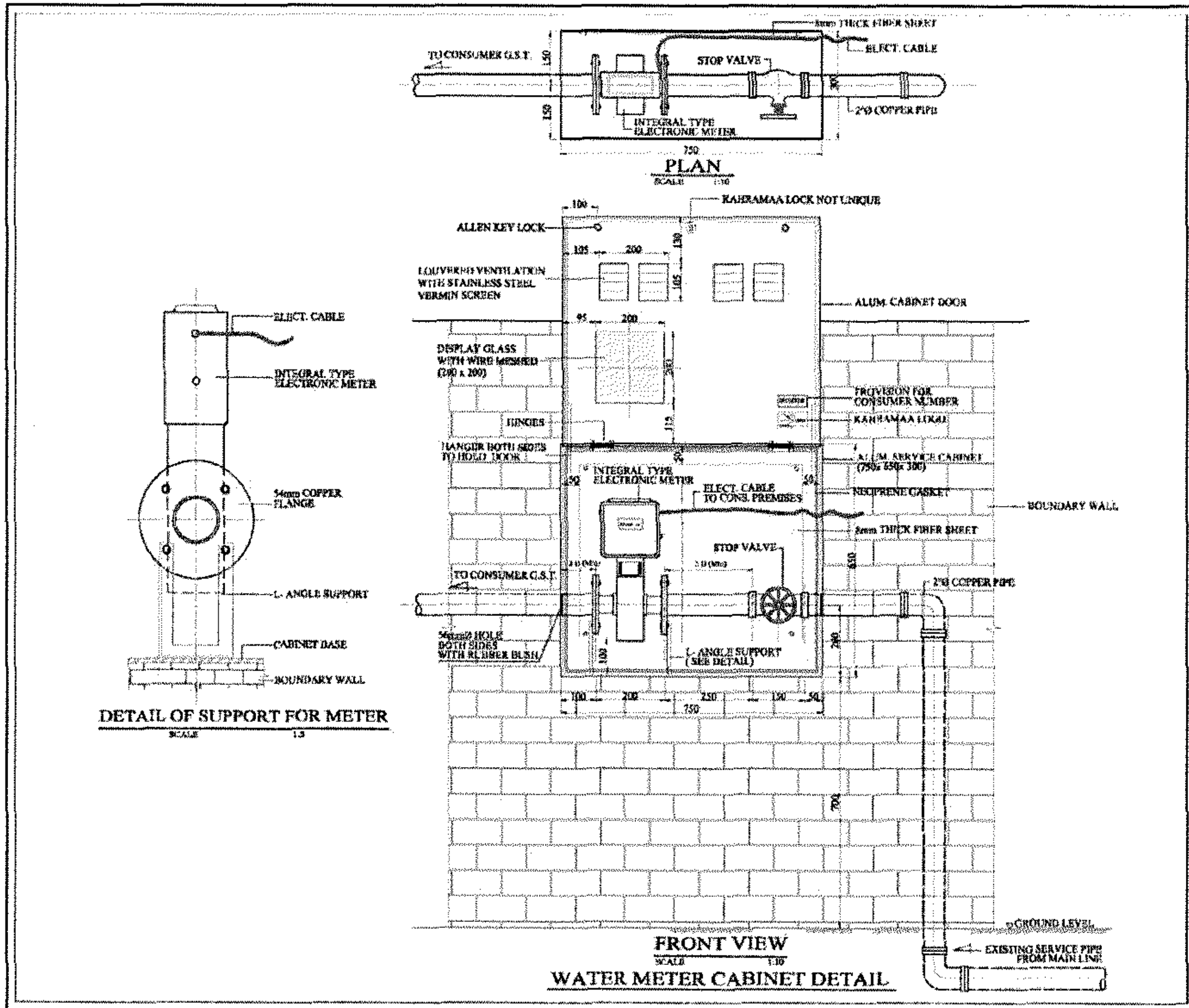
1. WATER METER SERVICE CABINET

- **Domestic Electronic Meter Cabinet – Aluminum**





PLAN
750
TO CONSUMER G.S.T.
TRANSMITTER
ELECT. CABLE
STOP VALVE
2"Ø COPPER PIPE
D/F SENSOR
KAHRAMAA LOCK NOT UNIQUE
ALLEN KEY LOCK
LOUVERED VENTILATION WITH STAINLESS STEEL VERMIN SCREEN
ALUM. CABINET DOOR
DISPLAY GLASS WITH WIRE MESHED (200 x 200)
PROVISION FOR CONSUMER NUMBER
KAHRAMAA LOGO
HINGES
HANGER BOTH SIDES TO HOLD DOOR
ALUM. SERVICE CABINET (750 x 650 x 300)
TRANSMITTER
ELECT. CABLE TO CONSUMER PERMISES
NEOPRENE GASKET
COMMUNICATION CABLE
BOUNDARY WALL
D/F SENSOR
STOP VALVE
TO CONSUMER G.S.T.
2"Ø COPPER PIPE
L- ANGLE SUPPORT (SEE DETAIL)
GROUND LEVEL
EXISTING SERVICE PIPE FROM MAIN LINE
FRONT VIEW
BULK WATER METER CABINET DETAIL
ELECT. CABLE TO TRANSMITTER
D/F SENSOR
L- ANGLE SUPPORT
CABINET BASE
BOUNDARY WALL
DETAIL OF SUPPORT FOR D/F SENSOR
NOTES :
1 All dimensions are in mm .
2 Aluminum cabinet thickness = 3mm
3 Overall Dimensions of cabinet Height = 650mm Width = 750mm Depth = 300mm
4. Integral type : Sensor & Transmitter (ELEC.) fitted together.
Remote type : Sensor & Transmitter are separated.
5. For Transmitter with A.C. powered supply, used A.C. power from consumer premises.
6. Battery power transmitter do not require A.C power supply from consumer premises.
7. As 2" Ø water meter is heavy, adequate support is mandatory at either sides of flanges, for Integral type & Remote types.
D = Dia of pipe.
8. Under Kahramaa logo the wording 'WATER' to be printed in English / Arabic
9. Colour of cabinet shall be White.
10. Hangers to hold door when in open position.
WATER NETWORK AFFAIRS
TITLE
SERVICE CABINET FOR 2"Ø ELECTRONIC FLOW METER (REMOTE TYPE)
DRG. No.: GIS/STD/30/02



NOTES :

1. All dimensions are in mm.
2. Aluminum cabinet thickness = 3mm
3. Overall Dimensions of cabinet: Height = 650mm
Width = 750mm
Depth = 300mm
4. Integral type : Sensor & Transmitter (EDC) fitted together.
Remote type : Sensor & Transmitter are separated.
5. For Transmitter with A.C. powered supply, need A.C. power from consumer premises.
6. Battery power transmitter do not require A.C. power supply from consumer premises.
7. As 2" D water meter is heavy, adequate support is mandatory at either sides of flanges, for Integral type & Remote types.

   D – Dia of pipe.
8. Under Kahramaa logo the wording 'WATER' to be printed in English / Arabic
9. Colour of cabinet shall be White.
10. Hangers to hold door when in open position.

REV	DATE	DESCRIPTION	DRAWN	CHD.

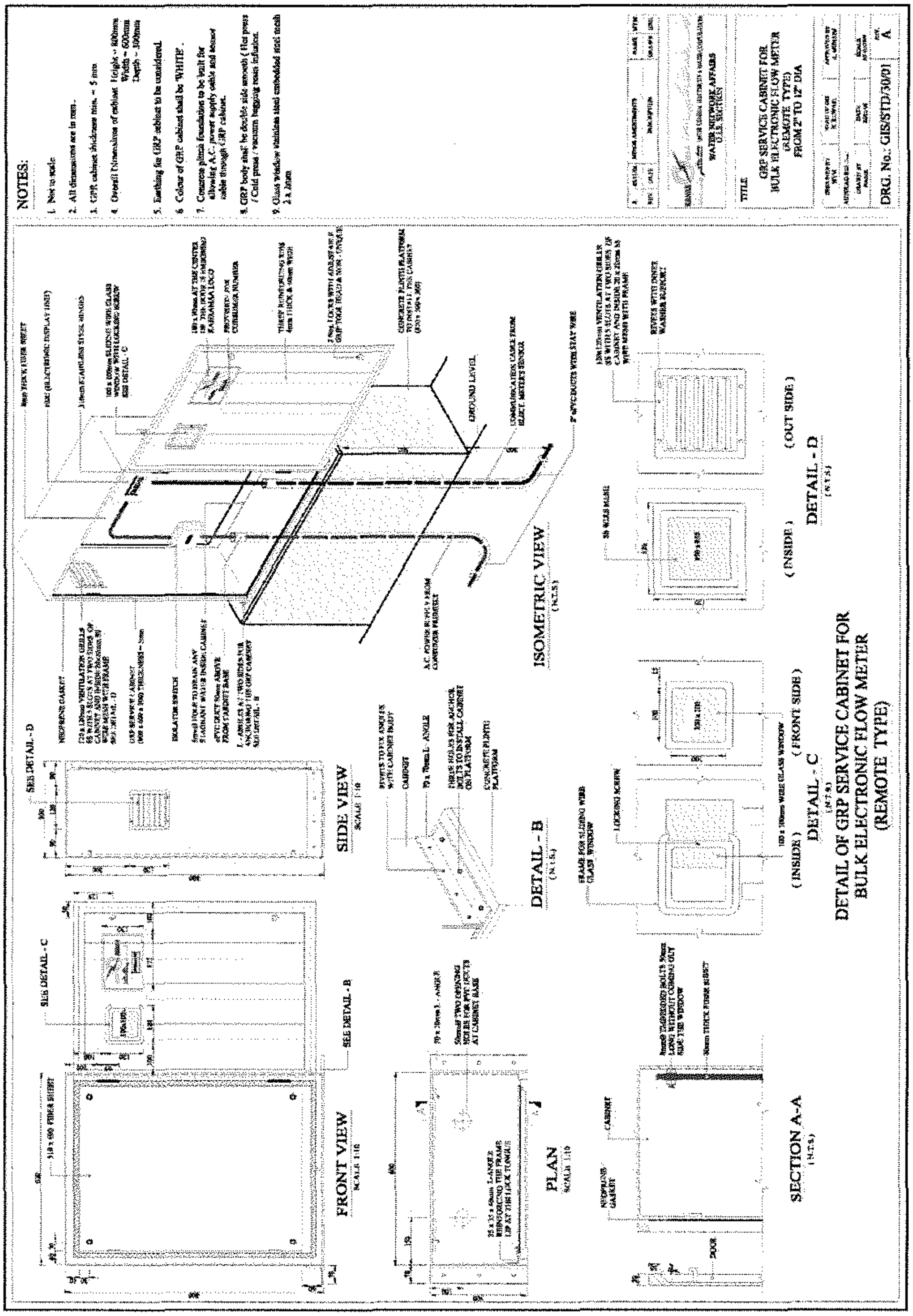
WATER NETWORK AFFAIRS
G.I.S. SECTION

TITLE

WATER METER CABINET FOR 2"Ø ELECTRONIC METER (INTEGRAL TYPE)

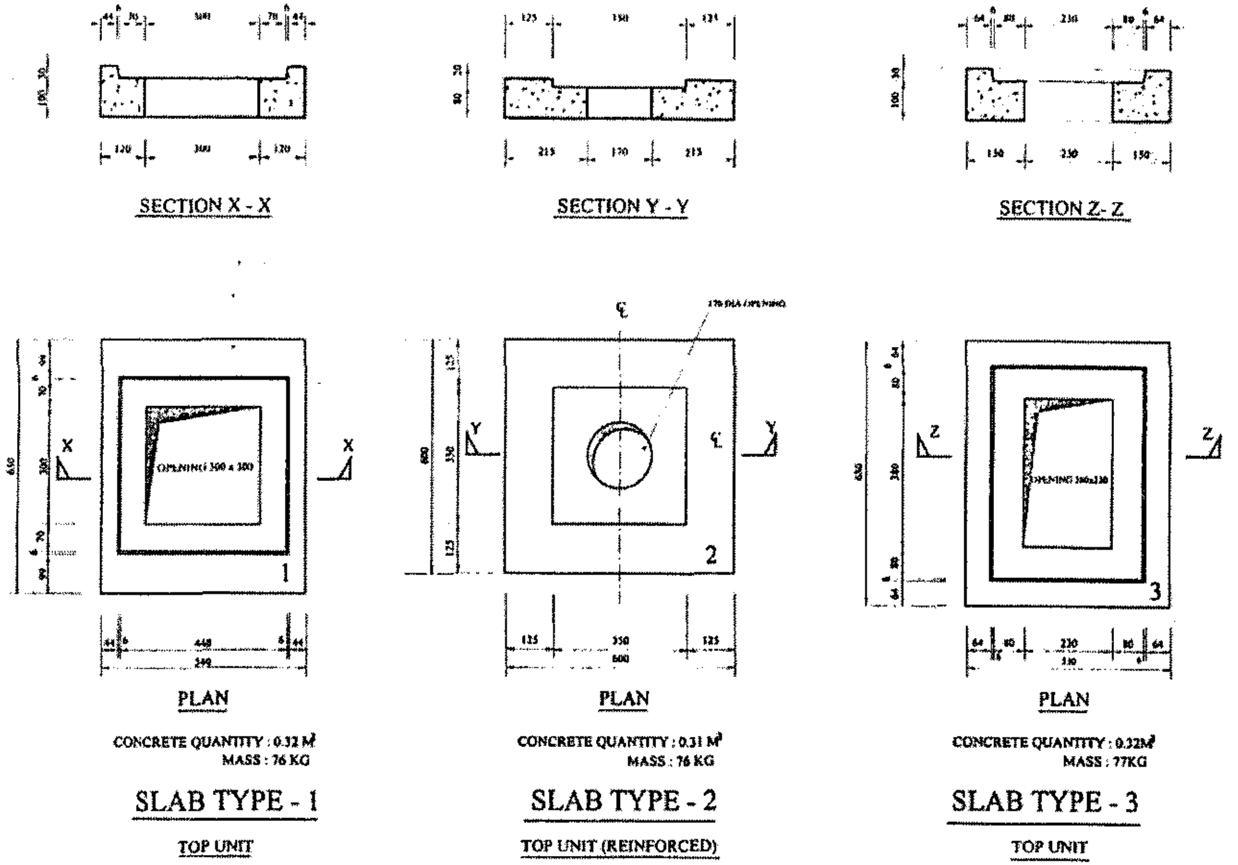
DRG. No.: GIS/STD/30/03

- **2" to 12" Bulk Electronic Cabinet- GRP**



2. PRECAST CONCRETE CHAMBER SLAB CONSTRUCTION DETAILS

NOTES:
ALL DIMENSIONS ARE IN MILLIMETRES



NOTE :- TYPE OF SLAB SHALL BE ENGRAVED ON THE TOP SURFACE FOR IDENTIFICATION

SLAB TYPE

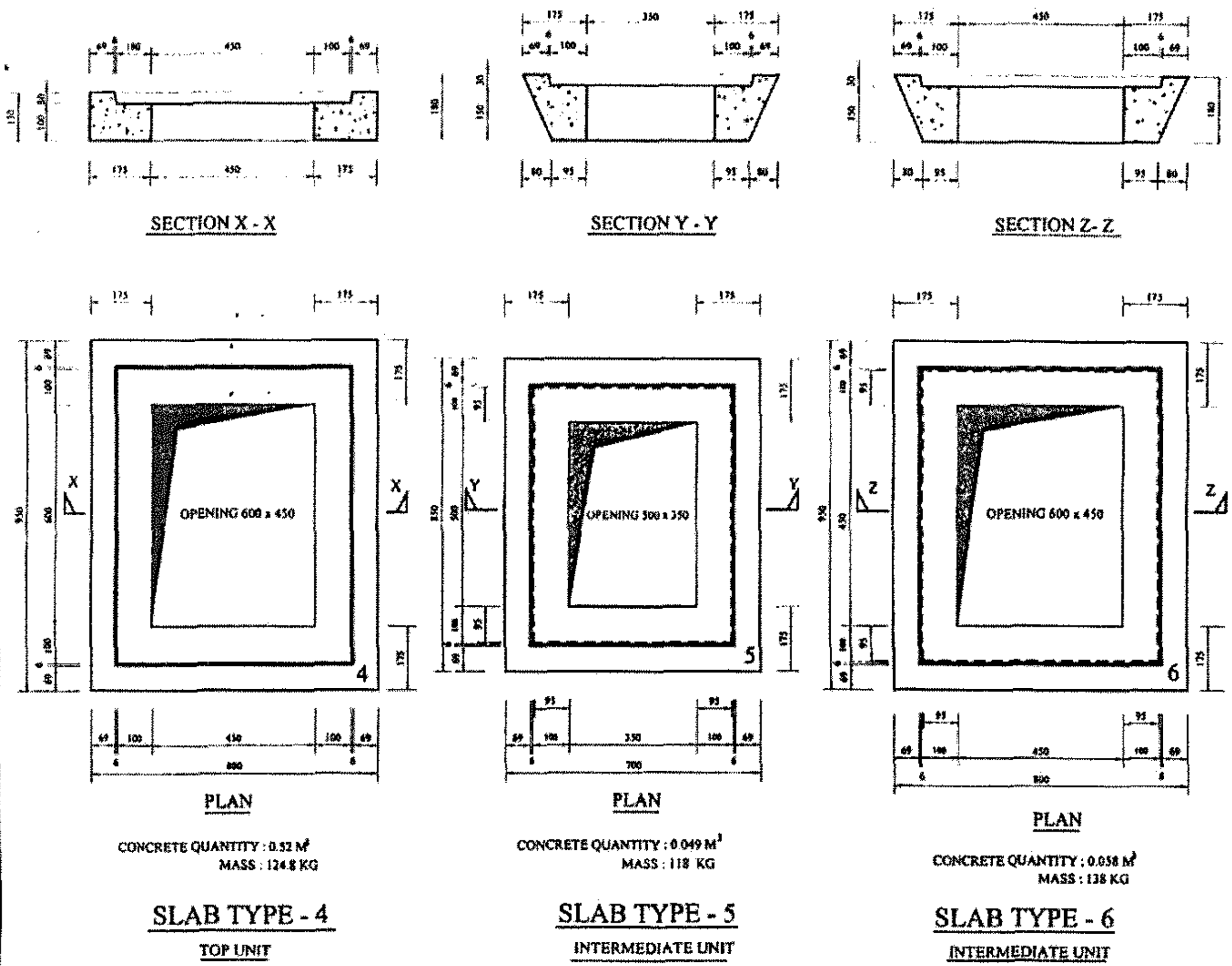
	TOP	INTERMEDIATE	BOTTOM
SINGLE AIR VALVE	1	5	8
DOUBLE AIR VALVE	4	7	10
S. VALVE 150 Ø & LESS	2	--	--
S. VALVE 400 Ø	4	6	9
HYDRANT	3	5	8

WATER NETWORK AFFAIRS

TITLE
PRECAST CONCRETE CHAMBER SLAB CONSTRUCTION DETAILS

AUTOCAD REF. NO.

