TENDER NO. 75-2026

CONSTRUCTION FOR NEW AQABA 400/132 KV MAIN CONVEYANCE SUBSTATION (AAWDCP) INCLUDING ASSOCIATED WORKS AT IPS, BPS1, AND RO

GENERAL TECHNICAL SPECIFICATION

FOR CIVIL WORKS

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1. GENERAL INSTRUCTIONS

The Terms and Conditions and Schedule of Rates shall be read in conjunction with these Specifications. Matters described in one part are not necessarily repeated in others.

1.1 Contractor's Responsibilities and EPC Risk Allocation

As stated in the special condition sheets, this is an EPC (Engineering, Procurement and Construction) contract on FIDIC Silver Book, which includes, in addition to works defined elsewhere, all civil engineering and building works and services. The Bidder must cover all requirements of the tender documents, and any other items not specifically mentioned but which are deemed to be necessary for the satisfactory design, construction of buildings, structures, operation, supply of materials, and construction and operation of all equipment at the substations, in full compliance with the Contract and Employer requirements.

The Contractor shall be deemed to have examined and satisfied himself as to all conditions affecting the Works, including but not limited to site conditions, topography, geotechnical and hydrological conditions, flood risks, environmental constraints, and the provision, construction, and maintenance of temporary access roads to the substations.

No additional costs will be considered for any items that have been overlooked but which are essential for the proper completion of the project in every respect. The Tender must include outline drawings and information to indicate the main proposals and materials being offered; however, any detail shown on the drawings shall be obligatory and shall be executed accordingly. The successful Tenderer will be responsible for the design, management, progress, construction, and setting to work of the Civil Works, which comply with the electrical requirements and equipment and scope of work.

Any reference to approval, acceptance, consent, agreement, review, or comment by the Employer shall be deemed to be for verification of compliance with the Contract requirements only and shall not constitute approval of design, materials, workmanship, construction methods, or temporary works, nor transfer any responsibility or liability from the Contractor.

Where reference is made to specific standards, codes, or specifications, such references shall be deemed to include the latest applicable edition thereof or any internationally recognised equivalent standard, and compliance therewith shall remain the sole responsibility of the Contractor. The Contractor shall ensure that all Works achieve the required performance, durability, service life, and fitness for purpose under the prevailing Site, environmental, and operating conditions, without entitlement to any additional payment, claim, or extension of time.

1.2 Site Visit, Site Conditions

the Bidder will be deemed to have visited the site before preparing his bid to ascertain the local conditions and local society under which the works will be carried out and to satisfy himself as to the availability of all labour, plant, materials and other items necessary for the satisfactory execution of the works. He shall collect for himself site levels, sub-soil data, and other information to enable him to estimate the bearing capacity, foundation requirements, etc., for use in the preparation of a Bid. The Bidder shall include for all local eventualities including local and social conditions, customs, practices, and any other circumstances that may affect the performance, progress, or completion of the Works. It is also the Contractor's entire responsibility to ascertain for himself the local regulations, import restrictions and customs duties, port facilities, loading and unloading, transportation, etc., and obtain his own information on all factors which might affect the supply, construction and completion of the buildings, site facilities and services, to meet the completion date for the substations.

The Contractor shall ensure that temporary access to each Site is available, safe, and suitable always during the execution of the Works.The Contractor shall be fully responsible for the provision, construction, improvement (if required), maintenance, and reinstatement of the access road(s) to all Substation Sites and shall take the existing condition of the access road(s) fully into consideration when preparing his Bid, pricing, and construction schedule.

The Contractor shall strictly comply with all applicable laws, local regulations, zoning requirements, and instructions issued by the municipality and any other competent authority in the Hashemite Kingdom of Jordan, including but not limited to building area limits, setbacks, height restrictions, coverage ratios, and any other applicable bylaws or regulations. The Contractor shall be fully responsible for any violation resulting from non-compliance and shall, at his own expense, remedy and rectify such violations, in addition to bearing any fines, fees, or compensations imposed by the authorities or incurred by the Employer as a result of such violation. The Contractor shall also be fully liable for any delay in the execution of the works arising from such violations or the rectification thereof, without entitlement to any extension of the contractual period.

After the award of the contract, the Contractor must make all necessary site surveys and sub-soil investigation required, before commencement of the detailed designs and working drawings. The sub-soil investigation should include determination of the design bearing pressure for foundations. Results of the investigations shall be made available to the Employer. The safe capacity of the sub-strata may be modified at the final design stage after completion of the full site survey and investigation, and finalization of the layout and structural details in accordance with the Contract. No adjustment to the Contract Price shall be made on account of any variation in the soil or bearing capacity conditions, whether requiring modification of the foundation design or otherwise, discovered during the final design or construction stages. The Contractor shall be deemed to have fully satisfied himself as to the ground and subsurface conditions, including the presence of groundwater or any other unforeseen underground conditions, and shall bear all risks and costs arising therefrom.

The Contractor shall, based on the results of the sub-soil, groundwater, and environmental investigations, determine and adopt the appropriate type of cement, concrete mix design, and protective measures in accordance with relevant international standards and best engineering practice.

The Contractor shall be deemed to have examined, verified, and accepted all site conditions affecting the Works. This includes, but is not limited to, topographical, geotechnical, hydrological, hydraulic, groundwater, flood risk, environmental, climatic, and seismic conditions. The Contractor shall bear full responsibility for the design and execution of all civil works in accordance with such conditions, and no claims shall be entertained arising from any site-related constraints or conditions.

the Contractor shall be deemed to have fully satisfied himself as to the adequacy, safety, and suitability of all temporary access arrangements to the Sites, including access roads crossing wadis, flood-prone areas, or environmentally sensitive zones. The Contractor shall be fully responsible for the assessment, design, construction, protection, and maintenance of any temporary access roads, crossings, culverts, box culverts, drainage structures, or protection works required to ensure safe and uninterrupted access to the Sites during construction and operation of the substations. All such works shall be deemed to be included in the Contract Price. The Contractor shall carry out, as part of his obligations, hydrological and hydraulic studies for each Site and for all access roads, including flood risk assessment and determination of design flood levels. Based on the results of such studies, the Contractor shall design and implement appropriate surface water drainage systems and flood protection measures to prevent inundation, erosion, or damage to the Works. No additional payment or extension of time shall be granted in respect of any requirements arising from such studies.

Any temporary or permanent works required to comply with environmental permits, traffic management requirements, or safety obligations related to access roads and site access shall be the sole responsibility of the Contractor and shall not give rise to any variation or claim. The Bidder shall also familiarize himself with all site safety, environmental, and security requirements applicable to electrical substation works. All personnel accessing the site shall comply with the Employer's safety procedures and obtain the necessary safety clearances prior to commencement of any work

1.3 Civil Program

The bidder shall submit an outline civil programme based on the overall programme showing how the works are to be completed in the time required. Within one month after the receipt of the Employer's order to commence works, the Contractor shall prepare and issue to the Employer a detail Civil construction programme for the works developed from the contents of the above schedule. In addition to the individual programme a key programme on a single sheet showing the phasing of the works as a whole shall be issued. The programme shall be submitted to the Employer for review/comment for conformity with the Contract requirements.

The Contractor may revise the programme as necessary, provided that the programme remains consistent with the employer and contract requirements and the Time for Completion.

1.4 Civil Sub-Contractors

All civil works including Electro-Mechanical works shall be executed by a local civil subcontractor.

The Contractor **must** provide, as part of its Bid, full details of any proposed Subcontractor for the civil engineering and building works design and/or construction and/or electromechanical services,

Including full details of comparable works carried out elsewhere by the subcontractor, together with details of the financial stability and general efficiency of the subcontractor proposed.

For the civil works, the Civil subcontractor shall be classified as a first grade in building construction according to the classification of the Ministry of Public Works and Housing in Jordan. Besides, it should be competent, qualified, and approved by the Employer and shall be nominated at the tendering stage.

For the electromechanical services works, the Sub-Contractor shall be classified as a first grade in renewable energy and electromechanics according to the classification of the Ministry of Public Works

and Housing in Jordan. Besides, it should be competent, qualified, and approved by the Employer and shall be nominated at the tendering stage.

The approval of any Sub-Contractor by the Employer shall not relieve the Contractor of any of his obligations, liabilities, or responsibilities under the Contract.

(Also, for more information, refer to volume 1- section2: instruction to tenderer)

1.5 Assistance to the Employer

The Contractor shall provide and maintain upon the site to be available for use by the Employer or the Employer's representative, all surveying instruments and testing equipment required for setting out and measuring the works and for controlling and testing the quality of materials and workmanship.

The Contractor shall provide all the assistance and services the Employer or the Employer's representative, may require, including labourers, chainmen, and others, for the purpose of checking the setting out, making tests, etc. Any checking, witnessing, inspection, or verification by the Employer or the Employer's representative shall not relieve the Contractor of any of his responsibilities, obligations, or liabilities under the Contract, including full responsibility for the accuracy of setting out, design, workmanship, and compliance with the Contract requirements.

1.6 Records

The Contractor shall keep at the Site accurate, complete, and up-to-date records and drawings of the Works as they progress and shall make such records available to the Employer or the Employer's representative upon request. The Contractor shall submit to the Employer, on a weekly basis, detailed returns of labour, plant, equipment, and materials employed on the Site during the relevant week, in a format suitable for review and record purposes. Upon completion of the Civil Engineering and Building Construction Works, and as a condition precedent to Taking-Over, the Contractor shall submit complete, accurate, and up to date as-built drawings reflecting the Works as constructed.

The as-built drawings shall be submitted in the following formats:

- Editable AutoCAD (DWG) files; and
- PDF files (and hard copies, if required under the Contract).

The as-built drawings shall show full details of the Works as constructed, including, but not limited to, the location, levels, dimensions, coordinates, and alignments of drains, services, foundations, roads, underground utilities, and all permanent Works. Any review or record-keeping by the Employer of such records or drawings shall not relieve the Contractor of his full responsibility for the accuracy, completeness, and correctness of the information provided

1.7 Samples, Testing & Inspection

The Employer may, at any time, request samples of proposed materials, workmanship, or construction methods, and such samples shall be provided by the Contractor without delay and at his own cost.

Before ordering materials, the Contractor shall submit for approval the names of manufacturers or suppliers proposed. When requested by the Employer or the Employer's representative, the contractor shall supply manufacturers' test or proof certificates. If he considers it desirable, the Employer may send inspectors to manufacturers or suppliers' premises to test materials before despatch to the site.

The Employer or the Employer's representative may, for verification purposes, arrange for inspections or witnessing of tests at manufacturers or supplier's premises prior to delivery to the Site.The Contractor shall bear full and exclusive responsibility for carrying out all tests, examinations, inspections, and quality control activities related to the Works and materials strictly at the laboratory in Jordan, and entirely at his own expense, in full compliance with the Contract provisions, the Employer's Requirements, and the General Specifications issued by the Ministry of Public Works and Housing. Site laboratory should be provided. Where any materials, workmanship, or Works are found not to comply with the Contract requirements, the Contractor shall, at his sole cost and risk, immediately remove such materials from the Site or demolish and remove the defective Works and replace them with compliant Works. Such rejection, removal, demolition, or replacement shall not entitle the Contractor to any extension of time, additional payment, or claim under the Contract.

Any review, inspection, testing, witnessing, comment, or approval by the Employer or the Employer's representative shall be for verification and monitoring purposes only and shall not relieve the Contractor of any of his obligations, liabilities, or responsibilities under the Contract.

Laboratory Approval and Testing Requirements

All tests and laboratory examinations required during the execution of the Works and upon completion of the Works shall be carried out by the Royal Scientific Society (RSS) and by a laboratory accredited by the Ministry of Public Works and Housing (MPWH) and approved by the Employer (NEPCO). Prior to commencement of the testing activities, the Contractor shall submit at least three (3) proposed laboratories, duly accredited by the Ministry of Public Works and Housing, in addition to the Royal

Scientific Society (RSS), for the Employer's review and approval. The Employer (NEPCO) shall have the right to select and approve the laboratory at which the required tests shall be performed.

The Contractor shall ensure that the selected laboratory holds valid accreditation covering the specific tests and testing methods required under the Contract. All tests shall be performed strictly within the accredited scope of the selected laboratory.

The Contractor shall be fully responsible for arranging, coordinating and carrying out all required tests, including sampling, transportation of samples, testing, reporting and any retesting required by the Employer. All costs and expenses associated with the required testing and laboratory services, including but not limited to laboratory fees, sampling, transportation, testing, reporting and retesting, shall be deemed included in the Contract Price and shall be borne entirely by the Contractor.

1.8 Bid Proposals

The Tender Documents describe the general scope, principles, and performance standards of the Civil Engineering and Building Works forming part of the Project and are indicative only.

The Contractor shall be responsible for developing and detailing the design and execution of the Works in accordance with the Contract and the Employer's Requirements. The Contractor may refine or vary the details of the indicative Tender Documents to suit his proposed solution, provided that the overall scheme, functionality, performance requirements, and standards of the Works are not adversely affected and remain fully compliant with the Contract. Any minimum dimensions, clearances, or performance criteria specified in the Employer's Requirements or Contract Drawings shall be mandatory and shall not be reduced or compromised by the Contractor. Details of the Contractor's proposed Civil Works solution shall be submitted to the Employer for review /comment.

Any review, comment, or lack of comment by the Employer or the Employer's representative shall not relieve the Contractor of any responsibility for the design, adequacy, or performance of the Works.

The Tender Schedule of Civil Works Proposals shall be fully submitted and shall list the principal sizes, materials, and finishes upon which the Tender is based. The Contractor shall be bound by the proposals stated therein unless otherwise varied in accordance with the Contract

1.9 Purchase from any source:

The Contractor shall allow in his price for the purchase of all materials, etc., from any source as may be necessary to maintain the progress of the works on condition that the subject materials shall meet specifications. All materials, equipment, and supplies shall strictly comply with the Contract requirements, applicable codes and standards, and the Employer's Requirements, and shall be subject to review by the Employer. The Contractor shall bear full responsibility for the selection of sources, manufacturers, and suppliers, including all risks related to availability, quality, delivery, logistics, customs, duties, and any associated delays. No claim for additional payment or extension of time shall arise from the procurement of materials from any source. Any review, comment, or acceptance by the Engineer or the Employer in relation to materials or sources shall not relieve the Contractor of any of his obligations, liabilities, or responsibilities under the Contract, including fitness for purpose.

1.10 Temporary Services:

The Contractor shall be solely responsible for arranging, providing, operating, maintaining, and removing all temporary services required for the execution of the Works, including but not limited to electricity, water, drainage, telecommunications, fuel, and any other utilities or services necessary in sufficient power, quantity, quality, and capacity. He shall be responsible for payment of all costs for these services up to tests on completion. All temporary services shall be designed, installed, operated, and removed in full compliance with: applicable health, safety, and environmental (HSE) laws and regulations, the Employer's HSE requirements, approved method statements and risk assessments, and relevant environmental permits and conditions.

The Contractor shall take all necessary measures to prevent pollution, environmental damage, excessive noise, dust, vibration, leakage, or contamination arising from the provision, operation, or removal of temporary services, including the proper handling, storage, and disposal of fuels, wastewater, and hazardous materials. The Contractor shall bear all costs, charges, fees, and expenses related to temporary services, including connection, consumption, monitoring, maintenance, disconnection, restoration, and removal, up to the completion of all tests on completion and Taking-Over of the Works. Any failure to comply with HSE or environmental requirements in relation to temporary services shall be rectified immediately at the Contractor's sole cost and risk and shall not entitle the Contractor to any extension of time, additional payment, or claim.

1.11 Employer's Representative's Office

The Contractor shall provide and maintain a fully furnished and serviced office for the sole use of the Employer at each substation throughout the duration of the Works as follows:

1. 400/132/33kV Main Conveyance Substation – AAWDCP Substation

The Contractor shall provide the Employer with:

- Four (4) prefabricated office buildings (skid-mounted caravans), each comprising two (2) rooms. Each room shall have a minimum size of 4.0 m × 4.0 m
- One (1) prefabricated building (skid-mounted caravan) for meetings, comprising one (1) meeting room with a minimum size of 4.0 m × 8.0 m. The meeting room shall be furnished with a high-quality central conference table and suitable conference chairs with a seating capacity for at least eight (8) to ten (10) persons.

2. BPS01 Substation

The Contractor shall provide the Employer with:

- One (1) prefabricated office building (skid-mounted caravan), comprising two (2) rooms. Each room shall have a minimum size of 4.0 m × 4.0 m.
- One (1) prefabricated building (skid-mounted caravan) for meetings, comprising one (1) meeting room with a minimum size of 4.0 m × 5.0 m. The meeting room shall be furnished with a high-quality central conference table and suitable conference chairs with a seating capacity for at least five (5) persons.

3. General Requirements

1. Each prefabricated office building shall consist of a toilet, a washroom, and a kitchenette. The office buildings shall be equipped with hot and cold running water, with drainage connected to a suitably sized septic tank, air conditioning for cooling and heating, electric lighting, internet and telephone connections between the offices, and national fax facilities.
2. The Contractor shall provide adequate personnel for daily cleaning, housekeeping, and general office services and shall maintain the offices, furniture, equipment, utilities, sanitary facilities, and surrounding areas in a clean, safe, and fully operational condition throughout the required period.
3. All rooms shall have insulated walls and roofs.
4. The Contractor shall remove this office from the site on completion for such a period as the Employer may require.
5. The Contractor shall provide hospitality services, including tea and coffee, and assign a full-time employee to serve the Employer's Representative and supervision offices at each project site for the entire duration of the project implementation period.
6. The offices shall be provided with furniture, including chairs, tables, a printer, and two (2) PC computers in total per Project Site, as well as stationery and photocopying service.
7. All costs associated with the provision, transportation, installation, furnishing, equipping, operation, maintenance, utilities, internet service, cleaning, hospitality services, office attendant, consumables, repairs, and subsequent removal of the offices shall be deemed to be included in the Contract Price.

2 SITE SURVEY

The Contractor shall survey the sites, to obtain the following:

a) Location of site relative to available published maps of the area.
b) Location of datum for setting out and levelling and establishing of minimum four survey control points with a permanent benchmark brass plate.
c) Establishment of site boundaries and reduced site datum level.
d) Position and condition of any approaches, bridges and access roads to and over the site.
e) Location of existing buildings on the site and surrounding areas.
f) State of flow in watercourses, etc., including highest recorded flood level (from local knowledge).
g) Existing site levels on a five-metre grid; and resultant contours at one metre vertical interval.
h) Condition of the site, including details of any prominent features on the proposed site or adjoining land, which may affect the scheme.
i) Drainage pattern of the area.

- The coordinate of the land of the **400/132/33kV main conveyance substation (AAWDCP):** (Coordination System JTM (geographic coordination for indication only)

X	y	x	y
303915.12	252802.45	34° 58' 41.466	29° 22' 53.3028
303884.85	252798.27	34° 58' 41.9484	29° 22' 48.7596
304085.93	252530.17	34° 58' 45.966	29° 22' 45.5988
304078.65	252749.85	34° 58' 54.1884	29° 22' 45.5988
303884.41	252526.85	34° 58' 53.7816	29° 22' 53.1588
303766.674	252765.0491	34° 58' 45.7932	29° 22' 54.7176
303778.220	252627.12	34° 58' 46.7328	29° 22' 55.0632

- The coordinate of **the land of the BPS01 substation:** Coordination System JTM (geographic coordination for indication only)

x	y	lat	long
302751.7	252380	29.37783	34.9678
302697.6	252380	29.37782	34.96724
302697.6	252349.5	29.37755	34.96725
302706.4	252322	29.3773	34.96735
302751.7	252322	29.37731	34.96781

A site survey plan at a scale of 1:200 shall be prepared, showing the survey results and the proposed layout of the new works. Copies of the plan shall be sent to the Employer.

The Contractor shall include in his scope all necessary slit trenching works required to verify and accurately determine the location of existing underground cables and services at the Site.

The Contractor shall ensure that all site survey and excavation activities are carried out in strict compliance with applicable safety regulations and best practices. All personnel involved in these activities should wear appropriate personal protective equipment (PPE) including helmets, safety boots, high-visibility vests, and gloves. The Contractor shall provide proper barricades, warning signs, and safe access around excavation areas to prevent accidents. Any hazards identified during survey or excavation shall be immediately reported to the Employer, and corrective measures shall be implemented without delay.

The Contractor shall be fully responsible for identifying, locating, protecting, and coordinating all existing underground and above-ground services, utilities, and obstructions. Any damage to such services shall be repaired or reinstated by the Contractor at his own cost and risk.

The Contractor shall take full account of flood risks, surface water runoff, drainage patterns, and seasonal variations identified during the site survey in the design and execution of the Works. No claim shall arise due to flooding, water accumulation, or inadequate drainage conditions.

All site survey, slit trenching, and excavation activities shall comply with applicable health, safety, and environmental (HSE) laws, regulations, and the Employer's HSE requirements. Any violation shall be immediately rectified by the Contractor at his own cost and without entitlement to any claim.

Submission of site survey plans and data to the Employer or the Employer's representative shall be for review. Any review, comment, or acceptance by the Employer shall not relieve the Contractor of any obligations or liabilities under the Contract. However, land provided by the owner may differ few meters to the final land which will be given in tendering stage later.

2.1 Sub-soil Investigation

After award of the contract, the Contractor is to ascertain for himself the nature of the sub-soil conditions over the site of the works, by means of bore holes and trial excavations etc. Samples shall be taken as necessary and tested to determine the physical and chemical characteristics of the various strata and of the ground water and subsurface water, if encountered. The following should be considered as a minimum requirement, assuming uniform conditions over the Site, but should be extended if many inconsistencies are encountered:

a) Depth of boreholes shall not be less than 12 metres or deeper as required to reach a competent bearing stratum suitable for the proposed Works, unless rock is encountered, in which case the thickness shall be proved to be greater than 1.5 metres on two boreholes. Where weak soils are encountered, boreholes shall be taken down to a load bearing stratum and adequate thickness proved on at least two boreholes.

b) Borehole records shall describe and indicate level of all soils encountered and indicate the natural water table level and subsurface water. Rock core records should specify total core recovery, solid core recovery and quality of the rock cored.
c) Where applicable, samples of soil shall be obtained from all soil strata or at two metre intervals in a single stratum and tested to determine physical and chemical properties, particularly with respect to substances which would react with concrete or other materials to be used in the Works.
d) Where applicable, in-site soil tests shall be applied to all soil strata or at two metre intervals in a single stratum – Standard Penetration Tests in non-cohesive soils and field loading tests in sensitive cohesive soils.
e) Ground water samples shall be obtained from each borehole and tested in accordance with approved practice.
f) Electrical resistivity of the soil shall be verified with minimum six samples, in accordance with approved American Standard.
g) The number, locations, of boreholes in substation buildings, switchyard, and under transformers shall be determined in full compliance with applicable Jordanian construction codes and the number shall not be less than 35 for the main conveyance substation (AAWDCP) and not be less than10 for the BPS01 substation. The locations of boreholes shall be subject to the Employer's review, and the Employer may require additional boreholes if deemed necessary without any entitlement to additional contract cost. All boreholes shall be executed only after obtaining the Employer's review.

Appropriate laboratory tests shall be carried out on all soil and groundwater samples to the extent necessary to adequately characterize subsurface conditions. All tests shall be in accordance with the latest edition of an approved American codes and standards.

Records of ground borings and trial excavations, results of in-situ tests and laboratory tests to determine the physical and chemical properties of the soil and ground water samples shall be incorporated into a comprehensive sub-soil investigation report.

The Contractor shall prepare an interpreted geotechnical report including recommendations for: earthworks, foundations, road pavements, concrete mix design, side slopes, foundation waterproofing and Isolation and fill materials, etc.

Sub-soil investigations shall be carried out according to the section **1.7 Samples, Testing & Inspection**. Work should be done to meet Jordanian and international standards.

The soil investigation report shall be approved by the Jordan Engineers Association.

The Contractor shall carry out a comprehensive Hydrological and Hydraulic Study for the Site and its surroundings, covering, as a minimum:

Identification of surface catchment areas affecting the Site.

Assessment of flood risks, including flash floods and wadi flows, where applicable.

Determination of design flood levels, flow directions, and discharge capacities for relevant return periods. Evaluation of surface water runoff characteristics and stormwater accumulation risks.

The hydrological and hydraulic study shall also include the assessment of groundwater and subsurface water conditions, including:

Presence, depth, fluctuation, and seasonal variation of groundwater levels.

Interaction between surface water, subsurface water, and foundations.

Potential impact of groundwater on excavations, foundations, basements, cable trenches, and underground structures. Based on the outcomes of the hydrological and hydraulic studies, the Contractor shall be fully responsible for the design and implementation of all necessary mitigation measures, including but not limited to:

-Surface drainage systems.
-Subsurface drainage systems.
-Dewatering systems.

Flood protection works such as culverts, channels, box culverts, retaining structures, diversion channels, or any other permanent or temporary measures required to safeguard the Works.

All hydrological and hydraulic studies shall be carried out in accordance with recognized international standards and codes, including approved American standards and best engineering practices, and shall be submitted to the Employer for review.

The Contractor shall ensure full coordination between the geotechnical, hydrological, and hydraulic studies so that the final design of foundations, earthworks, access roads, pavements, drainage systems, and waterproofing measures is fully integrated and suitable for the Site conditions. Any design modifications arising from the results of the sub-soil, hydrological, or hydraulic investigations shall be deemed included within the Contract Price and Contract Time.

The hydrological and hydraulic study shall be approved by the Jordan Engineers Association.

3 SCOPE OF WORK

The civil engineering and building works comprise the topographical survey of the site, sub-soil investigations, related studies and detailed design taking into consideration that the buildings should be designed to accommodate the plant being supplied on the contract and the Employers electrical requirements to allow future development, production of working drawings, provision of labour, plant and materials and construction the civil engineering and building works associated with the substations described below, including maintenance during the defect notification period.

The civil works and Electro-Mechanical works will include the buildings and external works, together with the required works to achieve as a Turnkey contract to fulfil the Employers requirement of the whole contract. All external walls of buildings shall be two meters away from any electrical equipment inside it.

External works include foundations for equipment, transformers, reactors, and substation buildings, cable trenches, ducts, and security fencing and gates, external lighting, roads, rain water drainage, temporary access road etc. and all associated works.

The dimension of the building and arrangement of the substation's components including the entrance of the substations are indicative only

The Civil Works for the National Conveyance Main 400/132/33 kV Substation (**AAWDCP**) (Aqaba South Coast– part of Land No. (325) basin (42) Almasane'a of Aqaba village (637) & a part of land No. (44) basin (1) Al Dura South Coast Village (641)) shall include, but not be limited to, buildings, equipment foundations, trenches, and basements. All such works shall be designed and constructed in accordance with the electrical requirements, equipment, drawings, and any other requirements, whether or not explicitly shown on the drawings or stated in the specifications.

1- The civil works of the **National Conveyance Main 400/132/33 kV Substation AAWDCP** shall include the following concrete buildings and as specified in tender drawing:

Control Buildings:

These will be reinforced concrete buildings consist of separate rooms for, AC plant, LVAC room, office room, camera room, control & relay room, switchgear room, store, battery room, telecommunication room, corridor, toilet with washroom, small kitchen.

All rooms shall be free of interior columns. The building shall be provided with sewage system and septic tank and shall be connected with the main source of water at the entrance.

Capacitor Buildings:

These will be reinforced concrete buildings consist of separate rooms for capacitor banks and shall be provided with an R.C. cable tunnel with steel ladders also, control room and switchgear room. the capacitor bank halls shall be provided with fences and partitions and shall be provided with a roller shutter door.

132kV GIS building:

These will be reinforced concrete buildings consist of separate rooms for, AC & PLC/TELE. room, control & relay room, GIS room, tariff metering room, battery room, AC room, and corridor.

All rooms shall be free of interior columns.

400kv switchgear Hall (GIS):

This building shall be of a reinforced concrete structure and rooms shall be free of interior columns. It should accommodate the 400 kV switchgear hall and should be fully weatherproof against dust and rainwater.

Transformer foundations:

transformers foundations from reinforced concrete as specified in drawing and required with oil sump, pit and with reinforced concrete fire walls.

Reactor foundations reactors foundations from reinforced concrete as specified in drawing and as required with reinforced concrete fire walls.

Guard house: at the entrance with toilet and small kitchen including sewage system, septic tank, and air conditioning type split unit (2 equipment). The total area of the guardhouse is at least 35 m².

Diesel Generator House and Bulk Fuel Tank

The dimensions of the diesel generator house and the bulk fuel tank shall be determined in accordance with the manufacturer's requirements and shall be subject to the Employer's review. A minimum clear distance of 2 m shall be provided around the generator. The outdoor fuel oil tank shall be located separately and provided with its own foundation.

Firefighting pump house and fire water storage tank

The dimensions of the building and water tank for fire protection shall be based on the manufacturer's requirements and shall be subject to the Employer's review. A minimum clear distance of 2 m shall be provided around the pump.

2- The Civil Works for **BPS1 Substation** shall include, but not be limited to, buildings, equipment foundations, trenches, and basements. All such works shall be designed and constructed in accordance with the electrical requirements, equipment, drawings, and any other requirements, whether or not explicitly shown on the drawings or stated in the specifications

33kV switchgear control building

This building will be far away approximately 1.5 Km (indicative only) from the National Conveyance Main 400/132/33 kV Substation in the MWI main project land.

These will be reinforced concrete buildings consist of separate rooms for, AC plant, office room, camera room, 33kV control & relay room, 33 kV switchgear room, store, battery room, AC & PLC/TELE. room, corridor, toilet with washroom, small kitchen.

All rooms shall be free of interior columns. The building shall be provided with sewage system and septic tank and shall be connected with the main source of water at the entrance.

Transformer foundations:

transformers foundations from reinforced concrete as specified in drawing and required with oil sump, pit and with reinforced concrete fire walls.

Outdoor equipment and trenches work

Guard house: at the entrance with toilet and small kitchen including sewage system, septic tank, and air conditioning type split unit (2 equipment). The total area of the guardhouse is at least 35 m².

Diesel Generator House and Bulk Fuel Tank

The dimensions of the diesel generator house and the bulk fuel tank shall be determined in accordance with the manufacturer's requirements and shall be subject to the Employer's review. A minimum clear distance of 2 m shall be provided around the generator. The outdoor fuel oil tank shall be located separately and provided with its own foundation.