DRG. NO. STD/1/41/1 REV C



NOTE :- TYPE OF SLAB SHALL BE ENGRAVED ON THE TOP SURFACE FOR IDENTIFICATION

NOTES:
ALL DIMENSIONS ARE IN MILLIMETRES

SLAB TYPE

	TOP	INTERMEDIATE	BOTTOM
SINGLE AIR VALVE	1	5	8
DOUBLE AIR VALVE	4	7	10
S. VALVE 350 Ø & LESS	2	--	--
S. VALVE 400 Ø	4	6	9
HYDRANT	3	5	8

REV.	DATE	DESCRIPTION	DRAWN	ENG

WATER NETWORK AFFAIRS

TITLE
PRECAST CONCRETE
CHAMBER SLAB
CONSTRUCTION DETAILS

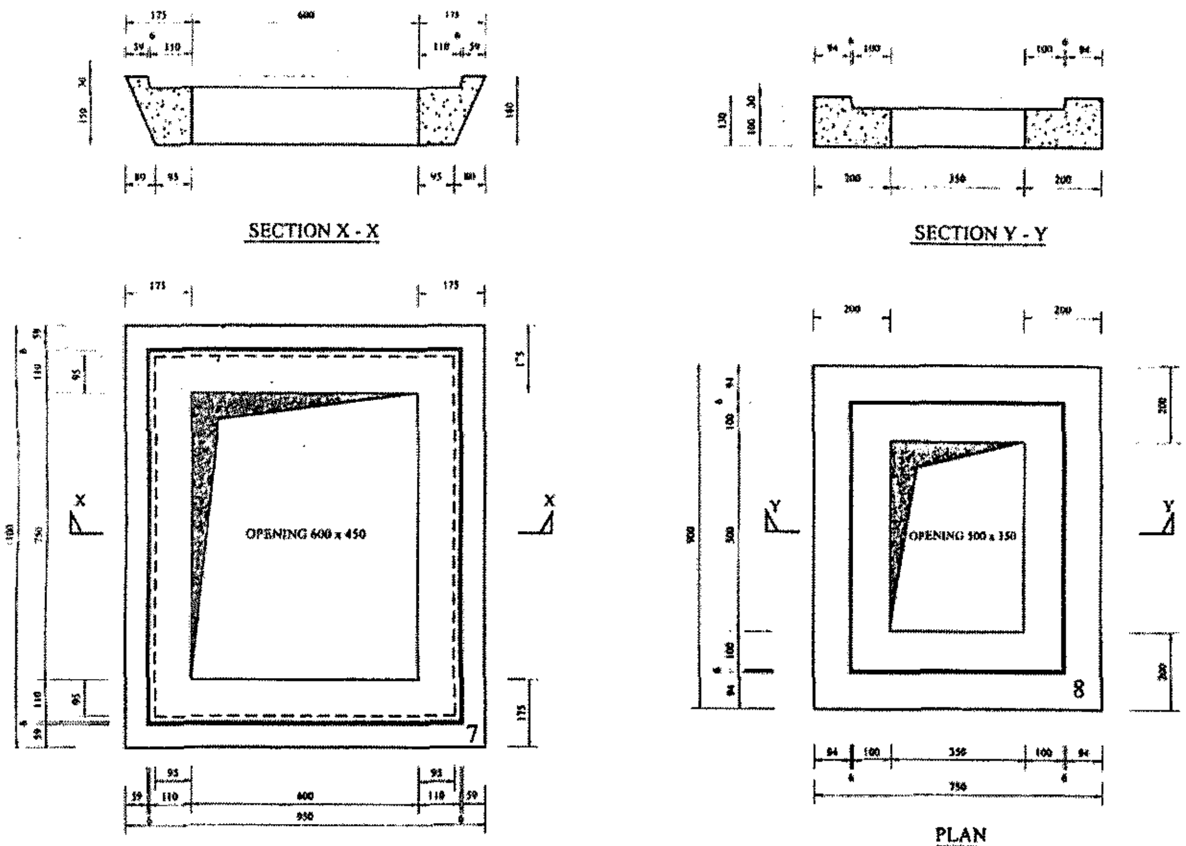
DESIGNED BY	CHECKED BY	APPROVED BY
WNA	NASSER AL SAWARI	WNA

QATAR SURVEY SHEET NO.

DRAWN BY	DATE	SCALE
AFTAB	FEB 2001	1 : 12

AUTOCAD REF. NO.

DRG. NO. STD/1/41/2 REV C



PLAN

CONCRETE QUANTITY : 0.066 M³
MASS : 158 KG

SLAB TYPE - 7

INTERMEDIATE UNIT

PLAN

CONCRETE QUANTITY : 0.059 M³
MASS : 140 KG

SLAB TYPE - 8

BOTTOM UNIT

NOTE :- TYPE OF SLAB SHALL BE ENGRAVED ON THE TOP SURFACE FOR IDENTIFICATTION

NOTES :
ALL DIMENSIONS ARE IN MILLIMETRES

SLAB TYPE

	TOP	INTERMEDIATE	BOTTOM
SINGLE AIR VALVE	1	5	8
DOUBLE AIR VALVE	4	7	10
S. VALVE 350 Ø & LESS	2	–	–
S. VALVE 400 Ø	4	6	9
HYDRANT	3	5	8

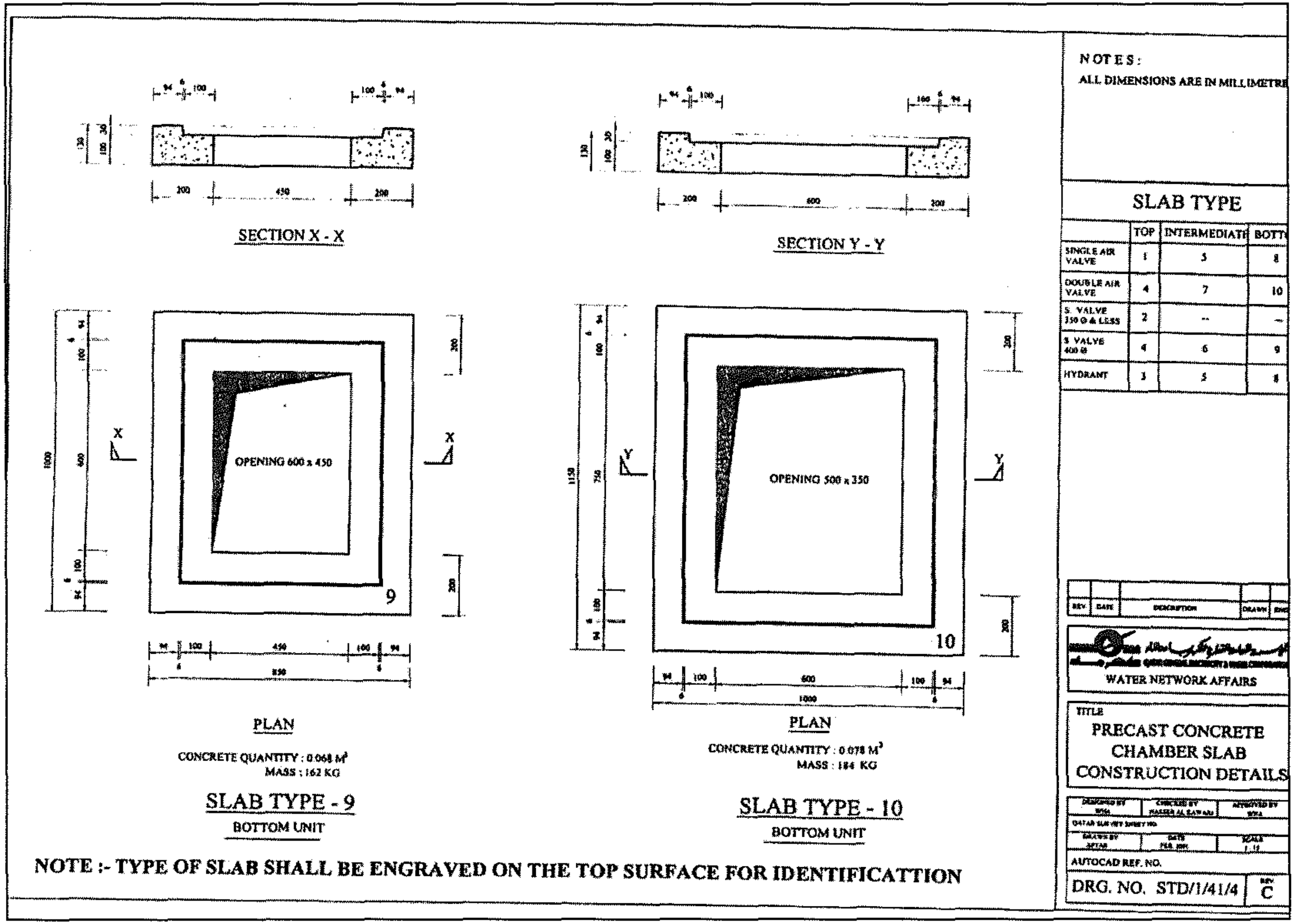
REV.	DATE	DESCRIPTION	DRAWN	CHKD

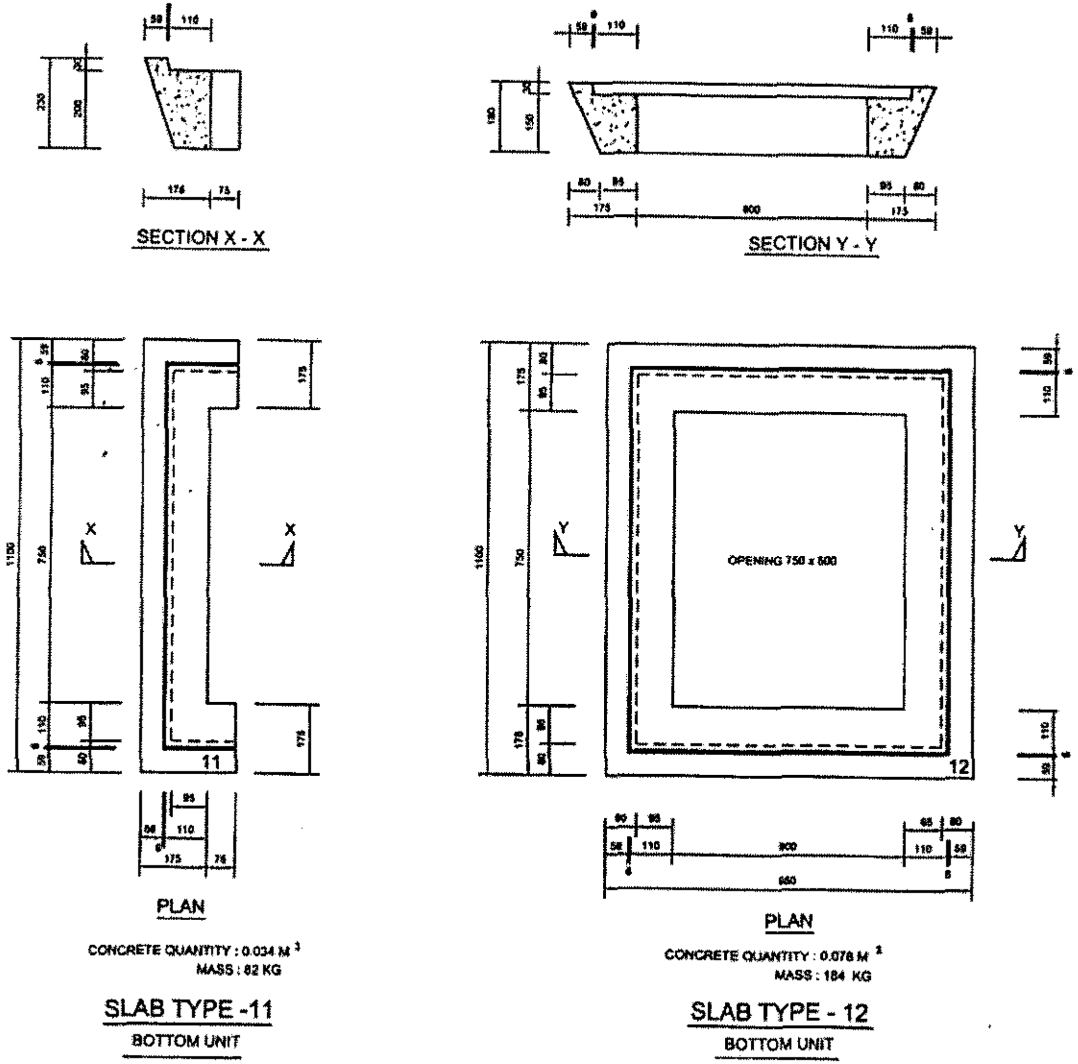
WATER NETWORK AFFAIRS

TITLE
PRECAST CONCRETE CHAMBER SLAB CONSTRUCTION DETAILS

AUTOCAD REF. NO.

DRG. NO. STD/1/41/3 REV C


NOTES:
ALL DIMENSIONS ARE IN MILLIMETRE
SECTION X - X
SECTION Y - Y
OPENING 600 x 450
OPENING 500 x 350
PLAN
CONCRETE QUANTITY : 0.068 M³
MASS : 162 KG
SLAB TYPE - 9
BOTTOM UNIT
PLAN
CONCRETE QUANTITY : 0.078 M³
MASS : 184 KG
SLAB TYPE - 10
BOTTOM UNIT
SLAB TYPE
TOP
INTERMEDIATE
SINGLE AIR VALVE
DOUBLE AIR VALVE
S. VALVE 350 Ø & LESS
S. VALVE 400 Ø
HYDRANT
WATER NETWORK AFFAIRS
TITLE
PRECAST CONCRETE CHAMBER SLAB CONSTRUCTION DETAILS
AUTOCAD REF. NO.
DRG. NO. STD/1/41/4
C
NOTE :- TYPE OF SLAB SHALL BE ENGRAVED ON THE TOP SURFACE FOR IDENTIFICATTION



NOTE :- TYPE OF SLAB SHALL BE ENGRAVED ON THE TOP SURFACE FOR IDENTIFICATTION

NOTES:

ALL DIMENSIONS ARE IN MILLIMETRES

SLAB TYPE

	TOP	INTERMEDIATE	BOTTOM
SINGLE AIR VALVE	1	5	8
DOUBLE AIR VALVE	4	7	10
S. VALVE 350 Ø & LESS	2	–	–
S VALVE 400 Ø	4	6	9
HYDRANT	3	5	6