Firefighting pump house and fire water storage tank

The dimensions of the building and water tank for fire protection shall be based on the manufacturer's requirements and shall be subject to the Employer's review. A minimum clear distance of 2 m shall be provided around the pump.

3- The civil works of the **associated works at IPS, BPS1, RO south and RO north** include the following concrete works and as specified in tender drawing:

Cable routing works

The works include all associated 33kV cable routing and interconnection works between the AAWDCP station, BPS1 station, RO North, RO South, and IPS, including all cable routing paths, installations, excavation works, concrete works, cable support systems, fixing works, and termination/connection points, as follows:

- 33kV cable routing and connection works from the AAWDCP station to the BPS1 station.
- 33kV cable interconnection works between the AAWDCP station and the connection points at RO North, RO South, and IPS.

General notes for all required works:

- Any additional facilities necessary to meet the Employers requirements of the Contract, applicable codes, standards, authority approvals, electrical requirements and operational needs, and to ensure the proper, safe, reliable, and continuous operation of the Substation.
- A basement shall be mandatorily constructed beneath every 132 kV GIS room, 33 kV switchgear room, and 400 kV switchgear hall (GIS).

3.1 General Requirements for Civil Works for all substations:

All civil works, both indoor and outdoor, shall be designed by the Contractor based on the actual site conditions, geotechnical, hydrological, hydraulic, environmental, and climatic conditions, and in full compliance with applicable local regulations, international standards, and the Employer's Requirements.

Indoor Civil Works:

The following list represents a general description of the indoor civil works of the buildings, but not limited to:

- Bulk excavation and imported filling material to reduced levels.
- Excavation for structures, foundation of the buildings, indoor cable trenches, tunnels, septic tank...etc.

- Reinforced concrete works, for the buildings, structures and equipment's, foundation trenches, tunnels, septic tank, ... etc.
- Concrete block works for internal walls.
- External Plastering should be of two layers executed from mortar cement with hardener, and the third layer should be of a ready packed from an approved and licensed company.
- Internal plastering should be of three layers of cement mortar with hardener.
- Internal Painting with eggshell finish.
- painting.
- Suspended false ceiling.
- Concrete screed layer with epoxy paint.
- Granite and porcelain tiles.
- Fixed aluminium windows, marble sills, and aluminium louvers.
- sliding aluminium windows with special profiles, including marble sills, steel protection, and double-glass panels.
- Steel protection for windows, including the oily paint with three coats, other than the primer (two coats).
- Metal and wooden doors.
- Roller shutter doors for GIS, control, and capacitor building.
- Wall-to-wall raised floor system.
- Steel gates for the internal fences of the Capacitor bank halls (Fence Gate).
- Galvanized chequered plates 8mm thick with galvanized kerbing steel angles for the covers of cable trenches.
- Complete sanitary installation for a toilet with a washroom and a small kitchen.
- Thermal insulation system for the external walls.
- A roof water tank with a minimum capacity of 2 m^3 shall be provided for buildings containing toilets and washrooms.
- For the guard house, one roof water tank with a capacity of 2 m^3 shall be provided, complete with all necessary fittings and piping connections to the underground water tank.
- Complete roof waterproofing system, including concrete screed layer with slopes and gutters, and a hot bitumen layer suitable for Aqaba hot climate and two layers of bituminous membrane.
- PVC pipes for cable ducts and cable trenches wherever needed.
- Eye wash stainless steel for the battery room.
- Complete electrical installation system with internal lighting, grounding, and lightning arresters
- Complete firefighting and alarm system
- Complete air conditioning and ventilation systems
- Telephone installations
- Footpath, 1.5 meters wide, around the buildings as specified with concrete tiles above a reinforced concrete slab.
- The rooms protected by fire suppression systems must be fire-resistant for a duration of two hours, including the windows and doors.
- Lower kitchen cabinets, height 90 cm, depth 60 cm, made of high-quality laminated wood, 18 mm thick, beech wood frame with all internal and external faces finished with Formica, soft white colour. Cabinets shall include drawers and doors with shelves, fitted with high-quality hinges, rails, and handles. Includes all materials, accessories, workmanship, and finishing.
- Bitumen painting for all building foundations (concrete parts contacted with soil)
- All external windows and doors for all buildings shall be dust-resistant, fabricated from aluminium corrosion-resistant frames with sealed joints and high-quality gaskets to prevent dust infiltration.
- The Contractor shall supply, deliver, and install furniture for all offices within the Substation buildings, each office should include an office desk, three office chairs, and a water cooler complete and ready for use.

The above lists of indoor civil works are indicative and non-exhaustive. The Contractor shall be fully responsible for the design, construction, completion, testing, commissioning, and handing over of all civil works necessary for the safe, durable, and fully functional execution of the Substation, whether or not such works are explicitly mentioned herein, and no additional payment shall be made for any works deemed necessary to fulfill the Contractor's obligations under this EPC Turnkey Contract.

Outdoor Civil Works:

The following list represents a general description of the outdoor civil works for substations, and not limited to the following:

- The contractor should demolish any available buildings yards or obstacles.

- Site clearance and earth work for site levelling (excavation & backfilling), for the specified area.
- Excavations for outdoor cable trenches, tunnels, equipment foundation, transformers, etc.
- Concrete works: reinforced concrete for outdoor equipment and transformers foundations, trenches, tunnels, retaining walls, septic tank, underground water tank, protective barriers, reinforced concrete water open channel, box culverts, etc, and plain concrete where required.
- External electrical sliding gate.
- External lighting.
- Temporary access road from the existing paved road to the parking areas inside the substation, including a rainwater drainage system.
- Permanent Internal roads, including a rainwater drainage system and box culverts.
- Manholes with sewage system, including septic tank.
- Boundary reinforced concrete (R.C) walls and R.C retaining walls, if needed, according to site level and topography, with fence as specified.
- if the level difference exceeds 1.2 m, the Contractor shall design and construct the wall as a retaining wall. The Contractor shall be fully responsible for the adequacy, stability, drainage, and performance of the retaining wall under all applicable load combinations and site condition.
- Complete rainwater drainage system including box culverts, reinforced concrete open channels, flood protection, perforated pipes, soak wags, manholes, and street inlets.
- All outdoor equipment foundations, including the foundations for transformers, reactors, cable tunnels, and cable trenches, etc.
- Fire walls between reactors and transformers, wherever needed.
- Laying stone chipping after levelling to a minimum thickness of 100mm, uniform size of 40mm laid on an approved geotextile filter membrane for the switchyard area.
- PVC pipes were required for cables.
- Galvanized mild steel patterned chequered plate cover,8 mm thick, for all outdoor cable trenches with galvanized steel kerbing angles with a stopper galvanized steel plate 25x8 mm welded with the kerbing angles.
- Concrete cover with a minimum thickness of not less than 10 cm for power cables trenches where required.
- Boundary fence on the top of boundary concrete walls consists of galvanized steel angles, wire mesh, and barbed wire according to the specifications.
- Underground water tank consists of reinforced concrete (capacity not less than 30m^3) with pumps and all fittings and pipes required to be connected to the control building, and guard house at the entrance, including the control panels and electrical works according to the Employer's review.
- Bitumen painting for the foundations and cable trenches of the outer faces below the ground.
- Galvanized Steel Ladder & Cage (Hot dip Galvanized) for the necessity of climbing to the buildings in the substation.
- Fire steel water tank as specified.
- Outdoor electric and mechanical works.
- Slope protection should be protected by a concrete slab with tones (rip-rap).

The above lists of outdoor civil works are indicative and non-exhaustive. The Contractor shall be fully responsible for the design, construction, completion, testing, commissioning, and handing over of all civil works necessary for the safe, durable, and fully functional execution of the Substation, whether or not such works are explicitly mentioned herein, and no additional payment shall be made for any works deemed necessary to fulfill the Contractor's obligations under this EPC Turnkey Contract.

4 DESIGN REQUIREMENTS

4.1 General requirements

All civil engineering and building work for every structure and item of plant required for the complete station complex, shall be designed and drawn in detail by the Contractor subject to provisions of this Specification. All designs shall be prepared in accordance with Jordanian Codes and codes of practice. In addition, all designs shall comply with the codes and requirements adopted by the Jordan Engineers Association (JEA) and the Jordan Civil Defense Directorate for the purpose of obtaining approval and authentication of the drawings and designs. All designs and drawings shall be issued by an engineering consultancy office classified as first grade (A) and approved by the Jordan Engineers Association. The Contractor shall be fully responsible for paying all fees related to the approval and authentication of the drawings by the Jordan Engineers Association and Jordan Civil Defense Directorate, as required for the licensing of the substation from municipality and any required authorities. Furthermore, the Contractor shall bear full responsibility for any failure to apply the codes and requirements adopted by the Jordan

Engineers Association and Jordan Civil Defence Directorate that may result in rejection, delay, or additional procedures related to the approval of the drawings and designs and licensing of the substation. The Contractor shall be entirely responsible for the stability and sufficiency of the works. The Contractor shall be responsible for the complete design and design check of the Works.

The preparation of design calculations shall include the calculation of stresses in all structural components and shall show how all loads are transferred to the foundations and to the ground and calculation sheets should be provided for the Employer's review.

Consideration shall be made in sizing members to eliminate excessive deflection or vibration during service. Suitable stress reductions shall be applied to slender compression members in accordance with the approved standard. Without prejudice to the above, all civil engineering and building works shall be designed and executed to be fully fit for their intended purpose, taking into account operational, environmental, and site-specific conditions, and shall ensure safe, reliable, and continuous operation of the Substation throughout its intended design life. Any rejection, re-submission, delay, or additional requirement imposed by the Jordan Engineers Association, the Jordan Civil Defence Directorate, the Municipality, or any other relevant authority shall be deemed to be included within the Contractor's obligations and shall not entitle the Contractor to any extension of time or additional payment.

4.2 Submission of Documents and Drawings

The Contractor will be required to produce full design calculations for the foundations, building structures, etc., and detailed working drawings and bending schedules etc. He will be responsible for the detailed designs, strength, and safety of the structures, to meet the structural, acoustic and environmental requirements of the buildings and other works. He will be responsible for ensuring that the design satisfies the requirement of all authorised local and national bodies. Design calculations and detailed drawings must be submitted to the Employer for review and comment only, before the relevant construction work is carried out and at least four weeks before the relevant drawing is required on site. Design calculations shall be in accordance with an approved method of computation and should take account of the most unfavourable combination of dead load, live load, wind load and earthquakes.

Within two months from the award of the Contract, the Contractor shall submit to the Employer a drawing register listing the number and title of each civil works drawing scheduled for production, together with the dates on which it is planned to submit each drawing to the Employer for comment and when each drawing is required on site. This register shall be updated to show revised and additional drawings found to be necessary, actual date of submission of each revision and date of each review.

Submission of designs and drawings should be at regular intervals, to ensure a steady flow of submissions. Checking and review may be delayed if large quantities of drawings are submitted at any one time. Notwithstanding any review, comment, or approval by the Employer shall not relieve the Contractor of any responsibility or liability for the correctness, completeness, safety, stability, or fitness for purpose of the design, calculations, or drawings.

The Contractor shall allow in his programme adequate time for preparation, submission, review, re-submission, and review of designs and drawings, and no delay, rejection, or request for amendment by the Employer or any authority shall entitle the Contractor to any extension of time or additional payment.

Proper allowance should be made at the structural design stage for the services (electrical, telephone, water, fire protection, air conditioning, drainage etc.,) so as to place them where they are readily available for maintenance and servicing and installed clear of the main structural members and foundations. The Contractor shall keep at the disposal of the Employer on site two copies of the construction drawings and shall submit full detailed construction drawings in four copies to the Employer for review. The Contractor shall divide the Works into suitable sections, i.e. plant foundations, auxiliary building, transformer compounds etc., and produce individual sets of calculations and drawings to include all members within these sections.

All sets shall be of similar format, self-explanatory and clear to review, including soft copy.

All sets of calculations shall be complete, bound and properly titled and given a unique drawing number. The binding shall be such as to allow the easy introduction of subsequent pages if required.

A fully detailed index shall be bound into and fronting each set. Following this shall be design information sheets. At the beginning of each section within the set, i.e. slabs, beams, columns, foundations etc., the following details shall be incorporated: -

a) The design approach shall be summarised.

b) Full details of manuals, design papers or other aids shall be given, with photocopies of relevant sheets if pertinent.

c) Full loadings shall be reiterated, with their derivations where appropriate.

d) Concrete and steel stresses shall be reiterated.

e) Cover to reinforcement shall be given.

f) Code references should be quoted and equations written out in full for initial computations, or subsequent new areas.

Should the Contractor be required to resubmit amended calculations sheets or additional sheets, they shall be annotated in the following manner to ensure coherence:

a) Amended sheets should retain the same sheet number, but have a lower-case revision letter suffix, i.e. sheet 14 when amended becomes sheet 14a, then 14b.

b) Additional sheets that need to be inserted shall be given the sheet number they are added to, plus an upper-case letter prefix, i.e. additional sheets to page 60 become A60, B60, C60 etc., and if subsequently amended, A60a, A60b etc.

All drawings shall be to scale and fully detailed with all wording in English and all dimensions given in metric units. All dimensions marked on the drawings shall be considered correct although measurement by scale may differ therefrom. Detail drawings shall be acted upon where they differ from general arrangement drawings. Drawings sizes shall conform to the requirements of the proposed ISO standard 'A' series of sizes. The maximum dimension being A0- 1189x841mm and the minimum size shall not be less than A4-210x297mm.

4.3 Design Loading:

a) Dead Loads: The loads acting on a structure consisting of the weight of all permanent construction, in accordance with Jordanian codes.

b) Live Loads Live loads on all roofs and slabs shall be not less than 1.5 kN/m², together with all other static loadings from water tanks, equipment, etc., unless higher loads are required by applicable codes, statutory regulations, equipment manufacturers' requirements, or the Contractor's design assumptions. Live loads shall be in accordance with Jordanian codes. Special attention should be given to loading the roof area where the air-conditioning / ventilation are installed concerning the additional weight.

c) Wind Load: All structures shall be designed in accordance with the requirements of the Jordanian code for a basic wind speed of 140 km/h.

d) Earthquake Load: Building and structures shall be designed for earthquake loading in accordance with the latest Jordanian codes as important buildings.

The structures and all parts thereof shall be capable of withstanding the prescribed settlement, deflection stress limits, temperature and shrinkage effects and the worst condition of the combination of the loads.

Construction loads shall be combined with other loads as required. The loads specified herein shall be considered minimum design loads. Where higher loads are required by applicable codes, equipment manufacturers' requirements, operational needs, or site conditions, the higher values shall govern the design. In addition to the above, all structures shall be designed to safely resist equipment loads, impact and dynamic loads, vibration effects, thermal actions, and maintenance loads, as applicable.

4.4 Design of Foundations

Foundations shall be designed to Jordanian codes and standards or Jordanian codes.

The design of the foundations for all structures and equipment are to be such that differential and total settlements or other movements shall not exceed acceptable limits. The design of these items is to be to submitted Employer for review. The designer of the electrical system/equipment will at the beginning of the contract, provides the loads transmitted and the differential and total settlement limits that can be tolerated by his equipment. The walls of all buildings shall be supported on reinforced concrete walls with a thickness of 37cm, extended down to the recommended foundation levels of the buildings.

All building foundations shall be provided with a waterproofing system.

The foundations for outdoor electrical equipment shall consist of pedestal and pad foundations. The Contractor shall design and construct all outdoor electrical equipment foundations in accordance with the following minimum requirements:

a) Pedestal of outdoor equipment foundations shall have a minimum depth of 100 cm.

b) Pedestal of Gantry and Earth mast foundations shall have a minimum depth of 170 cm.

c) Pad foundations shall have a minimum depth of 50 cm.

No tension is allowed between the foundations and the soil under it for all foundations of any structure or electrical equipment or walls.

The design of all foundations for buildings and outdoor equipment shall ensure that the imposed bearing pressure does not exceed the allowable soil bearing capacity of 200 kN/m^2 and comply with soil investigation report not exceeding the previous value.

All Works shall comply with the applicable standards, specifications, codes, and the Employer's Requirements. All concrete shall be ready-mixed concrete, supplied from a duly licensed and certified

batching plant, and manufactured, placed, and cured in full compliance with the Contract requirements, applicable standards, and relevant codes. Throughout the Works the Contractor shall be required to base all foundations on a sound formation. All formations must receive the Employer's review for use before being blinded with concrete. All trench and pit cover, etc., shall be designed for the same minimum loadings. In plant lay down and maintenance areas, all trench and pit covers shall be designed to withstand all possible plant loadings (truck). Where ground improvement methods are adopted, these shall be selected, designed, and implemented by the Contractor in accordance with the Jordanian Codes of Practice, Jordanian Standards, the Employer's Requirements, and the Contract requirements.

Where piling is adopted, the design of the piles and the foundations shall be the responsibility of the Contractor and shall conform to the relevant American codes and standards, including but not limited to ACI, ASTM, and AASHTO piling specifications.

Where foundations are supported on piles, they shall be adequately and properly tied to the pile heads.

Allowance is to be made for the provision of preliminary test piles to be placed and tested before any construction and during the design, in order to obtain suitable working loads for the proposed piles.

The foundation for steelwork and other forms of structure shall be designed to resist all loads and movements from the framework and wind/seismic forces. They shall be suitable for building in holding down bolts which should be provided with coring tubes, anchor plates, or steelwork. The foundations shall be placed at the appropriate levels to clear adjacent pipes.

All foundations constructed within the water table, subsurface water, or capillary rise zone shall be suitably protected against chemically aggressive ground conditions by an approved waterproofing and protection system. As a minimum requirement, the waterproofing system shall consist of two layers of bitumen-based membranes, in accordance with the recommendations of the soil investigation report and the prevailing environmental conditions, and subject to the Employer's review.

4.5 Steel Work Design

Steel work design shall be carried out in accordance with Jordanian codes or equivalent.

The design strength used shall be those given in the relevant standards for the specified grade of steel, using Grade S275 (or higher) in accordance with EN 10025 or equivalent international standards, or such other grade as may be proposed by the Contractor and demonstrated to comply with the employer and contract requirements. The use of back-to-back angles in structures shall not be permitted. All steel structures shall be adequately protected against corrosion to ensure durability, structural integrity, and satisfactory performance throughout the intended design life of the Substation. Corrosion protection systems shall be selected by the Contractor in accordance with the environmental conditions of the Site, including but not limited to temperature, humidity, salinity, atmospheric aggressiveness, and proximity to coastal or industrial areas. Unless otherwise specified, steelwork exposed to outdoor or aggressive environments shall be protected by hot-dip galvanizing in accordance with the relevant international standards.

Where painting systems are adopted, they shall consist of an approved multi-coat protective system suitable for the site conditions. Surface preparation, coating materials, application methods, dry film thickness, curing, inspection, and testing shall comply with the relevant standards and manufacturer's recommendations. All corrosion protection systems shall be submitted to the Employer for review. Any review, comment, or lack of comment shall not relieve the Contractor of any responsibility or liability under the Contract.

4.5.1 Design of runway beams for cranes

Crane runway beams shall be designed in accordance with BS 2853 and BS 5950. The Contractor shall make due allowance for all forces set up by vibration, shock from slipping of slings, kinetic action of acceleration and retardation and impact of wheel loads and transverse surge; they shall also satisfy all the requirements listed elsewhere. Where accurate positioning of loads by gantry cranes is required, the structure shall be designed so as to keep vertical and lateral deflections within 1:500th of the span.

Full consideration shall be given to movements due to changes of temperature; expansion joints being provided where necessary. Particular attention shall be paid to the design of gantry crane girders and rails so as to provide smooth running conditions for overhead travelling cranes.

Rails for travelling cranes shall be of adequate section, fixed to the crane beams by bolts or clips on soleplates to suit the crane offered and should be recommended by the crane manufacturer. These rails shall be laid to within 1.5 mm of the lines and levels shown on the drawings, provided that no more than 1 mm difference in level between a point on a rail and the corresponding point on the opposite rail. Deep girders shall be provided to minimise deflections and approved types of scarfed rail joints and shock-absorbing rail stops shall be provided.

4.5.2 Steel structure support for outdoor equipment

For all steel supports for outdoor equipment, the Contractor shall design, provide, and install steel angle sections with a minimum size of L70×70×7mm, complete with X-bracing of minimum size L40×40×4 mm.

For columns and girders of Gantries and Earth masts, the Contractor shall design, provide, and install steel angle sections with a minimum size of L150×150×15mm and shall provide X-bracing with a minimum size of L50×50×5mm.

4.6 Site Levels

The Contractor shall submit his proposed finished site levels, access road levels, and building floor levels to the Employer for review. Notwithstanding any such review, comment, or lack of comment, the Contractor shall be solely responsible for selecting, justifying, and implementing the final finished ground levels of each Substation, based on detailed hydrological, hydraulic, geotechnical, and environmental assessments. The selected levels shall ensure that the Substation is fully protected against flooding, surface water accumulation, groundwater intrusion, and adverse site conditions under all foreseeable scenarios. The final ground level shall remain above the potential flood level, and adequate permanent drainage systems shall be designed and provided to direct water away from buildings, structures, and equipment areas. In determining the finished levels, the Contractor shall take into account future expansion requirements, coordination with existing and proposed infrastructure, and all applicable safety, operational, and regulatory criteria. The Employer shall not be deemed to have approved, warranted, or assumed any responsibility for the suitability or adequacy of any site or finished level, and no claim shall be entertained in connection with flooding, water accumulation, groundwater conditions, or other site-related risks. The Contractor shall be fully responsible for levelling the entire Substation site in accordance with the tender drawings and for clearing the site of all vegetation, bushes, trees, buildings, and any other obstructions that may hinder the execution of the Works.

4.7 Roads

The Contractor shall, at his own cost and responsibility, provide, construct, maintain, and, upon completion of the Works, the temporary access roads required for each Substation Site, including access for construction activities, delivery of equipment, and heavy transportation.

The Contractor shall ensure that temporary access to each Site is available, safe, and suitable always during the execution of the Works. Road works shall be designed and constructed in accordance with the requirements of the Ministry of Public Works in Jordan. The Contractor's proposed site layouts shall allow for vehicular access to the various items of plant and electrical equipment, for installation and subsequent maintenance. The Contractor shall ensure that the vehicular access roads are levelled and graded and properly compacted with appropriate rollers, to ensure that the finished road is suitable for the maximum foreseeable imposed loads that can be expected from vehicles transporting the various items of plant and electrical equipment. In detailing the layout of the roads and parking area, special attention must be given to the manoeuvring of vehicles delivering plant, stores, spares, and other materials and equipment. The width of the permanent internal roads shall be at least 6.00 metres. The width of the internal roads leading to the transformer shall be not less than 7.00 metres, in accordance with the drawings and the Contract requirements. The Contractor shall be solely responsible for ensuring that such roads are suitable for the intended loads, transport, operation, and maintenance of the transformer. The internal permanent roads shall be provided with precast concrete kerbs, which shall be properly painted. The Contractor shall take the existing condition of the access road existing condition into full consideration when preparing his bid, pricing, and construction schedule.

The Contractor shall be solely responsible for coordinating with and obtaining all necessary permits, approvals, and clearances from all relevant authorities, including but not limited to municipalities, electricity distribution companies, public works departments, and any other concerned entities, in connection with the temporary access roads or any required modification to existing road alignments. No claim for additional payment or extension of time shall arise in respect of the provision, condition, maintenance, or removal of such temporary access roads, regardless of site conditions or authority requirement. The Contractor shall be deemed to have visited the Site, examined the existing conditions, and satisfied himself with all access road constraints prior to submitting his bid.

4.8 Drainage

Drainage shall be designed in accordance with the relevant American codes and standards published by authoritative organizations, such as FHWA / Hydraulic Design Manuals, AASHTO (American Association of State Highway and Transportation Officials), or other equivalent recognized standards. A surface water drainage system covering the complete site, including the areas of the future extension of the substation, shall be installed. The number of runs and outfalls, and pipe sizing must be sufficient to cope with the severest precipitations, with a factor of safety of 1.5. Within switchgear and other areas in which maintenance will be carried out, the drainage must allow uninterrupted access. Discharge of surface water to natural watercourses or external drainage systems shall be subject to compliance with applicable laws

and authority requirements. The Contractor shall be solely responsible for obtaining all necessary permits and approvals and for the adequacy and acceptability of such discharge arrangements.

In the neighbourhood of embankments and cuttings, surface water run-off is to be controlled by the provision of reinforced concrete open channels. The formation level of switchyard areas is to be formed with uniform cross-falls of about 1 in 300 in the same direction as the natural drainage path of the surrounding country. Provision shall be made for the disposal of surface water from roads, including street inlets, manholes and pipes. Surface water from the roofs of buildings shall be drained to down pipes that connect with the site drainage system. The whole site shall be provided with flood protection, including pipes, pipe culverts, reinforced concrete box culverts, and reinforced concrete open channels wherever needed. The switchyard area shall be provided with buried perforated pipes drained to the drainage system and a geotextile filter membrane below the chipping.

The Contractor shall ascertain whether main foul drainage is available locally, and if so, arrangements are to be made to connect from the substation toilets into this system. Where main drainage is not available, foul drainage shall terminate at suitably dimensioned septic tanks.

Drains shall be laid with regular gradients, such that full flow velocity exceeds 0.75 m/sec. Manholes shall be provided at each change in alignment or gradient, at the head of all sewers and branches, at every junction of two or more sewers, and wherever there is a change in size of sewers. All cable trenches shall be drained to the soakaways. The Contractor shall be fully responsible for the design, supply, and construction of an effective stormwater and surface water drainage system for the station. The final ground level must be above the potential flood level, taking into account site-specific topography, hydrology, and soil conditions. The system may include reinforced concrete box culverts, trenches, channels, or pumping systems as required to prevent water accumulation around buildings, equipment, and access areas. The design shall accommodate future expansions and coordinate with any existing or planned infrastructure (e.g., water conveyors, pipelines).

The drainage design report, including drawings, calculations, and specifications, shall be prepared, signed, and stamped by a Jordan Engineers Association (JEA) licensed engineering office, and shall be certified by the JEA prior to commencement of construction, as a statutory requirement. The Contractor shall bear all risks related to site flooding and stormwater management.

4.9 Cable Ducts and Trenches

The Contractor is responsible for all civil works required for the cable runs between switchgear and buildings, whether cables are buried, in ducts, or in cable trenches. Cable entries into buildings shall be through ducts or in cable trenches or tunnels. Trench covers outside buildings shall consist of hot-dip galvanized chequered steel plates as specified, except that power cable trenches shall be provided with reinforced concrete covers in accordance with the Contract requirements. The cable trenches at road crossing areas shall be designed as closed reinforced concrete tunnel. All buried cables must be protected by means of approved cable tiles or similar. Cable trenches shall be provided with positive drainage systems or soakaways of adequate capacity to prevent the accumulation of water under all foreseeable operating conditions. Where cable trenches or ducts enter buildings, appropriate arrangements shall be made for sealing these after installation of the cables to prevent ingress of water and vermin.

4.10 Substation Buildings

The substation equipment buildings shall be designed and constructed by the Contractor using reinforced concrete structural frames and roofs. The buildings shall be fully weatherproof and suitable for the environmental conditions at the Site. All external walls and roofs shall be fully insulated to achieve maximum thermal transmittance (U-values) of 1.14 W/m²·°C for walls and 0.57 W/m²·°C for roofs. The Contractor shall be responsible for the provision, installation, and connection of water supply systems, where required, for the substation buildings. All cisterns, sinks, basins, and similar fittings shall be provided with individual stopcocks located adjacent to each fitting. A header tank with a minimum capacity of 2 m^3 shall be provided for buildings containing toilets and washrooms. The tank shall be shaded from direct sunlight by louvered architectural screening structures integrated with the building elevations and shall be structurally supported by the roof. The header tank shall be connected either to the existing water supply system or to an underground water storage tank, as determined by the Contractor. Details of the lighting small power and air conditioning ventilation installations required are described in other Sections.

4.11 Waterproofing System.

A Complete roof waterproofing system with a concrete screed layer with a minimum thickness of 4cm, laid to falls in alternating bays. The roof shall be waterproofed with a special roofing system reviewed by the Employer. The system should be of a type that allows the use of the roof. The work also includes gutters and downspouts.

The roof waterproofing system shall be connected with the complete drainage system of the site installation of two complete waterproofing systems for roof slabs, but is not limited to, the following:

- Making of concrete screed layer with slope of ordinary concrete with compressive strength of 150 kg/cm2 after 28 days, and the finished surface shall be polished (Trowelled smooth), according to the

thicknesses and slope shown in the drawings, provided that the thickness at the gutters is not less than 4 cm for the screed, using plastering strip. Making of concrete inclined connection with parapet, and where necessary.

- Installation of a layer of asphalt rolls, 4 mm thick, reinforced with a layer of 200 g/m2 polyester.
- The system shall be based on a sloped screed with an asphalt layer (Primer) that conforms to technical specifications.
- Use a layer of hot oxidized liquid asphalt (115/15) as an adhesive layer for the rolls.
- The overlap between the side and front asphalt rolls shall be according to the technical asphalt specifications.
- Implementation of a groove in the whole perimeter of the parapet wall (1x2cm).
- The quantity surveying is for the horizontal square meter of the roof, the inclined connection, and all the above.
- The Contractor shall submit the catalogues of the above materials prior to use for review for conformity with the Contract requirements.
- The efficiency of the insulation layers is confirmed by conducting the required water test.

4.12 Construction Drawings

Wherever the Contractor proposes to construct any part of the Works other than as detailed on the Contract drawings, or where he prepares working drawings for his subcontractors, he shall submit duplicate copies of such drawings to the Employer for review, fully detailing his proposals. The Contractor shall maintain accurate drawings showing locations of all buried services encountered at the completion of the Contract. The Contractor shall provide one true-to-scale reproducible copy and two hard copies. and three CDs (compact disks) for all drawings (in AutoCAD DWG. format) according to the latest version of AutoCAD Software.

4.13 Transformers compounds

Civil works are included in this Contract for the transformers that will be supplied under another Contract. Provision shall be made for the catchments of oil spillage from the transformer resulting from mechanical or electrical failure. Precautions shall be provided to prevent pollution of streams, ground water irrigation ditches and other watercourses by leaking or ejected oil. Fire precautions shall be provided for the extinguishing of burning oil on entering the bund enclosing the transformer areas. The reinforced concrete foundation supporting the transformer shall incorporate built-in rails for rollers, etc, for unloading purposes and also haulage bollards.