WATER NETWORK AFFAIRS

TITLE

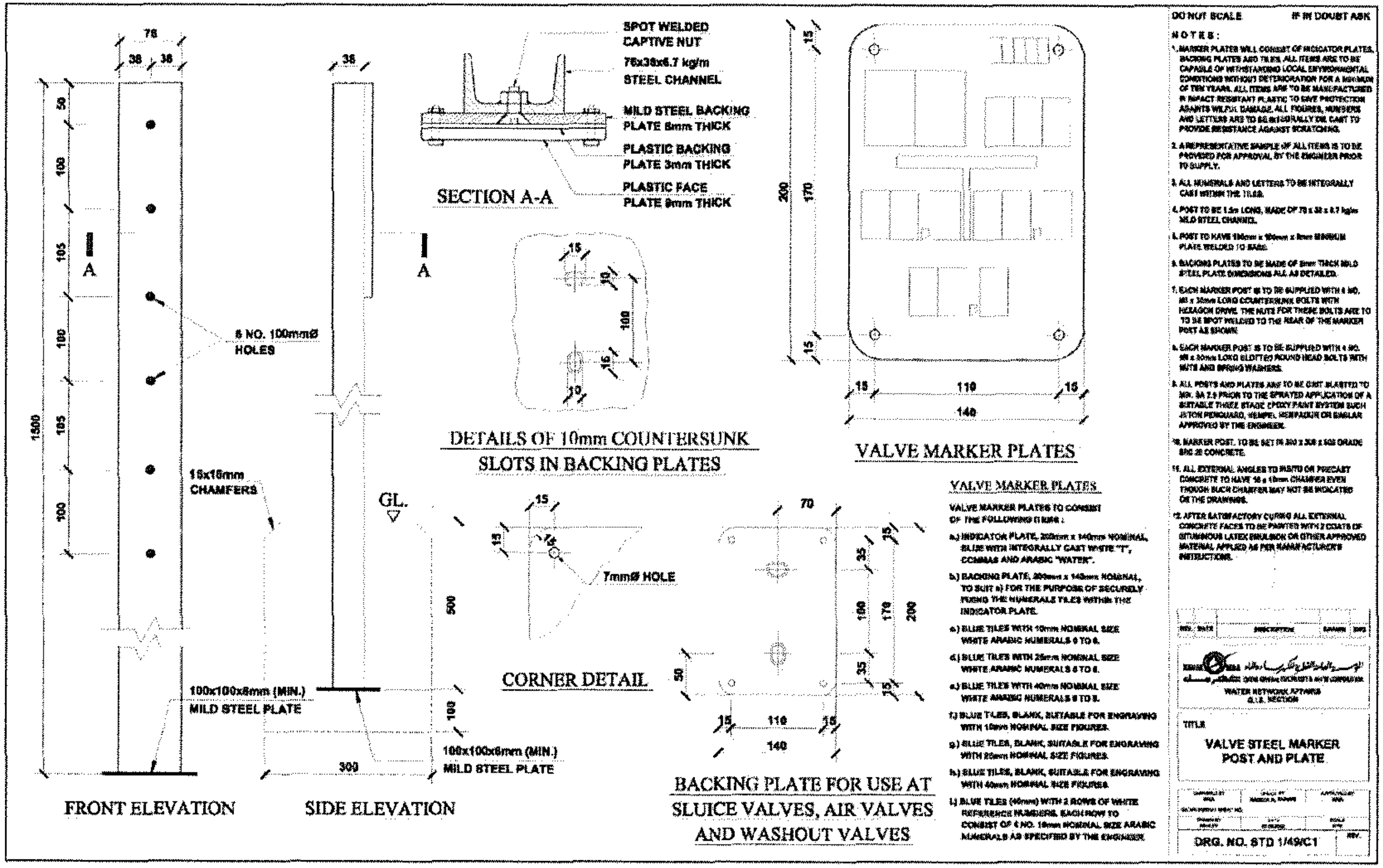
PRECAST CONCRETE CHAMBER SLAB CONSTRUCTION DETAILS

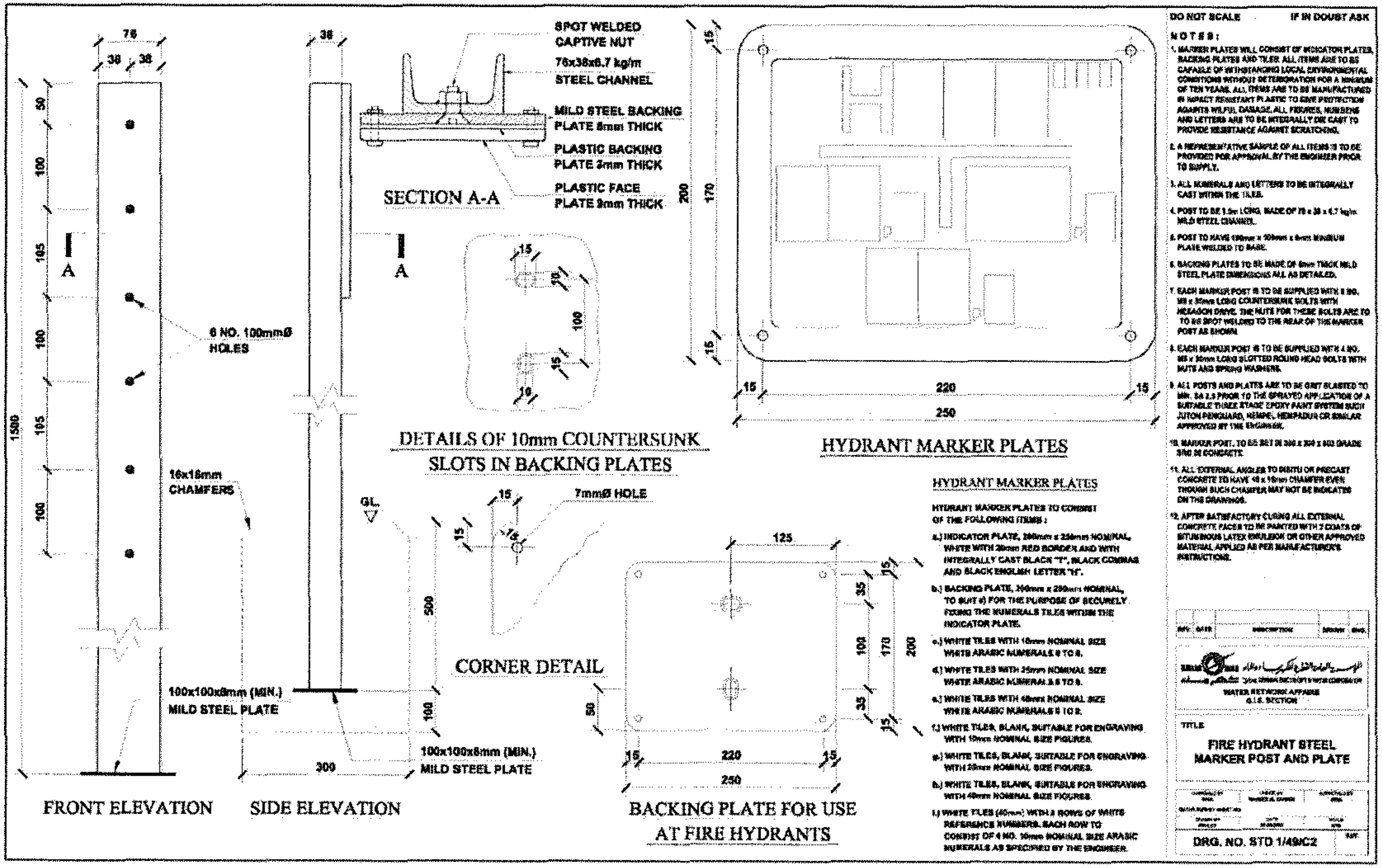
AUTOCAD REF. NO.

DRG. NO. STD/1/41/5 REV. C

3. MARKER POST, BACKING PLATES, AND PLATE

- Valve





SPOT WELDED CAPTIVE NUT
76x38x6.7 kg/m STEEL CHANNEL
MILD STEEL BACKING PLATE 8mm THICK
PLASTIC BACKING PLATE 3mm THICK
PLASTIC FACE PLATE 9mm THICK
SECTION A-A
6 NO. 100mmØ HOLES
16x16mm CHAMFERS
100x100x8mm (MIN.) MILD STEEL PLATE
DETAILS OF 10mm COUNTERSUNK SLOTS IN BACKING PLATES
7mmØ HOLE
CORNER DETAIL
GL.
FRONT ELEVATION
SIDE ELEVATION
HYDRANT MARKER PLATES
BACKING PLATE FOR USE AT FIRE HYDRANTS
DO NOT SCALE
IF IN DOUBT ASK
NOTES:
FIRE HYDRANT STEEL MARKER POST AND PLATE
DRG. NO. STD 1/49C2

APPENDIX A-10

GENERAL SPECIFICATION OF MAIN LAYING MATERIALS FOR WATERMAINS 2005

APPENDIX A-11

GENERAL SPECIFICATION FOR MAIN LAYING CONTRACTS

GENERAL SPECIFICATION

FOR

MAIN LAYING CONTRACTS

GMSC Table of Contents

SECTION - 1 : GENERAL

1.1 INTRODUCTION

This general specification for mainlaying contracts applies to potable pipe laying works. The work covered by these Specifications consists of installing water main pipe, fittings, valves, fire Hydrants, Service connections .... ; removing and replacing water services , main connections , excavations , Backfilling and compacting trenches to finish subgrade ; restoring roadway surface whenever required , disposing of debris and completing all other work specifically indicated in Contract document.

The clauses in this specification apply to the entire Works, whether on site or workshop employed elsewhere in connection with water Works.

These specifications to be read in conjunction with manufacturer specifications of materials and to all other relevant sections of the "Qatar Construction Specifications". Any clauses in this specification which relates to work or materials not required by the Works shall be deemed not to apply.

If materials manufacturer laying recommendations/ specifications are in any differences with theses pipe laying specifications, Contractor to submit full details of the said recommendation for Kahramaa's approvals prior to ordering and starting of the works

1.2 COMPLIANCE

The Contractor, unless otherwise stated in the Project Documentation, must comply with all requirements of the Qatar Construction Specifications that is relevant to the type of work forming any part of the Contract and not included in this Pipelaying Specifications.

1.3 Particular Requirements

Reference:

I-	QSC (latest addition)	Section 1	General Clauses
II-	"	Section 12	Excavation and Earthworks
III-	"	Section 5	Concrete Work
IV-	"	Section 6	Roadworks.
V-	Qatar Traffic Police Guide Book		

1.4 Code of Practice , Trenchworks in Highways

The Code of practice and Specifications issued by Highway Maintenance Section of the Ministry of Municipal and Agriculture Affairs shall be adhered to and followed by the Contractor.

1.5 Traffic Police Department

The regulations and requirements applied by the Traffic Police to all work in the Public Highway shall be adhered to and followed by the Contractor.

1.6 General Specification for Water Works Mainlaying Materials

The latest Specifications for Water Works Mainlaying materials, prepared by the concerned KAHRAMAA Department to be adhered to by the Contractor. All materials are to be used with potable water and must conform to any current regulations of State of Qatar in force for the purpose. All materials to be handled, stored, laid....etc in accordance with manufacturer recommendations subject to Kahramaa's approval.

1.7 Water GIS Specifications for Water Works

Contractor must prepare GIS and As-built Drawings in accordance with KAHRAMAA latest Standard and Specifications for Water GIS Data Specifications.

1.8 Notice Boards

1.8.1 Site Notice Board

The Contractor shall display a Notice Board at the site office in an approved position of a 2.00 m x 1.50 m minimum size, lettered to be both in English and Arabic. The board to include the Name and logo of QGEWC scheme title. Contractor's name, telephone number...etc. all as required by Kahramaa.

1.8.2 Trench Notice Board

The Contractor shall comply with the MMAA requirements and erect on each open trench a notice board 1.20 m x 1.00 m lettered in English and Arabic. The board to include QGEWC logo and name, contract title, Contractor's name, telephone number....etc. all as specified.

1.9 Site Office

The Contractor shall supply – for the Contract duration – Site Office in accordance with the Contract Specifications. The site office will be erected on a plot within the Contract Area, approved by the relevant Municipality.

SECTION 2 – ROAD CROSSINGS AND ACCESSES

2.1 General

No work will be authorized without prior approval by Kahramaa.

(a) Provide and maintain adequate bridging equipment for pedestrians to the satisfaction of Kahramaa;

or (b) Tunnel the pipes across the road or access so as not to disturb the surface, all to the approval of Kahramaa;

or (c) Excavate trench, lay pipe, backfill and substantially reinstate, all in quick succession, to the approval of Kahramaa.

or (d) In case of delays in the delivery of materials:
Excavate trench, immediately shall be backfilled and maintain an adequate road reinstatement to the satisfaction/ approval of Kahramaa until all required materials are available and approved. Re-excavate trenches, prepare for pipe laying, lay pipe and substantially reinstate immediately to the approval of Kahramaa.

or (e) Complete the required works by any combination of the above, to the approval of Kahramaa;

In addition, construction operation on public streets or roads shall be confined to a certain length to the approval of Kahramaa in order to minimize disturbances to road traffic and not to cause inconvenience to the public or to adjacent properties.

2.2 Pipelaying

The Contractor is expected to arrange the pipe laying across roads and access way crossings. The works shall be performed in sequence with adjacent pipe laying. Kahramaa has the right to withhold permission to cut pipes, install extra couplings at joints between previous pipe works laid for road crossings or access ways and pipe works laid in the adjacent trenches.

2.3 Major Roads

In major roads and dual carriageways the Contractor shall not close more than half the width provided for traffic in each direction without prior permission of Kahramaa, and agreement from the Traffic Police.

2.4 Minor Roads

In minor roads serving properties which, in the opinion of Kahramaa, have reasonably convenient alternative means of access, the Contractor shall not close more than half the width of the said road without prior permission of Kahramaa.

2.5 Minor Roads (Alternative Access)

On minor roads serving properties, if Kahramaa deems that an alternative convenient access would be more accessible to the minor roads serving proprieties. The Contractor may close the entire road to through traffic provided that the closure shall be for a limited duration to the satisfaction of Kahramaa and the Traffic Police.

2.6 Access to Properties

The Contractor shall note that great importance will be attached to allowing householders and others free uninterrupted passage for themselves and their personal vehicles to their properties. Water tankers must be able to reach ground storage water tanks for each property.

SECTION 3 WATCHING AND LIGHTING

3.1 General

The Contractor shall comply with the Qatari Traffic Police Guide Book, regulations and Qatari Construction Specifications (QCS) requirements related to this section.

The Contractor shall ensure that all open trenches and other workings are completely enclosed by a combination of existing features, e.g., walls and excavated spoil and purpose made barriers, which must be maintained to the satisfaction of Kahramaa from the time the ground is initially opened up until substantial reinstatement is completed. Small trial holes and other workings for valves, chambers, hydrants, testing, etc., are to be individually marked or surrounded to the approval of Kahramaa.

3.2 Barriers (Construction)

Barriers are to be 1 m. high or as otherwise approved by Kahramaa. Where existing soil is used as a barrier, a single approved marker 1 m. high or, a similar marker shall be placed at every 10m. with approved reflective warning tape strung between these markers for the full length of the trench.

3.3 Lights

i. Lights are to be provided, maintained and lit to the satisfaction of the Traffic Police and Kahramaa during the hours of darkness.

   i.a) At corners or substantial changes in the direction of the above barrier, or at markers placed as aforesaid where excavated spoil is used as a barrier; and

   i.b) At intervals of every 10m. a long the barrier other than the one of excavated spoil.

ii. Lights are required on barriers at areas where no member of the public nor any property holder or a visitor has an access to any property shall be placed to the satisfaction of the Traffic Police and Kahramaa.

iii. At road crossings, Lights are required for all barriers; the lights shall be adequately lit and maintained throughout the hours of darkness.

iv. All road construction signs shall be lit, or to be made of an approved reflecting material and shall be marked by two approved traffic warning cones.

3.4 Barriers (Traffic Safety)

i. Adequate Barriers as required by the Traffic police and as specified below or as otherwise required for the safety of the public, to the satisfaction of Kahramaa, shall be provided at all road crossings where the surface of the road is opened.

ii. At road crossings in dual carriage ways or streets carrying traffic in one direction only where part of the carriage way is disturbed at one time, the following shall be provided:

ii.a) Two pairs of appropriate and approved road signs, indicating road hazard due to road construction, the width of carriageway and number of lanes available for traffic shall be placed on both sides of the road on the approach side of the opening at distances of 100m and 200m.

ii.b) A 1m high barrier of approved construction and colouring shall be placed from a point 50m on the approach sides of the opening.

ii.c) On both sides of the opening, 1m high barrier of approved construction and colouring.

3.5 Road Crossings

At road crossings where roads carrying traffic in two directions in which only part of the width of the road is disturbed, the following shall be provided:

I) Two sides or two pairs of appropriate and approved road warning signs as specified in 3.3. ii (a) for dual carriageways, one set shall be placed on each side to warn approaching traffic from each direction.

ii) A barrier similar to 3.3 ii (b) for dual carriagways.

iii) Barriers similar to 3.3 ii (c) for dual carriagways.

3.6 Minor Roads

At road crossings in minor roads where the width of the road is opened for a trench, a barrier similar to that specified in 3.3 ii (c) for dual carriageways shall be provided.

3.7 Bridging of Excavation

Where adequate bridging is provided and maintained in position to the approval of Kahramaa, items 3.5 ii and 3.5 iii above need not be provided at dual carriageways and crossings in road carrying traffic in two directions; nor need any barrier to be provided where the whole width of a road is bridged, providing that adequate warning signs to the approval of Kahramaa, are positioned on each side of the road adjacent to the bridging. Warning signs shall also be maintained, to the approval of Kahramaa, where the surface of backfilled or reinstated trench in roadways is not sufficiently close to, and in conformity with, the line and level of the surrounding road surface.

3.8 Flagman and Watchman

Kahramaa may require that an approved flagman be provided by the Contractor to regulate the flow of traffic past the works, where the volume of traffic and the width left available for its passage require it. Where required by Kahramaa the Contractor shall provide a watchman to prevent theft from the site and to assist members of the public requiring passage through the works.

SECTION 4 - EXCAVATION

4.1 Clear Site

The description "clear site" shall include the removal of all grass, roots, rubbish, dead vegetation, weeds, scrub, saplings, trees not exceeding 300mm girth (measured 900mm above ground), stumps not exceeding 300mm girth (measured at ground level) and leave tidy. Also included in the description "clear site" shall be the removal of any building debris, excavated material and general rubbish found on the line of the trench for a sufficient width either side of the pipe center line to permit adequate working space.

The Contractor will be deemed to have assessed the amount of rubbish and debris to be moved at the time of his site visit and allowed for such removal in his rates.