Each transformer foundation shall be surrounded by a low wall enclosing an area or pit in which the entire oil content can be retained in the event of a major oil leak. The pit within the low wall is to be filled with 50 mm single size stone chippings, the total volume being such that the entire oil content of the transformer will be accommodated below the top of the chippings, i.e. within the voids. The chippings are to finish at a level 150 mm below the top level of the oil retaining wall. A sump is to be provided in one corner of the oil pit, to facilitate the removal of the oil or water by pump, without excavation of the chipping. The pit shall be provided with a steel grill below the chippings to reduce the pit size for oil volume.

5 FINISHES

5.1 Floors, ceiling, and walls finish for the control building, the capacitor building, the guard house, the diesel generator house, and the Firefighting pump house

ROOMS	FLOOR	CEILING	WALLS
132 kV Control & Relay Room	Raised flooring system	False Ceiling	plastering with3 Nos. Coats emulsion paint with eggshell finish
400 KV switchgear rooms	Screed with hardener and epoxy paint	False Ceiling	plastering with3 Nos. Coats emulsion paint with eggshell finish
132 GIS room	Screed with hardener and epoxy paint	Plastering with 3 Nos. Coats eggshell paint	plastering with3 Nos. Coats emulsion paint with eggshell finish
LVAC Room	Raised flooring system	False Ceiling	plastering with3 Nos. Coats emulsion paint with eggshell finish
TARIFF Metering Room	Raised flooring system	False Ceiling	plastering with3 Nos. Coats emulsion paint with eggshell finish
Office and camera Room	Granite tiles 20 mm thick	False Ceiling	Plastering with3 Nos. Coats emulsion paint with eggshell finish
P.L.C /Tele Room	Raised flooring system	False Ceiling	Plastering with3 Nos. Coats emulsion paint with eggshell finish
AC Plant Room	Screed with hardener and epoxy paint	Plastering with 3 Nos. Coats eggshell paint	Plastering with3 Nos. Coats emulsion paint with eggshell finish.
Storeroom	Screed with hardener and epoxy paint	Plastering with 3 Nos. Coats eggshell paint	Plastering with3 Nos. Coats emulsion paint with eggshell finish
Battery Room	screed with acid-resistant paint.	Plastering with acid-resistant paint finish.	Plastering with acid-resistant paint.
Toilet, Washroom & Kitchen (for all building and guard house)	Glazed porcelain tiles	False Ceiling	Glazed porcelain tiles
Corridors	Granite tiles 20mm	False Ceiling	Plastering with3 Nos. Coats emulsion

	thick		paint with eggshell finish
33kv switchgear room	Screed with hardener and epoxy paint	Plastering with3 Nos. Coats eggshell paint	Plastering with3 Nos. Coats emulsion paint with eggshell finish
Capacitor building	Screed with hardener and epoxy paint	Plastering with3 Nos. Coats eggshell paint	Plastering with3 Nos. Coats emulsion paint with eggshell finish
Guard room	Granite tiles 20 mm thick	Plastering with 3 Nos. Coats eggshell paint	Plastering with3 Nos. Coats emulsion paint with eggshell finish
Diesel generator	Screed with hardener epoxy paint	Plastering with an acid-resistant finish	Plastering with3 Nos. Coats emulsion paint with eggshell finish
Firefighting pump house	Screed with hardener epoxy paint	Plastering with an acid-resistant finish	Plastering with3 Nos. Coats emulsion paint with eggshell finish

All rooms shall be provided with wall skirting made of the same material as the floor tiles, with a height of 10cm.

5.2 Walls Finishes (External) for the buildings

The external walls of the buildings shall be double block construction. The outer layer shall consist of 150 mm solid blocks, and the inner layer shall consist of 150 mm hollow blocks. The two layers shall be mechanically tied together, with a 40 mm thermal insulation layer provided between them.

· External Plastering should be of two layers executed from mortar cement with hardener, and the third layer should be of ready-packed plastering material from an approved and licensed company.

· Internal plastering should be of three layers of cement mortar with hardener.

· Internal Painting with eggshell finish.

· The total wall thickness, comprising the solid block layer and the hollow block layer, shall be not less than 350 mm, including a 40 mm insulation layer consisting of high-density polystyrene boards and rock wool.

ADDITIONAL REQUIREMENTS:

· The thermal insulation shall comply with the requirements of the **Jordanian National Building Code – Thermal Insulation Code**, including the required thermal performance, material properties, and fire classification.

· External plastering shall be suitable for high-temperature and severe weather exposure. Alkali-resistant fiberglass mesh shall be provided at wall-to-column/beam interfaces, around openings, corners, and other areas susceptible to cracking, in accordance with the approved plastering system.

· External plaster shall be properly cured and applied over properly prepared blockwork in accordance with the manufacturer's recommendations and the requirements of the **Jordanian National Building Code – Building and Walls Code**.

Exterior Protective Coating

· Following completion and proper curing of the plaster, all external plastered surfaces shall receive a high-quality exterior-grade protective coating system specifically suitable for hot, coastal, and saline environments, including the climatic conditions of Aqaba.

· The coating system shall be:

- UV resistant;
- weather resistant;
- resistant to moisture penetration;
- resistant to alkali attack;
- resistant to salt and saline atmospheric exposure;
- resistant to peeling, blistering, and chalking; and
- suitable for application over cement-based plaster.

Primer

· A compatible alkali-resistant penetrating or masonry primer shall be applied to the cured plaster prior to the finish coats. The primer shall be compatible with both the plaster substrate and the proposed finish coating.

Finish Coating

· The final finish shall consist of a minimum of two coats of an approved exterior-grade coating system. The coating shall be factory-manufactured, uniform in colour, and supplied by a recognized manufacturer.

· The Contractor shall submit the manufacturer's technical data sheets, application requirements, recommended dry film thickness, and warranty for Employer review and approval prior to procurement and application.

Colour Uniformity

· The Contractor shall ensure uniform colour and appearance throughout each elevation. Mixing products from different manufacturers or different production batches shall not be permitted unless specifically approved by the Employer.

· All materials and workmanship shall comply with the applicable requirements of the **Jordanian National Building Codes**, relevant Jordanian Standards, approved manufacturer's specifications, and the Engineer's requirements.

6 MATERIALS AND WORKMANSHIP

6.1 Conformity with Standards:

The materials and workmanship, except where otherwise specified or authorised by the Employer, shall comply with the requirements of American Standards.

6.2 Provision of Samples Etc.

Provision of samples, inspection, test certificates, cost of tests, rejection of materials, shall be in accordance with Clause 1.7 of this Specification.

6.3 Setting out and Tolerances

The Contractor shall be responsible for all setting-out, irrespective of any checking by the Employer/Employer representative. The accuracy of all setting-out is to be better than +1 part in 4,500. The Contractor shall advise the Employer/Employer representative within 24 hours whenever a new setting-out peg is established, or an existing one destroyed and shall regularly furnish the Employer/Employer representative with layout plans showing all current setting-out and survey stations. The Contractor shall keep duplicate copies of all his field books and survey calculations written in the English language for inspection by the Employer/Employer representative.

The tolerances shown below shall rule on site unless the Contractor at time of Bid proposed alternatives submitted to the Employer for review and comment**.**

Masonry Work

1) Position in plan
   Fair faced or specified side from the designed position +15 mm
2) Length
   Up to and including 5.00 metre +15 mm
   Over 5m up to and including 10.00 metres +25 mm
   Over 6.00m +25 mm
3) Height
   Up to and including 3.00 m +15 mm
   Over 3 m up to and including 6.00 m +20 mm
   Over 6.00 m +25 mm
4) Thickness
   More than one block +15 mm
5) Level of bed joints
   Length up to but not exceeding 5.00 m +10 mm
   Over 5.00 m but not exceeding 10.00 m +15 mm
   Over 10.00 m but not exceeding 20.00 m +20 mm
   Add for every 5.00 m +5 mm
6) Straightness
   In any 5.00 m (not cumulative) +10 mm
7) Verticality
   In any 3.00 m +15 mm

Permissible Deviations On In-Situ Concrete

1) Plant and Other Foundations
   a) Position of centre line on plan from nearest building grid line +10 mm
   b) Dimension on plan -5 mm 0 mm
   c) Formation level +25 mm
   d) Surface level -5 mm 0 mm
   e) Sleeved bolt location +15 mm
   f) Sleeved bolt verticality 1 in 100
   g) Cast-in bolt location +2 mm
   h) Cast-in bolt verticality 1 in 300
   j) Bolt levels 0 mm +20 mm
   (NB. Where tolerances e) and f) conflict with g) and h) the latter shall govern.)
2) Components above Foundations (Excepting items in (c) below)
   a) Position of centre line on plan from nearest building grid line +10 mm

b)	Vertical: plumb in height of up to 0.5 m	+5 mm
	Over 0.5 m to 1.5 inclusive	+10 mm
	Over 1.5 m to 3 m inclusive	+15 mm
	Over 3 m to 30 m inclusive	+20 mm
c)	Cross section and linear dimensions of beams, slabs, columns and walls up to 300 mm	+5 mm
	Over 300 to 600 mm	+10 mm
	Over 600 mm to 1.5 m	+15 mm
	Over 1.5 m to 3 m	+20 mm
	Over 3 m	+30 mm
d)	Level of specified surface relative to the nearest TBM	+10 mm

The Employer/Employer representative may at their discretion, alter or specify new tolerances as necessary.

7 SITE CLEARANCE, EXCAVATION AND EARTHWORKS

7.1 Imported Filling

Unless otherwise described, directed or permitted, imported filling shall consist of previous, naturally occurring materials, free from mud, clay, silt, peat and vegetable or other injurious matter and water-soluble salts harmful to copper and other metals. Filling shall be imported only from approved areas. The filling material consists only of selected materials approved by the laboratory and conforms to the technical specifications issued by the Ministry of Public Works and Housing for the purposes of landfill, free of organic and clayey materials.

Filling shall be carried out in layers, the thickness of each layer shall not exceed 15 cm , and it shall be sprayed with water and rolled with automatic vibrating rollers to reach a maximum density of not less than 98% according to the modified Procter's test.

7.2 Site Clearance and Removal of Existing Structures

The Contractor shall clear all areas required for the execution of the Works of all unwanted materials, debris, rubbish, vegetation, trees, roots, and obstructions any building or structure or yards, except for those items identified to be retained. The Contractor shall take all necessary precautions to prevent damage to existing roads, pavements, surfaces, buildings, underground and above-ground services, and other facilities not required to be demolished. Any damage caused by the Contractor's site clearance activities shall be made good by the Contractor at his own cost, to the condition existing prior to commencement of the Works or better.

7.3 Excavation Generally

The whole of the excavations shall be carried out to the widths, lengths and depths shown on the approved drawings. The Contractor may excavate by any method he considers suitable, subject to be submitted to the Employer for review and comment and shall allow for the use of types of plant most suited for excavation in any location and at any time. The Contractor is to provide all strutting and shoring necessary for the safe execution of the works. The Contractor shall allow for excavating through any sort of material which may be encountered, including rock. The excavation and earthworks costs are deemed to be included in the Contractor Price and no increase in this will be permitted; this price shall also cover the cost of any necessary removal of excavated material and the supply of filling.

The Project Site includes existing buildings, sheds (hangars), structures, and other obstructions. The Contractor shall be fully responsible, at his own cost and risk, for the demolition, dismantling, removal, and disposal of all existing buildings, sheds, structures, and any other obstructions within the Site that may interfere with the execution of the Works. All such works shall be carried out prior to or in conjunction with the commencement of construction activities and in full compliance with applicable laws, regulations, environmental requirements, and safety standards. The Contractor shall be deemed to have inspected the Site and satisfied himself as to the nature, extent, and condition of all existing structures and obstructions. No claim for extension of time, additional payment, or compensation of any kind shall be entertained in connection with the presence, removal, or disposal of such buildings, structures, or obstructions.

7.4 Excavated Materials

Materials from the excavation may be used by the contractor for backfilling if submitted to the Employer/Employer representative for review. The Contractor shall remove surplus materials from the site to an approved dumping area. The Contractor shall at all times keep the site free from all surplus materials, rubbish and offensive matter.

7.5 Bottom Layer of Excavations

In excavations for foundations, a bottom layer of excavation 150 mm in thickness shall be left undisturbed and subsequently removed only when the concrete is about to be placed in order that softening or deterioration of the surfaces of the bottom of the excavated area by exposure may be avoided as far as possible. Lean Mix concrete 100 mm thick should be laid after inspection and submitted to the

Employer/Employer representativefor review. The bottom of all excavated areas shall be trimmed, levelled and well rammed. Concrete shall not be deposited thereon until the bottom has been inspected and submitted to the Employer/Employer representative for review.

7.6 Dewatering

All excavation works are to be kept dry and clean, in order that work is not affected or interfered with by water entering the excavations. The Contractor is to allow in his Bid for the costs of pumping, dewatering or other methods of dealing with the water entering the excavations from any source.

The arrangements made for dealing with water in excavations shall ensure that dewatering operations can be maintained continuously during the placing of concrete and the execution of any other works that could be affected by water in excavations. Adequate precautions must be taken against washing out of cement and concrete or to prevent the work being disturbed in any way. Water from pumping or other dewatering methods shall be properly drained away from the site or disposed of by tankers, so as not to inconvenience users of adjacent properties or sites. No concrete, masonry, brickwork or other materials shall be placed or built until the surfaces are properly drained.

7.8 Filling and Reinstatement

Filling for trenches, excavations and levelling of the Site shall be deposited in layers not exceeding 150 mm. Uncompacted thickness, each layer watered when necessary and well rammed or otherwise consolidated to within 98% of the maximum dry density obtained by use of a proctor standard compaction test. Where excavations, whether in rock or other material, are made to a greater depth than detailed, the intervening space shall be brought up to the proper level in plain concrete at the Contractor's expense. Any ground encountered in the excavations which, in the opinion of the Employer/Employer representative is not sufficiently strong to carry the loads which will be imposed on it, shall be excavated and replaced with a concrete mix reviewed by the Employer, all at the Contractor's expense. Any necessary earth retaining structure shall comply with the American code and standards. Where buildings or structures are to be founded on filled areas special attention shall be given to the foundation design. The Contractor shall precede construction on filled areas by ground investigations sufficient in extent to indicate a type of foundation design suitable for the site conditions. Where investigations have determined that significant differential movement may occur over the area of buildings or structures the construction method employed shall ensure that no long-term damage to buildings, plant or structures will result as a consequence of the ground conditions. The Contractor shall assess which of the following:

- **a)** Ground improvement,
- **b)** Refilling in thin layers with compaction,
- **c)** Foundations designed to withstand differential movement caused by settlement of the fill.

The contractor will provide a satisfactory solution for the conditions at site and all associated costs are deemed to be included in the Contract price.

7.9 Slips and Settlements

Should any slips occur in the excavations banks or filling during the excavation of the Works or during the period of maintenance, from any cause whatsoever, the Contractor shall execute the necessary remedial works in such a manner that the Employer shall review and comment, all at the Contractor's expense.

The Contractor shall make good all settlement of filling that may occur up to the end of the period of maintenance, at his own expense.

7.10 Earthworks and Slopes.

All earthwork top surfaces shall be finished off level and regular, and the sides of cuttings and embankment shall be properly trimmed to the detailed slopes as they become consolidated.

The slopes of soil surfaces shall be determined based on a Soil Stability Study, ensuring Permanent stability of slopes and structural safety. All slope surfaces shall be protected against erosion using appropriate measures, such as rip-rap or any other approved method.

7.11 Areas of Fill and Embankment

The Contractor shall be responsible for the stability of embankments, where formed either by cutting of filling, and precautions taken to protect the earthworks from deterioration under adverse weather conditions. Wherever applicable the recommendations contained in the following Codes of practice shall be followed in calculations, detailing the performance of the earthworks and drainage.

- **a)** Earthworks – British Code of Practice BS 6031:1981
- **b)** Civil Engineering Code of Practice No 2 on earth retaining structures, issued by the Institute of Structural Engineers, UK.

Embankments shall not be formed over inclined ground surfaces without previously forming the founding surface on which the material is to be placed to a benched profile.

Any necessary earth retaining structure shall comply with the recommendations of Civil Engineering Code of Practice No 2.

Where buildings or structures are to be founded on filled areas special attention shall be given to the foundation design. The Contractor shall precede construction on filled areas by ground investigations sufficient in extent to indicate a type of foundation design suitable for the site conditions. Where investigations have indicated that significant differential movement may occur over the area of buildings or structures, the construction method employed shall ensure that no long-term damage to buildings, plant, or structures will result as a consequence of ground conditions. The Contractor shall assess which of the following will provide a satisfactory solution for the conditions at site:

1) Ground improvement.
2) Refill with thin layers with compaction.
3) Foundations designed to withstand differential movement caused by settlement of the fill.

All associated costs are deemed to be included in the Contract price. All outdoor equipment foundations which are located at the fill area shall be constructed on compacted layers of base coarse material.

7.12 Explosives

The use of explosives will not be permitted as a general rule. In some cases, the Employer may authorise their use and, notwithstanding such authority or other conditions imposed by the Employer, the Contractor shall remain responsible for their use, including injury to any person or any damage to property, and for their safe storage. The Contractor shall make his arrangements for the obtaining of permits and for the payment of fees and licenses and all other matters connected therewith, and for complying with all national or local regulations imposed on the Contractor concerning the use of explosives.

The Contractor shall employ only properly qualified workmen in the handling and firing of charges. In order to prevent injury to life and damage to property adequate safety precautions shall be taken and proper warnings shall be given of all blasting operations. Blasting shall only take place at such time as may be submitted to the Employer's review.

7.13 Earthworks Scheme

The Contractor is responsible for preparing an earthworks scheme for levelling the site.

8. ROADS AND SURFACES

8.1 General

Access roads are to be properly defined, compacted and surfaced unless otherwise specified.

All works and materials should conform to the current standards specification for the construction of roads and bridges applicable in Jordan.

8.2 Materials

Base coarse shall consist of hard crushed natural stone or masonry broken as per specification. It shall be free from dust, rubbish, wood, vegetable or other injurious matter.

Broken stone and aggregates shall consist of hard crushed natural stone or gravel of approved sizes.

Bituminous wearing courses for roads shall be suitable for the extreme temperatures experienced in the area and shall comply with an authoritative and approved standard appropriate to the locality of the work. The details and grading of the aggregate and the bind contents shall be submitted to the Employer for review and comment. Sealing grit will be applied as required.

8.3 Drains to be completed

All drains, sewers, cable ducts and other necessary work below road formation level shall be completed, inspected and passed by the Employer's Representative before any road work is started.

8.4 Preparation of Formation

The upper 300 mm of the formation shall be of suitable soil (suitable means scarified, graded, rolled and having a minimum CBR of 15%); otherwise, the Contractor shall improve it to a strength of greater than 15 CBR by blending it with granular materials such as gravel and sand.

The formation shall be rolled to an even and uniform surface which shall be parallel to the finished surface of the road or path. Rolling shall be carried out with a 55-tonne power-driven roller unless otherwise ordered or permitted by the Employer.

8.5 Sub-Base

After the formation has been properly made, rolled, and submitted to the Employer/ Employer representative for review, a sub-base consisting of well-graded natural sand, gravel, or rock, or mixtures thereof (base coarse material), shall be laid in accordance with standards to give a finished thickness after compaction of not less than 240 mm, applied in layers of 120 mm each.

8.6 Prime Coat

Prime coat of 1.5 kg/sq.m liquid bitumen shall be sprayed in accordance with the best practice fitting to the locality of the work.

8.7 Bituminous Surface

A two-bituminous mix layer surfacing of 80mm overall thickness (40mm binder layer and 40mm wearing layer) shall be laid in accordance with the approved standard. With a minimum asphalt content of 6% binder coarse and 5% for wearing surface coarse.

8.8 Kerbs

Precast concrete curbs set on a concrete bed are to be laid on each side of the access and internal roads, to define the limits for vehicular access includes the krebstone painting with an oily paint necessary for them, which is resistant to weather conditions.

8.9 Trench Covers (indoor & outdoor)

All trench covers shall be hot dip galvanised mild steel patterned chequered plate 8 mm thick. Cable trenches supplied with hot-dip galvanised steel kerbing angles with a galvanised stopper steel plate 25x8mm welded with the angles according to the Employer's review and comment, except that the power cable trench should have a reinforced concrete cover with a 10 cm thickness. The steel chequered plate shall be provided with holes and galvanized handles, with one handle for every five covers, for handling purposes. The concrete cover shall be provided with holes and galvanized handles, with one handle for each cover, for handling purposes. All trenches crossing the roads shall be designed as a tunnel with adequate dimensions reviewed by the Employer.

8.10 Stone Surfacing.

Stone chippings for use as substation surfacing (switchyard area are to be clean, hard crushed stone graded from 25-40 mm

The formation in areas where stone chippings are to be used shall be well compacted to the Employer's/Employer representative review and comment. and treated with an approved total week killer, used in accordance with the manufacturer's instructions.

Stone chippings shall be laid and lightly compacted to a minimum finished thickness of 100 mm.

The chipping surfacing shall cover:

1- Entire switchyard equipment yard (all areas surrounding foundations, plinths, and cable trenches inside the switchyard).
2- All open ground fully enclosed by the internal roads, i.e., the whole surface area bounded by the inner edge of the internal roads.

9 CONCRETE

9.1 Design, Materials and Workmanship

Standards of design, materials, and workmanship are to be equal to or better than those laid down in the latest amended editions of American Standards and codes.

9.2 Testing General

Testing methods are to be in accordance with the relevant American codes (ASTM standard) except as submitted or requested by the Employer's representative.

The Contractor shall bear full responsibility for carrying out all tests and examinations of the works and materials related to the Project exclusively at the Royal Scientific Society, and entirely at his own expense, in strict compliance with the Contract provisions, the Employer's requirements, and the General Specifications issued by the Ministry of Public Works and Housing. The Employer reserves the right to reject any works or materials if such tests are not performed. Any such tests shall be deemed null and void and shall not be accepted. All concrete supplied and used for the project, as well as all concrete works, shall be ready-mix from a licensed factory and submitted to the Employer for review and comment. On-site mixing is strictly prohibited and will not be permitted under any circumstances.

Tests required by the Employer/Employer's representative will normally be carried out at an independent testing station. The cost of preparing, storing and transporting test specimens to the place of testing is to be borne by the Contractor where all the needed tests should be done by Royal Scientific Society Laboratories.

The Employer/Employer's representative shall have the right to order that any materials which do not meet with his approval shall not be used in the Works. The Contractor shall have the right to sample, test and give an opinion on such materials. If, after this, the materials are rejected by the Employer/Employer's representative, they shall be immediately removed from the Site by the Contractor.

The Contractor shall provide the Employer with facilities for materials testing on Site. The facilities may be those normally used by the Contractor.

All testing facilities on site shall be calibrated at regular intervals in the presence of the Employer's representative and whenever deemed necessary by the Employer.

9.3 Ready Mixed Concrete

Ready mixed concrete, as defined in American codes and standards, batched off the Site, may be used only with the agreement of the Employer and must comply with all requirements of the Contract.It shall be ready-mix from a licensed factory and submitted to the Employer for review and comment.

The concrete shall be carried by truck mixers. The concrete shall be compacted and in its final position within two hours of the introduction of cement to the aggregates. The time of such introduction shall be recorded on the delivery note, together with the weight of the constituents of each mix. In addition, the temperature of fresh concrete at the time of placement shall not be less than 6°C and shall not exceed 32°C, in accordance with ASTM C94 or the relevant national standard. When truck-mixed concrete is used, water shall be added under supervision at the central batching plant, as permitted by the Employer, but in no circumstances shall water be added in transit. Unless otherwise permitted by the Employer, truck mixer units and their mixing and discharge performance shall comply with the manufacturers requirement. Mixing shall continue for the number and rate of revolutions recommended in manufacturer's instructions. In the absence of instructions, mixing shall continue for not less than 100 revolutions at the rate of not less than seven revolutions per minute.

9.4 Cements

The cements shall comply with all the requirements of American standard latest edition. Sulphate resisting cement shall be used for concrete below ground level (concrete in contact with soil).

All cement of one type, except those types not manufactured in Jordan as appropriate, shall be obtained from the same source. The Contractor shall not use cement varying from that used in the preparation of trial mixes until the permission of the Employer/Employer's representative has been obtained and until any further trial mixes required by the Employer have been made and tested.

additional protective measures shall be provided as part of the Contractor's design responsibility. Such measures may include, but are not limited to, the application of bituminous protective coating in two layers, or any other approved protection system, subject to the Employer's review and comment.

The Contractor shall design and provide an appropriate foundation waterproofing and protection system based on the approved geotechnical, hydrogeological, and chemical soil investigation reports, to protect the foundations against groundwater, sulphates, and aggressive soil conditions, subject to the Employer's review and comment.

9.4.1 Total Alkali Content

The cement shall be tested to determine the total alkali content in accordance with ASTM C114-69 (Chemical Analysis of Hydraulic Cement) or BS 4550 Part 2:1970. Total alkali should not exceed 0.60%. The equivalent weight of sodium oxide shall not exceed 0.6% of the weight of cement, being calculated as follows:

- Equivalent weight of Na20 = Weight of Na20 + 0.658 x Weight of K20
- The above restriction shall be waived if the proposed aggregate is proved without doubt to be non-reactive.

9.4.2 Cement Delivery and Storage

The cement shall be delivered to site packed in sealed bags or proper containers, bearing the name of the brand and manufacturer and the number of the consignment. The approximate weight of the cement shall be legibly marked on each bag. The Contractor shall make the necessary arrangements for deliveries to be made sufficiently frequently to ensure freshness and in sufficient quantities to ensure that there is no suspension or interruption of the concreting work at any time.

The Contractor may use cement delivered in bulk; delivery arrangements shall be to the Employer's review, and each delivery must be accompanied by a manufacturer's test certificate.

Each consignment of cement shall be brought to the site in sufficient time to allow any tests to be carried out before the cement is required to be used.

Cement in bags shall be unloaded under cover and stored in a well-ventilated and weatherproof building used exclusively for this purpose. The floor of the building shall be at least 150 mm off the ground and an air space shall be left between the floor and bottom layer of bags.

If delivered in bulk an approved type of cement silo shall be used.

Each consignment shall be stored separately so as to permit easy access for inspection, and a record shall be kept so that each consignment may be identified. Storage shall be arranged so that the cement is used in order of delivery. Cement which is more than 12 weeks old from the date of delivery shall be retested on site for fineness, setting time strength and soundness in the presence of the Employer's representative and full test reports shall be submitted within 24 hours.

9.4.3Cement Test Certificates and Samples

All cement shall be certified by the manufacturer as complying with the requirements of the appropriate specification. The Contractor shall, when required by the Employer, obtain for him the manufacturer's test certificate for any consignment as soon as possible after delivery.

For every 50 tonnes of cement delivered to site and whenever required by the Employer, the Contractor shall take samples, under supervision, of the cement stored on, or delivered to the site.

9.5 Aggregates

Before the Employer can review any aggregate source, the Contractor shall furnish the following data:

i) Petrological group of rock
ii) Rock type within the group
iii) Shape
iv) Surface texture
v) Site content
vi) Grading curves
vii) Specific gravity
viii) Impact value
ix) Water absorption
x) Soundness
xii) Salt content
xiii) Alkali reactivity

The fine and coarse aggregates shall comply with BS 882 and above clauses, unless exceptions listed by the Tenderer in the attached schedule are submitted for the Employer to review.

The sources of all aggregates shall be permitted by the Employer.

9.5.1 Aggregate Physical Requirements

i) The weight of voided shells in fine aggregate shall not exceed 5%.
ii) The weight of the clay and fine silt fraction (smaller than ASTM sieve no. 200) shall not exceed 5% by weight for coarse aggregates or 10% by weight for fine aggregates.
iii) Absorption of fine and coarse aggregate shall not exceed 5% as measured in accordance with BS 812 or similar standard.
iv) The soundness of all aggregates shall be proved by a sodium sulphate test in accordance with ASTM C88-73, from which the loss over five cycles shall not exceed 10% for fine aggregates or 12% for coarse aggregates.
v) The apparent specific gravity of aggregates as determined by an approved test, such as BS 812, shall not be less than 2.5.
vi) Loss angles abrasion shall not exceed 37%.
vii) Alkali reactivity of aggregates should be in accordance with ASTM/C-227 and C-289. Only those aggregates considered to be innocuous should be permitted.

Where quarries win aggregate from bedrock, especially limestone of the dolomitic type, the rock shall be checked for surface alternation to hardpan. This may affect the surface for well over a meter depth and result in salt concentrations near the surface. Such rocks are also prone to other undesirable characteristics, including pockets of clay, salt, chalk or other friable material. Rigorous initial physical inspection is essential.

9.5.2 Aggregate Chemical Requirements

i) Fine and coarse aggregates shall not be potentially reactive with alkalis and shall be regularly tested in accordance with standard tests C228, C289, C342 and C586.
ii) Fine and coarse aggregate shall not contain more than 0.5% by weight of acid soluble sulphates (as S03).
iii) Fine aggregate shall contain no more than 0.1% by weight of chlorides (as NaCl) and coarse aggregate not more than 0.03%. Should these figures be exceeded the aggregate may still be considered acceptable in this respect provided the total sodium chloride concentration is not greater than 0.32% by weight of cement in the mix, irrespective of the origin of the chloride.
iv) Marine aggregates may be used provided that the content of chloride salt in the aggregate, expressed as the equivalent anhydrous calcium chloride percentage by weight of the cement to be used in the concrete, does not exceed 0.3% but where the proportion exceeds 0.1% by weight of cement, marine aggregates must not be used with high alumina cement or for pre-stressed concrete in circumstances where calcium chloride admixtures are not permitted. In addition, in concrete containing embedded metal, calcium chloride must not be added in such proportion that the total anhydrous calcium chloride in the admixture, plus the equivalent value of anhydrous

calcium chloride calculated from the chloride in the aggregate, exceeds 0.35% by weight of the cement. For the purposes of calculation, the anhydrous calcium chloride content may be taken as equal to the sodium chloride content or to 1.6 times the chloride ion content as appropriate.

9.5.3 Storage

The aggregates shall be stored at mixer positions in such a manner that intermingling of different sizes and types of aggregates is prevented. The stock-piles are to be protected from rubbish or windblown dust. Heaps of fine aggregate shall be capable of draining freely. Wet fine aggregate shall not be used until, in the opinion of the Employer, it has drained sufficiently to ensure proper control of the water/cement ratio.

9.5.4 Aggregate Sampling and Testing

The Employer shall have the right to require the Contractor at any time to draw samples of aggregate from stockpiles on the Site or any other location to be indicated by the Employer. All sampling and testing shall be in accordance with BS 812, BS EN 1097, or to American standards when no appropriate BS exists.

For each new source of aggregate and for each class of aggregate to be used sampling and testing shall be done at the rate of six samples and set of tests for each new source and each new class.

The Contractor shall allow for the whole range of tests to be carried out. For routine sampling and testing from an approved source the rate shall be one sample per 50 m of aggregate to be used or one sample per month whichever is greater. Such testing shall include those tests from BS 812 as are considered useful by the Employer for comparison with the results of the initial set of tests but the Contractor shall allow for the full range to be carried out.

Testing is to be carried out at an independent laboratory permitted by the Employer or alternatively on the site in the presence of the Employer's representative, where submitted to the Employer for review.

9.6 Concrete preparation

9.6.1 Water for Concrete

Concrete shall be supplied exclusively as ready-mixed concrete from a duly licensed and certified batching plant, in accordance with applicable laws, regulations, and standards. Site-mixed concrete shall not be permitted under any circumstances. The water used for making mortar and grout shall be clean, fresh, and free from injurious amounts of oil, vegetable or organic matter, or any other deleterious substance in suspension or solution. The mix water shall be continually monitored for salt content, and the concrete mix shall be designed accordingly to limit total salt content. The recommended TDS level for mixing and curing water is below 500 ppm.

9.6.2 Admixtures

Admixtures shall not be used without the Employer's review. Before the use of any admixture can be approved the Contractor must prove by trial mix procedures that the concrete will in no way be adversely affected even when twice the recommended dose is batched.

9.6.3 Concrete Strength Requirements

All concrete mixes shall be in accordance with the requirements of American standards (ASTM) or similar approved and as designated on drawings submitted to the Employer for review and comment.

a) Reinforced compressive cube strength shall not be less than 30 N/mm² after 28 days.
b) Compressive cube strength of the plain concrete shall not be less than 15 N/mm² after 28 days. Plain concrete shall be laid under reinforced concrete foundations, ground beams, trenches etc., with thickness not less than 100 mm.
c) Compressive strength of the plain concrete which is used for unreinforced parts of the structures shall not be less than 25 N/mm² after 28 days.

The strength requirements for each grade of concrete proposed in the design shall be proven by means of preliminary trial tests as specified later. The Contractor's designs and drawings shall show clearly the characteristic strengths, mix proportion and permissible deviation proposed for each grade of concrete to be used. The Contractor shall carry out frequent tests to the satisfaction of the Employer to check the relationship of the strength of concrete cured under site conditions to that cured under laboratory conditions.

9.6.4 Workability

The Contractor shall be fully responsible for selecting, designing, and achieving the required workability of each grade of concrete to suit the type of structural element, method of placing, degree of reinforcement congestion, and compaction method, without increasing the water content beyond that permitted by the approved mix design.

Concrete shall be of such consistency that it can be readily placed and fully compacted into all corners and angles of the formwork and around reinforcement without segregation, bleeding, or loss of cohesion. Upon removal of formwork, the concrete surface shall be uniform, dense, and free from

honeycombing, excessive surface voids, cracking, or dusting, and shall fully comply with the requirements of the Contract, approved drawings, and Specifications.

The adequacy of workability for each proposed concrete grade shall be demonstrated by the Contractor through preliminary trial mixes and workability tests carried out in accordance with the relevant ASTM standards, or other approved equivalent standards. All trial mixes, tests, and associated mock-up works shall be carried out at the Contractor's own cost.

The Contractor shall, for each concrete grade, provide a representative trial section of formwork complete with reinforcement, reflecting typical site conditions and reinforcement congestion. The minimum volume of concrete placed in such trial section shall be not less than 0.25 m^3 or half a batch, whichever is greater. The trial section shall be cast in the presence of the Employer using the same concrete mix, batching, placing, compaction equipment, and procedures proposed for the Works. The approved appearance and performance of the trial section shall constitute the reference standard for that concrete grade. Any modification to the approved mix design, materials, source of supply, or placing and compaction methods shall require repetition of the relevant workability trials, at no additional cost to the Employer. Where specific workability or slump values are specified or required, continuous compliance shall be verified by slump testing at a minimum frequency of one test per ten cubic metres of concrete placed or three tests per day of concreting, whichever is greater. The Employer may instruct additional testing whenever deemed necessary, without entitlement to additional time or cost. No water, admixtures, or other materials shall be added to the concrete at site after batching, except with the prior written approval of the Employer.

9.6.5 Transportation

The Contractor shall be fully responsible for the transportation of concrete from the approved batching plant to the Works. Concrete shall be transported and discharged using approved transit mixers or other approved means designed to prevent contamination, segregation, loss of materials, or excessive loss of workability. The transportation time, method, and handling procedures shall ensure that the concrete delivered to the point and time of placing fully complies with the approved mix design, specified workability, and all requirements of the Contract, without the addition of water or admixtures during transit or at site. Concrete that has segregated, partially set, lost its required workability, exceeded the permitted delivery time, or otherwise fails to meet the specified requirements upon arrival at site shall be rejected and removed at the Contractor's cost, without any entitlement to additional time or payment.

9.6.6 Placing

The concrete shall be placed in the positions and sequences indicated on approved drawings, in the specification or as directed by the Employer/Employer's representative, within one hour of mixing. All formwork and reinforcement contained in it shall be clean and free from standing water, snow or ice immediately before the placing of the concrete. The Employer/Employer's representative shall be given 24 hours' notice in order that he may check the work.

Except where otherwise directed, concrete shall not be placed unless the Employer or his representative is present and has previously examined and approved the positioning, fixing and condition of the reinforcement and of any other items to be embedded, the cleanliness, alignment and suitability of the containing surfaces and the adequacy and position of the plant.

The concrete shall be deposited as nearly as possible in its final position and in such a manner as to avoid segregation, displacement of the reinforcement, formwork or other embedded items. Placing shall be continuous between specified or approved construction joints. Works shall be brought up to full thickness in 500 mm maximum compacted layers as the work proceeds.

Where chutes are used to convey the concrete, their slopes shall not be such as to cause segregation and suitable spouts or baffles shall be provided to obviate segregation during discharge. Concretes shall not be allowed to fall freely more than 1.5 metres except with the Employer's review and comment. Where pneumatic placers are used the velocity of discharge shall be regulated by suitable baffles or hoppers where necessary to prevent segregation or damage and distortion of the reinforcement, other embedded items and formwork, caused by impact. Upon arrival at the places of deposition the concrete truck driver must present to the Employer's representative a chit from the concrete batcher stating (a) the grade of concrete (b) the workability (c) the aggregate size (d) type of cement and (e) time of batching of the concrete.

If concreting is not started within 24 hours of approval being given, approval shall again be obtained from the Employer/Employer's representative. Concreting shall then proceed continuously over the area between construction joints. Fresh concrete shall not be placed against in situ concrete which has been in position for more than 30 minutes unless a construction joint is formed. When in situ

concrete has been in place for four hours, or less as directed by the Employer/Employer's representative, depending upon the mix, type of cement and weather conditions, no further concrete shall be placed against it for a further 20 hours.

Concrete, when deposited, shall have a temperature of not less than 5ºC and not more than 32ºC. It shall be compacted in its final position within 30 minutes of discharge from the mixer unless carried in purpose made agitators, operating continuously, when the time shall be within two hours of the introduction of cement to the mix and within 30 minutes of discharge from the agitator. Except where otherwise reviewed by the Employer/Employer's representative, concrete shall be deposited in horizontal layers to a compacted depth not exceeding 500 mm where internal vibrators are used or 300 mm in all other cases.

Unless otherwise agreed by the Employers, concrete shall not be dropped into place from a height exceeding 1.50 metres. When trunking or chutes are used, they shall be kept clean and used in such a way as to avoid segregation.

No concrete shall be placed in flowing water. Underwater concrete shall be placed in position by tremie tube or by pipeline from the mixer. Full details of the method proposed shall be submitted in advance to the Employers and his review obtained before placing begins. Where the concrete is placed by a tremie tube, its size and method of operation shall be in accordance with BS 8004. During and after underwater concreting, pumping or de-watering operations in the immediate vicinity shall be suspended until the Employer permits such operations to be resumed.

Concrete shall be placed in the locations and sequences shown on the approved drawings, in accordance with the Specification and the approved method statements, within the time limits specified in the approved concrete mix design and the relevant ASTM / ACI standards, taking into account the cement type, admixtures, and ambient conditions.All formwork, reinforcement, and embedded items shall be clean, properly fixed, and free from standing water, snow, ice, or any deleterious materials immediately prior to placing concrete.

The Contractor shall give not less than 24 hours' prior notice to the Employer/Employer's representative before commencement of any concreting works for inspection purposes. Such notice or inspection shall not constitute acceptance of the works nor relieve the Contractor of his full responsibility for compliance with the Contract. Concrete shall be deposited as close as practicable to its final position and placed in a manner that prevents segregation, bleeding, or displacement of reinforcement, formwork, or embedded items. Placing shall be continuous between approved construction joints, and concrete shall be brought up to full thickness in horizontal layers in accordance with the approved method statement and applicable standards.

Concrete shall not be dropped freely from a height exceeding 1.5 metres, unless otherwise permitted in the approved method statement. Where chutes, trunking, or similar conveying equipment are used, they shall be clean and arranged to prevent segregation.

Each delivery of ready-mixed concrete shall be accompanied by a valid delivery ticket stating the concrete grade, workability, maximum aggregate size, cement type, and time of batching. Concrete delivered without complete and valid documentation shall be rejected.

Fresh concrete shall not be placed against in-situ concrete that has commenced setting, except at approved construction joints. The timing of successive pours shall comply with the approved mix design, cement type, ambient conditions, and relevant ASTM / ACI requirements.

Concrete at the time of placing shall have a temperature not less than 5°C and not greater than 32°C. The Contractor shall implement all necessary hot and cold weather concreting measures at his own cost. Concrete shall not be placed in flowing water. Underwater concrete shall be placed by tremie tube or pipeline from the mixer in accordance with approved method statements and relevant standards. All risks, methods, and costs associated with underwater concreting shall be borne entirely by the Contractor. The Employer/Employer's representative shall have the right to reject any concrete that does not comply with the requirements of the Contract. Rejected concrete shall be removed and replaced by the Contractor at his own cost and without entitlement to additional time or payment.

9.6.7 Compaction of Concrete

The concrete shall be fully compacted throughout the full extent of the layer. It shall be thoroughly worked against the formwork and around reinforcement and other embedded items, without displacing them. Successive layers of the same lift shall be thoroughly worked together.

All concrete shall be compacted to produce a dense, homogeneous mass. Unless otherwise reviewed by the Employer/Employer's representative, it shall be compacted with the assistance of vibrators. Sufficient vibrators in serviceable condition shall be on site so that spare equipment is always available in the event of breakdowns.

Vibration shall not be applied by way of the reinforcement. Where vibrators of the immersion type are used, contact with reinforcement and all inserts shall be avoided, so far as is practicable. Concrete shall not be subjected to vibration between 2 and 24 hours after compaction. Concrete shall be fully and effectively compacted throughout the entire depth of each layer to produce a dense, homogeneous, and durable mass, free from voids, honeycombing, or segregation. Concrete shall be thoroughly worked against the formwork and around reinforcement and all embedded items without causing displacement or damage. Successive layers within the same lift shall be properly compacted together to ensure full bond and continuity.

Unless otherwise specified in the approved method statement, all concrete shall be compacted using suitable mechanical vibration. The Contractor shall provide and maintain an adequate number of serviceable vibrators of appropriate type and capacity at site, including sufficient standby equipment to ensure uninterrupted concreting operations in the event of equipment failure. Vibration shall not be applied through reinforcement. Where immersion-type vibrators are used, direct contact with reinforcement, ducts, inserts, and embedded items shall be avoided as far as practicable to prevent displacement, damage, or loss of cover.

The duration and method of vibration shall be sufficient to achieve full compaction without causing segregation, excessive bleeding, or laitance. Concrete shall not be re-vibrated or subjected to vibration once initial setting has commenced, except where specifically permitted by the approved method statement and relevant ASTM / ACI requirements. All compaction operations shall be carried out strictly in accordance with the approved method statements, mix design, ambient conditions, and applicable standards. Any defects arising from inadequate or improper compaction shall be rectified by the Contractor at his own cost, without entitlement to additional time or payment.

9.6.8 Vibrators

Unless otherwise directed by the Employer/Employer's representative, approved power-driven vibrators of the immersion type shall be used. They shall be inserted at such distances apart or applied in such a manner as will ensure that the concrete is satisfactorily and uniformly compacted. The Contractor shall ensure that a sufficient number of vibrators are on hand at all times including allowance for breakdown of vibrators. As a general rule, one working vibrator shall be available for each 6 m^3/hr of concrete being placed.

Vibrators shall penetrate the full depth of the layer and where concrete is placed over previously placed concrete not more than four hours old, the vibrators shall enter and re-vibrate that layer to ensure that successive layers are well knitted together.

Over-vibration, causing segregation, surface laitance or leakage through formwork, shall be avoided. Immersion vibrators shall be withdrawn slowly to prevent the formation of voids. Vibrators shall not be used to work the concrete along the forms, or in such a way as to damage formwork or other parts of the structure or displace the reinforcement of other embedded items.

Internal vibrators shall be capable of producing not less than 10,000 cycles per minute and external vibrators not less than 3,000 cycles per minute.

The Contractor shall be fully responsible for the selection, provision, operation, and maintenance of concrete vibrators suitable for the nature of the works, concrete mix, method of placing, and degree of reinforcement congestion, in accordance with the approved method statements and relevant ASTM / ACI standards.

Approved power-driven immersion-type vibrators shall be used unless otherwise specified in the approved method statement. Vibrators shall be inserted at appropriate spacing and operated in a manner that ensures uniform and effective compaction of the concrete throughout the full depth of each layer, without segregation or damage.

The Contractor shall ensure that a sufficient number of vibrators of adequate capacity are available on site at all times, including fully operational standby units, to allow uninterrupted concreting operations in the event of equipment failure. All costs associated with the provision, operation, maintenance, and replacement of vibrators shall be borne entirely by the Contractor.

As a general guideline, the quantity and capacity of vibrators shall be adequate to match the rate of concrete placement and the characteristics of the works; compliance with minimum quantities shall not relieve the Contractor of his obligation to achieve full and proper compaction.

Where concrete is placed over previously placed concrete that has not commenced initial setting, vibrators shall penetrate into the underlying layer to ensure full bonding and continuity between successive layers, in accordance with the approved method statement.

Over-vibration causing segregation, excessive bleeding, surface laitance, or leakage through formwork shall be avoided. Immersion vibrators shall be withdrawn slowly and carefully to prevent the formation

of voids. Vibrators shall not be used to transport concrete within the formwork, nor in any manner that may damage the formwork, reinforcement, or embedded items.Internal vibrators shall be capable of achieving effective compaction consistent with the requirements of the approved method statement and applicable standards, and shall operate at frequencies suitable for the concrete mix and equipment manufacturer's recommendations. External vibrators, where used, shall be of adequate capacity and frequency to achieve proper compaction without causing damage.

Any defects, damage, or non-compliance arising from inadequate or improper vibration shall be rectified by the Contractor at his own cost and without entitlement to additional time or payment.

9.6.9 Construction Joints

Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be indicated on the drawings and the Employer's review.

When not indicated on the drawings, the following general rule shall apply:

- **Columns**: Joints in columns are to be made at the underside of floor members and at floor levels. Haunches and column capitals are to be considered as part of and continue with the floor or roof.
- **Floors**: Joints in the floor system are to be located at or near the quarter points of the span in slabs and beams, except where otherwise instructed.
- **Walls**: Vertical joints away from corners. Horizontal joints above splays or openings.

Maximum expansion joint spacing for RC walls is 12.0m. Whenever the placing of the concrete is discontinued other than at the exposed faces, this discontinuity shall form a construction joint. Construction joints are to be made only along a horizontal or vertical plane, except that in the case of inclined or curved members, they shall be at right angles to the principal axis. Care shall be taken to prevent offsetting of the joint and to ensure water tightness. The joints shall in every way satisfy the requirements of the Employer and be fully detailed on drawings prior to submission for approval.

When work is resumed adjacent to a surface which has set, the whole surface shall be thoroughly roughened. It shall be cleaned of all loose and foreign matter and laitance and washed with water immediately before placing the fresh concrete which shall be well compacted against the joint.

9.6.10 Construction Bays

The Contractor shall agree with the Employer/Employer's representative, prior to the commencement of concreting, upon the sequence of placing concrete and positions of vertical and horizontal joints, whether shown or not on the drawings.

In general, slabs in excess of 6 metres in length and/or width and walls exceeding 6 metres in length shall not be poured in one operation and subsequent adjacent bays shall not be concreted within seven days. The maximum area of any pour shall be 100 sq.m.

In the light of experience, the Employer/Employer's representative may consider the above pour size limits to be excessive and will have the authority to reduce them. As an alternative to alternately bay construction, shrinkage gaps of up to 1 metre in the width may be left at 6-meter intervals; the shrinkage gaps shall not be concreted until concrete on all sides is at least seven days old.

Expansion joints shall be fully detailed on construction drawings before submission for approval. Minimum width of foot joints to be 25 mm except for shaded areas 12 mm.

Expansion joints shall be filled with bitumen impregnated fibreboard to full depth and width. The infilling will be permitted to be used as permanent formwork only for the second casting. Where the fibreboard is exposed, it shall be cut back for a depth of at least 2 cm from the chamfered edge, filled and pointed with a resilient liquid polysulphide polymer sealant to the manufacturer's instructions.

Where dowel bars are indicated on the drawings forming part of a joint they shall be held securely horizontal and perpendicular to the joint during concreting.

Dowel bars shall be plain mild steel bars conforming with BS 4449; they shall be straight and coated at one end with approved bond breaking compound, which shall consist essentially of 66% of 200 pen bitumen blended not with 14% light creosote oil and, when cold, brought to the consistence of paint by the addition of 20% solvent naphtha, or another approved compound.

Plastic caps used in expansion joints shall be rigid and securely fixed to the dowel to prevent the ingress of concrete during casting of the slab. The packing used within the cap shall be an insert compressible material. All dimensions must be shown on drawings prior to submission for approval.

9.6.11 Joining New Concrete Work to Existing

Existing concrete shall be broken out as described or directed and scrabbled to form a suitable key for the concrete. Where necessary the reinforcement in existing concrete shall be exposed, cleaned and bent to its correct shape. New reinforcement shall be securely wired to the existing.

The Contractor shall be fully responsible for the design, preparation, execution, and performance of all works required to join new concrete to existing concrete, including verification of load transfer, structural adequacy, durability, and watertightness. Existing concrete shall be broken out to the required lines and levels shown on the approved drawings or as required by the approved method statement. The exposed surfaces shall be roughened by scabbling or other approved mechanical means to expose sound aggregate and provide an effective mechanical key. All loose, weak, or deteriorated concrete, laitance, dust, and foreign materials shall be completely removed.

Where required by the design, existing reinforcement shall be carefully exposed and cleaned of all rust, laitance, and concrete residues. Any adjustment or bending of existing reinforcement shall only be carried out where demonstrated by the Contractor's design to be structurally acceptable and in accordance with applicable codes and standards. New reinforcement shall be securely fixed and tied to the existing reinforcement in accordance with the approved drawings, ensuring adequate development length, anchorage, and continuity.

Bonding agents, dowels, shear connectors, waterstops, or other connection systems shall be provided where required by the Contractor's design or shown on the approved drawings and shall be installed strictly in accordance with the approved method statements, manufacturers' recommendations, and applicable standards. All works associated with joining new concrete to existing concrete, including surface preparation, reinforcement works, bonding, and concreting, shall be carried out entirely at the Contractor's risk and cost.

9.6.12 Curing

Concrete shall be protected during the first stage of hardening from the harmful effects of sunshine, drying winds, cold, rain or running water. The protection shall be applied as soon as practicable after completion of placing by a method to be submitted to the Employer/Employer's representative for review.

The Contractor shall put forward his proposals for curing concrete to the Employer's/Employer's representative, review before any concreting work commences. On vertical surfaces, the curing membrane shall be applied immediately after removing the formwork.

No concrete shall be allowed to become alternately wet and dry.The temperature of curing water shall be the same as the concrete +10ºC. General concrete shall be wet cured for at least seven days with further four days of dry protection.

The Contractor shall be fully responsible for the curing and protection of all concrete to ensure the required strength, durability, and long-term performance in accordance with the approved mix design, method statements, and applicable ASTM / ACI standards.

Concrete shall be protected immediately after placing and finishing from the harmful effects of rapid moisture loss, direct sunlight, drying winds, rain, cold, flowing water, or any other adverse environmental conditions. Curing shall commence as soon as practicable and shall not be delayed beyond the time limits specified in the approved method statement.

The Contractor shall submit detailed curing proposals, including methods, materials, duration, and weather-related measures, as part of the method statement for approval prior to commencement of any concreting works. Any review or comment by the Employer shall not relieve the Contractor of full responsibility for the adequacy and effectiveness of the curing measures.

Curing shall be carried out for a minimum period in accordance with the approved mix design, cement type, ambient conditions, and relevant ASTM / ACI requirements. Where curing compounds or membranes are used, they shall be applied uniformly and in strict accordance with the manufacturer's recommendations and applicable standards. On vertical surfaces, curing membranes or other approved curing methods shall be applied immediately after removal of formwork. On horizontal surfaces and other exposed concrete, curing shall be continuous and uninterrupted for the specified duration.

All measures required for hot weather or cold weather concreting, including additional curing and protection arrangements, shall be implemented by the Contractor at his own cost.

Any defects, loss of durability, or non-compliance arising from inadequate or improper curing shall be rectified by the Contractor at his own cost and without entitlement to additional time or payment.

9.6.13 Trial Mixes

The Contractor shall submit not less than three weeks before the commencement of manufacture of preliminary trial design mixes, the following information to the Employer's review in respect of each grade of concrete.

a) Grade of concrete.
b) Title of particular trial mix.
c) The grading of the aggregates.
d) The ratio by weight of all the constituents of the concrete.

e) The expected compacting factor and slump.
f) Full details of the proposed site quality control.
g) Full details of the proposed laboratory for testing.

The Contractor shall also confirm his proposed testing regime and acceptance criteria for the Preliminary Trial Mixes which should be based on American codes (ASTM Standard). Should the proposal not be approved by the Employer, then the Contractor shall comply with the paragraph on preliminary test cubes and the two following paragraphs below.

Before commencing the Works, the Contractor shall submit to the Employer for review and comment, full details of the mixes he proposes to use, with their anticipated strength, which must be based on the satisfactory results of these preliminary tests.

The Employer shall, if he so desires, be present at all preliminary tests. The Contractor shall inform the Employer of his intention to carry out such tests and the time and place of the tests at least 24 hours before they take place.

Neither the mix proportions nor the source of supply of materials shall be altered without the prior of the Employer's review except that the Contractor shall adjust the proportions of the mix as required, to take account of permitted variations in the materials. Such approval shall be subject to the execution, to the Employer's satisfaction, of trial mix procedures set out herein.

9.6.14 Works Test Cubes

Before commencing any concreting in the Works, the Contractor shall submit for approval his proposed testing regime for the Works' concrete. Should the proposals not be submitted to the Employer for review and comment. the Con9tractor shall comply with the next two paragraphs below. For the first ten days that a particular grade of concrete is produced, or where there is a lapse of two weeks or more between successive pours of the same grade of concrete, three samples shall be taken on each day and three cubes shall be made from each sample. Two shall be tested at seven days and the other at 28 days. After the initial ten days, samples of designed mixes shall be taken at the reduced rate given in below Table with the provision that at least one sample shall be taken on each day that concrete of that grade is used. Three cubes shall be made from each sample, one being tested at seven days and the remaining two at 28 days.

TABLE – Sampling rates for design mixes after ten-day run-in of concrete grade (3 cubes shall be made from each sample).

Rate	One Sample to be taken every day or every: -
A - Critical Structures e.g. Masts, cantilevers, columns	10 m^3
B - Intermediate Structures e.g. beams, slabs, bridge decks	40 m^3

The cubes shall be made, cured, stored and tested in compression in accordance with BS 1881. The tests shall be carried out in a testing laboratory submitted to the Employer for review and comment. The laboratory must provide evidence that its equipment and procedures comply with BS 1610 and BS 1881 and that its testing machines are regularly checked and adjusted for accuracy. Full details of the qualifications of all laboratory staff will be required by the Employer.

Reports of all tests made shall be supplied direct from the laboratory to the Employer within 24 hours of the cubes being tested. The Employer's representative on site shall have the authority to stop all further concrete work until acceptable tests results are forthcoming. Up-to-date records shall be kept by the Contractor at the Works of positions in the Work of all batches of concrete, of their grade and of all test cubes, cores and other specimens taken from them. Copies of these records shall be supplied to the Employer at weekly intervals or upon request by the Employer.

9.6.15 Compliance of Works Test Cubes with Specification

When submitted proposed testing regimes, the Contractor shall also detail his proposed acceptance criteria for the Employer's review and comment. When this is not forthcoming the Contractor shall comply with the next two paragraphs below. The rules of compliance for works cubes are different to those in Clause for Trial Mixes. Compliance with the characteristic strength shall be assumed if the conditions given in both (a) and (b) are met:

a) The average strength from any group of four consecutive test results exceeds the specified characteristic strength by 3N/mm² for concrete of grade C-30 and above (i.e. characteristic strength = 30 N/mm²) or 2N/mm² for concrete of grade C-15 and below (i.e. characteristic strength = 15N/mm²).

b) The strength determined from any test result is not less than the specified characteristic strength minus 3N/mm² for concrete of grade C-25 and above or 2N/mm² for concrete of grade C-15 and below.

The quantity of concrete represented by any group of four consecutive test results shall include the batches from which the first and last samples were taken, together with all intervening batches. When a test result fails to comply with (b), only the particular batch from which the sample was taken shall be at risk. Compliance criteria remain the same irrespective of every rate of sampling or the same grade concrete in different structures. Where a minimum or maximum cement content of a designed mix is specified and compliance is assessed by observation of the batching or from autographic records, the cement content shall not be less than 95% of the specified minimum or more than 105% of the specified maximum. Where compliance of cement content is assessed from the results of analysis tests on fresh concrete, the cement content shall not be less than 90% of the specified minimum or more than 110% of the specified maximum.

Failure of Concrete to Meet Test Requirements

If the strength of the specimen is less than the appropriate specified minimum crushing strength or if, in the opinion of the Employer, the concrete fails to meet the specified requirements in other respects, the concrete in that part of the Works of which it is a sample will be considered not to comply with the specified requirements. As and where directed by the Employer, cylindrical core specimens shall be cut from the hardened concrete in the Works for the purposes of examination and testing. The cutting equipment and the method of doing the work shall be submitted to the Employer for review and comment Before the preparation for testing, the specimens shall be made available for examination by the Employer. Testing of the core shall be in accordance with approved standards. Recourse may also be made by the Employer to such non-destructive means of testing as ultrasonic pulsing and Schmidt rebound hammers. If the test results fail to meet the specified requirements, the portion of the Works from which the non-complying samples were taken shall be deemed rejected. The Contractor shall, as directed by the Employer, demolish and reconstruct such Works at his own expense and without any entitlement to an extension of time or an increase in the Contract Price.

9.7 Formwork

Forms shall be so designed and constructed that the concrete can be properly placed and thoroughly compacted and that the hardened concrete while still supported by the forms shall conform accurately to the required shape, position and level, subject to the tolerances specified and to the standards of finish specified later in this Section. The Employer may request the Contractor to provide sample panels of formwork for approval, at the Contractor's expense. When concrete is to be vibrated, special care shall be taken to maintain the stability of the formwork and the tightness of the joints during vibrating operations.

The material and position of any ties passing through the concrete shall be submitted to the Employer for review and comment. The whole or part of the tie shall be capable of being removed so that no part remaining embedded in the concrete shall be nearer the surface of the concrete than the specified thickness of cover to the reinforcement. Any holes left after the removal of ties shall be filled, unless otherwise directed by the Employer, with concrete or mortar of approved composition.

9.7.1 Removal of Formwork

All formworks shall be removed after the specified curing period in accordance with Jordanian standards and without causing any damage to the concrete. The use of form-release oil or any other material to facilitate removal shall be subject to the Employer’s review and comment.

All formwork for pits, ducts and holding down boltholes must be so constructed that it can be easily collapsed to facilitate withdrawal after the initial set of the concrete. The Contractor's proposed method for the construction and fixing of the formwork for boltholes pockets shall be submitted to the Employer for review and comment before construction. The top of the shuttering shall be suitably covered to prevent entry of excess grout, materials used for curing, ...etc. Solid timber must not be used for forming holding down boltholes. Bolthole’s formers may be made of plywood, expanded metal, polystyrene or other method submitted to the Employer for review and comment, who may require the Contractor to carry out a test pour, using the proposed bolthole former. The Employer shall be informed in advance when the Contractor intends to strike any formwork. The time at which the formwork is struck shall be the Contractor's responsibility. The formwork may be struck when the concrete has, in the opinion of the Employer, attained a compressive strength of not less than 10N/mm² or twice the stress to which it will then be subjected, whichever is the greater. In the absence of cube test results the periods before striking given in the table below may be used for ordinary Portland cement:

Formwork shall be constructed so that the side forms of members can be removed without disturbing the soffit forms and its props are to be left in place, when the soffit forms are removed these props shall not be disturbed during the striking.

Location	Surface temperature of concrete	
	Not less than 16 C	Not less than 7 C
Beam side, walls and columns	2 days	3 days
Slab (formwork)	12 days	15 days
Beams (formwork)	16 days	21 days

9.8 Finishes of Concrete

The Contractor shall state precisely on his plans which of the types of finishes described hereunder he intends to use in the various locations. Any defective concrete finish will be rejected. The Employer may at his discretion order the defects to be cut out and made good.

Plastering of defective concrete, as a means of making good will not be permitted, except that in case of minor porosity on the surface the Employer may approve a surface treatment by rubbing down with cement and sand mortar of the same richness as in the concrete. This treatment shall be made immediately after removing the formwork. The formwork shall be fair face shuttering (smooth boards with thickness not less than 18mm) for the following concrete:

- The full height of the equipment foundations sides.
- Both sides of the concrete walls and retaining walls.
- External and internal faces for cable trenches.
- Any exposed concrete.