4.2 Existing Services

i. Not with standing any information given on the drawings or supplied by Kahramaa, the contractor shall be responsible for locating all services crossing or closely paralleling the line of the trench by consultation with the relevant Services Department and by hand excavating trial holes in advance of his main excavation.

ii. All excavations carried out in the vicinity of 33 KV or above and overhead cables must not commence or continue without an Electricity representative being present at all times.

iii. If a service is damaged Kahramaa and the appropriate Service Representative shall be informed immediately. The Contractor's attention is drawn to relevant Services Department regarding penalties for damage to their services.

v. Trial holes will be dug by hand in sufficient number to ensure that all services on the route of the pipeline are uncovered. Trial holes will be of sufficient size and depth to enable clear identification of service type, to route and, where appropriate, diameter.

vi. Once located, all services are to be adequately protected from damage and fully supported during the works in such a fashion as to prevent any distortion or damage to the service.

4.3 Limitation of the Works

i. Works shall be arranged in one continuous length from end to end except where agreed by Kahramaa, at road crossings and accesses to neighbouring properties and elsewhere, where the express agreement of Kahramaa in writing is obtained to facilitate the orderly completion of the works.

ii. Where the Contractor's rate of progress on one length of workings is insufficient to complete the works within the Contract Period, Kahramaa may require the Contractor to make all necessary resources available to open further lengths of workings. Should the Contractor fail to do so, Kahramaa will restrict the Contractor to such lengths of workings that he can complete in an expeditious and timely fashion and will exercise all powers provided in the Contract for use should the Contractor fail to complete the works within the Contract period.

iii. The total length of workings in progress at any state between initially opening up the ground and substantial reinstatement to the satisfaction of Kahramaa, including any road crossing or other place contained therein where work is not started or is already completed shall not exceed 500m without the express permission of Kahramaa in writing.

iv. The length of excavated or partially excavated pipe trench open and containing no pipes within a length of workings shall not exceed 200 m without the express permission of Kahramaa in writing.

v. The pipework shall be tested immediately after partial backfilling in accordance with Section 9 of this specification.

4.4 Licensing of Trenches

Kahramaa shall obtain the R.O.2. Forms from all the other services and Planning Departments. Once these have been received the Contractor shall be issued with those and the R.O. 3 Form.

The Contractor shall obtain Traffic Police Approval and submit a copy of this to the Highway Maintenance Section, Ministry of Municipal and Agriculture Affairs before commencing work and there after for each renewal. The Contractor shall give an advance notice 2 week before expiry date.

4.5 Trench Excavation

i. General

The Trenches and other excavations are to be excavated to the lines and dimensions indicated in the specification shown on the Drawings, or as Kahramaa's Representative may from time to time direct. Road materials, paving stones, turf, soil or other material forming the surface of the ground shall be laid aside so as not to become intermixed with other excavated material.

Revolving wheel cutters attached to mechanical plant, or similar approved methods, must be used to cut and break the bituminous material prior to work being carried out by mechanical excavators or by hand.

Where excavations are carried out, adequate boards or metal sheets approved by Kahramaa must be provided as protection for the adjacent bituminous surfacing and as a temporary base for excavated material.

Except with the specific approval of Kahramaa all excavated material must be removed from site immediately to enable working areas and traffic lanes to be clean and free from obstacles for the duration of the works. The cost of doing so is to be included in the price stated in the Bill of Quantities for excavation.

ii. **Mechanical Excavation**

Where a mechanical excavator is used, the trench taken out by the machine shall have not less than 80mm on each side and at the base of trench to be taken out by hand-trimming. The bottom of the trench shall be carefully levelled with a straight edge or where directed by Kahramaa's Representative or where longitudinal grades are shown on the drawing with boning rods using not less than three profiles over 50m spacing set up using proper levelling techniques and to the levels shown on the drawings. The excavation is to be neatly made to receive the bedding so that each pipe barrel may rest along its whole length upon firm ground with exception of a short length at the joint which shall be unsupported.

iii. **Protection of Trench & Excavation**

The contractor shall, at his own expense, provide and fix all timbering pilling and shoring required to maintain the sides of the excavation for the safety of his workmen, adjoining property, to the satisfaction of Kahramaa's Representative for as long as necessary removing the same as required, remaining responsible for the safeguarding of adjoining property and roads during the construction and including the maintenance period.

iv. **Depth of Trench**

Trenches, except where otherwise stated, shall be excavated to a depth as indicated in the Bill of Quantities, but generally to a minimum cover of 900mm form the existing ground surface to the crown of the pipe, but not withstanding this shall be graded to falling or rising grades as required.

v. **Deeper Excavation**

v.a) Deeper excavation will be required at all sluice valves, air valves and fire hydrants positions or as directed by Kahramaa's Representative.

v.b) If the Contractor excavation deeper than the required formation level, he shall, at his own expense fill up the extra depth with well compacted granular material as specified hereinafter, or with Grade S.R.C.20 concrete where ordered by Kahramaa's Representative.

vi. **Disturbed Areas**

The Contractor shall take precautions to avoid disturbing the finished trench formation and shall make good the disturbed areas and excavate any wet or puddled material, which might result from failure to do so. The voids shall be filled and made good with approved material prior to the laying of any pipes.

vii. **Width of Trench**

The minimum width of trenches shall be the external diameter of the pipe, plus 175mm on either side. The total trench width shall not exceed the external diameter of the pipe, plus 200mm on either side. Kahramaa's Representative may instruct the contractor to carry out additional work to strengthen the pipeline, refill and compact the overcut at the Contractors expense.

viii. **Jointing Cavity**

The cavity of adequate size shall be excavated in the sides and bottom of the trench or left in the pipe bed at each joint and sling position to allow ample space for making a perfect joint and to allow the free withdrawal of the sling without risk of damage to any external covering of the pipe.

ix. **Withdrawal of Trench Supports**

Withdrawal of supports shall be carried out as bedding, sand surround, refilling proceeds, care taken to keep the sides of the trenches solid, to fill and compact all the spaces left by the withdrawn sheeting and framing. Trenches close to existing structures shall, if Kahramaa's Representative so directs, be opened in short lengths and backfilled or partly filled with concrete or such other material, as Kahramaa's Representative shall direct.

x. **Trenches in Rock**

Where rock or boulders are present in pipe trenches, the sides of trench shall be trimmed to a width such that when the pipe is laid to the correct line and level no projection of rock comes within 175mm of the outside of the pipeline at any point. In rock the pipes shall surrounded with approved granular material.

4.6 Excavation in Soft Ground

If, in the opinion of Kahramaa's Representative, any portion of the trench bottom is too soft to support the pipes, the Contractor shall excavate down to a more solid stratum. The extra depth shall be refilled with approved granular material or Grade S.R.C.20 concrete, properly compacted and laid to form an even bed.

4.7 Hand Excavation

i. Where a new line is to be laid adjacent to an existing live main, such that clearance between mains is one meter or less, the contractor may mechanically excavate to within minimum 500mm of the existing main, or as directed by Kahramaa's Representative. The remaining excavation to be done using hand held non-mechanically driven tools.

ii. The Contractor is to take very possible care to ensure that the existing live main is not damaged if the live main has to be closed down, the Contractor will be responsible for both repairing this main and supplying adequate quantities of potable water to the consumers denied a supply due to the damage caused.

4.8 Blasting

i. **General**

In special circumstances blasting of rock may be approved. Kahramaa approval shall be subject to the contractor obtaining written permission for use of explosives from all relevant parties and in particular the Police Department, the Civil Engineering Department and the Qatar Force.

ii. The Effect of Blasting on Other Structure and Services

The Contractor shall be held responsible for damage to structures or other services. The Contractor shall take whatever steps that considers necessary to record the effects of his operations.

iii. **Control of Throw**

All blasting shall be covered with approved mats to restrain small rocks and debris being thrown out of the trench. These mats are to be used at all times unless prior written permission from the Kahramaa is obtained.

iv. **Safety Procedures**

The Contractor shall take the appropriate safety procedures during execution of the Contract and in particular he shall carry out in full the safety procedures as recommended by Nobel's Explosives Company Limited.

v. **Warning of Intended Blasting**

When a blast is ready for firing, the Contractor shall take the following action:

v. a) all approaches shall be guarded to prevent access during firing.

v. b) audible (klaxon) and visual (flags) warnings shall be given in a manner approved by Kahramaa.

v. c) He shall ensure the everyone takes adequate cover.

vi. **Firing**

Kahramaa's Representative shall count the number of charges as they explode and shall confirm with the Contractor that there are no misfires.

vii. **Misfires**

After firing the Contractor shall thoroughly inspect the blasted area. When a misfire occurs the Contractor shall remove it immediately by firing or by recovering it in the manner laid down in the Nobel Safety Procedures.

On Completion of the Contract, the Contractor shall give a written assurance that no unfired explosives remain on the site or Works.

viii. **Vibration from Blasting**

viii. a) Where the blasting will occur in the vicinity of existing structures and structures under construction and the Contractor shall control the blasting such that no damage is caused to either.

viii. b) The determination of vibration levels shall be the responsibility of the Contractor but it no case shall the vibration level exceed the following:

Type	Peak particle Velocity mm / sec
In the vicinity of existing structures	25
In the vicinity of structures under construction	12

viii c) The Contractor shall provide suitable instruments to measure the vibration levels and they shall be erected at all adjacent existing structures and all structures under construction.

viii d) A minimum of 6 No. instruments shall be provided and erected in approved locations.

ix. **Maximum Size of Fractured Material**

The fractured material shall be of suitable size to be excavated with an excavator at a later date and in no case shall the size of one boulder be greater than 1 m.

x. **Daily Records**

The Contractor shall submit daily to Kahramaa copies of the graphs showing the siting, date, time and mode of measurement. Also records of the explosives used in each blast and any delay used.

4.9 Water in Excavations

All excavations shall be kept free from water at all times, adequate pumping plant, including special de-watering equipment shall be provided by the Contractor who shall also make his own arrangements for the disposal of all water encountered in the excavation.

The Contractor is to note that in certain areas the Municipality will not permit the discharge of water onto the roads, footpaths, central reservations or roundabouts and in these areas the pumped water will have to be tankard away from the site.

Contractor should note that to discharge into the sewers that approval must be obtained from Sewerage Division, Ministry of Municipal and Agriculture Affairs.

When pumping is necessary the material in and around the excavations shall be disturbed by pumping and where local discharge is permitted all sumps shall be formed well clear of the trench excavations and when no longer required such sumps will be filled in with suitable material or dealt with as directed by Kahramaa's Representative.

SECTION 5 - BACKFILLING TRENCHES

5.1 Imported Granular Material and Selected Excavated Material

i. Imported granular material shall comprise either of natural dune sand or crushed clean hard limestone or be a mixture of these. The sand and/or crushed limestone shall be obtained from an approved source.

ii. Granular material shall contain no excessive quantities of dust, soft or flaky particles, shells congealed lumps, nodules of soft clay, shell, alkali or other contamination likely to affect adversely the compaction of the material or to cause damage to pipes.

iii. The sulphate content (as SO3) of the material shall not exceed 0.4% by weight and the Chlorides as (CI) shall not exceed 0.10% by weight.

iv. Prior to commencement and during progress of works the Contractor shall provide Kahramaa with samples of the proposed granular material to be used in the works, along with their soil test results and shall obtain his written approval for its use. This sample will be retained by Kahramaa for comparison with deliveries to the site during the works.

v. The grading of fine aggregate when determined by the method described in B.S.812 shall lie within the respective limits specified within the following table:

B.S. Sieve Size (mm)	Percentage Passing by Weight	
	Normal Sand	Crushed Rock
4.76	95 - 100	90 - 100
2.40	70 - 95	60 - 90
1.20	45 - 85	40 - 80
0.60	25 - 60	20 - 50
0.30	5 - 30	5 - 30
0.15	0 - 10	0 - 15

vi. The total quantity of fine dust through No. 22 mesh sieve in fine aggregate derived by crushing rock, shall be determined by the method described in BS 812 paragraph 14 and shall not exceed 8% by weight.

vii. The total quantity of clay and silt in natural sand shall not exceed 4% by weight when determined by the field setting test described in BS 812 paragraph 15.

5.2 Method of Backfilling Trenches

i. Backfilling of trenches will wherever practicable be undertaken immediately that the specified operations preceding it have been completed satisfactorily.

For Major Works i.e., any works over 100m in length, the Contractor will be required to conform to the Certification Form RO5 which will be completed by the Road Engineer.

No backfill layer shall be covered by the next layer of construction until it has been inspected, tested and approved by the Road Engineer.

If any approved layer is subsequently damaged or disturbed by any means of cause whatsoever, then it shall be reinstated to the Specification requirements and to the satisfaction of the Road Engineer prior to placing the next layer of Construction all at the Contractors expense.

Note: This Clause also applies to Bituminous Materials.

ii. **Sub-Contractors**

The Contractor is required to nominate, prior to commencement of the works, an approved road works Sub-Contractor he intends to employ for the completion of the Works in Dual Carriageways.

iii. **Pipe Bedding**

Before the pipes and fittings are laid in the trench, and immediately after the final 80mm of excavation has been done by hand down to pipe invert level other than in rock, where the excavation will be taken down to invert level minus 150mm, Kahramaa will inspect the formation as to its suitability to receive the sand bedding, pipes and fittings.

iv. **Sides and Crown of Pipe**

After Kahramaa has given its approval to the bedding, the pipes and fittings can be laid. Joint holes can be excavated in the bedding but under no circumstances must bedding be excavated at any other point along the length of the pipe barrel without the written permission of Kahramaa.

Any pipes found "bridging" at any point will be removed and the bedding made complete and re-complete to the correct level.

The excavation (other than where chambers are to be constructed) will be backfilled with graded material as specified in 5.1, in layers of no more than 150mm thick before compaction which shall be wetted and well compacted with narrow wooden rammers up to 250mm above the crown of the pipe. Before any further backfilling takes place Kahramaa's approval must be given, any defects found shall be made good.

v. **Backfilling above the Sand Surround**

With Kahramaa's approval the remaining depth of trench can be backfilled with excavated material in layers of not more than 200mm depth before wetting and compaction each layer shall be compacted with vibrating trench roller or plate compactor to at least 95% of the Mod. AASHO density at optimum moisture content. Cut backs shall comply with KAHRAMAA drawing STD 1/55 B.

5.3 Unsuitable Material and Final Backffilling

Any materials classified as unsuitable materials by Kahramaa, shall be removed from site and not to be used as a trench backfill material. Tripping, shoveling or dropping the materials from a height or bcakfilling the trenches in such a manner as Kahramaa considers might be damaging to the pipes or their covering shall be prohibited. Sufficient space shall be left to receive the materials removed from the surface in order to return the surface to its original condition. Except in carriageways or paved areas the backfill material shall be brought up to existing ground level. When the ground surface in the line of the trench consists of sweet soil the final layer shall be sweet soil to the same thickness as previously existed. Where rock is exposed at ground level the top of the backfilling shall be protected against erosion by a layer of stones from the excavation to the satisfaction of Kahramaa.

5.4 Surplus Material

After the refilling of trenches, any surplus materials from trench excavation shall be removed to the Municipal Refuse Tip or a tip as instructed by Kahramaa's Representative.

5.5 Backfilling of Road Crossings

In the case of excavation in any existing or proposed carriageway the lower portion of the trench shall be backfilled as per Clause 5.2, using suitable materials not larger than 50mm diameter upon which the Contractor shall provide a raft of 200mm (minimum) thickness of plain concrete class 15/30, as detailed on KAHRAMAA drawing STD 1/55 B.

5.6 Laying PVC Marker Tape

Blue PVC marker tape shall be laid directly above the watermain, 300mm below finished ground level and 200mm below the service connection line.
Under carriageways the tape shall be laid on top of the concrete protection to the watermain or as directed by Kahramaa's Representative.

5.7 Reinstatement

i. General

Reinstatement will not commence until approval has been obtained from the Road Engineer and shall comply with the Code of Practice for Trench Works in the Highway.

ii. Clean Surfaces

Immediately prior to the application of a prime or tack coat all loose and objectionable material shall be removed from the surface to be treated by brushes or compressed air, to the satisfaction of the Road Engineer and kept clean at all time. Adjacent surfaces and kerning must be protected against application of prime and tack coats.

iii. Prime Coat

Prime coat shall consist of cut-back bitumen M.C.I. heated to a temperature of 60 degree - 80 degree C and sprayed at a rate of 1 litre/sq. metre on to the approved sub-base layer.

Bitumen emulsion may be used in place of M.C.I. applied at a rate to ensure penetration atleast 16mm into the sub-base to the satisfaction of the Road Engineer.

In all cases where emulsion is used it must be dilute to the manufacturer's recommendations.

iv. **Tack Coat**

The material to be used for tack coat shall be cationic bitumen emulsion complying with clause KI-40 of B.S. 434 and applied at a rate of 0.33-0.45 litres/sq. metre by a mechanical spraying tank or pressure hand-spraying equipment onto bituminous surfaces.

v. **Inclement Weather**

The spraying of prime coat, tack coat and the laying of bituminous materials shall not be carried out when the road surface is wet or when air turbulence is sufficiently strong to blow sand or dust on to the exposed treated surfaces.

vi. **Interim Reinstatement**

When the sub-base has been constructed and approved, the adjacent bituminous layer on each side of the trench shall be cut back using spade type chisels and air compressors, or other approved means, to provide a staggered and stepped joint, the sides of which are to be vertical and parallel to the trench and to the dimensions shown in Appendix 4 of the Code of Practice.