Top finish shall be smooth steel-trowelled for:

- Equipment foundations.
- Top of concrete walls.
- The tolerance of top level of concrete surface of transformer foundations shall not be exceed 3mm.
- Bottom slab of cable trenches and tunnels.

All exposed concrete edges shall have 25x25 chamfer.

9.8.1 Surface Treatments

Where concrete is to be treated with sodium silicate or a similar dust preventive coating, this must be carried out within 14 days of the concreting of the foundation and be applied in accordance with the manufacturer's instructions.

9.9 Reinforcement

Steel reinforcement shall be one of the following:

a) Hot-rolled mild steel round bars complying with BS 4449 or equivalent standards, to be submitted to the Employer for review and comment. High tensile steel, either (i) cold worked deformed bars or (ii) hot-rolled bars complying with BS 4449, to be submitted to the Employer for review and comment.

b) Welded steel mesh reinforcement complying with BS 4483 or similar approved.

Bars greater than 40mm in diameter will not generally be used. Reinforcement shall be stored clear of the ground on sufficient supports to prevent distortion of the bars. Mild steel and high tensile steel are to be stored separately.

The Contractor shall supply the Employer with a certificate for each consignment from the steel manufacturers showing that the steel meets the requirements of the Specification. One tension test and one bond test shall be made for each lot of 50 tonnes or less supplied for the permanent works. Steel reinforcing bars shall be kept clean and shall be free from pitting, loose rust, mill scale, oil, grease mortar, earth paint or any material which may impair the bond between the concrete and reinforcement or disintegration of the concrete. Reinforcement may be bent on site, or alternatively off the site, by an approved method. The Contractor shall arrange for bending equipment suitable for bending both mild steel and intermediate grade bars. Mild steel shall be bent at temperatures in the range 5°C to 100°C. The shapes of the bends and lengths must comply with the applicable recommendations of BS 8666 AND BS EN ISO 4066 or otherwise specified on the Drawings and Bending Schedules to be submitted to the Employer for review and comment. The Contractor shall provide any chairs or other subsidiary reinforcement necessary to keep the reinforcement in its correct position. The concrete cover over such subsidiary reinforcement shall not be less than that over the reinforcement generally.

The Contractor shall provide adequate scaffold boards to ensure that the reinforcement is not displaced by being walked upon during the placing of the concrete or other operations.

Mesh reinforcement shall be fixed flat in the works over the whole of the areas indicated on the approved drawings. Adjoining sheets of mesh shall overlap by at least 300mm.

Loose small pieces of fabric shall only be used where they are essential for fitting into small confined parts of the works. Areas of fabric reinforcement shall be nett with no allowance included for laps or waste. Fabric reinforcement shall be delivered to site only in flat sheets.

Bends, cranks and other shapes of reinforcement shall be to the dimensions specified, otherwise all bars shall be truly straight. Bending of reinforcement shall be carried out round a former having a diameter of at least four times the diameter of the bar. The bending dimensions shall comply with BS 8666 and BS EN ISO 4066 unless otherwise specified on the bending schedules.

Cover blocks used for the correct positioning of reinforcement shall be of a type to be submitted to the Employer for review and comment. They shall be rigid, inert and capable of supporting the reinforcement in its correct position with the required cover without deforming. They shall not impair the finish on the concrete nor cause the formwork to deform locally. Reinforcing bars shall be tied together at every intersection using 16 swg soft pliable annealed steel wire. When an F3 finish soffit is specified, stainless steel tying wire shall be used to prevent rust staining. Immediately prior to concreting, all reinforcement shall be wire brushed to remove all wind-blown contaminants such as salt.

9.9.1 Concrete Cover to Reinforcement

a) The minimum concrete cover for durability to any reinforcing bar shall be as follows:

Concrete Above Ground

Internal faces of suspended slabs:	30 mm
Exposed faces of slabs, beams, walls and columns:	50 mm
Internal faces of columns and walls:	50 mm

Concrete Below Ground

Faces in contact with soil:	75 mm
All other faces (e.g. internal faces of basement wall):	50 mm

For other locations, the exposure condition and cover shall be submitted to the Employer for review and comment.

All faces of the concrete below ground shall be treated with bitumen damp proof material.

9.9.2 Testing of Reinforcement

The Employer shall have the right to select at any time samples of steel reinforcement for testing in accordance with the relevant approved standard.

9.9.3 Bar Bending Schedules

The Contractor shall provide fully dimensioned Bending Schedules giving the location and bending of every bar shown on the drawings. Unless otherwise stated on the Bending Schedules, all bars shown will be dimensioned in accordance with a national or international standard, to be submitted to the Employer for review and comment, e.g., British Standard 8666 and BS EN 3766.

9.9.4 Prevention of Corrosion Below Ground

The Contractor is to ascertain whether or not the substrate contains any corrosive qualities which will have a deleterious effect on reinforced concrete. If such conditions are evident, only an additive, to be submitted to the Employer for review and comment and in accordance with the manufacturer's recommendations, is to be incorporated in the concrete mix.

9.10 Additional Requirements in Hot Weather

Concrete placed during extremely warm weather shall be in accordance with ACI 305, "Recommended Practice for hot weather concreting". The climate factors affecting concrete in hot weather are high air temperature and reduced relative humidity, the effects of which may be considerably more pronounced with increases in wind velocity. Therefore, if in the opinion of the empolyer, there is a prevailing arid wind all concreting shall be temporarily stopped until the weather conditions are suitable for further concreting. During summer months when daytime temperatures and drying conditions are critical, concrete placing shall be scheduled insofar as possible during the period from dawn until noon and no concrete shall be placed from noon until 9 p.m. without authorization by the empolyer. Generally, no concreting shall be carried out in ambient temperature above 40oC. In ambient temperature above 30o, special precautions shall be taken during concreting operations. Concreting shall be planned in such a manner that a pour is competed up to an approved construction joint before the temperature rises above the permissible limit. Coarse aggregate shall be sprayed with potable water to effect cooling by evaporation and the mixing water tank and supply pipelines shall be insulated and shaded.

Except as otherwise noted, the maximum temperature of concrete at the time of placement shall be within 5oC of the mean daily ambient air temperature, but shall not exceed 32oC under any conditions. For massive concrete (defined as "Any large volume of cast in place concrete with dimensions large

enough to require that measures be taken no cope with the generation of heat and attendant volume change to minimize cracking"), maximum temperature of concrete at time of placing shall not exceed 16oC. set retarder, as specified herein under materials, shall be used when ambient temperature exceeds 210C. If such a temperature cannot reasonably be maintained, the Employer shall be notified and the mix redesigned to compensate for loss of strength resulting from higher mix temperature, unless the CONTRACTOR can demonstrate by calculation that the temperature rise of the mass can be regulated to acceptable levels to control thermal cracking. The use of cooled water for mixing, or crushed at 0oC will be acceptable.

The quantity of ice shall be such that total mixing water requirement, which is also dependent on moisture content of aggregate and mix proportions, shall not be exceeded. Mixing of concrete shall be continued until the ice is completely melted. Maximum elapsed time after the cement is added to the mix until placement of concrete shall not exceed the time limit imposed for concreting under mild temperature conditions.

Mixing drums and transporting equipment shall be shaded, painting white and spray cooled as applicable to limit heat gains as much as possible.

Formwork and construction joint surfaces shall be wetted with fresh water before concreting commences to ensure that they are sufficiently cool to avoid a flash set when concreting.

The CONTRACTOR shall be required to take all precautions necessary when the rate of evaporation is expected to approach 1.0kg/m2/hr or required by the ENGINEER. These precautions consist of dampening subgrade and forms, placing concrete at the lowest practicable temperature (i.e., use of cooled water), erecting windbreaks and subshades, reducing time between placement of the concrete and the start of curing, and minimizing evaporation, particularly during the first few hours subsequent to placing concrete by a suitable means such as applying moisture by fog spraying. Generally, all the concrete shall be hot sun and drying winds and excessive ambient temperatures during placing, curing and maturing for a period of not less than one (1) month or as directed by the ENGINEER.

During hot weather inspectors shall record at frequent intervals, as determined by Employer depending on circumstances, temperature, general weather conditions (clam, shade air and ambient, windy, clear, cloudy) and relative humidity. The record shall include checks on temperature of the concrete ingredients and of concrete as delivered and after placing in the forms. Data shall be correlated with the progress of work so that conditions surrounding the construction of any part of the structure can be ascertained. A copy of the weather data shall be included in the permanent records of the work.

9.10.1 Concrete placing

Placing shall not commence until sufficient standby pumps and vibrators are on site to cope with breakdowns. No concrete shall be batched until formwork is ready and all reinforcement fixed in place.

The area of each concrete pour frontage shall be kept to a minimum and suitable means shall be provided to avoid premature stiffening of concrete placed in contact with hot dry surfaces. Where necessary the surface, including reinforcement, against which the concrete is to be placed shall be shielded from the rays of the sun and shall be sprayed with water to prevent excessive absorption by the surfaces of water from the fresh concrete.

In hot weather concrete shall be deposited in horizontal layers to a compacted depth not exceeding 300 mm and internal mechanical vibrators shall be used.

Due to rapid stiffening in hot weather all clean-up operations such as application to resin cure membranes and dust reducers and surface finishing, etc. shall follow closely behind final tamping.

9.10.2 Curing

All concrete shall be covered for at least 14 days after placing and kept continuously wet for the initial 7 days. The temperature of curing water shall be within 10°C of that of the concrete. Air shall not be permitted to circulate between concrete and curing materials

9.10.3 Testing

Initially the Contractor shall double the number of test cubes made. A limited number shall be cured under site conditions in order to ascertain the relationship between site-cured samples and lab-cured samples. The number of slump tests shall initially be twice that normally required.

Air temperature shall be measured every two hours, and the temperature of every batch of concrete shall be recorded as it is deposited at the workplace.

9.11 Additional Requirements in Cold Weather

During cold weather daily temperature forecasts shall be obtained from a source submitted by the Employer, and concreting programmed accordingly.

The precautions detailed below shall be taken when either the ambient temperature is 2°C and falling or the temperature of the freshly placed concrete is 9°C and falling, to ensure that the temperature of the concrete when placed does not fall below 6°C until it has thoroughly hardened.

Calcium chloride may be used as an accelerator only with mass concrete. No concrete containing embedded metal may have calcium chloride added.

Adequate measures to the Employer's approval shall be taken to ensure that the aggregates are free from frost, ice and snow and that the mixing water which shall not exceed 60°C, is of sufficient warmth to ensure that the temperature of the freshly placed concrete shall be not less than 6°C. No aggregate shall be drawn from a storage bin or stockpile covered with ice, frost or snow unless the top layer is removed in such a manner as to ensure that any aggregate used is not contaminated by ice, frost or snow. If the ambient temperature is likely to fall below 0°C all freshly placed concrete shall be protected by means of braziers, lagging or steam heat under covers, the method to be used being left to the discretion of the Contractor provided it prevents the water in or on the surface of the concrete from freezing. The method to be used shall be agreed by the Employer's before the cast has commenced and the necessary steps taken to ensure that the protective measures are ready to be carried out as soon as required. All concreting shall cease, as soon as it is practicable to stop placing, immediately the air temperature falls below 6°C. In the case of large masses of concrete this may be waived at the Employer's discretion.

10 GROUTING OF STRUCTRUAL STEELWORK & PLANT

10.1 Grouting

No grouting shall commence until the Contractor has submitted full details of the proposed grouting methods, materials, procedures, and quality control measures to the Employer for review. Such submission shall be made not less than twelve (12) weeks prior to the intended commencement of any grouting works. Before plant grouting commences the Civil Responsible shall check with the relevant Electromechanical plant Responsible that the proposed methods and materials are acceptable, and that no special resin additives or similar are necessary.

10.2 Materials for Grouting

The cement and water shall be as described in clause (9) of this Specification. The "all-in" aggregate for grout shall consist of hard siliceous sand, and granite chips, gravel or crushed stone, or other suitable inert sharp material with similar characteristics having clean, hard, uncoated grains, free from lumps, soft or flakey particles, shale, crusher dust, slit, alkali, loam, organic matter or other deleterious substances. The aggregate should be of uniform grading, and it should be of such a size that 100% will pass through a 10 mm mesh and not more than 10% will pass through a 150micron mesh.

Dry packing mortar shall consist of cement and fine aggregate proportioned by weight in the ratio one part cement to two parts fine aggregate. Water shall be added such that the slump of the mix does not exceed 6mm. Mixing placing and protection shall be in accordance with appropriate preceding clauses. Where required by the plant manufacturer, a premixed non-shrink resin grout may be used. Full details of the proposed grout, including manufacturer’s data, method of application, and performance characteristics, shall be submitted to the Employer for review before use. he mixing and the placing of the grout shall be carried out strictly to the manufacturer's instructions and the grout shall have a compressive strength of not less than 30 N/mm².

10.3 Admixtures

Where required to achieve non-shrink performance, suitable admixtures shall be incorporated into the grout as part of the Contractor’s design and execution of the Works. Full details of the proposed admixtures, including manufacturer’s data and performance characteristics, shall be submitted to the Employer for review before use. All admixtures shall be selected, proportioned, added, and mixed strictly in accordance with the manufacturer’s instructions and the requirements of this Specification.

10.4 Surface Treatment

The concrete surface to be covered by grout shall be thoroughly cleaned and prepared to remove all laitance, loose material, oil, grease, and other deleterious substances, and to provide a sound, roughened surface ensuring proper bond with the grout. The method of surface preparation shall be selected by the Contractor and shall not cause damage or micro-cracking to the concrete. The use of power hammers or other aggressive mechanical methods shall not be permitted where they may adversely affect the integrity of the concrete.

10.5 Supervision

All works in connection with grouting beneath structural steelwork and plant shall be carried out under the direct supervision of a suitably qualified and experienced person employed by the Contractor. Details of

the proposed supervisory personnel, including qualifications and relevant experience, shall be submitted to the Employer for review prior to commencement of the grouting works.

10.6 Mixing

Prior to the commencement of any grouting works, the Contractor shall submit full details of the proposed grout mix design and mixing methods to the Employer for review.

The Contractor shall be fully responsible for the adequacy, suitability, consistency, and performance of the grout mix and the mixing procedures adopted.

10.7 Formwork

Edge formwork shall be fixed around each base plate generally to the level of the top of the plate unless specified to the contrary by the Employer. The clearance space between the formwork and the base plate shall normally be 75 mm but exact clearance shall be decided on the site for each operation. On the side from which the grout is to be poured forms shall be at least 150 mm high in order to provide a head to ease placing. The exposed edge of the grout or concrete shall be chamfered or bull nosed with steel trowel where so indicated on the drawings. The formwork shall not be removed until the grout has achieved sufficient strength to prevent damage, displacement, or cracking, and in any case not earlier than twenty-four (24) hours after completion of grouting, unless otherwise justified by test results or manufacturer's recommendations. The Contractor shall notify the Employer prior to removal of the formwork.

10.8 Placing

At least two hours before the commencement of grouting, the concrete surface to be grouted shall be thoroughly saturated with water, the surplus being removed just before grouting commences.

Foundation bolt holes shall be filled with grout up to within about 25mm of the top, care being taken to ensure that the bolts are not displaced. 7 days after the grouting of the boltholes, the Contractor will tighten the bolts and carry out a final alignment check. Upon completion of the final alignment check, the Contractor shall notify the Employer and shall then complete the grouting beneath the structural steelwork and/or plant baseplates, ensuring that the grout completely fills the space, is thoroughly compacted, and is free from air pockets or voids. Grout or concrete shall be cured by covering with moist hessian for a period of five days. The hessian shall be wetted at least twice in each 24 hours. Exposed surfaces of grout and concrete beneath items of plant shall be prepared and given two coats of an oil and alkali resistant coating. Grout or concrete shall not be placed when the air temperature or the temperature of the concrete is lower than 6°C.

10.9 Defective Work

Any grouting that in the opinion of the Employer is defective shall be cut out and replaced at the Contractor's expense.

11 METAL WORK

Mild Steel

Mild steel shall comply with the relevant standard and shall be galvanised for parts which are not accessible, or in open air, or come in contact with moisture. All other parts, except reinforcement to concrete, shall be primed as described under the clause for painting.

The Contractor shall be fully and solely responsible for the selection, design, detailing, fabrication, protection, installation, adequacy, safety, durability, and long-term performance of all metal works, including mild steel works, galvanising, copper works, zinc works, aluminium works (including aluminium windows and aluminium patent glazing), tubular hand railings, ladders, and chequer plates, under the prevailing Site, environmental, and operating conditions.

Copper

Copper shall be pure and perfectly malleable. Tubes shall be of 1.0mm wall thickness up to 19mm nominal bore and 1.2mm up to 38mm nominal bore. Joints and connections shall be formed with compression fittings of approved manufacture. Plate shall be up to a thickness of 2 mm.

Zinc

Zinc sheet shall be of good colour, free from cracks, dross, overlaps, scales, and any other defects, which might be detrimental to its working properties. All zinc shall be at least 0.8 mm thick. No iron or copper shall be used in contact with zinc.

Galvanising

Where steel members are specified to be galvanised, they shall be so treated after all cutting, drilling, punching, and removal of burrs has been carried out. Galvanising shall be applied by the hot dip process and shall consist of a coating of zinc weighing not less than 610 g/sq.m of surface. The zinc coating shall be smooth, clean, of uniform thickness, and free from defects. The preparation for

galvanising itself shall not adversely affect the mechanical properties of the steel. The testing of the zinc coating on galvanised articles shall be carried out in accordance with BS EN 1461 2022. Where environmental, exposure, or site conditions so require, the Contractor shall provide increased zinc coating thickness or enhanced corrosion protection measures beyond the stated minimum, at no additional cost to the Employer, to ensure fitness for purpose and long-term durability.

Tubular Hand railing

Tubular hand railing where used shall be 25mm nominal bore 'medium' tube and handrail standards shall be 25 mm nominal bore 'heavy' tube. Handrails and standards shall be galvanised.
Tubular hand railings shall be designed and constructed to safely withstand the applicable horizontal and vertical loads arising from crowd use, maintenance activities, and industrial operation, as relevant to their location and function.

Chequer Plate

Mild steel chequer plate (raised pattern) shall be fabricated from first grade mild steel with a minimum thickness over the plan portion of 8 mm. Weight of individual panels shall not exceed 60 Kg. All mild steel chequer plate shall be galvanised after cutting to their required size.
The Contractor shall be fully and solely responsible for verifying and ensuring the load-carrying capacity, structural stiffness, deflection, and overall structural adequacy of the works under all applicable loading and service conditions.

Ladders

Access ladders are to be galvanised mild steel. Where access ladders are provided, the Contractor shall design, supply, and install appropriate fall protection measures, including but not limited to safety cages, vertical lifelines, railings, landing platforms, or other equivalent systems, as required to ensure safe access and use during operation, inspection, and maintenance.

Aluminium Windows

Aluminium windows shall be obtained from an approved manufacturer and of a type, design, colour and finish to be selected by the Contractor and reviewed by the employer for general compliance with the Specification. All opening windows shall be provided with integral flyscreens which shall be removable for cleaning and maintenance, the aluminium should be of double glass of special profile from approved manufacture.
Installation of protection steel fabricated includes grinding and smoothing the area of electricity welding and the oily paint with three coats, other than the primer (two coats).
Aluminium window frames are to be formed of extruded anodised aluminium sections to BS 1474 and of aluminium alloy type H9 or such other alloy as determined by the Contractor to be suitable for the climatic and atmospheric conditions prevailing at the Site.
The construction of aluminium windows, including hardware, etc. is to comply with requirements of BS 4873 or other recognized standard.
Where possible, aluminium windows shall be fixed after all structural and wet finishes are completed but, in any case, they shall be kept clean and protected from damage at all times. Splashes of cement, plaster, etc., which occur on the aluminium during the construction period shall be immediately cleaned off. Care shall be taken during dispatch and storage on site to prevent damage to the windows. Allowance shall be made when fixing frames for expansion of aluminium members so as to prevent distortion of frames or cracking of glass. The perimeter of the frames shall be pointed with an approved mastic.

Aluminium Patent Glazing

The clauses above referring to approved type, finish expansion, protection, etc. of aluminium windows shall also apply to patent glazing. The minimum patent glazing shall comprise extended aluminium bars of adequate section to suit the span required and incorporating such condensation channels, cord grooves, glazing rebates and continuous aluminium wings as may be necessary. Shows or stops must be provided to prevent the glass sliding out. Glass shall be secured on the internal face against greased asbestos cords in the preformed channels and on the external face with continuous aluminium wings bolted through the bars. Proprietary trimming or sealing strips complying with the requirements of the Specification.

Other Materials

Materials not herein fully specified, and which may be offered for use in the works shall be first class quality and of such kind as is generally used in first class work. The Contractor shall be fully and solely responsible for determining and ensuring that all materials offered or delivered for use in the Works are suitable for their intended purpose and comply with the requirements of the Specification. External ferrous metalwork shall be galvanised.

Workmanship Generally

All plates and sections shall be true to form, free from twist and straightened before any fabrication work is started on them. Each piece of work shall be distinctly marked before despatch in accordance with a marking diagram to be provided by the Contractor.

External Metal Doors

Generally metal doors shall be supplied complete with frame, fixing lugs and glazing clips or beads as required. Mild steel doors shall be of approved manufacture and comply with the requirements of BS 6510 with regard to materials and workmanship. External doors shall be formed of hot rolled mild steel sections, electrically welded and rust proofed by galvanising, metallizing or sherardizing process as required. The rust proofing shall be sufficient to withstand the 72-hour salt spray test as provided for in BS 1391 and are to be guaranteed against defects for 12 months. All external doors shall be dustproof and provided with panic bolts. The Contractor shall be fully and solely responsible for the design, selection of materials, corrosion protection system, structural adequacy, weather tightness, durability, security performance, and fitness for purpose of all external metal doors under all site, climatic, and operational conditions. Compliance with BS 6510, BS 1391, any testing, inspection, or guarantee period shall not relieve the Contractor of any obligations or liabilities under the Contract.

12 MASONRY WORK

Masonry works, design and workmanship should be in accordance with Eurocode 6 (BS EN 1996).

All masonry shall be built plumb, square and true to dimensions and lines, with full mortar joints. Horizontal joints shall be level and true. For bed joints, a thick bed of mortar shall be spread and only slightly furrowed, so that the joint will be filled completely with mortar. The ends of the units shall be buttered with an ample quantity of mortar and the unit shoved into place, so that the end joint is filled completely with mortar. In making closures, sample quantity of mortar shall be spread in the closure space, the closure units buttered on both ends and rocked into place, so that both end joints and the bed joint are filled completely with mortar.

The Contractor shall be responsible for the correct location, size and proper construction of all openings, must abide by the technical masonry craft procedures, including masonry reinforcement, joint horizontal reinforcement, expansion joints, control joints, and make all provisions for a proper execution of work according to perfect masonry requirements and following the detailed construction drawings.

The Contractor shall be entirely responsible for weather tightness of the exterior masonry walls. The workmanship shall be such that no leaks to the interior shall occur in the exterior walls because of defective workmanship or materials, from failure to fill completely all joints or to properly install all flashings and weep holes as detailed and/or specified elsewhere.

All joints in masonry shall be filled with mortar and all exposed joints shall be tooled. When the joint mortar has become thumb print hard, all exposed joints shall be tooled with a rounded stainless steel, ceramic or other non-staining jointer, compressing and sealing the joint mortar and the masonry units. Joints not exposed to view or weather or joints in surfaces to be covered with other materials may be cut. Reinforced concrete tie beams shall be constructed within the masonry walls, if the area of the wall is more than 24 m² in both vertical and horizontal directions.

Mortar for Masonry

Mortar for use with blockwork shall be mixed in the proportions of 1:1:6 cement, lime sand by volumes. Cement to be ordinary Portland cement Type I or Type V, lime to be hydrated lime. Mortar may be mixed by hand or mechanically. Hand mixing shall be carried out on a clean, watertight platform. The ingredients shall be mixed thoroughly in the required proportions, first dry and then with the addition of water until a uniform colour and suitable consistency is obtained. The mortar shall be used within one hour of the addition of the mixing water and any mortar not then used shall be discarded. For internal walling the mortar may be mixed in the proportions of 1:2:9 cement, lime, sand by volume.

Miscellaneous Materials for Masonry

Water absorption of the masonry material shall not exceed 0.5% by mass, when tested in accordance with ASTM C140 or equivalent standard.

Masonry materials reinforcement shall be pre-formed truss type masonry reinforcement, galvanised per ASTM A153, class B-2, complete with preformed corner and intersection units.

Cavity truss type masonry reinforcement for cavity wall, with two (2) side rods on each wythe, standard 3.80 mm (9 gauge) side and cross roads shall be used (unless heavy duty 5mm (3/16 in.) side rods are specifically noted), with deformed side rods, hot dip galvanised after fabrication, overall width 50 mm (2

in.) less than total wall width, with side rods properly spaced for the indicated wythe width. Preformed units shall be provided for corners and intersections.
Anchors and ties, where required, shall be installed as shown on the construction drawings or as required by the masonry design. Masonry passing steel or concrete surfaces shall be anchored to steel or concrete or corrugated anchors of dovetail, hook or weld on type as appropriate for the surface, installed on 410 mm (16 in.) centres.
Weep holes shall be provided over through wall flashings in wall, at bottom of wall and elsewhere as required for proper drainage. Weep holes shall be spaced 610 mm (24 in.) on centre and shall be formed with plastic tubing extending into the cavity and left in place.
Dovetail anchors where required or specified in the construction drawings shall be 12 gauge hot dip galvanised, corrugated steel, sized as required for the particular installation. Slots shall be heavy gauge, hot dip galvanised steel, sized to receive the anchor sizes required. Sizes of anchors and slots shall be as shown on the construction drawings. Membrane flashing shall be reinforced, homogeneous, waterproof, impermeable sheeting compound of elastomeric substance, which has been reduced to a thermoplastic state and extruded into a continuous sheet. The thickness shall be as noted on the detailed construction drawings, but not less than 1.66 mm (1/6 in.) thickness. The sheeting shall not be physically deformed when stretched at room temperature and shall be suitably stabilised to resist exposure without physical deterioration when subjected to weather meter testing. The materials shall show no signs of cracking or flaking when at temperatures of -29°C (-20°F), it is bent through 180° over a 0.8mm (1/32in.) mandrel, and over the same size mandrel in the opposite direction through 360°. The product shall carry the manufacturers or brand name at frequent intervals.
Membrane flashing cement shall be a cold setting cement compatible with the flashing materials, as recommended by the membrane flashing manufacturer and used in accordance with the manufacturer's instructions. Joints shall be completely filled to the indicated bead depth, backed where necessary with joint backing. Finished joints shall be continuous and weather tight, neatly finished. Colour of the sealant shall closely match the colour of adjacent concrete, mortar joints or metal, blending therewith in appearance.
Polysulphide caulking shall be gun grade, non-sag, one part polysulphide sealant. Joint backing, where required, shall be closed cell polyethylene joint backing, oversized to compress into the joint. Depth of sealant shall be equal to joint width in joints 13 mm (½ in.) wide and smaller and in joints wider than 13 mm (½ in.) shall be one half of the joint width or 13 mm (½ in.) whichever is greater. Primer, where required, shall be as recommended by the sealant manufacture. Silicon caulking shall be gun grade, non-sag, one part silicone construction sealant, joint backing, where required, shall be closed cell polyethylene joint backing, oversized to compress into the joint. Depth of sealant shall be one half of the joint width. Primer, where required, shall be as recommended by the sealant manufacturer. The Contractor shall be fully and solely responsible for the selection, design adequacy, compatibility, installation, performance, durability, weather tightness, drainage effectiveness, crack control, corrosion protection, and fitness for purpose of all miscellaneous masonry materials, reinforcements, anchors, flashings, sealants, and accessories under all site, loading, and environmental conditions.

Caulking Schedule

Caulking, except where otherwise specifically noted on construction drawings, shall be as follows:

Joint	Caulking Type
Window, door and louver frames	Silicone caulking
Exposed steel wall columns	Polysulphide caulking
Masonry control joints	Silicone caulking
Expansion joints	Silicone caulking
Pipe sleeve exterior walls	Silicone caulking
Miscellaneous non-moving joints	Polysulphide caulking
Miscellaneous joints subject to movement	Silicone caulking

Control joint gaskets shall be performed, factory extruded, solid rubber sections of either the regular or wide flange type as shown on the construction drawings. Materials for the wide flange type shall be similar to the regular type except that the edge shall be a compressible neoprene compound edge.
The Contractor shall be fully and solely responsible for the selection, compatibility, movement capacity, durability, weather tightness, and fitness for purpose of all caulking materials and joint sealing systems under all site and environmental conditions.

Concrete Blocks

Fine and coarse aggregates for forming blocks shall be aggregates from natural sources of hard, durable material or other approved, free from deleterious substances. Sand shall be graded 2 mm down and coarse aggregates shall have particles not larger than 10 mm. Cement should be Portland cement. Precast concrete blocks shall comply with EN 771-3 and shall have a compressive strength of 35 kg/sq.cm average for 10 blocks calculated on the gross area of block. Minimum strength of individual block 28 kg/sq.cm. Minimum thickness of the walls as specified. Blocks shall be cast in metal moulds and vibrated, then cured for at least seven days

Jointing

External fair faced walls shall be weather struck faces of walls, which are to be plastered or rendered, shall have their joints raked out to form kay. All other wall faces and partitions shall be flush jointed. All jointing shall be completed with pointing as the work proceeds.

Block Laying

All blocks shall be kept damp during building and shall be laid on a full bed of mortar. All joints shall be completely filled with mortar. The thickness of the horizontal mortar joints shall not exceed 40 mm to every four joints. Sealed movement joints shall be formed where necessary.

This includes splicing of the block walls with side columns using longitudinal reinforcement of 2Ø8 mm for every two courses (each 60 cm in length), and galvanized mesh (Galvanized Expanded Metal Lath Mesh) matching the width and the full length of each block row. Blockwork shall be built with three courses to 600 mm in a uniform manner, in truly level courses, and truly vertical or battered corners and other advanced work shall be racked back and not raised above the general level more than one meter. Toothing shall be used only where provision has to be made for a future extension. Both leaves of cavity walls shall be built up simultaneously. Galvanised flat twist wall ties of an approved pattern shall be bedded with a slight fall towards the outer face and shall be provided in alternate courses at intervals of 1m and staggered horizontally. Additional ties shall be used near the sides of all openings at the rate of one for each 400 mm of opening height. The cavity shall be kept clear of mortar droppings and rubbish, and the inside mortar joints shall be finished flush as the work proceeds.

Where so described or directed, reveals and piers, together with air bricks, fixing bricks for jointer's other work and other relevant items shall be built in as the work progresses.

Walls shall be constructed with complying with the requirements of the Specification and relevant standards expanded metal reinforcement every second course. Where shown on the drawings and at the jambs of all openings, the hollow concrete blocks shall be filled with weak concrete, well tamped down and carried from base slab to top of such openings. Cavities shall be kept clear of mortar droppings or other debris. Where blockwork is built against steel columns, provision should be made to tie the blockwork to the columns every second course, by means of a rod welded to the steel columns and bedded into the blockwork. Where the blocks abut reinforced concrete columns and where indicated elsewhere, the blocks shall be tied to the columns every second course by means of dovetailed masonry slots cast into the columns. Windowsills shall be precast and flush jointed in 1:2 cement mortar, or as indicated and shown in the construction drawings.

Holes and chases shall be cut out or left in the walls as required and provision shall be made for making good to achieve the requirements of the Specification.

On completion, all blockwork shall be cleaned down and mortar dropping and other marks removed. Defective blocks or workmanship shall be made good.

Protection Against Damage

Architectural features, finished surfaces shall be protected against damage during the progress of the works. Sills, jambs and head shall be protected by casings as soon as built.

Precautions during Inclement Weather

Newly laid blockwork shall be protected from the harmful effects of sunshine, rain drying wind, running or surface water and shocks. Any work that may be damaged shall be taken out and pointed as necessary to achieve the requirements of the Specification. Any costs incurred in carrying out such remedial work shall be borne by the Contractor.

Damp Proof Course

A damp proof course material complying with the requirements of the Specification and suitable for the prevailing site conditions shall be laid under walls above ground level so as to exclude rising moisture.

General

All natural stone, cast stone and precast concrete copings, sills, lintels, dressings and any similar items shall be hoisted into position and bedded, jointed and pointed in 1:1:6 cement, hydrated lime, sand mortar or as required to achieve the requirements of the Specification

13 FLOOR LAYING

Screeded beds

Concrete floors, which are required to be surfaced with screed, shall have a roughened surface, produced by hacking and wire brushing. The roughened concrete floor shall be cleaned, wetted preferably overnight, the surplus water removed and 1:1 cement/sand grout brushed into the surface, keeping just ahead of the screed bed. The screed bed shall be 70 mm thick and shall be well compacted and levelled with a screeding board and steel trowelled smooth. If the screed is the finished surface, it should be treated with an a silicate of soda solution complying with the requirements of the specification hardener to prevent dusting. The screed shall be mixed in the proportions of 1:2.4 (cement, sand, 10mm aggregate) by volume with the minimum quantity of water necessary to give a good hard smooth, steel trowelled finish. The section hereof concerning concrete applies.

Rigid screed battens shall be fixed on continuous beds of mortar to prevent movement when screeds are being laid and compacted. The screed battens shall be fixed to true lines and levels.

The bay sizes shall not exceed 15 sq. metres and the length of any one bay shall be limited to 1½ times the width. The bays shall be laid alternatively, i.e. in chequerboard fashion, a minimum of 24 hours being allowed to elapse between the laying of adjacent bays. The screed shall be reinforced with 50 mm mesh wire with 3mm wire thickness, and the bays separated by strips of 50mm galvanized steel angle or other suitable material. Screeded beds shall be cured for at least seven days, using polythene sheeting or such other method as determined by the Contractor, who shall remain fully responsible for achieving the required performance, durability, and fitness for purpose.

Raised Modular Flooring

The underside and all four edges of each panel are to be protected to Class I and Class 0 spread of flame. The panel is to meet the fire rating requirements of BS 6266. The floor system shall be suitable for a uniformly distributed floor loading of 18 KN/m^2 . and the panel steel support should be galvanized and braced (horizontal bars should tie between the jacks in the two directions). Surface covering of the panels shall be as dictated by the requirements of the room floor finish in which the modular floor is to be provided. The floor support system shall be effectively and continuously earthed. The floor system must comply with the conductivity/resistivity requirements for static electricity which is 2 x 10^^{6} ohms maximum and 5 x 10^^{6} ohms minimum resistance measured from floor surface to building earth.

The Contractor shall be fully and solely responsible for the design adequacy, fire performance, structural capacity (including uniform, point, and temporary loads), stability, bracing, earthing continuity, electrostatic performance, durability, and fitness for purpose of the complete raised floor system under all construction, operational, and environmental conditions, and compliance with the stated standards or values shall not relieve the Contractor of such responsibility.

Electrical panels shall be supported on rigid steel frames, fully braced in all directions, and anchored directly to the structural slab. The raised floor system shall not be used to support any panel loads.

Protection

All floor finishes shall be protected from damage by following trades and other causes and any damage, howsoever caused shall be made good by the Contractor at his own expense to achieve the requirements of the Specification.

Defects

Floor finishes will be rejected if they prove to be defective, due to cracking, crazing, curling, uneven surfaces, or lack of adhesion. Rejected floor shall be replaced at the Contractor's expense to the satisfaction of the **Employer**.

14 CARPENTRY, JOINERY AND GLAZING

14.1 Timber

Timber for carpenter's or joiner's work shall be hardwood of approved quality, the best of a species and suitable for the proposed purpose. All timber shall be subject to inspection by the Employer, piece by piece, both before and after finishing. The Contractor shall provide all necessary labour and facilities for the inspection of timber.

14.2 Preservative

Where appropriate, timber shall be treated with an approved preservative against rot or termite attack. The backs of frames to be fixed to walls and all other bedding surfaces shall be painted two coats preservative before fixing. All fixing blocks, pallets and other hidden timber shall be so treated prior to fixing.

14.3 Workmanship

The quality of workmanship shall be of approved standard. All carpenter's work shall be left 'from the saw' unless otherwise described or directed. All joiner's work shall be wrought and finished with a clean, even smooth surface.

14.4 Faults

Any carpenter's or joiner's work which shrinks, splits, fractures, parts in the joints or shows any other defect shall be removed or replaced to the satisfaction of the Employer.

14.5 Internal Doors

Internal doors shall be flush faced, solid core timber with painted timber frames of approved manufacture and are to be guaranteed against defects for 12 months.

14.6 Fire Resisting Doors

Fire resisting doors, frames and furniture shall be of approved manufacture and satisfy the test requirements of BS 476 part 8.

14.7 Roller Shutter Door

Supply and install complete electrical, mechanical and manual roller shutter door gate of heavy gauge of galvanized steel, dimensions according to owner approval.
Consisting plates should be of galvanized steel with thickness not less than (0.9)mm.
Patented interlocking profile edges with inset rubber seals providing fully weathered panel or panel joints with double flexible seal to close the clearance gap between the door head and inside face of structural lintel. Rubber strip should be provided at the lower edge to prevent dust entry to the building.
Guide tracks are of galvanized rolled steel sections of (1.5)mm thickness and (120)mm depth with friction resistant steel strips.
The door is operated by electrical motor to control opening the door on a fixed speed rate supplied with up and down, stop and control box, limit switch, overload protection and quick release facility for ease conversion to emergency manual operation.
In addition to a three (open, close and stop) press key with a control lock.
Upper galvanized box, gear set and crank arm for mechanical operation besides handles and holes for manual open and close are required.

14.8 Builder's Ironmongery

All necessary builder's ironmongery shall be selected by the Contractor to comply with the requirements of the Specification. Samples shall be **submitted to the employer for review**. The selected items shall be provided in sufficient quantities by the Contractor who shall then fix them into position in the best manner.

14.9 Pin Tumbler Cylinders

Pin tumble cylinders shall be of a type approved by the Engineer. The cylinder shall be made of brass and chromium plated. The lock manufacturer shall supply the cylinders required to comply with the locking system referred to in clause 15.12 below and shall supply the required special keys ready for use. The Contractor shall provide three keys for each individual lock and twelve master keys. All keys shall be labelled with the room number, building code or master key number, as appropriate, and shall be handed to the Employer on completion of each building.

14.10 Door Closers

Door closers shall be of the overhead hydraulic type, in air-conditioned areas and as required by the Engineer. They shall be of an approved type and provided with fine adjusting facilities. The size of the door closer shall be relative to the weight of the door leaf and shall be submitted to Employer for review. All internal doors shall be provided with door closers.

14.11 Door & Window Fittings

All Metal fittings such as hinges, locks, door handles, door bolts, etc. shall be made for heavy duty and mounted in adequate numbers. Samples of the selected fittings for doors shall be held by the Engineer at the Site, for future comparison. Hinges shall be of steel, brass or aluminium, with washers selected appropriately. Where necessary, doorstops shall be provided.

14.12 Locks

Cylinder mortice lock and latch sets shall be fitted to all doors except toilet cubicle doors.

Lever handles shall be fitted to both sides of internal doors, but to the inside only of external doors. Single pin tumbler cylinders shall be provided in locks on doors, which are to be locked from outside only, wherever no through traffic exists and which lead to rooms not permanently occupied. Double pin tumbler cylinders shall be provided in locks on all other doors.

Cylinder mortice lock and latch sets shall have a spring bolt operated by lever handles or key as appropriate and a dead bolt operated by key. Toilet cubicle doors shall be fitted with mortice or rim dead locks, turn operated from inside only and having 'Vacant'/'Engaged' indication on the outside, in distinct symbolism. The external doors shall be provided with panic bolts with lever handles.

14.13 Glass

Glass shall be wired cast or clear sheet of minimum thickness of 6.0 mm complying with BS 952, free from all defects, obtained from an approved manufacturer. The Contractor shall show on his drawings the thickness of the glass proposed for the various locations. Obscured glass shall be roughcast, plain rolled or figured obscured glass.

14.14 Glazing

Glass in glazed internal doors shall be bedded in wash leather. For external timber doors, approved genuine linseed oil putty shall be used. The edge of the glass shall be embedded in the back putty, and then secured by glazier's springs. The front putty shall stop 2 to 3mm from the sight line of the back rebate, so that the paint can seal the edge of the putty to the glass without projection. The surface of the putty shall be painted within 28 days of glazing. No glazing shall commence until rebates have been painted with primer. Glazing compound for aluminium windows shall be generally of an approved polysulphide type. The glass shall be bedded against the frame on the external face with the compound and secured on the internal face with an extruded aluminum beading, screwed or clipped and studded to the frame in an approved manner so as to securely retain the glass. Glazing compound or an approved proprietary type of plastic trim shall be used where necessary to ensure a weatherproof seal. Allowance shall be made when fixing frames for expansion of aluminium members so as to prevent distortion of frames or cracking of glass. The perimeter of the frames shall be pointed with an approved mastic.

14.15 General - Glazing

On completion of the works, all broken or cracked glass shall be replaced and all glass cleaned inside and out, to the satisfaction of the Employer.

15 DRAINAGE, PLUMBING AND SEWAGE DISPOSAL

All drainage design, material and workmanship shall be in accordance with approved standards and Codes of Practice. All drains shall be laid in straight lines and regular gradients as described or directed. Great care shall be exercised in setting out and determining the level of the drains. All drains shall be kept clear from earth, debris, superfluous cement and other obstructions during and after laying. All drains shall be provided with rodding eyes, inspection covers, etc. to ensure that every length can be rodded effectively in the event of a blockage. Without prejudice to the foregoing requirements, the Contractor shall be fully and solely responsible for the complete design, setting out, levels, gradients, hydraulic adequacy, construction, testing, and long-term performance of all drainage, plumbing, and sewage disposal systems under all operating, environmental, and site conditions.

Drain Pipes

Drain pipes shall be UPVC pipes and fittings of approved manufacture, **class 4 (10 bar)** according to SASO 14, DIN 8062, DIN 19532, or schedule 40 according to ASTM D-1785.

Concrete Beds and Casings

Concrete beds and casings to drainpipes under roads shall be of weak concrete and of 200 mm minimum thickness. Elsewhere, the pipes and ducts shall be laid on and surrounded with approved granular material. where drainpipes or ducts cross or run beneath roads, pavements, or trafficked areas, the Contractor shall design, provide, and execute the concrete beds, casings, and any additional protection necessary to withstand all permanent and temporary traffic loads, construction equipment loads, and impact effects, in accordance with the requirements of the Traffic Loading / Road Crossings provisions of the Specification.

Testing

After completion, drains shall be subjected to an air test, in which a pressure equal to 150 mm of water is to be applied for a period of five minutes without dropping below 125 mm head. Any defects revealed

shall be made good at the Contractor's expense. Where required by the Specification, applicable standards, or deemed necessary by the Contractor to demonstrate compliance, the completed drainage system or any part thereof shall be subjected to a water test.

Manholes

Manholes shall be generally in accordance with BS CP 301. Galvanised malleable cast iron step irons are to be provided and built in as work proceeds. Where manholes are located beneath roads or within trafficked areas, the Contractor shall design and construct the manholes, covers, frames, and associated works to withstand all permanent and temporary traffic loads, in accordance with the requirements of the Traffic Loading / Road Crossings provisions of the Specification.

Manhole Covers: Manhole covers shall comply with BS 497 and shall be heavy-duty.

Septic Tank:

The septic tank, where main drainage is not available, shall be constructed in an agreed position at least 20 meters from any building. The design shall be to recognised standards such as BS CP 302 and reviewed by the employer for general compliance with the Specification. The tank shall have separate fresh air inlet and outlet pipes and be provided with access openings. The effluent from the tank shall be drained to a soakaway pit of adequate capacity, constructed with walls of hollow concrete blocks laid on their sides. The soakaway pit shall be covered by a concrete slab, with access through a manhole cover. The capacity of the septic tank shall be designed to service five persons as a minimum in permanent attendance conditions.

Submersible pumps:

The contractor shall be responsible for procurement, install, commission and connect piping for a minimum of 2 No.s of submersible pump for all switchgear and GIS tunnels & basement if any and with the following specifications:

1-) procurement, install and commission a single stage submersible with rated head of no less than 10 meters and rated flow rate of no less than 9 m3/hr. submersible pumps discharge line size shall be no less than 2 inch and shall be made of galvanized pipe type, the pump shall be furnished with a grinder/shredder to breakdown solid particles.

2-) the contractor shall be responsible to procure and install the following appearances, fittings and instruments to operate the pump to its best operational capability:

a-) copper type valves before suction and after discharge side.

b-) strainer at suction side.

c-) copper type check valve at discharge side.

d-) a minimum of 2 electrical floatation devices connected to the pump control panel, where one shall be used to start the pump and the other shall be used to indicate a high-water level alarm.

e-) procurement, installation of the pump control panel and connect wirings and cables required to operate the pump with all its instruments.

F-) minimum of two pressure gauges with interfacing of nominal diameter no less than 80mm and reading range of 0-6 bar.

G-) preparing suitable sump/pit for the pump with dimensions suitable for the best operational capability of the pump.

H-) All fittings, pipes, valves required to connect the pump and the end of the discharge line shall be located outside the building to suitable water collecting point where caution shall be considered that discharged water shall not return back to the building.

I-) the pump top shall be covered by suitable means (Wire mesh/perforated steel cover) and shall not be left open (unguarded)

Pipes:

All piping materials and fittings for the water supply system shall be of approved make and suitable for potable water applications. The materials shall be selected in accordance with the service location and installation conditions as specified below:

1. **External Water Piping**: All external water supply lines shall be from galvanized steel pipes, complete with all necessary fittings, supports, and protective coatings, suitable for outdoor exposure and in accordance with relevant international standards. This is applied wherever potable water is required for a building Galvanised steel pipes shall have threaded joints of an approved type. They shall be secured to the structure or suitable concrete pads with galvanised steel saddle clips at not more than 1.5 meter centres.

2. **Internal Water Piping**: wherever potable water is required for a building, the below specifications shall be followed:
   - **Guard Room:** Internal water supply piping shall be of CPVC or PPR type, complete with compatible fittings and accessories.
   - **Any building requires potable water including:** Internal piping shall be as follows:

     A- From the termination point of the external galvanized line at the roof level up to the main water distribution cabinet, piping shall be of CPVC or PPR type.

     B- From the water distribution cabinet to the sanitary fixtures and water taps, piping shall be of PEX type, installed with approved fittings and in accordance with the manufacturer's installation instructions.

     c-) potable water pump with Easy press feature shall be supplied to provide water to buildings at suitable flowrate, the pump shall be placed on building roof furnished with all required piping according to specifications as required for external and internal piping mentioned in specifications.

Pipes to wash hand basins and WC cisterns shall be 20 mm bore and supply pipes to header tanks 25 mm bore.

CPVC/PPR pipes shall be installed within walls and properly protected against mechanical damages.

Sanitary Installations

The sanitary installation for each toilet, wash room, kitchen, guard room and others shall contain the following but not limited to:

- Three gallon capacity flushing cistern
- Porcelain glazed Eastern WC of approved quality with ½" water tap
- White porcelain wash basin of approved high quality with high quality chrome water mixer soap holder, shelves, mirror.
- Shower basin with all requirements
- 2m3 water tanks (2 for each building or apartment or guard house), made of galvanized sheets metal with a thickness of not less than 2 mm.
- Electric heater (capacity not less than 75 litres)
- All sanitary fittings and pipes.
- Boosting pump (easy press) for each building or apartment.
- Eye/face wash unit complete with pump, controller and all requirement for the battery rooms.
- Stainless-steel sink (Double drain sinks) of 120 x 60 cm dimensions.
- Distribution water cabinets made of 1.6 mm thick sheet.

Wash hand basins shall be of semi-pedestal type (490 x 600 mm approximate dimension), made of vitreous china, white colour, first-grade quality, complete with all necessary accessories and fittings. The wash basins shall include chrome-plated hot and cold water single lever mixer tap of high quality and well known brand with smooth operation and corrosion resistance finish. The wash basin shall include also mirror of suitable size mounted above the basin, and a shelf from vitreous china installed below the mirror in addition to wall mounted soap holder made from vitreous china. complete plumbing accessories shall be provided including but not limited to chrome plated angle valves (hot and cold), flexible connection hoses from angle valves to mixer tap, bottle trap or P-trap connected to waste outlet complete with all fittings for proper drainage connections.

Porcelain glazed Eastern WC of approved quality 490 x 560 mm approximate dimension, made of white colour porcelain, It shall include high-level water flushing cistern of a capacity of not less than 3 gallons the eastern WC set shall include chrome fittings and chrome faucets of 0.5 inch in addition to manual wash hose spray and all the requires material. It shall include also a porcelain paper holder of 6 x 6 inches dimensions, and water installations for the sanitary parts attached to the toilet. Furthermore, it shall include UPVC) high-pressure drainage pipes of 4 inches diameter to connect it to the nearest vertical sewage pipe or the nearest manhole outside the building, however, the wall thickness of the (UPVC) pipe must be not less than 5.3 mm

Cistern supported brackets shall be screwed to 30 mm timber chamfered backboards which shall be plugged and screwed to the walls. Stainless-steel sink (Double drain sinks) of 120 x 60 cm dimensions, with siphons of diameter 1.5 inch connected with overflow, chains and plugs, a single handle chrome mixer for cold and hot water (single lever mixer) with a long and curved movable neck, to pour in the vertical direction. Acrylic shower base of high-quality European origin, approximately dimensions 80x80 cm, with its own drain, chain and a plug, soap holder of glazed porcelain dimensions 6x12 inches,

chrome single–lever bath/shower mixer of European origin, in addition to hand shower, shower rail set and silver flex shower hose.

Electric water heater that works on electric energy with a capacity of 80 Liters and a power of 2 kW. The cylinder is made of two layers of galvanized metal sheet with full insulation between the two layers by high density CFC free polyurethane foam in accordance with the General Specifications, the paint of the external sheet shall be in white, and with the paint type (polymer paint coating) to reduce heat loss and insulate the inner surface with corrosion-proofing treatment. The electrical heater set shall include all the required parts, including pipes, flexible chrome connections, holders, built-in thermostat, the magnesium anode, safety valve…etc

Distribution water cabinets made of 1.6 mm thick sheet, the cabinet shall be white powder coated with thermal paint. Each cabinet shall include brass fittings such as: brass manifolds, clamps, couplings, nipples, tees, elbows, PEX crimp ring, push fit fitting, sub-valves, main valves, shut off valve for each individual utility, automatic air vents….etc.

Eye/face wash station with collection basin in the battery room, with manual operation by a push plate operate eye/face wash unit. It shall include all installation requirements such as but not limited to: installation of pipes of 1-1/4 inch and drain 3 inch, floor trap, connecting drain pipes according to the Employer's instructions, a pressure pump with "Easy Press" together with all required electrical & piping connections, the washbasin has a plastic basin reinforced against corrosion and chemical fumes, and the water flow rate must be not less than 20 lpm for eye wash, at a work pressure of 2-3 bar (at operating temperature 20-37°C). Unit will be complete with universal safety sign. The pump set shall be shaded by a metal sunshade. Overflow pipes from WC cisterns shall be 20 mm bore.

Glazed ware shall be of best quality and type and manufacture subject to review and comment by the Employer. Fittings shall be securely fixed in an approved manner. Cisterns shall be plastic wherever possible.

Taps and water mixers and all visible metal fittings shall be chromium plated, heavy duty quality. Drinking fountain outlets (if required) shall be clearly labelled. All fittings shall be individually isolated with a stopcock in the water supply pipe.

Workmanship

The layout of the plumbing shall be to approved standards and of the highest workmanship, with all bends to easy sweeps and bores and thickness maintained throughout.

Ventilation:

The system shall be properly ventilated by continuing the soil pipe above the highest branch upwards above roof level.

Overflows:

Overflow pipes shall be taken from the tops of cisterns and set to discharge in a prominent position.

Water Heaters:

Each basin, sink and shower unit shall be supplied with hot and cold water. The hot water shall be provided by approved electric water heaters, serving one or more units. The heaters shall be properly lagged. The capacity of the heaters shall be adequate for fittings which they supply.

Cleaning:

On completion of the works, all sanitary fittings shall be left in a clean and proper condition.

16 PAINTING AND DECORATING

Paints and Other Materials

Paints for priming, undercoating and finishing shall be ready mixed paints of the best quality for the intended due use and comply with relevant standards. All paints shall be obtained from an approved manufacturer who shall certify that the paint is suitable for the intended purpose. Plant for use on concrete or blockwork shall be of a type specially prepared for this purpose. Linseed oil should be best quality refined raw or boiled linseed oil. Turpentine shall be best quality. No substitutes shall be used unless they comply with the requirements of the Specification. Knotting shall be of the best quality, consisting of shellac dissolved in methylated spirits and shall be free from resin and naphtha.

Stopping shall be hard patent white lead stopping, composed of one-part white lead and two parts linseed oil putty with the addition of a small quantity of gold size. The stopping shall also include mastic with a silk finish to ensure a smooth and even surface.the final paint shall be vinyl silk touch paint to enhance surface smoothness and the final appearance.

General

All work shall be properly cleaned and rubbed down between each coat in a way, and using materials, recommended by the manufacturers of the paints concerned. No coat shall be commenced until the previous coat has been verified by the Contractor to be dry, hard and satisfactory, and reviewed by the

employer for general compliance. Each coat shall be of a distinct colour from the preceding one and all colours shall be selected by the Contractor and reviewed by the employer for general compliance with the Specification. All paint shall be applied in accordance with the maker's recommendations and shall not contain more than a minimum quantity of thinners or dispensers necessary to permit the satisfactory application of the paint. Spray painting will not be permitted except for internal faces of walls and ceiling. All other paint shall be thoroughly brushed into and completely cover the surface. Ironmongery shall be removed before painting and refixed when the paint is dry.

Woodwork

All timber required to be built into, bedded or fixed against brickwork masonry or concrete shall be given two priming coats and one undercoat on the concealed surfaces. All woodwork required to be painted shall be knotted, primed, stopped and painted with two undercoats and one high gloss finishing coat.

Hardwood which is not required to be painted shall be made perfectly smooth, prepared and oiled twice with linseed oil. Alternatively, it shall be stained and wax polished, or treated with two coats of a varnish complying with the requirements of the Specification.

Iron and Steelwork (except Structural Steelwork)

All surfaces shall be dry and thoroughly cleaned of all loose scale, rust and grease before painting is commenced. Iron and steelwork, which is to be built into or against blockwork, masonry or concrete shall be painted with two coats of black bitumastic paint. All other iron or steelwork, except galvanised metal, shall be painted with two priming coats, one undercoats and two finishing coats. One coat or primer shall normally be applied at the manufacturer's works. Galvanised metal shall be painted with one coat calcium plumbate primer at works, followed by one undercoat and one finishing coat of oleo-resinous paint.

Bitumastic Painted Surface and Coated Pipes

Bitumastic painted surfaces and coated pipes shall be thoroughly cleaned to remove grease, dirt or other deleterious matter, and then painted with one coat of sealer, one coat of leafing aluminium, one coat of undercoating paint and one coat of high gloss finish.

Copper Surfaces

Copper surfaces shall be thoroughly cleaned with white spirit and then painted with two coats of undercoat and one coat of high gloss finish.

Concrete, Blockwork and Plaster

Where required by the Specification, fair faced blockwork, plastered walls and the soffits of concrete roofs shall be prepared and painted with one coat of anti-suction primer, followed by one undercoat and one finishing coat of emulsion paint with eggshell finish type. All paint shall be of a type complying with the requirements of the Specification and suitable for the required purpose.

Touching-up and Cleaning Generally

At the completion of all works, the Contractor shall clean down the premises; wash paving and steps, wash and lather down wall tiling, etc; clean all sanitary fittings; touch-up paintwork; examine all roofs and leave water tight; clean-out all pipes and leave the whole of the premises in a clean, sound and perfect condition ready for immediate occupation.

17 CABLE DUCTS

Ducts:

Cable ducts may be pitch fibre, PVC plastic, or other materials selected by the Contractor and demonstrated to comply with the Specifications and applicable standards, subject to review by the employer.

General

All cable ducts shall be laid in straight lines and regular gradients between cable pits, as directed. All ducts shall be kept clear from earth, debris and other obstructions during and after laying.

All cable ducts shall be designed, supplied, and installed by the Contractor to suit the required cable sizes, loading conditions, and site environment, in accordance with approved standards.

Concrete Beds and Casings

Concrete beds and casings to cable ducts under roads, buildings, floors and foundations shall be of lean concrete and of 150 mm minimum thicknesses. Elsewhere the ducts shall be laid and surrounded with approved granular material of 150 mm minimum bed thickness and 300 mm minimum cover, or such greater thicknesses as necessary to ensure adequate protection and long-term performance.

Cable Ducts:

After the cable ducts have been completed, a cleaning rod shall be drawn through each duct and a No. 8 gauge galvanised iron finishing wire drawn in after the rod. The ends of the ducts shall be plugged with a wooden plug and the finishing wires left in the ducts.

Cable Pits

Cable pits shall be provided at the ends of all cable ducts. Cable pits may be constructed of bricks, concrete blocks, institute concrete or precast concrete rings and cover slabs. In each case, the material shall be in accordance with the relevant sections of this specification. Cable pits shall be sized according to their depth to provide sufficient working space and access for maintenance. When constructed of blockwork, they shall be rendered internally with sand/cement mortar finished with smooth vertical surfaces. Where precast concrete rings are used, they shall be surrounded with concrete 150mm thick. Galvanised malleable iron steps are to be provided in all cable pits over one meter deep and built in as work proceeds. Without prejudice to the foregoing requirements, the Contractor shall be fully and solely responsible for the design, sizing, structural adequacy, safety, durability, and fitness for purpose of all cable pits, including their ability to withstand all applicable loads, groundwater conditions, and environmental effects.

18 FENCING AND GATES

Main Gate

The gate shall be an electrical motorized sliding gate motors width not less than 6.0m and a height not less than 2.0m. The gate shall be provided with a personal door width of 1.0 meters. All steel works of the gate shall consist of tubes 1.5 mm, steel sheets double-faced 1.5 mm thick, and perforated metal sheet, including oil painting with primer. The gate shall be provided with a reinforced concrete ground beam and steel rails for the upper and bottom of the gate, with wheels and all accessories. The electrical motor shall be 1-phase with a load capacity of one tonne to be moved and controlled from the guard house. Also, manual control is required for the gate and remote control. The gate shall be provided with a locking system suited and master keyed with the door locks of the building. All gate details shall be subject to review and comment by the Employer. The motorized gate system shall be provided with all necessary safety devices, including photocells and emergency stop functions, and shall operate reliably under normal and manual modes in the event of power failure. All steel components shall be adequately protected against corrosion, and the Contractor shall carry out all necessary testing of the complete gate system to demonstrate full compliance with the Contract requirements, at his own responsibility.

Boundary Fences

The perimeter of the Site shall be enclosed by reinforced concrete walls, constructed either as boundary walls or as retaining walls with a thickness not less than 200mm, with a fence installed on top of these walls, in accordance with the following specifications:

- Excavation for the wall foundation.
- Reinforced concrete for walls and its foundations. Height of the walls shall be according to the substation site finished levels and not less than 2.8m above the ground level.
- Hot-dip galvanized steel angles 50 x 50 x 5 mm, length 0.9 m spaced 3.00 m fixed in the top the concrete.
- Hot-dip Galvanised wire mesh height 0.9 m minimums.
- Stringing wires 4 mm. 3 rows.
- galvanized spiral mesh with a diameter of 3 mm, razor style (blades), so that each horizontal 1 meter contains four spiral loops with a diameter of 60 cm for the entire length of the wall, which conforms to the specifications, and is duly installed on the barbed wire
- Ranked struts will be repeated every 18.0 m long and at the corners of the fence.
- The angle posts shall have cranked tops set at 45° to the angles outward, to which shall be attached three strands of galvanised barbed wire to BS 4102.
- Installation of drain pipes with a diameter of 8 inches, in addition to “Weep Holes” ø4“(inches) where necessary, and with the distances as per Jordan retaining wall code requirement
- Making of expansion joints and execution of expansion joint fillings with a thickness of 20 mm from compressible materials and sealants for all visible faces 20×20 mm according to the drawings, noting that expansion joints are implemented for every 12 m (horizontal m) of the wall.
- The reinforced concrete wall and fence system shall be structurally designed to withstand all applicable loads, including wind and seismic actions, in accordance with approved standards and site conditions. All works shall be adequately protected against corrosion, and drainage behind the wall shall be executed to prevent water accumulation, all subject the Employer's review.