Prime and tack coats shall be sprayed at the specified rates ensuring that the sides of the bituminous joints have been adequately coated. Sufficient time must be allowed to enable penetration of the prime coat into the sub-base or complete breaking of the bitumen emulsion before placing any bituminous macadam. During this period traffic shall not be allowed on either surface, the Contractor shall provide temporary diversions if necessary and additional protection of the work if required.

vii. **Bituminous Material**

The manufacture of bituminous coated materials for use in the highway shall be carried out only by the Government approved batching plants. The supplier shall be nominated by the contractor and be approved by the Road Engineer prior to the execution of the works.

viii. **Type of Construction**

The construction shall conform to the cross - sections shown in Appendix 4 of the Code of Practice and KAHRAMAA drawing STD 1/ 55 relating to single or dual carriageway roads as appropriate.

Each finished layer of bituminous macadam shall be laid in a single pass to obtain the correct tolerances. The Contractor must determine the thickness of the uncompacted layer in order to achieve the correct final compacted thickness.

ix. **Single Carriageway Roads**

Dense Bitmac Single Course laid to a compacted thickness of 70 mm.

x. **Dual Carriageway Roads**

Dense Bitmac Base Course laid to a compacted thickness of 90 mm and Dense Bitmac Wearing Course laid to a compacted thickness of 40 mm.

In certain special cases alternative materials may be specified by the Road Engineer.

5.8 CED Requirements for Reinstatement

i. Phased Reinstatement

Where specified the reinstatement of the road opening shall be completed in two separate phases as follows:

a. First Phase to be carried out immediately after water mains works are completed (either partially or wholly) and in accordance with all the requirements of this specification and to the details shown in Appendix 4 to HMS Code of Practice.

b. 2nd Phase to be undertaken 28 days before the expiry of the maintenance period and to the requirements given in Clause 5.8.1. ii and the details shown in Appendix 4 to HMS Code of Practice.

ii. Requirements for Reinstatement

a. For all reinstatement works to major roads above sub-grade level, the works shall be carried out by a CED approved Grade 'A' roadworks Contractor.

b. 2nd phase reinstatement works to all roads shall be carried out by a CED approved Grade 'A' road works contractor. The reinstatement of the wearing course shall be carried out using the appropriate machinery and a method approved by the Road Engineer.

c. Reinstatement of all road openings in major roads shall be carried out in two phases. For minor roads, crossings shall be reinstated in a single phase using the appropriate detail in Appendix 4 to HMS Code of Practice, or as otherwise directed by the Road Engineer. Trench runs along the carriageway on minor roads shall be reinstated in two phases.

d. The dimensions given in the Appendices for the width of reinstatement are minimum figures and may be varied for each individual location if required and as directed by the Road Engineer.

iii. Maintenance Period

The Contractor shall be responsible for maintenance of the road reinstatement for a period of 12 months or otherwise as stated in the contract document.

During this period the Contractor must ensure that the surface of the reinstatement meets the requirements of this Specification with particular attention being paid to finish surface level.

iv. Rectification

All materials, which do not comply with this Specification, shall be removed and replaced.

Sub-grade and Sub-base formation rectification shall be in accordance with the Code of practice and Specifications for road openings in the Highway.

High spots shall be graded off, low spots shall be scarified and filled with selected fill material and the whole area re-watered and re-compacted to Specification.

v. **Bituminous Layers**

Measurement of level and tolerance shall be made by the Contractor while the material is still warm and where necessary rectification carried out immediately. Regulation after compaction will not be permitted and the whole area may require to be removed to the full depth of the layer and reconstructed with fresh material.

Should any construction layer suffer damage on removal of defective bituminous material then the affected layer shall either be removed or reconstructed to the limits designed by the Road Engineer.

All replacement materials shall comply with the requirements of this Specification.

No additional payment shall be made for any rectification.

vi. **Final Inspection and Adoption**

On completion of the maintenance period the Road Engineer will inspect the finished reinstatement.

Where the reinstatement is satisfactory for adoption by the Highway Maintenance Section. Contractor's retention money shall be released and responsibility for future maintenance of the surface shall pass to CED.

Where the reinstatement is unsuitable for adoption by the Highway Maintenance Section, the Road Engineer will instruct the Contractor of his requirements for satisfactory completion. The Contractor will be responsible for arranging such works for which no additional payments shall be made.

In the event of the Contractor failing to meet his responsibility, the Road Engineer shall arrange for any necessary remedial works and recover the cost from Kahramaa. This cost shall then be recovered from the Contractor's retention monies by Kahramaa.

SECTION 6 - MATERIALS AND MAINLAYING

6.1 Handling of Materials

Pipe, fittings, valves, hydrants and fittings accessories shall be loaded and unloaded by lifting with hoists or skidding or as per manufacture specification otherwise approved by Kahramaa.

6.2 Collection of Materials from KAHRAMAA Stores

The Contractor shall collect and take delivery of materials only during the restricted opening times of the Stores.

The Contractor shall apply in writing a minimum of 7 days before he requires the issue of materials for the next phase of his works.

He shall collect and take delivery of materials when accompanied Kahramaa's representative. The Contractor shall liaise as necessary on every occasion when materials are required.

The Contractor shall transport the materials to site or approved tape wrapping factory and then to site.

6.3 Delivery of Materials

The Contractor will take delivery of materials either from the materials permanent or temporary pipe stores or direct from the manufacture transport at the site of the works.

The Contractor must either quote a price for examining, loading at the Ministry's stores transporting to the site of the works, if the materials are delivered by the Manufacturer, which ever is indicated in the Bill of Quantities.

When the Contractor takes charge of the materials they shall be examined by him to ensure that they are sound and undamaged notifying Kahramaa of any damaged or faulty to be dealt with Henceforth, the contractor shall be responsible for their safe handling and custody. Any materials found damaged after the contractor has taken them over or damaged during the course of the work shall be repaired by the contractor as per KAHRAMAA specification, or if Kahramaa's Representative so decides, be replaced by the KAHRAMAA and the cost subtracted from the contractors payment certificate.

Should delay arise owing to the non-delivery of pipes, fittings or other materials, the Contractor shall not be entitled to any expenses or compensation in respect of such delay, but Kahramaa may allow an extension of the contract time as approved by the KAHRAMAA for in clause 44 of the General conditions of contract.

6.4 Protection of Materials before installation

6.4.1 Pipes

The Contractor shall arrange a suitable storage area for the duration of project and subject to Kahramaa approval.

He shall ensure that the pipes are stacked neatly on timber battens in parallel method with spigots and sockets laid to alternative ends and using wooden battens between rows (size and location of battens shall be as manufacture specification) and the maximum recommend number of layers as manufacture specification, the whole to the approval of Kahramaa.

He shall ensure that the pipes are stacked neatly on timber battens with spigots and sockets laid to alternative ends, the whole to the approval of Kahramaa.

The Contractor shall at all times prevent any use whatsoever of the pipes as shelter or store and shall not allow any articles to be placed or upon them.

6.4.2. Valves & Fittings

The Contractor to store valves & fittings of any type near the site of the works, he shall arrange a suitable storage area and shall take every care to prevent damaged to valves & fittings and their ancillary equipment and they must not be in contact with the ground but on timbers or planks and provide adequate wedging between each fitting in the base layer and at the sides. As directed by Kahramaa's Representative. valve headstocks, motor gearing or indicators shall be removed adequately labelled for identification stored carefully in weatherproof premises and be reconnected after erection of the valves.

Electrical equipment shall be protected from the damp and the damp-proofing seals shall remain intact until the electrician is ready to connect up the equipment.

Air valves are to be stored under cover, in a vertical position with the top of the valve uppermost. Under no circumstances are air valves to be stored such that the ball is subjected to sunlight. Resilient seated sluice valves are to be stored in the same fashion as air valves the whole to the approval of Kahramaa.

6.4.3. Other Materials

Rubber seatings, gaskets, polyethylene film, wrapping tape, adhesive tape, PVC coated copper pipe, copper fitting, PVC duct and other anti-corrosion materials and all other equipment and materials liable to be adversely affected by the heat and sunlight are all to be stored in end door cool place. Bolt, nut, washer should be stored under cover in dry conditions and before used should be lubricated.

6.5 Conveyance of Materials to the Site

The Contractor shall provide all transport required for conveyance of pipes from the place of delivery to along the pipe trenches to and from any temporary storage ground, care being taken that no inconvenience is caused to occupiers of land or obstruction to traffic on the roads. The Contractor shall ensure that any damage to the coating or wrapping on the outside of the pipe is repaired before being laid in the trench and any lining on the inside is not damaged, either during transport or before, after or during the operation of pipelaying. In handing bitumen coated pipes, each pipe shall be supported at two points, the slings made of wide belting shall be used for the purpose in order to prevent any injury to the coating or lining of the pipes.

The Contractor shall return any surplus pipes or fittings transported to the site or unused off cuts shall be returned to the KAHRAMAA store or as directed by Kahramaa's Representative, unless otherwise specified in contract document.

6.6 Laying, Jointly Pipes and Specials

Pipes and special castings will have flange joints, couplings, bolted glands, Tyton, joints or similar. Before the pipes are laid they are to be carefully brushed before the pipes through to remove any soil, stones or other matter, which have entered. Pipelaying shall commence at low points, i.e., washout branches and proceed towards summits, i.e., air-valve locations unless with the special consent of Kahramaa. Pipes are to be lowered singly into the trench brought to proper inclination, firmly bedded and made to rest throughout their whole length as specified. Before the pipes are socketted the joint shall be carefully cleaned and dried. No dirt or water is to be allowed to enter before the joint is made. No packing of any kind shall be used to locate the pipes in position in the trench.

Pipes, valves, fittings and other materials shall be handled, moved, lifted or lowered, connected with the least possible impact and handling equipment using slings made of terylene, nylon or other suitable synthetic fibres capable of withstanding the required loads, all to the approval of Kahramaa.

6.7 Joints

6.7.1. When setting and assembling flange work care shall be taken to ensure that the flanges are correctly positioned as required that the component parts of the joints are clean and dry that the faces and bolt holes are brought firmly together that the bolts are evenly tightened up in the correct sequence and that the bituminous protection of the flanges is made good.

6.7.2. Proprietary Joints

The Contractor shall obtain from the Manufacturer or his Agent the services of a skilled pipe jointer to demonstrate the correct method of making all proprietary or patented joints and all jointing out strictly in accordance with Manufacturer's instructions.

6.7.3. Flexible, Mechanical Joints

The spigots and sockets of all types of flexible jointed pipes shall be thoroughly cleaned before jointing rings are placed and jointing completed. Notwithstanding any flexibility provided in the pipe joints, pipes must be securely positioned to prevent movement during and after the making of the joints and no person shall be employed on the jointing of pipes who is not thoroughly experienced and skilled in the particular work in hand. No deviation from a straight line will be allowed without the Kahramaa's approval. Any such deviation shall be provided with thrust blocks if so instructed.

6.8 Cutting Pipes

Pipes shall be cut by a method, which provides a clean square cut of pipe and lining and then chamfered where required without being shattered or separated.

All cut or trimmed ends and the parts of any pipe on which the coating may have suffered damage shall be re-coated with non-toxic coal tar epoxy paint as manufacture specification.

6.9 Collars and Closers

Where loose collars are used to join pipes cut for closers special tools shall be employed to keep the inside of the pipes flush and the collars concentric with the pipes while the joint is being made.

6.10 Sluice Valves and Fire Hydrants

6.10.1. Faces and Seating

Gunmetal faces and seatings of all sluice valves shall be kept clean and free dirt or grit of any kind. No valve shall be laid and operated without first wiping the gunmetal faces with a clean cloth dipped in clean non - mineral oil. After such cleaning every care is to be taken to ensure that no extraneous matter enters the valve during the laying process. The gate groove in the base of the valve is to be thoroughly cleaned by hand before laying the valve.

Should bitumen, cement or any other matter be deposited on the gunmetal faces or seatings it shall be dissolved using proprietary solvents or carefully removed by methods that do not involve scraping the gunmetal faces.

6.10.2. Oiling of equipment

Before any sluice valve or hydrant is commissioned, all gears, bearings and spindles should be oiled with approved oil as recommended by the valve manufacturer. Oil baths be topped up to the appropriate levels and all grease nipples charged with grease of approved manufacture.

6.10.3. Stuffing Boxes

Every stuffing box shall be examined when the main is under pressure test and leaking boxes shall be adjusted or repacked with square plaited lubricated packing, or 'O' rings of approved manufacture. The stuffing box shall not be so tightly adjusted or packed as to materially affect the friction of the packing on the spindle.

6.11 Air Valves

Air valves shall be checked before the main is tested to ensure that the balls and faces are not damaged and that there is no dirt or other deleterious material in the cavities of the body. All air nozzles shall be probed to see that they are clean.
Air relief valve assemblies shall not be installed directly to any storm drain or sanitary sewers system.

6.12 Connections to Existing Live Water Mains

Where no tee has been left for future development, the connection shall made using an approved cutter or under pressure drilling tee and drilling machine.

The pipe where is to be fitted will be clean, dry and free from all rust, dust, grease, wrapping tape or any other deleterious matter and shall be painted with the quick drying primer.

After fitting and drilling the whole tee shall be protected as per these specifications, section 8.2.111.

All works and jointing materials required for the connection to existing live or dry water main are to be paid for as part of the appropriate item in the Bill of Quantities.

6.13 Protection of Equipment during Laying

All pipes, valves, fittings and their ancillary equipment shall be protected before and after erection against collapse of earthworks, falls of materials, concrete and cement droppings, wood and other shavings and all deleterious material.

6.14 Sealing Ends of Pipes

Immediately after laying, the open ends of the pipes shall be sealed with unperforated wooden plugs of appropriate size or approved expanding stoppers to prevent the entry of extraneous matter or water which might contaminate or damage or affect the working of the system.
These plugs are not to be removed until the end in question is no longer classified as an open end.

6.15 Buoyancy of Pipes

The Contractor is to note that in certain circumstances jointed pipes are liable to float kin moderately flooded trenches i.e., less than halfway up the barrel of the pipe even though partially backfilled. The Contractor must take every precaution in preventing pipes floating and shall make good any damage occurring from this cause at his own expense. In no case shall the filling of the pipes with water be permitted to prevent floating.

6.16 Anchor Blocks, Thrust Blocks, Support Blocks Etc..

At curves on the pipelines, either horizontal, vertical or a combination of both bends or elsewhere, the pipes must have thrust blocks of concrete Grade S.R.C 20 to the dimensions shown on the drawing or the drawing or as directed by Kahramaa's Representative.

The cost of shuttering is to be including in the rate entered in the appropriate item in Bill of Quantities.

6.17 Sealing Abandoned Mains

Abandoned mains broken into during main-laying works are to be sealed with concrete placed into the open end of the broken main.

SECTION 7 - SERVICE CONNECTIONS

7.1 General

This specification covers laying of MDPE pipes with associated fittings for size range 20mm (1/2") up to 63mm (2") underground and aboveground.

7.2 Excavation & Backfilling

Excavation and backfilling for MDPE service connection will be in accordance with section 4 & 5 of this specification noting that pipe depth shall be 600mm as detailed in the projects specifications.

MDPE service pipe shall have 100mm sand bedding, 150mm sand cover above crown of the pipe, another 150mm selected backfill material with 100% compaction, and backfill material of varied depth up to ground level, all in accordance with Road Dept Highways Maintenance Section requirements.

The minimum width of trench excavation is to be service pipe duct diameter (either 100mm or 150mm) used plus 200mm and maximum width of trench excavation is to be service pipe duct diameter used plus 300mm.

7.3 Materials

All materials supplied shall conform to the KAHRAMAA latest specifications for materials used in Pipelaying construction and service connection work.

7.4 Service Connection Size

The sizes of service connections will differ, in no circumstances shall the sizes of the connection exceed the following values:

Diameter of Main	Maximum Size of Connection with Saddle
80mm	20mm
100mm	25mm
150mm	32mm
200mm	40mm
300mm	50mm
300mm	63mm

Under no circumstances whatsoever will service connection will be made to Primary or Rising Mains, i.e., 400mm dia and greater.

7.5 MDPE pipes and fittings Installation Instructions

Trench marker tape with aluminium strip in the middle shall be laid at minimum 450mm depth below ground level along route of pipe.

The Contractor shall tap distribution main at depth of minimum 900mm and bring MDPE pipe from ferrule to a higher elevation without use of any fittings, as far as possible, so that

MDPE pipe could be laid at a minimum depth of 600mm from ground level, from distribution main till it reaches customer boundary wall.

When laid above ground along customer wall premises or elsewhere, Polyethylene Pipe shall be protected with GRP duct of minimum thickness 3mm.

Two sizes are allowed; 2" duct for 20mm ($^1/_2$"), 25mm ($^3/_4$"), 32mm (1") & 40mm ($1^1/_4$") and 3"duct for 50mm ($1^1/_2$") & 63mm (2").

The GRP duct shall start from ground level and be extended to an appropriate height to secure exposed MDPE pipe near the water meter service cabinet. The GRP duct shall be of semi-circular shape and be firmly fixed to the wall with brackets.

7.6 Works to be taken by the Contractor

7.6.1. Fitting a Saddle

An approved saddle shall be fitted to the pipe.

7.6.2. Drilling

An approved pipe drilling machine shall be mounted on the pipe over the saddle and accurately centred. After tightening the drilling machines fully, the pipe and saddle shall be drilled, tapped to the appropriate B.S.P. thread in one continuous operation, care being taken that excessive pressure is not used the drill is about to penetrate the pipe, causing spalling of the inside face. On completion of this operation the machine shall be removed leaving a continuous taper thread penetrating the saddle and pipe.