19 WALL AND CEILING FINISHES

Materials

Cement, sand, hydrated lime, gypsum plaster, expanded metal lathing, flat headed galvanised nails, galvanised staples and wire shall all comply with approved standards. Materials shall be carefully stored in a dry weatherproof store until required for use.

Preparation of Backgrounds

Backgrounds for plasterwork shall be prepared by carefully brushing to remove dust and other adherent particles of any other material likely to impair the bond the undercoat with the structure. If under suction occurs on the background surface, this shall be sprinkled with water to prevent drying the applied plaster.

Joints of blockwork, which is to be plastered or rendered, shall be raked out to a depth of 13 mm.

All plastering and finishing works shall be executed in accordance with approved standards and best construction practices, to uniform thickness, plumb, level, and true to line. Completed wall and ceiling finishes shall be adequately cured and protected from damage by subsequent trades until Taking-Over, and any defective work shall be made good at the Contractor's sole cost.

Interaction of Materials

In no circumstances shall cement be used in the same mix as gypsum plaster, nor shall the two materials be allowed contaminate each other. Only materials inadvertently contaminated shall be rejected from site.

Plasterwork

Undercoats shall consist of Portland cement, hydrated lime, and sand gauged in the proportions 1:1.6. The undercoat shall be keyed to take the finishing coat and allowed to dry out completely before the latter is applied. Finishing coats shall be applied in accordance with the recommendations of the manufacturer of the particular brand to be used. The total thickness of the two coats shall not be less than 15 mm. Plasterwork shall be properly cured between coats in accordance with best practice and manufacturer's recommendations. Any plaster finishes found to be cracked, deboned, uneven, or otherwise defective shall be removed and made good at the Contractor's sole cost, subject to the Employer's review.

External Rendering

External rendering shall be applied in two coats, with an approved waterproof agent added to the mixes. The walls shall be wetted before the application of the first coat, which shall be finished flat and vertical by straight edge, and scored to form a key. The second coat shall not be applied until the first coat has dried out completely. Immediately before application of the second coat, the surface of the first coat shall be wetted and the second coat shall be applied by machine (Tyrolcan) to give a finish of uniform thickness and texture. An external rendering shall be protected from rain and direct sunlight for a period of 7 days.

Workmanship Generally

All proprietary brands of plaster or plastering materials shall be selected and applied strictly in accordance with the manufacturer's instructions regarding the different purposes and backgrounds for which they are intended. Particular attention shall be paid to the manufacturer's instructions regarding the time allowed to elapse between mixing and using. The plastering shall be carried out by men experienced in this type of work, and the whole work shall be finished to a true and even surface, free from all defects. Any cracks or other defects shall be cut out and made good. External rendering works shall be executed under suitable weather conditions and to uniform thickness, in accordance with approved standards and manufacturer's recommendations. Any rendered surfaces showing cracking, debonding, unevenness, or other defects during execution or prior to Taking-Over shall be removed.

20 CEILINGS

Horizontal Suspended Ceiling

The horizontal suspended ceilings to areas shown on the drawings shall generally be of non-asbestos mineral fibres approved incombustible panels in an exposed T grid. The boards shall be of a self-finished type. The ceilings shall be accurately aligned with the levels.

The panels shall be secured with locking clips to the grid. The visible face of the panels shall have a self-finished surface. The exposed T grid shall be aluminium or galvanised steel adequately supported from the R.C roof slab above, on adjustable straps and hangers as required.

At perimeter walls and columns, the grid shall be neatly trimmed with angle trimmers.

If required, for air-conditioning purposes, slots or grilles will be incorporated in the ceiling grid system. These shall be neatly formed and edged in materials matching the grid.

In other areas where required and shown on the drawings, the ceiling shall be made airtight at individual panel supports and at junctions of ceilings and walls.

The suspended ceiling system shall comply with the following additional requirements:

a) Fire Performance: Ceiling panels and exposed grid systems shall achieve a fire reaction classification of Class 0 or Class A surface spread of flame, in accordance with approved international or local standards.

b) Moisture Resistance: In humid or wet areas, ceiling panels shall be moisture-resistant with a minimum relative humidity resistance of RH ≥ 90%.

c) Panel Thickness: The minimum thickness of ceiling panels shall not be less than 12 mm, unless otherwise subject to review by the Employer.

d) Suspension System and Loads: The suspension system, hangers, and fixings shall be designed and installed to safely support the self-weight of the ceiling system together with any additional imposed loads from integrated services.

e) Coordination with Services: All ceiling works shall be fully coordinated with mechanical, electrical, fire-fighting, lighting, and other building services, including the provision of access panels where required.

f) Access and Maintenance: The ceiling system shall allow easy removal and reinstatement of panels to facilitate inspection, maintenance, and replacement of services above the ceiling.

g) Airtightness: Where required for air-conditioning performance or designated functional areas, the ceiling system shall be made airtight at panel supports and at junctions between ceilings and walls.

h) Protection and Defects: All ceiling works shall be adequately protected from damage by subsequent trades until Taking-Over. Any damaged or defective panels, grid components, or accessories shall be replaced by the Contractor at his sole cost.

Additional Treatment to Ceilings

Under concrete roofs where areas are to be air-conditioned, a 25 mm thick insulating foam glass slab shall be fixed to the concrete roof soffit by battens. Other equal and approved insulating materials and methods of fixings may be used, subject to the employer review. The insulation material shall be non-combustible and suitable for use in air-conditioned areas, providing adequate thermal and moisture resistance to prevent condensation. Any alternative material or fixing method shall demonstrate equal or superior performance. and shall be subject to the employer prior review.

Suspended Ceilings and Linings Generally

The Bidder shall specify the type and manufacture of his proposals for the above ceilings, in the schedule included in the documents.

Samples of materials shall be submitted to the employer for review and comment before ordering.

21 Porcelain Tiles

Colored porcelain tiles from the specified manufacturer and origin, with an absorption rate (0.00% – 0.50%) for bathroom and kitchen floors and walls. The tiles shall be of the specified color, subject to review by the Employer. It includes the installation of mortar of cement and sand (with a ratio of 4:1) and grouting using a special-colored grout, sand, and aggregate size 5–10–16 mm, under the tiles, with the necessary thicknesses and accurate machine cutting, deemed included in the Contract Price. The thickness is 10 mm, and the spacing is done using plastic spacers with a thickness of 1 mm. The breaking strength ≥ 250 lbf (1.11 kN) for individual tiles ≥ 225 lbf (1.00 kN). The bond strength ≥ 50 psi (0.34 MPa).

The finished work shall be left clean and free from all materials: cleaning down must not be carried out with materials which will scratch or in any way impair the finished work. Final polishing shall be done with a dry cloth. The Contractor shall be responsible for the adequate protection of the tiling from all damage until the handover. Any damage that does occur shall be made good by the Contractor at his own expense. Prior to commencement of works, samples shall be submitted for review and comment by the Employer. The finished works shall be left in a condition subject to review and comment by the Employer

22 Granite tiles

Granite to be supplied and installed shall be first-class hardness and polished granite, uniform in colour and appearance, free from cracks, cavities, or visible defects. The material shall conform to ASTM C615 – Standard Specification for Granite Dimension Stone and be subject to review and comment by the Employer, including a bedding layer consisting of mortar and graded aggregate (8–10 mm), laid to achieve full support and level tolerance, and grouting with a special, ready-to-install mortar with a cement base in a color that matches the color of granite from a source reviewed by the Employer, and automatic

cutting for closure parts. This includes polishing before the electrical installation works and also includes mechanical polishing after the completion of the electrical installation works. The granite shall be of foreign origin, with dimensions and color reviewed and commented on by the Employer. The finished work shall be left clean and free from all materials: cleaning down must not be carried out with materials that will scratch or in any way impair the finished work. Final polishing shall be done with a dry cloth. The Contractor shall be responsible for the adequate protection of the tiling from all damage until handover. Any damage that does occur shall be made good by the Contractor at his own expense. The shell of the work shall be left in a state to be reviewed by the Employer.

Granite Physical Properties:

Physical Property	Requirement	ASTM Test Method
Absorption by weight (max)	0.40 %	ASTM C97
Density (min)	160 lb/ft³ (2560 kg/m³)	ASTM C97
Compressive strength (min)	19,000 psi (131 MPa)	ASTM C170
Modulus of rupture (min)	1,500 psi (10.34 MPa)	ASTM C99
Abrasion resistance (Ha, min)	25	ASTM C241 / C1353
Flexural strength (min)	1,200 psi (8.27 MPa)	ASTM C880

23 Marble tiles

The Contractor shall supply and install marble finishes in accordance with Jordanian Standards. The marble shall be of high-quality, free from cracks, chips, and discoloration, with uniform color and texture. All marble shall be properly cut, polished, and fixed using approved adhesives and grouting materials. Joints shall be straight, even, and neatly finished. Any marble found defective or not complying with the specifications shall be removed and replaced at the Contractor's sole cost. All works shall comply with best construction practices and relevant standards.

Prior to commencement of installation, the Contractor shall submit marble samples and, if required by the Employer, construct a mock-up panel for review and comment. No bulk installation shall commence until such review and comment is received.

24 PERMITS TO WORK AND OVERHEAD LINE RESTRICTIONS

a) The Contractor shall take into account that High Voltage and/or Extra High Voltage transmission towers, overhead transmission lines, and associated equipment will be constructed and installed within and/or in the vicinity of the Main Substation site under a separate contract by the Employer and/or another contractor.

   Such works are not included in the Contractor's Scope of Works. However, the Contractor shall take into account the planned and/or ongoing execution of such works and shall fully coordinate its activities with the Employer and the other contractor(s), as required.

   The sequence and timing of such works may differ from the Contractor's Works and may take place before, concurrently with, or after the Contractor's activities. The Contractor shall accordingly coordinate its design, construction programme, site access, temporary works, material deliveries, lifting operations, and other site activities to avoid any interference, obstruction, or conflict with such works

b) The Contractor shall provide reasonable access and coordination necessary to facilitate the execution of the works under the separate contract and shall not obstruct, interfere with, or cause damage to such works or the facilities associated therewith

c) During the execution of the Works, the whole or any part of the Site may be energised at High or Extra High Voltage. The Contractor acknowledges and accepts that such conditions form part of the Site conditions and shall not entitle the Contractor to any extension of time or additional payment. The Contractor or any of his Subcontractors shall only be permitted to carry out Works under the Employer's written Permit to Work system.

d) Details of the Employer's "Permit to Work" system may be obtained on application to the National Electric Power Company.

e) Where works have to be executed under or near existing live overhead transmission lines or equipment, special precautions should be taken. The precautions are essential for the safety of the operators of the plant and men concerned in the works. The Contractor is responsible for ensuring that the precautions are rigidly adhered to.

f) No person, equipment or part thereof or any other thing must approach within a defined safety clearance, depending on applied voltage, of the conductors of live points of equipment.

g) All plant, for example, crawler, truck or other mobile cranes etc. are required to be fitted with a strop which will limit the elevation of the site jib necessary "live" clearance while the crane is in transit or

working under or near lines of live equipment. The strops are to be attached by a locking device having a different key. Keys are to be surrendered to the employer's representative prior to the entry of any plant into the vicinity of live conductors or plant. All equipment working or passing under or near live conductors shall have the employer's written approval to do so.

h) The Contractor shall provide suitable warning notices in English and all other languages in use on site. These notices shall be submitted to the employer for review. Notices shall be placed in a number and positions as required by the employer's Representative and the Employer.
i) Height gauges of the proposed design shall be placed in appropriate positions for review by the Employer and/or Employer's Representative.
j) The Contractor shall remain solely and fully responsible for the safety of all persons, plant, equipment, and the Works at all times, and no review, comment, consent, or omission by the Employer or any of his representatives shall limit or reduce such responsibility
k) The Contractor shall ensure that all personnel working in proximity to energised equipment are suitably trained, authorised, and inducted in accordance with the Employer's safety procedures.

25 Contractor's Obligation for Permits and Licenses

The Contractor shall be solely responsible for obtaining all necessary permits, licenses, and approvals required for the construction, commissioning, and operation of the station from the relevant governmental and regulatory authorities, such as the municipality and the Civil Defense Directorate or other governmental and regulatory authorities. This includes, but is not limited to, environmental, municipal, utility, and safety permits necessary for the full legal operation of the project. The Contractor shall bear all costs, fees, efforts, and administrative procedures associated with the permitting process, and shall ensure that all licenses and approvals are obtained in a timely manner in accordance with the project schedule. Failure to secure the required permits shall not be considered a valid justification for project delay. The Contractor shall be responsible for obtaining all necessary licenses and approvals required for the station and shall pay all associated costs, fees, and charges.

The Contractor shall be fully responsible for obtaining, at his own cost and in due time, all required access permits, security clearances, and approvals from the relevant military, security, or governmental authorities for entry to the Project Site, which may be located within or adjacent to a military or security-restricted area.

This obligation shall apply to all the Contractor's personnel, staff, labor, consultants, suppliers, and Subcontractors, prior to commencement of any Works on Site.

The Contractor shall take into account that the issuance of such permits and security clearances may require a considerable period of time, and shall accordingly make all necessary arrangements and submissions sufficiently in advance. Any delay arising from failure to obtain such permits or clearances in a timely manner shall be entirely at the Contractor's risk and shall not entitle the Contractor to any extension of time, additional payment, or claim of any kind.

SECTION 2

GENERAL TECHNICAL SPECIFICATION

FOR ELECTROMECHANICAL WORKS

26 LIGHTING SYSTEM AND SMALL POWER DISTRIBUTION

The scope of work shall include designing, supplying, furnishing, delivery, installing, testing and connecting all normal ac lighting, emergency dc lighting, lighting panels, lighting fixtures, lamps, ballasts, switches, receptacles and welding receptacles, including all associated electrical wiring, conduit, fittings, support hardware and any other equipment necessary for a complete and satisfactory installation of the lighting and receptacles systems, in accordance with the Specification, including, but not limited to the following principal areas:

- Outdoor switchyard areas.
- Control buildings.
- Outdoor roads lighting.
- Guard House.
- Capacitor building.
- Diesel generator room.
- Switchyard fencing.
- Pump House.
- **All buildings in the Substation.**

The minimum lighting intensities for various areas are listed herein. It shall be the responsibility of the Contractor that fixture quantities and locations are such that these values of light intensities, as applicable, are maintained for the normal lighting system.

- Outdoor HV operating areas (132KV-400KV …) 35 Lux
- Control & Relay rooms 550 Lux
- Toilet 250 Lux
- Offices 550 Lux
- Store/ Workshops 500 Lux
- Capacitor 550 Lux
- Battery room 550 Lux
- Roads 35 Lux
- Fences 35 Lux
- Tariff Metering RM 550 Lux
- LVAC room 550 Lux
- Corridors 250 Lux
- AC& PLC/TELE Room 550 Lux
- Diesel generator room 350 lux
- Guard house 350 lux
- HVAC room 350 lux
- 33KV Switchgear room 550 lux
- 132KV G.I.S Switchgear RM 550 lux
- 400KV switchgear hall 550 lux
- Pump House 450 lux
- 132KV Relay & Control RM 550 Lux
- A/C Room 400 lux
- Control room 550 Lux
- Kitchen 250 Lux
- Telecom Room 550 Lux
- A/C PLANT 400 Lux

The outdoor lighting (road lighting and switchyard lighting) shall be automatically controlled by a photocell and astronomic timer, where the photocell and the astronomic timer shall be connected in parallel and located in the main outdoor lighting distribution board. The Substation gantries shall not be used to mount any outdoor lighting; however, the earthing masts may be used for this purpose.

27.1 Normal lighting

27.1.1 Lighting Fixtures and Lamps

Lighting fixtures shall be of led type for indoor lighting installations, street installation and switchyard area. The driver card shall cut off at 270 V and shall resume normal working when nominal voltage is applied again. This is to ensure protection of luminaries from neutral faults and error in connection.

Efficiency of driver electronics shall be more than 90%. The LEDs should be driven at the suitable current and within the permissible limits specified by the LED chip/lamp manufacturer.

The fixture shall be designed so as to have lumen maintenance of at least 70% at the end of 50,000 hours.

Power Factor of the electronic drivers should be at least > 90% with THD <15%.

Colour temperature of the proposed white colour LED shall be 4500K-5000K.

The output of LED shall be more than 130 lumen per watt at operating current.

The colour rendering index (CRI) shall be more than 0.8 with cool white light output.

For the suspended ceiling areas, the indoor lighting fixtures shall be recessed to blend with the ceiling and shall be of led panel type, however, for the non-suspended ceiling areas surface mounted fixtures shall be used. The fixtures for 400kv switchgear hall and 33Kv Switchgear Room and 132KV G.I.S Switchgear shall be industrial led light fixtures system. The lighting fixtures shall be accessible and easy for maintenance or replacement.

Road lighting fixtures shall be installed on galvanised steel poles. A heat shield shall protect each unit from the direct rays of the sun. The light distribution of each unit shall conform using the available fixture refractor distribution adjustment to the configuration of the respective area.

Poles shall be of hot dip galvanised steel construction, approximately nine (9) m nominal mounting height. The poles shall be anchored to a concrete base by not less than four (4) corrosion protected bolts, top of concrete base shall be 400mm, above finished grade. All outdoor area fixtures, poles and accessories shall be finished with a corrosion resistant paint. Each pole shall be equipped with a base section of sufficient size to house an inspection trap, lockable door, MCB cable entry and terminations for both the incoming and secondary cables feeding the light sources. Lighting fixtures shall be provided

with a corrosion resistant finish on all interior and exterior parts. Fixtures in outdoor areas shall be vapour and moisture proof with minimum degree of protection IP60.

The lighting fixtures shall be complete in every respect, including LED panel, driver and accessories such as gaskets, mounting brackets, metal fittings for row lining or suspension from ceiling metal frames for flush mounting, etc. Explosion proof fixture shall be used in the battery room and in any other areas exposed to explosion hazard (if any).

Industrial fluorescent fixtures equipped with metal louvers shall generally be used to illuminate the faces of switchgears, motor control centres, cabinets and instrument panels. All staircases shall have normal and emergency lighting. Surface mounted enclosed fixtures shall be used. Three (3) way switches shall be used for all the staircases, corridors and rooms with two (2) doors.

Exit lights shall be LED type consisting of adequate size box with the word "Exit" in English and Arabic. Normal ac and emergency dc supply shall be provided for all exit lights.

Area lighting, road lighting, outdoor storage areas and open parking areas lighting shall be by means of pole mounted single or grouped fixtures as required.

27.1.2 Lighting Switches, Receptacles and Cover Plates

Toggle switches shall be rated 10A 230V, specification grade, quiet type.

Receptacles shall be of three pin shuttered and switched type, MK type or equivalent, shall be rated 13A, 230V two pole plus earth type. Sockets in toilets and outdoors shall be weather proof and shall have earth leverage protection set at 5mA.

Cover plates for toggle switches and receptacles shall be foreseen.

Toggle switches shall be mounted 1.2m centre line from finished floors.

Receptacles shall be mounted 0.5m to centre line from finished floors.

Devices installed outdoors shall be of the weatherproof type and approved for the purpose.

27.2 Panel boards

Panel boards shall be 400/230V, 3-phase, four (4) wire of the bolted-on circuit breaker type or any other type, with the capacity and type of circuit breakers as required for the loads served. Panel board design and construction shall be in accordance with the applicable requirements. A minimum of 20% of each type and rating of circuit breakers shall be provided as installed spares. The Contractor shall balance the loads on the three phases in panel boards as far as possible. A description of the load on each circuit of each panel board shall be typewritten on a card mounted in a cardholder pocket within the panel board.

Panel boards mounted indoors shall be of sheet steel construction with hinged doors and shall be surface or flush mounted as required. Panel boards mounted outdoors shall be weatherproof. The cables feeding the distribution boards shall be connected directly to the incoming isolator or neutral bar as appropriate unless otherwise indicated by the specification. All electrical panel cables shall be sourced from the LVAC room, where each building shall have its own electrical panel inside. notwithstanding the foregoing, stacking all panels in one building shall not be accepted.

voltage regulator(stabilizer)

A voltage regulator(stabilizer) must be installed to supply and protect the loads of electromechanical equipment and devices against overvoltage conditions and transient voltage surges, and should be including the following:

1. LIGHTING SYSTEM
2. Socket Outlets
3. AIR CONDITIONING AND VENTILATION SYSTEM including secondary split unit systems
4. FIRE PROTECTION including clean agent AND fire DETECTION SYSTEMS including smoke, heat and aspirating smoke detection

All above points are excluding the fixed water spray-deluge type- firefighting system.

27.3 Socket Outlets (Receptacle) and Fused Spur Outlets

The Contractor shall design, furnish, install and connect suitable receptacle systems for 230V single phase convenience outlets and 400V three phase power outlets.

Each socket outlet shall comply with the requirements of the British Standards 1363 or equivalent and shall be the interlocked shuttered and switched types arranged for surface or flush mounting in single or multi units as appropriate. The power sockets in toilet, kitchen and outdoors shall be weather proof type.

Each fused spur outlet shall be equipped with double pole isolator, a fuse to British Standard 1362 or equivalent and where required front entry for flexible connection.

Each socket outlet and fused spur outlet shall be equipped with a galvanised metal box with earth terminal. In office areas, control rooms and maintenance type areas (such as switchgear rooms,

equipment rooms and the like) the sockets shall be so arranged that any point can be attainable with a 3m extension cord. A 3-phase power socket shall be installed in the 33KV switchgear room & 132KV G.I.S Switchgear RM & 400KV switchgear hall.

The 400V power outlet system shall include suitable 400V, 3-phase, four (4) wire heavy-duty fused power receptacle outlets suitable for supplying welding machines. The design shall include a sufficient number of power receptacles in strategic locations throughout the plant such that any equipment may be connected with a portable connection cable no longer than 30m. The Contractor shall supply five 30m portable extension cables with plugs of the type of sockets installed.

The outlets shall be 63 Amp, 5 pole type /3 phases, 1 neutral, 1 ground).

27.4 Fixture Installation

The Contractor's drawings shall indicate the type of fixture at each location.

Receptacle circuits must be completely separated from lighting circuits and one (1) circuit shall not consist of more than four (4) 13 A single-phase outlets.

Outdoor lighting circuits shall be automatically controlled by photo-electric cells and astronomic timer connected in parallel and manually controlled by a selector switch. All other circuits shall be directly controlled from the relevant panel boards. Upon completion of the installation of fixtures and at the time of final inspection, fixture and associated equipment shall be free from defects and any reflectors or glassware broken, bent or discoloured shall be replaced at the expense of the Contractor. All lighting circuits, except those for street lighting shall consist of not more than ten (10) fixtures with a total power not exceeding 1000W.

27.5 Emergency Lighting

27.5.1 Fixed Fixtures

Emergency lighting shall be dc operated and automatically energised during an ac voltage failure. Emergency lighting shall provide sufficient lighting levels for safe emergency escape from the building.

Emergency lighting shall be energised from the 110-volt dc supply.

The system shall be arranged so that on failure of the normal ac supplies to the lighting installation the emergency lighting system will automatically be energised and de-energised automatically upon ac voltage recovery; however, the emergency lighting shall be turned on and off by means of pushbuttons located at the main accesses of the buildings after the system has been energized.

In suspended ceiling areas recessed fixtures to blend with the ceiling shall be used. In non-suspended ceiling areas, surface mounted fixtures shall be used. The minimum lighting intensities for various areas are 10 lux. All indoor areas shall be provided with emergency lighting.

27.5.2 Portable units

Emergency portable light shall be provided as per relevant clause of this section. Sixteen portable lights shall be provided for the substation. The portable emergency lighting fixtures supplied shall have a built-in battery rated for three hours and complete with battery chargers and solid-state inverters, and shall be supplied with all necessary supporting brackets of galvanized steel suitable for wall mounting. The portable emergency lighting fixtures shall be of twin unit, suitable for prolonged use with no maintenance. The Contractor shall submit schematic along with all details and general arrangement drawing for approval.

27.6 Conduits and Boxes

Conduits and boxes shall be of recessed heavy duty plastic material, however, a hot dip galvanized conducts maybe used in some areas and subjected to engineer approval. If metallic, all conduits and boxes shall be grounded.

27.7 Cables

Cables having external protection (conduit) shall be unarmoured PVC or XLPE insulated cables or single-phase PVC or XLPE insulated; cables which are unprotected shall be sheathed multicore types manufactured and tested to the requirements of BS 6004, 600/1000V grade of equivalent. Sheathed types shall be equipped with an earth continuity conductor.

Armoured cables shall be PVC or XLPE insulated filled and sheathed single wire armoured and PVC sheathed overall and be manufactured and tested in accordance with the requirements of BS 6346, 600/1000V grade or equivalent with black outer sheath. Jute fillings will not be permitted.

27.8 Installation of lighting protection system for all buildings

Installation of lighting protection system for all buildings and equipment.

27.9 Earthing:

- Refer to the Jordan electrical installation code to determine any items not specified below regarding the specifications and conditions of the necessary earthing system and how to implement it.

- All equipment and tools in this part are tested to ensure the effectiveness of the earthing system and to provide what is necessary to conduct these necessary tests according to the general regulations for electrical installations.
- The earthing conductor must reach all machines, equipment, power sockets, sub-distribution panels, box sewers, and any related piece of metal in the building, provided that the earthing conductor connectors must be a single line connected from the switchboard to the farthest point in the building's electrical installations, and any branches of the earthing line shall be by means of permanent connections fixed mechanically and in accordance with the general regulations for electrical installations.
- The earthing rods must be made of copper with a diameter of not less than (20) mm with a pointed head, and they must be placed in a cement hole with a metal cover over it, and the length of the rod is not less than 1.2 meters.

28 Telephone Installation:

A. Telephone cabins and phone boxes: -
   - Telephone junction boxes must be of a multi-purpose type, of a suitable size, and their location can be controlled
   - The cabins must contain all the necessary parts to receive the ends of the wires.
   - There must be an identification board on the cabins, as approved by the Client.
   - Made of Sheet Steel with a thickness of 15 mm and galvanized.
   - The cover is made of Cold rolled sheet steel at least 2.5 mm thick.
   - Use the appropriate machine to install the cover on the cab.
   - The cabin must be (Flush mounted).
   - The color of the exterior cabin is residential.
   - The process of painting in two colors, one basic and the other residential (final paint).
   - Outdoor cabins must be equipped with protection from external conditions.

B. Phone sockets must be of the (flush mounted) type and must contain terminal parts to be installed inside the box.

C. Telephone cables:
   - It must be insulated with a double layer of PVC material, and cables consisting of more than one pair of cables must be linked together with an insulating material and cover (PVC).
   - An additional 0.4 mm^2 grounding line shall be provided in each cable for each 1-10 pairs of cables and an additional 0.6 mm^2 grounding line for more than 10 pairs.
   - Telephone cables that are planted directly in the ground must have a metal shield for protection.

D. Main Distribution Center (MDP): It must be compatible with the cabins, cables and sockets mentioned above, and according to the specifications of ITU related to this regard.

E. Reference is made to international specifications and standards for specifications not specified in the above items.

F. The installation of the telephone outlets to be done control rooms, switchgear, telecom room, offices and capacitors.

G. All telephone socket of type (four-wire RJ11 telephone socket, MK or similar) offices and capacitors.

29 VIDEO Surveillance System basic components:

1. All surveillance cameras shall be of IP camera type
2. All cameras shall be furnished with True WDR feature along with processing capability of ne less than 120db.
3. All cameras shall be furnished with suitable IR night vision.
4. DORI standard shall be the basis for cameras design and selection

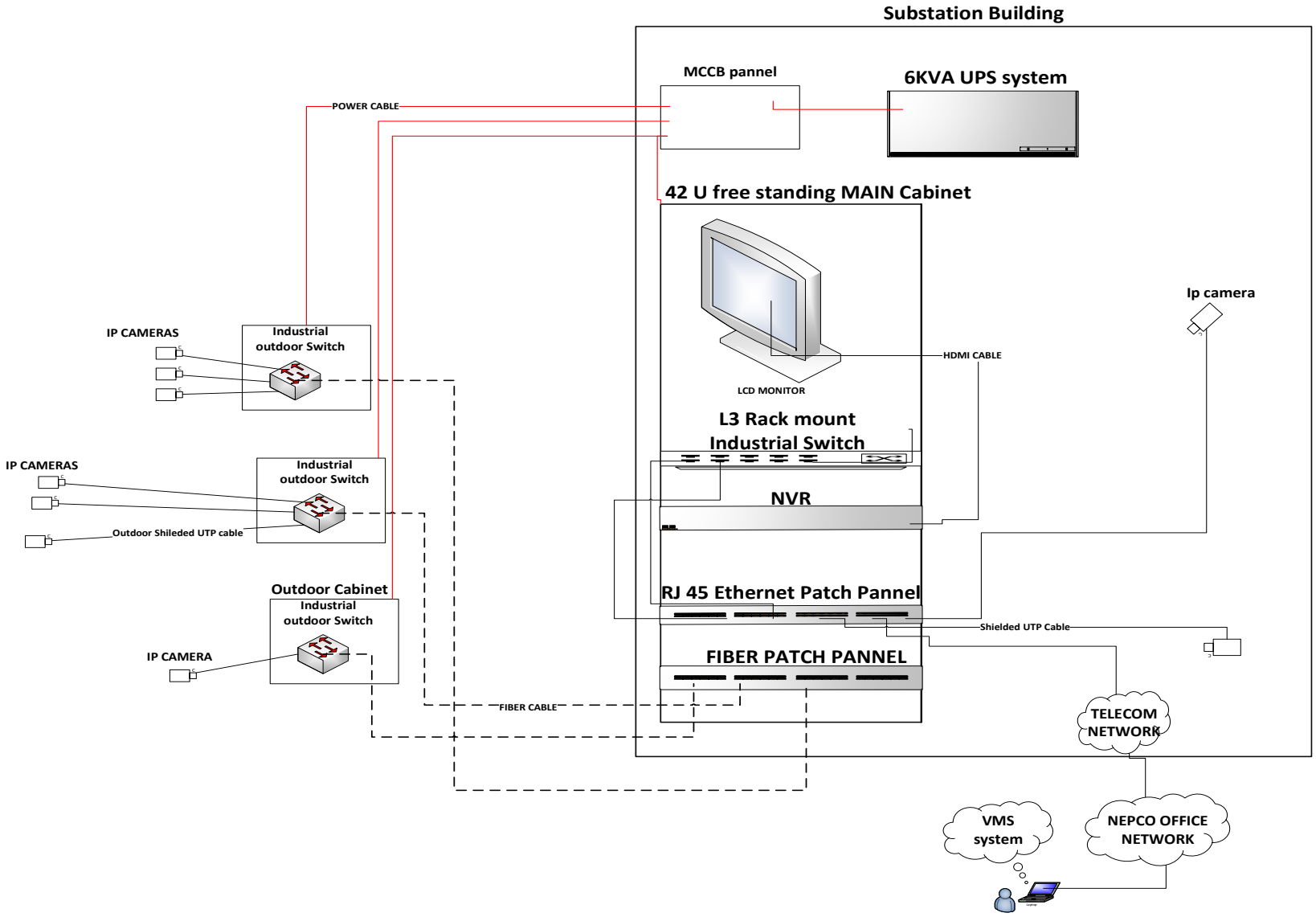
requirements	Coverage	The place
The camera shall be able to cover the whole gate with vehicle (VIN) identification number plate tracing and detection with high quality image such that the numbers are legible	**Identification**	**Main substation gate**
The camera shall be able to cover all incidents and actions occurring within the switch yard	**Observation**	**Switch Yard**
The Camera shall be able to detect and identify with face recognition feature for people faces entering the buildings in high quality and clear image	**Identification**	**Substation buildings entrance**
The camera shall be able to cover all incidents and actions occurring within GIS and switchgear buildings	**Observation**	**GIS & Switchgear buildings**

29.1 GENERAL terms:

A. General terms:

1. ANPR (Automatic Number Plate Recognition) should be supported and running on the camera and the NVR with all required licenses. Enabling searching the play pack for specific vehicle.
2. Quantities **(if not mentioned)** of basic components or subcomponents will depends on the suggested design.
3. All cabling (Fiber or ethernet) must be suitable of outdoor harsh environment installation with UV resistance and must be approved by NEPCO.
4. Fiber optics terminations and cabling must be guided and approved by NEPCO communication staff.
5. All Ethernet Cabling must be double shielded with UV resistance characteristics and termination point must be well grounded with metallic keystones and metallic RJ45 connectors and should be approved by NEPCO.
6. 42 U main cabinet should include a drawer/shelf for lcd monitor.
7. Outdoor Ethernet cabling which is not directly facing sunlight must be done through protected industrial PVC conduits.
8. Outdoor Ethernet cabling which is directly facing sunlight must be done through protected GI or metallic conduits.
9. No PoE extenders is allowed whatever the situation was.
10. Every building must be supplied with at least one (1) PoE industrial network switch either installed inside or outside the building.
11. Every network switch must be securly mounted and placed in apropriate cabinet either outdoor or indoor.
12. Media converters are not allowed whatever the situation was. All termination must be done using apropriate sfp tracievers.
13. All sfp trancievers modules must be industrial grade and from the same vendor of the network switch.
14. All the required specifications are stated as minimum.
15. Any deviation from the required specifications will be rejected>
16. Centralized managemt software should support all features required by the NVR system.
17. All network switches vendor should be statd as Leader in Gartner Magic Quadrant for Wired at least a year before this tended is published.
18. Ip addressing for network switches and cameras should be agreed with NEPCO Network stuff.