7.6.3. Fitting the Ferrule

The ferrule of the service connection shall be entered into the previously bored saddle and pipe then finally tightened up to give a leak proof connection while not overstressing the pipe.

7.6.4. Connections

One connection shall be given to each property unless otherwise as directed by Kahramaa's Representative.

7.6.5. Making the Connection at Boundary Wall

Each new property shall have an approved water meter cabinet which the connection shall be made to. The Contractor is to ensure that all damages to the properties is made good to the Kahramaa's Representative and the consumer satisfaction.

SECTION NO. 8 - CORROSION PROTECTION

8.1 General

All buried pipes and related fittings shall be protected from corrosion by the application of a PVC/Bituminous corrosion protection tape and sleeving.

All pipes and fittings whether collected from KAHRAMAA stores or supplied by the Contractor shall have the appropriate external corrosion protection as set out below. This protection shall be in addition to that applied at the manufacturer's factory in accordance with latest detailed specification for pipelaying materials.

8.2 Pipes and Fittings

8.2.i. All rust, millscale, dirt, oil grease, loose coating etc., is to be removed from the pipe surface, including the internal surface of the socket by grit-blasting to BS 4232 (2nd quality) and if necessary by using an oil solvent such as Xylene. After removal of all dust and within four hours of grit-blasting all exposed surfaces are to be coated with a primer recommended by the manufacturer of the approved PVC/Bituminous wrapping tape. The primer is to be touch-dry before wrapping commences.

8.2.ii. Wrapping of Pipe Barrel

a. The entire external surface of the pipe shall be clean, dry and free from all rust, dust, grease or any other deleterious matter.

b. The clean dry, surface to be brush primed with one thin continuous coat of the tape manufacturer's quick drying (Drying time approximately 10 minutes).

c. The clean, dry, primed prepared pipe surface to be machine wrapped with the approved tape. The tape to be applied spirally with a minimum of 25mm overlap or otherwise as directed by Kahramaa's Representative using sufficient tension to ensure the tape conforms and adheres to the pipe surface. End laps between successive rolls to be minimum 200mm. The wrapping shall extend as close to each end of the pipe as practicable, so the pipe can be jointed in the trench damage to the wrapping.

d. After the pipes are jointed the step between the spigot and socket area is to be shaped-up with the Tape Manufacturer's Putty to give a smooth surface profile for wrapping. The joints shall then be wrapped as described above and the joint wrap to extend a minimum 150mm onto the existing wrap on either side of the joint.

e. Any transit damage to the wrapping tape will be repaired before the pipe is wrapped in the sleeving and laid in the trench.

8.2.iii. Wrapping of Buried Flanges, Valves and other Fittings

a. Buried flanges, valves and fittings shall be protected by approved PVC/Bituminous protection wrapping tape, plus primer and putty supplied by the tape manufacturer.

b. All exposed metal surface of the object to be protected and existing protective coating at each extremely to be cleaned free of all rust, weld spatter, millscal, dirt, dust, lime wash and other deleterious matter.

c. The clean, dry, prepared surface to be brush primed with one thin continuous coat of quick drying primer and allowed to dry completely.

d. Where necessary the dry, cleaned, primed surfaces to be shaped up using cold applied moulding putty packed into crevices around bolts etc., to provide an even contour suitable for wrapping.

e. Specially wrap to a clean, dry, prepared surface with the approved tape, employing a minimum 25mm overlap and using sufficient tension to ensure conformability. End laps between adjoining rolls to be a minimum of 150mm or as directed by Kahramaa's Representative.

8.2.iv. Pipes and fittings shall be sleeved in accordance with clause 8.4 of this Specification.

8.3 Repair to Damaged Pipes

Some pipes display minor damage such as chipping of the cement lining at the spigot end and some pipes display severe damage such as distortion of spigot ends and consequent break-up of cement lining.

Minor damage to linings shall be repaired by thoroughly cleaning any exposed iron and applying a cement mortar mix to a nominal thickness of 0.5mm. Sulphate resisting cement shall be used in a ratio of at least one part cement to 3.5 parts of sand (by mass). The water used must be clean and disinfected or as per manufacturer recommendation.

Severe damage will be brought to the attention of the Kahramaa who will detail the method of repair. Generally the pipe will be cut back to a true circular undamaged section and finished as Clause 6.7 this specification.

8.4 Polyethylene Sleeving

All pipes and fittings shall be wrapped with approved polyethylene sleeve, (blue in colour).

The polyethylene film will be supplied in tubular form and it is to be placed round the barrel of the pipes or fittings and fixed with sufficient overlaps as required by Kahramaa and taped with an approved tape of minimum width of 50mm.

All such sleeving is to be done before the pipes and fittings are lowered into the trench.

After the pipes and fittings have been lowered into the trench and jointed, the polyethylene film shall be folded over the joints with an overlap of 300mm or as directed by Kahramaa's Representative.

The Contractor is to ensure that the fold is positioned such that it is on the crown up the pipe.

The Contractor is to ensure that there is a continuous film of polyethylene between pipes and fittings and the surrounding backfill material. Any tear in this film is to be made good to the satisfaction of Kahramaa. No backfilling of the pipe is to take place until Kahramaa's Representative has checked and passed the integrity of the polyethylene protection.

8.5 External Faces of Blockwork and Concrete Structures below ground

Al external faces of blockwork and concrete work below ground are to be protected from chloride attack by applying two coats of approved bituminous latex emulsion to the exposed faces.

The upper surface of all blinding concrete is to be similarly treated thus ensuring that all external faces are fully protected.

8.6 Pipe Crossing New Roadwork

Not withstanding any of the foregoing clauses the protection of pipes crossing new roadworks when laid in advance of new pipeline construction shall be as follows:

a. Pipes and fittings crossing the dual carriageways of new road construction shall be surround with Grade S.R.C.30 concrete minimum thickness 150mm or in 'A' class roads protected by a 200mm thick concrete raft.

b. Pipe shall be temporarily strutted to prevent vertical and horizontal movement when placing in situ concrete and using vibrating pokers.

c. Bottom vibrated concrete shall have a W.C. ratio suitable for allowing the concrete to flow freely down one side only of the pipeline, to pass under the barrel of the pipe and to rise to a mid-barrel position both sides of the pipe.

d. Concrete construction joints shall be formed at the mid-barrel position and properly formed stop ends shall be inserted in the trench to form vertical construction joints. The C.C joints shall be wire brushed after the concrete has set to remove laitance and the joint shall be wet brushed and rendered with mortar 15mm thick 3:1 mix before.

e. Top concrete shall be tamped by hand with the backs of shovels and can follow curvature of pipes. Likewise in large pipeline construction the bottom of the trench can be rounded providing at all times the concrete cover surround is less than 150mm thick.

f. Clauses 8.2, 8.4 and 8.5 not apply to any pipes or concrete placed in accordance with clause 8.6.

SECTION NO. 9 - HYDRAULIC TESTING

9.1 General

The Contractor is to note that the pipelines are to be subjected to the following hydraulic tests:

1. Test to a pressure of one and half time the working pressure or to a pressure of 9 bars which is the greater and is to be carried out on section of main during laying.
2. After completion of all sections of similar diameter, a test shall be carried out at the specified pressure on the completed pipeline.
3. After completion of service connection, a test of 6 bars shall be carried out on the completed pipeline.

The first test is to be to a pressure of 9 bars and is to be carried out on sections of main during laying. The second test (final) is to be 6 bars, carried out on the competed pipeline and is designed to test the service connections.
In general testing should not be carried out against closed valves, however, with Kahramaa's approval and entirely at the Contractor's own risk, the final 9-bar test can be carried out in sections against closed valves.

9.2 Initial Test

This test will be carried out on short section of main, maximum length to be 1.5 kms. with joints left exposed, with in service connections installed and against proper stop-ends. Under no circumstances this test to be carried out against closed valves.

Each section of pipeline is to be tested to a specified pressure, such pressure being recorded at the lowest point on the test section.

The Contractor is to supply all necessary pumps, water, approved blank suitably drilled and tapped for use as temporary test ends, small bore pipework to fill the main supplying the test hand, pressure guages, isolating cocks, measuring vessels for measuring the quantity of water lost during the test period and all other materials necessary to ensure successful testing of the section.

All work and materials required for the initial testing are to be paid for as part of the pipelaying rate.

Testing is to be carried out in accordance with the requirements of CP2010 part 3 (iron pipelines). For details of the method of testing see clause 9.4 below.

9.3 Final Testing

This test will be carried out when the pipeline has been fully completed i.e., all service connections made fully backfilled and reinstated, all valve chambers complete etc.

The test is to be done as far as the external stop-cock on the service connection and under no circumstance is the test pressure to be transmitted through the service connection to the consumer's internal pipework.
The pipeline is to be tested to a specified pressure, such pressure being recorded at the lowest point on the test section.

The Contractor shall include in his pipelaying rate to supply and install the required number of flexible couplings to joint together all sections of the pipe after testing.

The Contractor is to supply all materials as specified in Clause 9.2 of this Specification. All work and materials required for the final test are to be as part of the pipelaying rate.

9.4 Testing Method

Where pipes are being tested by sections, each section must be properly sealed off with stop and securely anchored to prevent any movement. Unless otherwise specified, the maximum thrust on the stop ends for the 9 bar test is shown in the table below and all anchors have to be designed to take this thrust.

Pipe Diameter mm	Thrust Tonnes
100	0.7
150	1.58
200	2.8
300	6.4
400	11.3
600	25.3
900	57.2
1200	101.7

If the anchor is to be made of concrete, testing must not start until the concrete has developed adequate strength.

After the Contractor is satisfied that all stop-ends are adequately anchored, the section under test is to be filled with water taking care that all air displaced either through vents at the high points or by using a swab or a sphere. The Contractor shall make his own arrangement for the supply and disposal of water used for testing which shall be provided by the Contractor at his own cost and removed from the nearest convenient approved source.

After filling the pipeline, must be left under operating pressure for a period to permit the lining to absorb water, pipeline movements, the release of any air still remaining in the section etc.

The test will last for a period of 24 hours after which time the pressure will be noted and the seals removed.

If a drop in pressure occurs, the quantity of water added in order to re-establish the test pressure should be carefully measured.

Unless otherwise specified this quantity should not exceed 0.1litres per millimeter of pipe diameter per kilometer of pipelinc 24 hours for each 30m head of pressure applied.

The requirements per kilometer per day are shown in the tables below: -

9 bar test Pipe Diameter (mm)	Quantity of Water Litres/km/24 hours
100	30
150	45
200	60
300	90
400	120
600	180
900	270
1200	360

6 bar test Pipe Diameter (mm)	Quantity of Water Litres/km/24 hours
100	20
150	30
200	40
300	60
400	80
600	120
900	180
1200	240

If the test is not satisfactory i.e., the amount of water to be pumped in to bring the pressure back to the test pressure is greater than the quantities given in the tables above, the fault is to be found and rectified. Where there is difficulty in locating faults, the section under test, where it is in initial test should be sub-divided and each part tested separately. For the final test, such sub-division can be done by closing valves. All fittings and other materials required for re-testing is responsibility of the Contractor.

If no faults can be found, then one of the following methods can be utilize to find the leak.

1. Visual inspection of each point not backfilled.

2. Use of a bar probe to detect signs of water in the vicinity of backfilled joints.

3. Aural inspection using a stethoscope or listening stick in contact with the pipeline.

4. Use of an electronic listening device, which detects and amplifies the sound of any escaping fluid.

5. Injection of dye into the test water (only of use in water logged ground).

6. Introduction of nitrous oxide into the test water and using an infra-red gas concentration indicator to detect the pressure of any nitrous oxide that has escaped through the leak.

The Contractor attention is drawn to Clause 4.9 of this specification and is to note that the same constraints are present when disposing of water used for testing.

All pressure tests on mains will be done using water pressure tests and under no circumstances will pneumatic testing be permitted.

SECTION NO. 10 - SWABBING AND STERILIZATION

Before final commissioning of the pipeline, the Contractor shall swab and scour the pipeline to ensure that it is free from obstructions, debris and sediment.

All materials, equipment and water required for hydraulic swabbing, sterilization shall be responsibility of the Contractor.

10.1 Swabbing

One of the following methods shall be used to swab the pipeline. Kahramaa shall instruct the Contractor as to which method is to be utilized.

10.2 Hydraulic Swabbing

A foam plastic cylinder swab, which meets the approval of Kahramaa, shall be inserted into the pipeline and driven by hydraulic pressure through the pipeline. The dimensions of the swab shall be as follows:

i. Pipe diameter less than 300mm

Swab diameter	=	1.25 x pipe diameter
Swab length	=	2 x pipe diameter

ii. Pipe diameter greater than 300mm

Swab diameter	=	pipe diameter + 75mm
Swab length	=	1.5 x pipe diameter

The pipe shall be swabbed in one length or in series of sections as directed by Kahramaa's Representative.

Should the swab jam at any point, it will be the Contractor's responsibility to either dislodge the swab or to locate it and remove a section of pipeline adjacent to the swab to facilitate removal of both the swab and the blockage.

Swabbing will be continued until such time as all obstruction are removed and the swab freely through the main.

10.3 Dry Swabbing

A form plastic cylinder swab which meets the approval of Kahramaa shall be inserted into the pipeline at the beginning of pipelaying and pulled through each pipe as it is laid by means of a rope, thus providing an effective dry swab. To avoid contamination and infestation, an expandable plug shall be fitted at the end of the pipe at each break in the working day and when pipelaying is suspended. The swab shall be replaced at regular intervals to ensure a tight all round fit.

All swabbing costs are to be covered in the billed rates.

10.4 Scouring

After the pipeline has been successfully swabbed, the pipeline is to be flushed with clean water. The scouring shall be continued until the water runs clear and the Contractor shall ensure that no erosion or silting occurs in the water courses or drains into which the water is discharged. The Contractor is to work within the requirements of Clause 4.9 of this specification.

10.5 Sterilization of Water Mains

After the mains have been tested and approved by Kahramaa, swabbed and flushed out, the mains shall be slowly filled with clean water containing a chlorine solution injected by means approved by Kahramaa.

In general hypochlorite solution will be added to the Water passing into the main such that the measured chlorine residual is 20-mg/1 (p.p.m.). After all the mains to be sterilized have been filled, the mains shall be left full of the chlorinated water for a period of 24 hours. After this period the main is to be emptied, filled with clean water and left for a further period of 24 hours. Then Bacteriological Test is to be carried out and sample shall be taken from the front points of main by authorised KAHRAMAA personnel, who will measure the level of chlorine residual.

If the tests fail, the procedure is repeated until satisfactory results are achieved. The Contractor shall be responsible for achieving satisfactory results and the cost of abortive work due to failed tests shall be met by the Contractor.

SECTION NO. 11 - MEDICAL CERTIFICATE

11.1 Contractor's Workforce

Each member of the Contractor workforce who will be working of Water Mainlying and Water Towers/Reservoirs contracts shall be medically examined to establish his freedom from the Carrier State. The Contractor shall supply all medical certificates to Kahramaa as proof. The certificates to be valid for the duration of the Contract period.

11.2 Certification

The medical certificates shall state that the person has been checked for the following:

a. Salmonella typhi
b. Salmonella Paratyphi A
c. Salmonella Paratyphi B
d. Non-specific Salmonella

11.3 Medical Examination

The medical examination shall consist of: -

a. Blood Test
b. Bacteriological examination of stools & urine on a minimum of three occasions at weekly intervals.
c. X-Ray.

11.4 Re-examination

If after the medical examination the person suffers any illness associated with looseness of the bowels or any illness necessitating his absence form work for more than five days then he shall be medically examined again to determine if it is safe for him to be employed on work which could lead to contamination of the Water supply system.

SECTION NO. 12 - RECORD DRAWINGS

12.1 KAHRAMAA Water Pipeline Contracts

a. The Contractor shall not backfill any of the works constructed by him until the KAHRAMAA Surveyors have dimensioned and triangulated all the information required for the production of the necessary record drawings.

b. Where in the interest of Public Safety the Contractor has the right to backfill the works, he shall excavate as necessary all bends, tees junctions, valves, fire hydrants, triangulate these fittings.

12.2 Infra-Structure Contracts

a. The Ministry of Municipal Affairs and Agriculture Consultant on Infra-Structure Contracts is to ensure that the Contractor complies with para 12.3 a and b.

b. Infrastructure Contractors are also required to comply with paras 12.3 a to f.

12.3 General

a. The Contractor shall keep accurate record drawings of the arrangement, positions and details of all works constructed by him. The drawings will be of a form and to scales approved by Kahramaa's Representative, generally 1:1000, and shall be prepared as the work proceeds in ink on transparent plastic film and a digital format.

b. As soon as each drawing has been completed, two dye-line prints shall be submitted to Kahramaa's Representative for approval.

c. If the drawings or documents are not approved, one copy shall be returned to the Contractor with marked indications of alterations required. Upon final approval one copy of the drawing or document shall be "Approved" by Kahramaa 's Representative.

d. After such approval is given, the contractor shall supply to the Kahramaa's Representative two dye-line prints, the original drawing, one ISO size AI negative and digitally formated of each for the use of Kahramaa.

e. All record drawing shall be completed within 30 days of the pipe laying works.

f. Record drawings will show accurately the exact locations of all pipes, tees, bends, junctions, valves, fire hydrants, service connection, PVC pipe, etc. fully dimensioned and triangulated.

g. All as-built drawings must be submitted as per Water GIS Specifications.

12.4. Headworks Contracts

a. In the case of foundation works or where Kahramaa considers it necessary the Contractor shall before the surface of any portion of the ground is interfered with or the work is put in hand in conjunction with Kahramaa examine the Site and the plans and sections of the Works and take such additional levels or other measurements as may be necessary and shall agree as to the surface levels etc., with Kahramaa. Such agreement shall be recorded in writing and shall be signed by the Contractor and the Kahramaa's Representative.

b. The Contractor shall prepare record drawings of all the permanent work as executed. The record drawings shall show all variations and modifications made during construction and shall be agreed and signed by the Contractor and the Kahramaa's Representative. Such drawings shall show clearly any deviation from the lines, levels, runs of conduit, piping, drainage, ductwork and the like, equipment location and other changes so that a complete record of the works s completed shall be available.

c. All record drawings shall be in the English language.

d. The record drawings shall show the general arrangement of all plant, equipment and auxiliaries, position of all switchgear, pumps, motors and motor starters, all cable and conduit runs, interconnecting wiring diagrams, positions of all electrical outlets, lighting and power systems, fittings, switches, flow sheets, control panels, air and water systems, flow sheets, control schematics, valve charts and full details of all integral systems. These drawings shall also include the names of all manufacturers' model and type numbers, details of motor sizes, speeds, vee belts, pulleys, as well as all details or duty and rating of all items of plant. Schematic diagrams shall be clear and easily read.

e. In addition one framed and glazed full size Electrical Distribution diagram shall be erected and installed in each plant room. A similarly mounted diagram for all ducted and piped services (indicating all dampers, valves and controls) shall also be erected and installed in each plant room.

f. Record drawings shall be prepared on plastic film and submitted prior to completion of the relevant part of the works.

g. Following approval of the record drawings by the Kahramaa's Representative, the Contractor shall provide the following:

   i. Full size set of all as-made drawings as follows:
      * One off each on dimensionally stable plastic film.
      * One off each on each on high quality durable paper.

   ii. Two microfilm negatives of all as-made drawings mounted on card and contained in an index file system.

   iii. Reductions to A3 size of all as-made drawings as follows:
      * One off each on dimensionally stable plastic film.
      * Three off each on high quality durable paper bound into volumes related to the separate section of the works.

h. The Contractor shall be fully responsible for providing copies of any or all of the above documents required by KAHRAMAA or other record drawings determined by KAHRAMAA for their records.

j. All record drawings and documents shall be completed and supplied within 60 days of the commencement of the Maintenance Period.

APPENDIX A-12

REGULATIONS FOR CLEARANCES AND WORKS IN THE VICINITY OF EXTRA-HIGH VOLTAGE INSTALLATIONS

KM Regulations for Clearances and Works in the Vicinity of Extra-High Voltage Installations

Document Control

Department	Document Type	Document Title
KM- EN (ENA)	Regulation	KM Regulations for Clearances and Works in the Vicinity of Extra-High Voltage Installations

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Prepared By	**Approved By**
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Table of Contents

1. Introduction

This document is issued as KM document with first issue in 2006 and named as:

"KM Regulations for Clearances and Works in the Vicinity of Extra High Voltage (EHV) Installations".

It is a KM procedure and regulations document set by KM for all authorities to follow.

The document was originally issued in 12.05.1991 as a MEW (Ministry of Electricity and Water) Circular No. 6 for 1991.

- And aimed at the realization to protect KM installations and render guidance to other utilities and services, previous Ministerial Circular 6/1991 has been up-dated, revised and issued as: **"KM Regulations for Clearances and Works in the Vicinity of Extra-High Voltage Installations"**.

2. Purpose

This document is issued by KM under the authority established by the Emiri Decree 2000. The purpose of the regulations is to:

- Prevent damage or interference to KM's extra-high voltage installations;
- Ensure safe and continuous supply of electricity.
- Ensure safe working practices by contractor while working in the proximity of KM's EHV installations.

The regulations stipulate the conditions for execution of public services works in the vicinity of EHV electricity installations.

3. Scope

These regulations apply to the Transmission Extra High Voltage System assets of Electricity Networks Affairs - ENA.

These regulations apply to all persons, organizations and governmental bodies carrying out any type of works in the vicinity of KM's Extra High Voltage installations to facilitate construction of roads and infrastructure, new installations, maintenance and repair of utilities in the vicinity of the cable installations.

4. Responsibilities & Authorities

KM is the responsible and authority body for the enforcement, interpretation and update of these Regulations. The KM representative to be contacted for all matters relating to these regulations is Electricity Networks Affairs - ENA.

5. Definition of Terms

KM – KAHRAMAA, Qatar General Electricity and Water Corporation
ENA – Electricity Network Affairs
EHV- Extra High Voltage
ROW –Right of Way /Way leave/Reservation
SIS – Services Information Sheet.
RO – Road Opening
OHL- Overhead Transmission Line

6. Articles

Article (1)
To issue this circular under the titled subject "*KM Regulations for Clearances and Works in the Vicinity of Extra-High Voltage Installations*" with the aim of notifying all authorities, persons, organizations and government bodies which carry out the supervision and execution works for Public Services on roadways, public places to conform with the requirements provided in their plans and relevant methods of execution in case these works interfere or affect the present and future EHV electricity installations.

Article (2)
All Ministries, Government Departments, Organizations and Bodies persons, organizations and government bodies concerned must comply strictly with the contents of the documents detailed in this circular, copy of which enclosed in both Arabic and English languages. Also all those, concerned must distribute this circular to all Directors of Projects, Consultant and Contractors currently engaged by them or those prospective contractors.

Article (3)
Any questions on the contents of the circular can be directed to Electricity Networks Affairs, KM.

<u>ESTABLISHING TEMPORARY OR PERMANENT INSTALLIONS IN THE VICINITY OF EXTRA HIGH VOLTAGE (EHV) ELECTRICITY PLANT</u>

<u>Introduction</u>

This provides rules for planning and construction of roadways, pipe-lines, buildings, structures and other works in the vicinity of high voltage installations of KM. These rules cover the following High Voltage Transmission Installations:

a. Overhead lines – 400 kV, 220 kV, 132 kV, 66 kV & 33 kV
b. Cable installations – 400 kV, 220 kV, 132 kV, 66 kV & 33 kV (including associated pilot and Fiber Optic cables either laid alongside of power cables or laid independently without power cables)
c. Primary substations – 400 kV, 220 kV, 132 kV, 66 kV & 33 kV

All activities in the vicinity of EHV installations shall be subject to prior approval of ENA, of KM. The compliance with these rules alone does not absolve the responsibility of the concerned party from obtaining the necessary approvals from the concerned section of KM & other state departments. Approval of such works to the Contractor shall be in the form of Service Information Sheets (SIS) supported by relevant documents as per the procedures, prior to the establishment of any work within the boundary limits and time period as described therein.

For any queries related to the EHV installations, please contact ENA, Planning Department for existing record drawings and for future proposals. Issue of SIS will be issued by the Transmission Department.

1. Overhead Lines

1.1 General Requirements & Definitions:

1.1.1 KM has the right of way (ROW) of 25 meters for 33kV/66kV/132kV, 50 meters for 220kV and 400 kV (mandatory requirements) widths on either side of the centre line of overhead transmission lines unless otherwise defined for specific locations. Right of the way for transmission lines operating at voltages other than these levels will be advised when such are added to the system.

1.1.2 Other than the roadways and boundary fences of security establishments any temporary or permanent structures / buildings, parapet walls, etc. shall not be permitted within the above way leave limits. With regard to services crossing the way leave they should be under-grounded and kept 25 meters (minimum) away from the nearest tower foundation of 33kV/66kV/132kV, and at minimum 35 meters for 220kV / 50 meters for 400kV respectively for overhead lines.

1.1.3 The nearest side of the road reservation to the nearest tower foundation shall be at-least 25, 35 and 50 meters for 33kV/66kV/132kV, 220kV and 400kV overhead lines respectively.

1.1.4 The pipelines (water, oil/gas etc.) crossing the way-leaves of 33kV/66kV/132kV,220kV and 400kV shall be 25, 35 and 50 meters (minimum) respectively away from the nearest base of tower leg . Where it is not feasible to avoid parallel running of the metallic pipelines, cables and fences with the overhead lines within the way-leave or outside, in specific and special cases, KM (Director ,ENA) shall accord the approval only after establishing that responsible authorities shall comply with KM requirements to counter the detrimental effects of their services or infrastructure on overhead lines and vise-versa, proven by measurements and calculations that the interference effects are with in permissible limits. Pipe lines cathodic protection should not adversely affect any KM installations such as O/H Lines Pylon foundations and Earthing. All pipe lines shall be under grounded within the OHL defined way leave (ROW)

1.1.5 The use of OHL way leave (ROW) as a road or vehicle track is not allowed. Dumping of rubbish is prohibited within the limits of way leaves and it is the Government rule "Not to tip rubbish except in allocated areas".

1.1.6 All excavation within the way leave shall be backfilled and compacted to withstand the loads of maintenance machinery having a G.V.W of up to 36tons. All excess material shall be removed and, surface reinstated to the original condition to permit free access of maintenance vehicles/machinery as above. The backfilling shall be carried out as per the Civil Engineering Standards followed by the Public Works Authority (PWA) for back filling and compaction. A compaction certificate shall be obtained by the contractor from the approved laboratory/consultant and shall be submitted to Transmission Department of KM along with the completion certificate and As-Built Drawings/Documents for the work with in the OHL way-leave (ROW) duly signed by the client, consultant and the contractor and stating that KM requirements are completed with the provisions of circular no.6 (revised) in accordance to checklist Form provided by KM

1.1.7 Two weeks prior to the commencement of any work within the way leave, the contractor shall advise KM Transmission Operation & Maintenance Section (Transmission Department) and obtain a Service Information Sheet (SIS) (where the relevant procedure of Transmission Department shall be strictly followed) from the Head of Transmission O & M Engineer. The Transmission Department reserves the right to stop any construction activities within the way leave limits, in the absence of Service Information Sheet or works which are carried out in a manner contrary to the instruction given in the Service Information Sheet or have not obtained the necessary approval of the appropriate KM Department as required under different clauses of the regulation.

1.2 <u>Roadways</u>

The construction of roadways shall conform to the guidelines as detailed in Para 1.2.1 to 1.2.6

1.2.1 The finished road surface shall have a specific minimum clearance (mandatory requirement) below the bottom conductor of overhead line, under the designed operating conditions. Such clearance depends on the line voltage and other design parameters.

Direct height measurements at site are misleading, as the height of the conductor along the profile would vary considerably when operating at maximum design temperature. The Transmission Department (ENA) of KM shall, therefore, be consulted to obtain the design values to each individual case and the applicable minimum clearance.

1.2.2 The nearest side of the road to a tower foundation shall make allowance for installation of crash barriers, if so required which should not be less than 25 m from the nearest point of the tower foundation.

1.2.3 Free access from the road-ways to the maintenance tracks shall be provided. The access shall be properly ramped & compacted to suit the maintenance vehicles having a G.V.W of up to 36 tons. Barrier gates shall also be provided as required.

1.2.4 Guard wire and poles of approved type, strictly in accordance to KM standard drawing and specification, shall be erected by the contractor at 75 meters ahead of the crossing point of the line. The poles shall be galvanized and painted over with red & white strips. The Red and White paint shall be of reflective florescent type. Guard wire height shall be based on 3m, 4m and 5m clearances below the level of the lowest conductor under rated operating conditions for the 33Kv/66kV/132kV, 220kV and 400kV overhead lines respectively.

The guard wires carrying approved type warning shall be strung across the roadway at the above mentioned minimum clearance (mandatory requirement) below the level of the lowest conductor under rated operating conditions/temperatures. Every installation shall be subject to prior approval of the Transmission Department (ENA) of KM.

1.2.5 Guard wires / poles shall be erected by the contractor prior to the establishment of any work within the 25, 35 and 50 meters way leave limits for 33kV/66kV/132kV, 220 kV and 400 kV respectively..
Use of heavy construction equipment such as bucket, excavators, mobile boring equipment, cranes, etc... Having extendable arms with longer reach is not permitted within the way leaves for safety reasons.

1.2.6 The roadways shall be designed to run with minimum interference to the overhead lines (preferably perpendicular to the line when crossing). Construction of roundabout or part thereof or T-offs or road junctions within way leave (ROW) limits is not permitted.

1.3 Pipe-lines

1.3.1. Pipe-lines shall not be laid parallel to the overhead line within the limits of a way leave (ROW).

1.3.2 All pipes within the way leave shall be buried and adequately protected against weight of heavy maintenance machinery used for overhead lines having G.V.W of up to 36 tons. If cathodic pipelines protection is necessary, then the design of such protection should not affect O/H Lines foundations and Earthing systems and shall not interfere with the protection systems of transmission lines..

1.3.3 Pipe-line crossing the 33kV/66kV/132kV, 220kV and 400kV transmission lines way leave (ROW) shall be 25, 35 and 50 meters (minimum) respectively away from the nearest base of tower leg...

1.4 Boundary Fences

1.4.1 Boundary fences shall not be laid parallel to the overhead line within the limits of a way leave (ROW). The safe distance for proposed fences running parallel to the transmission overhead lines shall be proved for safety by calculations, by contactor or their consultants.

1.4.2 Where necessary, fences running parallel to the transmission lines or crossing the way leave (ROW) of lines shall be earthed using appropriate means to avoid any electrical accidents while working on the fences.

1.4.3 Access gates without horizontal top beams shall be provided at the points of crossing of way leaves.

1.4.4 Free access for the maintenance staff shall be provided / arranged on day and night basis.

1.5 Gardens & Land-Scapping

Development of gardens, planting of trees, etc. within the limits of way leaves shall be prohibited.

1.6 Street Lightening

Street Lighting columns and over head wires are not permitted within the way leave. Where due to lighting and traffic safety requirements the street lighting columns are essential within the overhead lines way leave (ROW) , in specific and special cases, KM (Director, ENA) shall accord the approval only after establishing that no other alternatives are practicable and that responsible authorities shall comply with KM requirements .

1.7 Installations of Plant Outside the Way leave which May Influence EHV Services

1.7.1 Firing ranges shall be located well away from the electrical installations (transmission lines and substations) such that it shall not impose any danger to the personnel and the installations of the department.

1.7.2 Ammunition stores shall be located well away from the installations such that accidental casualty to the stores shall not cause any damage to the EHV installations.

1.7.3 The radar and similar radiating installations shall be located at a distance such that the level of radiation at the site of KM installations is within the acceptable limits to ensure safety of personnel & avoid mutual interference between both installations.

1.7.4 High structures whether temporary or permanent are not permitted to be constructed within its falling distance + 5 meters from the nearest O/H line conductor deflection with "full wind" design conditions.

1.7.5 HV or EHV cables shall not run parallel to the EHV overhead lines within or outside the OHL way leave. Where due to specific site conditions and technically justified reasons, the parallelism is unavoidable; KM (Director, ENA) shall accord the approval after establishing that no other alternatives are practicable and that responsible authorities shall comply with KM requirements. The Project contractor / consultant shall study the impact of such parallelism of cables with OHL and vice versa and shall prove by calculations that it is safe to lay the cable along the propose cable route. Cables crossing the 33kV/66kV/132kV, 220kV and 400kV transmission lines way leave (ROW) shall be 25, 35 and 50 meters (minimum) respectively away from the nearest base of tower leg.

1.8 Passage of High Loads under the OH Lines:

The Transporter or the end user of transported goods shall check the height of the cargo that could be transported safely under the lines in consultation with the O&M (Transmission) section of Transmission department of KAHRAMAA. Head of O&M (Transmission) section shall be notified minimum 14 days in advance about the proposed movement of "High Load" under the line(s) enabling them to study the feasibility. The end user/transporter shall provide all assistance and support to facilitate safe passage of the loads. Necessary co-ordination between different departments and other utilities / law enforcing agencies shall be carried out by the end user.

2. Cable Circuits

2.1 General Requirements & Definitions

2.1.1 This heading covers all types of EHV cables (Power, Pilot, Telemetry and Fiber Optic) which are installed beneath the ground level.

2.1.2 Typically, the cables are 'off road' installations, except at road crossings where the cables are inside concrete ducts filled with bentonite. There are few exceptions where some of the cable circuits are allowed to remain along the extended carriageway with certain conditions by prior agreement.

2.1.3 The cable routes shall be free of any permanent temporary structures. KM reserves its right to excavate along the cable route for necessary repair works.

2.1.4 Cables are normally buried directly in the ground in trenches located as per applicable Road Hierarchy or inside open ground in the dessert i.e.; inside the carriageway, under the payment, across the road, inside ducts, or in the dessert.

Where ever cables have been laid/installed, KM has the ROW along the cable routes; the horizontal width of the ROW is generally 1 to 4 meters depending on the installation arrangement.

2.1.5 Although KM can furnish reasonably accurate drawings/records of the routes of these cables the responsibility of positively ascertaining the location and depth of a cable rests with the parties involved with the works at the vicinity of the cables.

2.1.6 Usually, KM Data Base maintains records of cables installed in the ground. The records are reasonably accurate but, not a guarantee of the precise location and depth of the cable. It is possible that some cable circuits have not been entered in the records or that they are in the process of being entered in the records.

2.1.7 The existence of EHV cables beneath the ground shall be ascertained by taking trial holes over the cable route, without depending on the available records.

2.1.8 Usually, the cables are buried such that the average depth from the ground level to the top of the cable protective tile is 1.1 meters. The location of the cable along the route is usually identified with cable route markers but, the accuracy of information is not guaranteed as it is possible that the cable route markers may have been shifted by others without approval of KM.

2.1.9 Within the cable reserves no excavation will be allowed except for the crossing of other services e.g. telephone lines, pipe-lines or to make trial holes for the positive identification of the cable.

2.1.10 Excavations parallel and very close to the cable route but, out side the ROW will be allowed only if the total length of traverse is not more than 500 m and that there is no danger to the existing installation from collapse. Where the proposed new service very close to the route extends for more than 500 m, the concerned utility shall produce induced voltage calculations to confirm that there installation is safe from Induced voltages and Step & Touch voltages.

2.1.11 Foundations and civil structures (Temporary or permanent) will not be permitted in the close proximity to the cable circuit. A minimum horizontal distance of 1.5 m from such structures to the nearest edge of the cable trench shall be observed provided that excavations for such structures are not deeper than the bottom level of the cable trench. For deep excavations below the level of cable trench, advice of KM shall be sought to establish the horizontal distance that could be permitted.

2.1.12 Any posts of the fences and sign boards crossing the cables way leave should be erected outside the way leave limits.

2.1.13 KM shall be informed of all the development works which involve the cable reservation and specific approval shall be obtained prior to detailing any works in these areas. The Operation and Maintenance (O&M) Section of Transmission

Department shall be informed 14 days prior to commencement of any excavation work in the vicinity of cables and necessary Service Information Sheet (SIS) /Clearance shall be obtained.

2.1.14 The use of mechanical excavators shall not be permitted for excavation work approaching three meters to the cable reservations and within ROW. All excavations shall be done manually. Limited use of jackhammer under direct supervision may be allowed by KM.

2.1.15 Excavation approaching three meters to ROW and deeper than 1.1 meters shall be protected by shuttering to prevent collapse of soil protecting the cable circuits.

2.1.16 The excavation Contractor shall provide a competent person (approved by KM) at site at all times to receive the instruction from the representative of KM concerning requirements to safeguard the integrity of the cables.

2.1.17 Removing Cable protective tiles and exposing the cable installation is not allowed unless the Contractor has been served with a Safety Document as per the rules and regulations of KM supported by an approved method statement concerning the procedure protecting the cable installation. The exposed cables shall be normalized exactly to the original condition. Usually, the cables are embedded in dune sand or inside stabilized backfill below the cable tiles. The bedding below the cable tiles, installating cable tiles, Backfilling and Reinstatement above the cable tiles shall be supervised by an authorized person on behalf of KM. Any dislocated cable route markers shall also be reinstated.

2.1.18 Any damage to the installation will be subject to a claim for reimbursement of cost of repairs including the consequential loss against the contractor.

2.1.19 When the cables are running parallel to the EHV OH lines or crossing them the necessary impact of fault on lines and vice versa shall be studied and provided to Kahramaa before commencing any excavations.

2.1.20 The Explanatory notes concerning EHV Cable installations as set out in, Appendix 6 of this document is supplementary and shall be complied with.

2.2 New Roadways

2.2.1 Cable reservation is either provided along the central reservation or the edge of the roadway. The development of existing roadways in some cases has encroached the cable reservations. In such cases the existing cables shall be diverted and rerouted as off road installations free of cost to KM. System outages for such works shall be between 01st of November to 30th March of the following year subject to prior agreement with KM.

2.2.2 Where KM has agreed to keep to cables under the extended carriageway, KM reserves the exclusive right of excavation of even newly laid road for repair works, if this becomes necessary. Any future revision to the existing Road Hierarchy must comply with KM reservation and corridor requirements and shall obtain prior approval of KM.

2.2.3 At all crossing points of roads & cable reservations, approved type and number of cable ducts shall be provided for future cable circuits. Spare cable ducts shall also be provided at the existing cable crossing points.

2.3 Telephone, Water, Sewerage & Gas Services

The service facilities for telephone, water, sewerage, gas, etc. shall not be permitted to be laid within the cable reservations. The following minimum clearances shall be observed for respective service lines at crossing points. Such crossings may not be permitted if the cable's rating / integrity will be affected in any way by the services to cross the cable reserve.

Service/Utility	Vertical clearance (Minimum)
Water & TSE Mains (to cross below EHV cable level)	500 mm
Water distribution lines	200 mm above cable protective tile
Sewerage Mains (to cross below EHV cable level)	1000 mm
Drainage	500 mm below the cable or 200 mm above the cable protective tile
Gas pipes	600 mm
Telephone lines	200 mm above the cable protective tile
LV / 11kV cables	150 mm above the cable protective tile

3. Substations

3.1 The current building permits regulations regarding minimum set back distances from neighbor's boundaries should be complied with for adjacent premises. At present a 3.0 m set back is required from the substation boundary lines fixed at the approved site co-ordinates lines.

3.2 The design of dwellings and commercial building shall take into consideration that harmful objects are not thrown into the substation or exhaust from dust extractors etc. discharged in a manner which may cause serious damage or pollution to the EHV installations.

3.3 Prior to commencement of construction work in proximity to the outdoor high voltage installations, necessary safety measures, shall be observed.

3.4 KM substation entrance shall be kept clear all the time where no car parking is allowed near or around the substation .In neighborhood of KM installation dumping of scrap/rubbish or storage of dangerous materials (gas/explosives) or Building of High Rise Multi-story building over looking the substation or utilization of open space for sports activity shall be strictly prohibited.

4. *General Liabilities*

4.1 It is the responsibility of the authorities installing other services to ensure that no detrimental effects are encountered due to proximity of EHV installations (e.g. effects of induced voltages, cathodic protection, interference with T.V. & Radio reception etc.).

4.2 No work which may cause pollution or other detrimental effects to KM installations is permitted in the proximity of EHV services.

4.3 The contractor shall indemnify the KM against accidental injury or death to their personnel working in the proximity of live installations. It is the responsibility of the contractor to ensure that proper safety measures are taken by their personnel working in the proximity to EHV installations.

4.4 The above guidelines do not negate the need to carry out the Road Opening Procedures or any other procedure requested by other sections of KM or any other departments for the same other reason.

4.5 Neither these guidelines nor any information gathered from any other official source will absolve liability for damage.

4.6 As-Built Drawings would require to be submitted to KM for location of Road crossing ducts, Diversion or Relocation of EHV /HV installations to up-date KM records.

5. Appendix (A)

EXPLANATORY NOTES CONCERNING EHV CABLE INSTALLATIONS

Wherever the existing cable installations may be affected by the proposed development work, the requesting authority shall make an application to KM for *Service Information Sheet* (SIS) and carryout initial investigations by taking *Trial Holes* along the EHV cable route to ascertain the exact position of cables and the depth to the top of cable cover. The investigation should generally be undertaken prior to the award of Contract by the concerned Authority.

In the event EHV installations are within the proposed development work the requesting authority shall examine alternative options and ensure that the existing installations are unaffected. Where this is not possible, EHV cable installation shall be diverted and re-routed. The funds for such additional works shall be met from the concerned Service Authority unless otherwise KM agrees to meet the expenditure.

Where the existing installations will not be affected the work may proceed with the consent of KM and upon completion of works the concerned authority shall submit as built drawings 1:500 scale showing precisely the modifications with respect to EHV cable installations marked to scale in Soft Copy and Hard copy formats acceptable to KM, GIS Data Base Section. The characteristic points shall have 1:20 scale therein.

The following requirements are complementary to those already stipulated as above and shall be satisfied as a minimum for any activity within the vicinity of EHV installations.

1. After the preliminary investigations, detailed drawings shall be submitted on 1:500 scale drawings showing the precise location of other services and the proposed development works with respect to existing EHV installations superimposed on single sheets.

2. KM shall have the right to excavate within the cable reservation, be it new roadways, pavements, walkways, roundabout, centre reservation etc., and remove any obstruction whatsoever at any time should it be necessary to attend to cable repair and maintenance.

3. Where the line of the proposed carriageway/hard shoulder infringes on existing cable installation which has hitherto remained as an *off road* installation, and where the depth from final surface level to the top of the cable cover is not more than 1.1 m over a length not exceeding 10 m of every 100 m of cable route, suitable RCC raft protection may be installed with the consent of KM. The proposed raft protection shall incorporate the following requirements and the proposed installation details and methodology shall be submitted to the Department for review.

   - 250 mm wide with suitable lifting facility
   - Capability of withstanding 10 Ton wheel load
   - Vertical opening of 100 mm diameter exactly above the cable to facilitate testing of cable. This shall be at every 1 m intervals along the length of cable.
   - The length of the raft extending 0.5 m beyond each outside edge of cable tile.

- 200 mm dune sand bedding between the top of cable tile and bottom of raft protection.

4. In the event of widening of the road (or part thereof), the cable ducts of the existing road crossings shall be extended to cover the increased area falling under the new road including a length of 0.5 m beyond the furthest edge of the proposed curb line on each side of the extended carriageway/road crossing. Split ducts shall be used for the existing cables, which shall be filled with *BENTONITE Mixture* after installation. All the ducts shall be sealed with caps to prevent the migration of contaminants inside the ducts. The work shall be co-coordinated and carried out with the approval of the Department.

5. Spare ducts shall be constructed at road crossings.

6. Wherever, roundabouts are proposed over the line of sight of existing cables, such sections of cables shall be re-routed to fall under a Footpath/ pavement of the out side edge of the roundabout.

7. Delineation Bollards/Vehicle barrier posts shall be erected at locations close to valve pits, tank pits to prevent trafficking from vehicles.

8. Constructions such as water gullies, soak pits, chambers, water mains, high mast foundations, Traffic signal control equipment, Traffic Radar Cabinets shall be located one meter away from the nearest edge of cable protective cover, Tank pit or cable joint bay.

9. Use of heavy mechanical excavators (other than hand operated pneumatic jack hammers) or driving sheet piles within 3m reach of the nearest edge of cable cover, cable joint and tank pits are not permitted.

10. Heavy machinery engaged in the civil construction or road works shall be located in such a manner that the operating load/thrust/weight will not be applied directly on the cable installation.

11. Trench excavations parallel to the cable installations shall have a minimum separation of 1.0 m to the nearest edge of cable tile. Only 30 m of trench shall remain open at any time unless suitable shoring, timbering and shuttering are provided acceptable to KM, to protect the EHV installation and the cable from collapsing.

12. Laying of metal pipes over a long distance parallel to cable in close proximity is not permitted unless the concerned authority satisfies that the *Step* and *Touch Potentials* at any point of the pipe line do not exceed 65 Volts.

13. Temporary access or approach roads so required for diversion of vehicular traffic during the progressive stages of construction works, which falls over the cable installations shall be subject to limitations noted under (4) above.

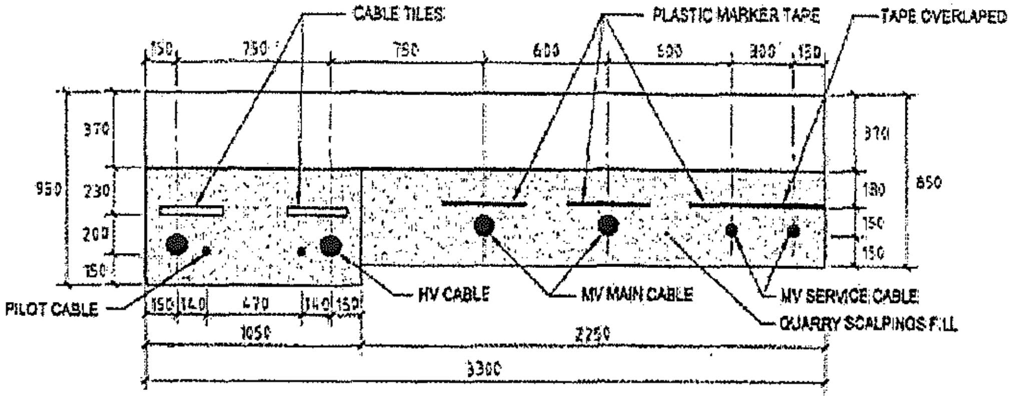
14. The hard surface, if any, falling above the cable installation shall be loosened by pneumatic jack hammers or similar machinery prior to scooping out the debris to prevent the transmission of vibration to the cable installation below.

15. Where the requirement of other services, such as water mains, telephone, sewerage mains etc. necessitate the crossing of EHV installations, prior approval of KM shall be obtained for the precise location and the method of crossing. Where the proposed services shall cross under, the EHV cables shall first be exposed and temporarily protected in a manner acceptable to KM. Such protection measures shall be made with the cables switched off for which purpose 14 days notice will be required. In the event KM is unable to arrange the outages as requested, such reworks shall be programmed during the period spanning from 01st November to 30th March of the following year when the plant can be conveniently taken out of service.

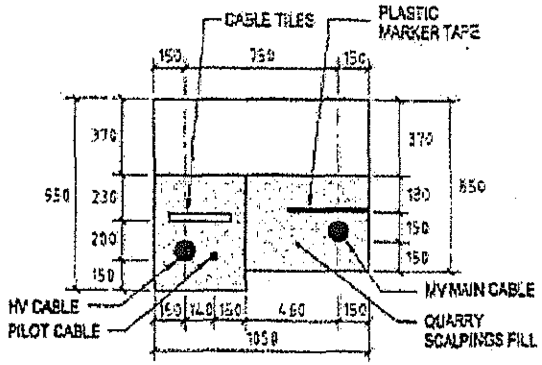
16. Work within the EHV reservation shall be continuously supervised by the authority or the Consultant engaged in the proposed development work. However, if it becomes necessary to disturb the cable installation or expose the cables such works shall be carried out only after obtaining necessary *safety documents.*

17. Continuous interaction shall be maintained by the authority or the consultant with KM as the work progresses in order to ensure highest safety and security to the integrity of EHV installation(s).

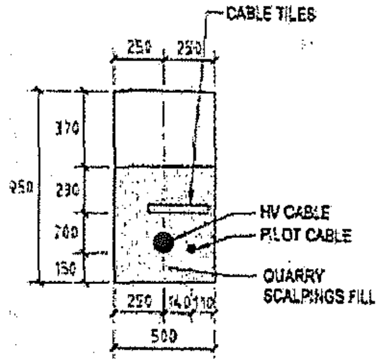
- END -



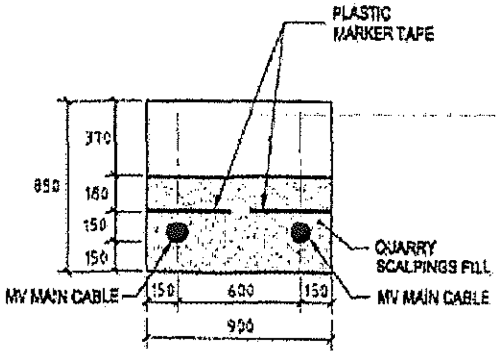
2 x 11HV + 2 x PILOT + 2MV MAIN + 2 x SERVICE CABLES



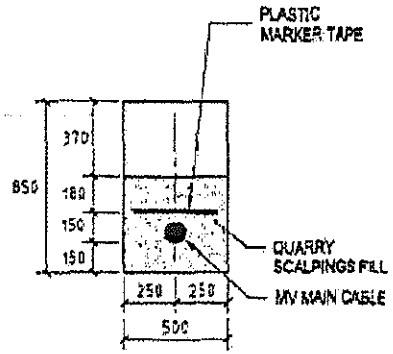
1 x HV + 1 x PILOT +
1 x MV MAIN CABLES



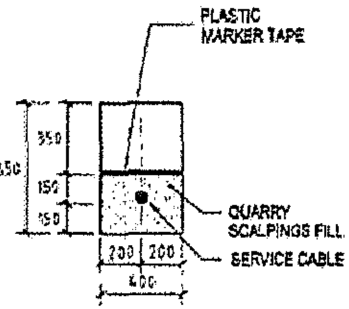
1 x HV + 1 x PILOT



2 x MV MAIN CABLES



1 x MV MAIN CABLE



1 x MV SERVICE CABLE

IN PRIVATE PROPERITY ONLY

NOTES:-

1 MINIMUM CLEARANCE

CENTER LINE OF CABLES - NEAREST EDGE OF UTILITY, PIPE CABLE OR T.V. CABLE = 0.60 M

CENTER LINE OF CABLES - ANY STRUCTURES = 1.0M (EXCLUDING: UTILITY MANHOLES, STREET LIGHTS, STREET FURNITURE,TREES)

2 CABLE TILES AS PER DRG. NO. STD/TCH/02 AND PLASTIC MARKER TAPE AS PER DRG. NO. STD/TCH/03.

3 THIS DRAWING SUPERSEDES DWG. No. EWD/ED-21.

4 ALL MEASUREMENTS ARE IN mm

KAHRAMAA كهرماء المؤسسة العامة القطرية للكهرباء والماء QATAR GENERAL ELECTRICITY & WATER CORPORATION

ELECTRICITY NETWORK AFFAIRS شؤون شبكات الكهرباء
NETWORK PLANNING DEPARTMENT إدارة تخطيط الشبكة
قسم قاعدة بيانات الشبكة
NETWORK DATABASE SECTION

TITLE: TRENCH DIMENSIONS AND CABLE CLEARANCES FOR DISTRIBUTION(HV & MV)

DATE	xx-5-2002	SCALE	1 : 25
DRAWN	SAS	DESIGNED	
CHECKED	RCR	APPROVED	
REF.			

DRG. No. STD/TCH/01

REVISION 0 SHEET No. 1/1