B. Diagram:


Substation Building
MCCB pannel
6KVA UPS system
POWER CABLE
42 U free standing MAIN Cabinet
LCD MONITOR
HDMI CABLE
Ip camera
IP CAMERAS
Industrial outdoor Switch
L3 Rack mount Industrial Switch
NVR
IP CAMERAS
Industrial outdoor Switch
Outdoor Shileded UTP cable
RJ 45 Ethernet Patch Pannel
Shielded UTP Cable
Outdoor Cabinet
Industrial outdoor Switch
IP CAMERA
FIBER PATCH PANNEL
FIBER CABLE
TELECOM NETWORK
VMS system
NEPCO OFFICE NETWORK

A. Industrial aggregation Indoor Switches compliance sheet:

Layer 3 (L3) Industrial aggregation Indoor Switches minimum specifications				
Minimum Specifications		**Compliance**		
		YES	**NO**	**Note**
high-performance ruggedized Layer 3 switch with high-density Power-over-Ethernet (PoE/PoE+) capabilities suitable to be used in harsh industrial environments.				
form factor	1 U rack-mount			
Copper 10/100/1000 PoE/PoE+ Ports	24x port ,Auto MDIX, Auto negotiation.			
PoE standards	802.af			
	802.at			
PoE power budget	minimum 370 watt			
Extended operational temperature range	-40 to 75C			
Hardened for vibration, shock, surge, and electrical noise immunity				
Uplink ports:	Support 4x 1/10 GbE single-mode or multi-mode fiber.			
	SFP transceivers modules quantities and types will depends on design			
Switching Capacity	128 Gbps			
L3 Forwarding throughput	95 Mpps			
Unicast MAC addresses	32K			
Number of VLANs supported	1000			
Support Voice VLAN.				
Support IEEE802.1Q tagging for all ports.				
Spanning Tree Protocols:	STP			
	RSTP			
	MST			
	PVSTP+.			
LLDP/LLDP-MED.				
IPv4/IPv6 Multicast: PIM-SM, PIM-SSM, PIM-DM.				
IGMPv1/2/3, IGMP snooping, IGMP filtering, multicast routes and groups.				
L3 features	static routing			
	RIP			
	OSPF (multiple area)			
	VRRP			
	Policy Based Routing (PBR)			
Link Aggregation Control Protocol (LACP).				
LACP different load sharing Algorithms: Source/Destination - MAC/IP/TCP/UDP.				

Layer 3 (L3) Industrial aggregation Indoor Switches minimum specifications				
Minimum Specifications		Compliance		
		YES	NO	Note
Security:	L4 ACLs , port based, vlan based and SVI based.			
	Port access control (802.1x).			
	802.1x Multiple supplicants.			
	802.1x VLAN with assignment.			
	802.1x Enterprise mode: RADIUS/TACACS, EAP.			
	MAC filtering/restriction.			
	Dynamic ARP inspection (DAI).			
	DHCP snooping.			
	IP source guard.			
	BPDU and root STP filtering/protection.			
	Port based unicast/multicast/broadcast storm control.			
	Control plane security/protection.			
	Management ACL			
	Radius/local admin login authentication			
	multiple user privilege			
L2/L3 QoS	L2/L3 marking (802.1p, DSCP/IP)			
	ingress policing			
	egress scheduling (strict priority, weighted round robin)			
	Congestion avoidance capabilities(Tail drop , WRED).			
Power Supply	should support AC 100-240V 50-60Hz			
Local and remote port Mirroring.				
Management and Monitoring	Console, Telnet, SSHv1/2, HTTP/HTTPs, Syslog, NTP, SNMP v2c, SNMPv3, FTP, TFTP, SCP, NetFlow/sFlow.			
Temperature sensor.				
delivery	12 weeks			
warranty	5 years			
Others	Leader in Gartner Magic Quadrant for Wired			

B. Industrial Outdoor Switch Compliance:

Industrial Outdoor switch minimum specifications				
Minimum Specifications		**Comply**		
Feature	**Description**	**YES**	**NO**	**Notes**
Mounting	Industrial rugged DIN rail mounted chassis with all accessories			
Port Details	Minimum 8 x 10/100 BASE-Tx POE Ethernet interfaces: Auto MDIX, Auto negotiation and configurable as port-based vlan interfaces and IEEE802.1Q tagging and should support layer 3 switch virtual interfaces (SVI) for each VLAN			
	Two 10/1 gigabit optical uplinks ports: *should also support 1000 Base Lx/Lh , 1000 Base Zx, 1000 Base Sx, 1000 Base Tx.1000 Base Bx*			
industrial SFP transceivers	SFP quantity and type will mainly depends on the suggested design.			
IP security	IP Layer 2 to Layer 4 traffic filtering; supports global ACL, VLAN ACL, port ACL, and IPv6 ACL.			
Power Budget	Min of 400W supporting 90W per port			
POE Standard	IEEE 802.3af,IEEE 802.3at, 802.3bt			
IP Layer 3 functionality	dual stack, DHCP relay agent. Static route, RIPv1/v2, RIPng, OSPF, OSPFv3, ECMP, IS-IS, IS-ISv6, BGP, BGP4+, VRRP, and VRRP6			
IP Multicast	IGMP v1/v2/v3, IGMP v1/v2/v3 snooping and IGMP fast leave. Port-based multicast traffic statistics			
Extended temperature	Extended temperature (–40°C to +65°C) and dust proof, Temperature sensor, Storage temperature -40°C to +85°C			
Switching capacity	Min 95 Gbps			
Forwarding rate	Min 70 Mpps			
Total number of MAC addresses	Min 16K MAC addresses			
Total number of IPv4 routes (direct + indirect)	Use 8K			
VLAN IDs	4K VLAN IDs			
Total Switched Virtual Interfaces	Min 512			
Jumbo frame	9K bytes			
L2 protocols	Support Voice VLAN.			
	Spanning Tree Protocols: STP, RSTP, MST, VLAN STP			
	LLDP/LLDP-MED+			
	Link Aggregation Control Protocol (LACP) on 10/100/1000BASE-Tx interfaces			

Industrial Outdoor switch minimum specifications				
Minimum Specifications		**Comply**		
Feature	**Description**	**YES**	**NO**	**Notes**
Security	Hierarchical user management and password protection			
	DoS attack defense, ARP attack defense, and ICMP attack defense			
	Binding of the IP address, MAC address, port number, and VLAN ID			
	Port isolation, port security, and sticky MAC			
	Blackhole MAC address entries			
	Limit on the number of learned MAC addresses			
	IEEE 802.1x authentication and limit on the number of users on a port			
	AAA authentication, RADIUS authentication, and NAC			
	CPU defense			
	IEEE 802.1x authentication, MAC address authentication			
	NAC(network Access Control) seamless integration with CoA and dynamic authorization with downloadable access lists support and port VLAN enforcement.			
Quality of Service	Rate limiting on packets sent and received by a port			
	Packet redirection			
	Port-based traffic policing and two-rate three-color CAR			
	Eight queues on each port			
	DRR, SP and DRR+SP queue scheduling algorithms			
	Re-marking of the 802.1p priority and DSCP priority			
	Packet filtering at Layer 2 to Layer 4, filtering out invalid frames based on the source MAC address, destination MAC address, source IP address, destination IP address, TCP/UDP port number, protocol type, and VLAN ID			
	Rate limiting in each queue and traffic shaping on ports			
	Profinet RT, Ethernet/IP, Modbus TCP, and OPC UA mainstream industrial protocol forwarding			
High availability	link aggregation protocols (LACP, PAgP, and static), redundancy and high availability protocols			
Management	WebUI, CLI, Remote Monitoring, SNMP, Console, Telnet, SSHv1/2, HTTPs, Syslog, NTP, SNMPv3.			
Memory	2GB RAM and 1GB Flash			
	The switch should natively support 48-57V DC input voltage.			
	The switch should support BOTH AC(220V) 50/60 Hz and DC (110V) natively or through external power module with input overvoltage, input undervoltage, and input overcurrent.			
Warranty	5-years onsite OEM warranty includes advanced hardware replacement prior to the return of the defective hardware within 24 hours			
Support	24/7 technical support (around-the-clock) and software upgrades for critical bug fixes and security vulnerabilities.			
End of Sale/Life Statement	Proposed models should not be end of sale or end of life			
Gartner Report	Leader in Gartner Magic Quadrant for Wired and Wireless LAN Infrastructure.			

C. Network Video Recorder (NVR) compliance:

Network Video Recorder(NVR) and peripherals minimum specifications			
	Compliance		
Minimum specifications	YES	NO	Notes
Industrial-grade processor			
ruggedized and suitable for harsh dusty environment			
Minimum 32-channel IP video			
Smart H.265+/Smart H.264+/H.265/H.264/MJPEG; H.265 auto switch			
384 Mbps incoming/recording/outgoing bandwidth.			
Support Raid0/1/5/6/10			
HDD interface :16 SATA ports,hot swappable, up to 16 TB each			
HDD specifications :16 TB ,6Gb/s;7200 RPM ; 256 MB cache			
Number of HDD : Sixteen (16) (configured as Raid 5)			
Up to 24MP resolution for live view and playback			
SMD Plus; video metadata; ANPR; people counting; stereo analysis; crowd distribution; heat map;ANPR			
managemt interface: https web and Local GUI			
Network Protocols:SNMPv1/2 ;DNS; SMTP; IPv4 Multicast;TCP/IP			
ONVIF 21.12 Interoperability (Profile T; Profile S; Profile G); CGI; SDK			
minimum 2xHDMI ports			
minimum 2xVGA ports			
minimum 2x 10/100/1000 Mbps Ethernet ports, RJ-45			
minimum 2x USB ports			
Power Supply : 100–240 VAC, 50-60 Hz			
Operating Temperature : –10 °C to +55 °C			
Operating Humidity : 10%–90%			
form factor/installation: standard 19" rack mountable with all accessories			
alarm output : minimum 6 channels			
alarm input :minimum 10 channels			
25-Inch FHD (1920x1080), 5 ms, 165Hz ,VGA port, HDMI port monitor			
optical wireless mouse			
ANPR(Automatic plate number recognition) feature is running and licenced appropriately			

D. UPS system Compliance:

UPS system minimum specifications			
Minimum Specifications	**Compliance**		
	YES	**NO**	**Notes**
On-Line UPS Double Conversion with Advanced DSP and 3-level technology			
Rating: 6KVA/6KW			
Single-Phase Input/Output 230VAC 50Hz			
Output power factor 1.0			
Active power factor correction (APFC), input power factor up to 0.99			
High efficiency 95% (up to 98% in ECO mode)			
Input voltage range (110 ~ 288 Vac) and frequency range (40 ~ 70 Hz)			
50 / 60 Hz frequency auto sensing			
Internal batteries for backup time at standard full load not less than 10 minutes.			
Dual-input design, supporting independent bypass			
Flexible battery configuration (settable 16 - 20 pcs batteries)			
Digitally controlled charger			
Linear derating in low voltage input reducing battery discharging times, extending the service life of battery			
Intelligent battery management, automatic floating / equalizing charge control, charger dormancy control, increasing battery life by 50%			
Settable delayed start time when mains power is restored, reducing the impact on power grid or generator			
Fan speed varies intelligently with temperature, reducing noise and extending its service life			
LCD+LED display, multi-functional keys operation, friendly human-machine interface			
Advanced multi-platform communications			
RS232 and smart card slot included			
SNMP card			

E. MAIN Cabinet Compliance:

MAIN Cabinet (Indoor Cabinet) minimum specifications			
Minimum Specifications	**Compliance**		
	YES	**NO**	**Notes**
IP20 protection			
HxWxD :42Ux800x800. free standing			
“U” marked for 19” mounting.			
1x24xport Ethernet Patch Pannel			
Contains 16x ports Fiber Patch Pannel			
Cable entry points on the top and bottom for secure access.			
8-way PDU.			
top side cooling fans tray with at least 4xfans.			
All Metal (non glass) front door.			
Castor wheels kit with locks and fixed leveling feets should be supplied.			
Adjustable mounting profiles, front and rear.			
Removable front ,back and side doors to simplify installation			
Key lockable front,back and side doors			
Three (3) separate 19" cable managements bars			
Drawer/Shelf for LCD monitor			

F. Outdoor Cabinets Compliance:

Outdoor cabinets minimum specifications			
Minimum Specifications	Compliance		
	YES	NO	Notes
IP 66 protection			
Wall mount and Pole mount Options with all accessories			
Humidity 5% ~ 100%			
Working Temperature: -10～55℃			
Solid metal doors.			
The cabinet has cable entry holes at the bottom of the cabinet.			
SF/UTP and Fiber cables departure and entrance points should be water and dust proof			
switch mounting: Din rail ***OR*** cabinet integrated (depending on the outdoor industrial switch form factor).			
fiber box splicing capacity minium 2 cables with total of 32 splices.			
8xport Fiber patch panel			
DIN-rail, circuit breaker, grounding kit and terminal clamps included			
Lightning protection			

G. Centralized management and monitoring software Compliance:

Centralized management and monitoring software minimum specifications	Compliance		
	YESY	NO	Notes
The software is intended to be installed on 1-system administrator/operator machine. 2-monitoring users machine.			
System Administrator should be able to add,configure and centrally manage remote devices(NVRs)			
System Administrator should be able create accounts and assign priveliges to monitoring users regarding cameras they are able to live view and playback recordings			
software is fully compatible with wide range of NVRs and cameras vendors			
customize video walls/dashboards for live views and playback recordings			.
fully compatible with the proposed NVR video compression codecs ,features and cameras features			
should be able to run on Microsoft Windows 10,11			

30 AIR CONDITIONING AND VENTILATION SYSTEM

The scope covers design, deliver, installation, wiring and connection in place and in operable manner the air conditioning and ventilation systems including the required HVAC equipment, duct work, piping work, spare filters, all necessary control devices, distribution boards and cables to connect the distribution boards to the main supply and to the HVAC equipment. The HVAC system shall incorporate primary and secondary air conditioning and ventilation systems as follows: -

1. The primary HVAC systems shall be from centralized type with all required duct works and electrical distribution boards.
2. Ventilation systems shall be incorporated for the battery room , diesel generator room, pump room and workshop room with all required duct works and electrical distribution boards, additional ventilation system shall be used for the WC, Kitchen and Wash Room
3. The secondary (stand by) air-conditioning system must be from split unit type.

The air conditioning systems shall cover the 132Kv Control & Relay Room, 33Kv Control & Relay Room, Tariff metering room, LVAC room, PLC, Telecom room, offices, DC Charging room, 33KV switch gear rooms, Capacitor building ,Control buildings & control rooms, offices, 400Kv switchgear hall (if required by the switchgear's equipment manufacturer), battery room, 132Kv GIS room (if required by the GIS's equipment manufacturer).

The ventilation systems shall cover the diesel generator room, workshop (store), pump room WC, Kitchen Additional air conditioning equipment shall be installed in the Guard House.

Independent air-conditioning and ventilation systems shall be provided for the Battery Room.

The Battery Room air-conditioning and ventilation systems shall be designed and provided in accordance with the recommendations and requirements of the battery manufacturer.

The ventilation system shall be designed to adequately remove hydrogen and other gases that may be released from the batteries during normal operation, charging, or abnormal conditions. The ventilation system shall be automatically controlled and monitored based on the hydrogen concentration and other gases generated by the batteries, as applicable, and in accordance with the battery manufacturer's recommendations.

The Battery Room shall be provided with an independent air-conditioning system capable of maintaining the room temperature and relative humidity within the limits specified by the battery manufacturer. The air-conditioning and ventilation systems shall be provided with independent controls, monitoring, alarms, and safety interlocks, as required, to ensure that the specified environmental conditions and safe hydrogen concentration levels are continuously maintained.

The Contractor shall obtain and submit the battery manufacturer's latest recommendations, including the required temperature, relative humidity, ventilation rate, hydrogen concentration limits, gas generation rates, and any other relevant environmental requirements, for review and approval prior to finalizing the Battery Room HVAC and ventilation design.

For the detailed design of the air conditioning and ventilation system, reference shall be made to NEPCO specification for HVAC system included here with: -

30.1 SCOPE OF WORK

This Section of the works covers the complete design, supply, delivery, installation, testing, balancing and putting into operation the Heating, Ventilating and Air conditioning system required for the Substation. All Heating, Ventilating and Air conditioning systems shall operate at anticipated conditions normally and shall be fully automatic in operation and shall be capable of maintaining internal conditions within the bands of temperature and humidity specified.

The Contractor shall carry out the required design, sizing, calculations, drawings and layout of the HVAC systems. The Contractor shall furnish actual equipment layouts.

The Contractor shall be responsible for providing all material, labour, erection equipment and tools necessary for a complete installation, start up, testing and balancing of all air-conditioning systems within the scope of his work as specified herein and as shown on the drawings.

30.2 GENERAL REQUIREMENTS

All heating air conditioning design and construction shall be in accordance with the following codes and standards.

- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
- Sheet Metal and Air Conditioning Contractors National Association Inc (SMACNA).
- Air Moving and Conditioning Association (AMCA)
- National Fire Prevention Association (NFPA)
- The Heating and Ventilating Contractors Association of the United Kingdom specification.
- American National Standards Institute (ANSI)
- National Electric Code

30.3 AIR CONDITIONING

The following areas at the substation shall be air conditioned: -

- 33 kv Control and Relay Room (Central air conditioning)
- Generator room(ventilation)
- 132 Kv Control and Relay Room (Central air conditioning)
- control rooms & control buildings (Central air conditioning)
- AC PLC & TELECOM Room. (Central air conditioning)
- Tariff & Metering (Central air conditioning)
- LVAC Room. (Central air conditioning)
- DC Charger Room
- Battery room (Independent air-conditioning and ventilation systems)
- Store(ventilation)
- 400 KV switchgear hall (HVAC system according to equipment manufacturer recommendations).
- 132 KV GIS switchgear room (HVAC system according to equipment manufacturer recommendations)
- Capacitor building (Central air conditioning)
- 33 kv Switch Gear Room (Central air conditioning)
- Office Room. (split unit)
- Guard house (split unit)
- Pump house(ventilation)
- Kitchen & W.C. (extraction only)
- Any other room required by the owner.

30.3.1 Central Air Conditioning

Air conditioning shall be provided in the form of central station air handling equipment located in the Air conditioning plant room (A.C room) in addition to air cooled refrigeration condensing unit in addition to the form of roof top package installed on the roof of the control building. The systems shall handle predominantly re circulated air with a controlled quality of fresh air introduced at the Plant Rooms (for the purpose of CFM testing& balancing the fresh air will be considered zero). Air handling plant and the roof top package shall incorporate multi-circuited direct expansion cooling coils, where the air handling plant shall be served by externally mounted air-cooled refrigeration condensing unit.

Centralized air conditioning system shall consist of an air-cooled condenser, indoor air handling unit include DX evaporator coil, fan, electric heaters, sand trap louver, insect screen, fresh re circulated air mixing section, pre-filter, bag-filter, differential magnetic pressure gauges for pre filter and another for bag filter, the system shall include also all required dampers, motors, starters, disconnect switches and controls. units shall be completely factory charged, tested for operation and wired complete for automatic operation. Separate (integrated is not acceptable) Motor/Manual operated volume dampers shall be provided in the supply and return of air conditioning unit and before each Diffuser/grill. Motorized fire dampers for supply & return air duct shall be supplied at each room penetration, Sound attenuators shall also be furnished for both supply and return duct, where the contractor shall take into consideration the total pressure loss imposed by all duct and duct accessories when sizing AC & ventilation equipment

HVAC Electrical Distribution panel(s) EDP for air conditioning & ventilation system in buildings shall include but not limited to the main supply cables from the LVAC room and out to HVAC Distribution panel and to the HVAC equipment, contactors, overloads, circuit breakers, relays, indication lamps, switches, etc. according to electrical specifications to operate all HVAC units and fans and each item of the EDP must have a name plate.

The centralized HVAC systems shall include but not limited to the following:

- Ozone friendly refrigerant freon R134a shall be used for the central HVAC equipment.
- Only non-flammable refrigerant shall be used.
- Electrical interlocking of HVAC system with the fire alarm and firefighting system.
- Air conditioning unit shall have working and safety controls including emergency stop buttons and local electrical supply isolation switch to isolate the supplies into air handling units and compressor units for maintenance.
- Units shall have internal electric air heating elements unless otherwise specified.
- Control wiring of air conditioning unit being offered must feature the following minimum requirement of safety interlocking and the protection devices.

- Safety electrical interlocking of evaporator fan motor with compressor, electrical heater operation. In the case of electric heater, additional mechanical interlocking through an airflow switch is required.
- Liquid line for each refrigerant circuit shall contain filter drier replaceable core, solenoid valve, sight glass, 2 shut off valves one before the filter drier and one after.
- Charging nipples with Schrader connection for charging purpose at discharge, suction and liquid lines and for low/high pressure switches.
- Phase failure protection.
- Compressor shall be occupied with suction & discharge shut off valve.
- Manually reset oil deferential switch, manually reset high pressure and automatic reset low-pressure cut outs for compressor protection. However, automatic low-pressure resets with lock out relay is acceptable.
- Time guard circuit for preventing compressor rapid recycling, of adjustable range from 3 minutes to 5 minutes or as recommended by the manufacturer.
- Filter static differential pressure switch will be connected to one of the digital input signal ,the filter are dirty after 30 minutes " adjustable", after the pressure switch is triggered.
- compressor Crank case heater.
- Time delay relay for sequence starting of multiple compressor systems.
- Inherent thermal protection for compressor motor winding, evaporator fan motor winding, and condenser fan motor winding.
- A lockout relay shall be incorporated to prevent the unit from restarting whenever the unit stops due to tripping of protection devices.
- Power circuit breaker & contactor for each compressor, fan & electrical heater stage in addition to control circuit breaker.
- Automatic pump down feature.
- Built-in real time clock for time schedule of unit operation.
- All necessary control systems to control the temperature in the air-conditioned rooms.
- Factory mounted programmable microprocessor controller capable to provide control air to air unit, low & high ambient, lead-lag management for compressor operation in addition to choose between cooling/heating program.
- The controller shall be able to show a list of necessary readings such as: discharge, suction, and oil pressure, on coil and off coil temperature,
  ambient temperature, indoor temperature. suction and discharge pipes temperature, hour working meter for compressors, number of
  starts for compressors and fans.
- The micro process shall show a list of possible alarms, faults, and warnings. Time and data of these alarms, faults and warnings shall be shown too.
- Microprocessor module is capable of displaying the result of a run test that includes operation of every protection switch, thermostat, fan, and compressor before unit is started. Microprocessor module shall be capable to control the whole operation of the air conditioning system including the economizer operation (if economizer is required).
- The indoor unit control system shall utilize an air flow switch as a protection for the electrical heater and humidifier (if the humidifier is required by the BOQ.).
- The minimum thickness for the air handling unit inner panel shall be 0.7mm and for the outer panel the minimum thickness shall be 1.2mm.
- The electrical heater shall be protected via airflow switch in addition to manual & automatic cut out in case of absent of airflow.
- The drain pan for the evaporate coil condensate water shall be from 316 austenitic stainless steel.
- Copper Capillary tubes shall be from the high quality flexible type (copper capillary tubes are to be used and it shall be exceptionally well protected to ensure they are not exposed to any kind of impact or physical damage).
- Current overload for each compressor & fan motors.
- Reinforced concrete base for each HVAC equipment unit, the top surface of the base shall be smooth- finished, level and raised at least 200 mm above the surrounding floor.
- Air handling units-whether used for ventilation or air condition- and package air conditioning units shall be provided with complete wind driven air intake hood/louver in addition to assemblies including sand trap louvers, insect screens and muti-stage filtration system.

The filtration system shall consist of at least one stage of aluminum washable filters followed by one stage of bag filters, Differential pressure gauges (magnehelic type) for each filter stage, Spare filters consist of four sets of bag filters and two sets of aluminum filters, based on the number, types and sizes of filters installed in the air conditioning and ventilation units.

Enough accessibility to the condenser side in such way the compressors and their control switches and liquid unit accessories can be accessed by removing the access door and without entering

inside the condenser side (V shape air cooled condenser for the central condensing unit and for the roof top package is a must). All equipment must be capable of continuous operation at rated capacity during periods of high atmospheric dust concentrations as will occur during periods of severe sandstorms for all ambient temperatures ranging from 0 to 55 degrees C (32 to 131ºF) and with maximum expected wind velocity of 29 m/s.

For all switchgear rooms, Central air conditioning shall be used if relays are part of the switchgear panels. Otherwise, the manufacturer recommendations shall be followed, Moreover, if the length of switchgear rooms exceed 25 meters, then at least two central air conditioning units shall be installed to serve the building.

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30.3.2 Split Unit Air Conditioner

A sufficient number of split air conditioners shall be supplied as a secondary air conditioning system in all air-conditioning areas, where the sum of all split units' capacities shall not be less than the capacity of the primary centralized air conditioning system. The split air conditioning units shall meet the following specifications

1- Cooling & Heating operation i.e. Heat pump model.
2- Capacity shall be not less than 12000 BTU/Hr (1 ton refrigeration) Based on 50°C ambient temperature and 27 °C indoor temperature for cooling and 5°C ambient temperature and 20 °C indoor temperature for heating mode.
3- Air supply flow rate must not be less than (300) CFM for each 1 ton refrigeration.
4- Wireless remote-control operation is a must.
5- Power supply should be (230)V, (1)PH, (50)Hz .
6- Washable dust filter to catch most small dust particles.
7- In the heating mode the indoor units fan speed is controlled according to the evaporator's temperature, only when the temperature warm enough the fan begins to operate.
8- DC-inverter system.
9- The condenser fins shall be coated with rust resistant coating; the tubes of the coil shall be copper.
10- Defrost function to remove ice formed on the outdoor unit during heating operation.
11- Two service shut of valves (for high and low sides pressure).
12- The drain pipes shall be not less than 32 mm diameter and from rigid types (i.e. UPVC or CPVC) the flexible type is not allowed, the drain pipe shall be installed inside the adjacent wall.
13- Cables shall be used to connect the indoor and outdoor units, the minimum cables cross section areas used for power connection shall be (3x4mm2).
14- The pipes connect the indoor and outdoor unit shall be insulted over their entire length and the insulation shall be covered with special white colour tape.
15- The minimum copper pipe length between indoor and outdoor unit should be at least 5m length.
16- The copper pipes and cable between the indoor and outdoor units must be one piece (i.e. any welding joint or flare joint or any other kind of joints will be rejected).
17- The minimum thickness for the outdoor unit steel base must be 4mm (if steel base will be used).
18- Ozone friendly refrigerant shall be used (R410a is preferable)
19- Split air conditioning units shall have a cooling capacity of not less than 1.5 tons and not more than 2.0 tons of refrigeration per unit unless otherwise approved by the Engineer.
20- The split unit compressor shall be T3 type suitable for extreme tropical and hot climates.

30.4 Mechanical Ventilation

Supply and Extract ventilation systems shall be provided to serve the following areas: -

1- Store.
2- WC, Kitchen and Wash Room (Extract only).
3- Diesel generator room
4- Fire Water pump room.

Supply air handling plant shall consist of a sand trap, fresh intake louver, insect screen, pre-filter, bag-filter, differential magnetic pressure gauges, fan, motor, volume dampers, and distribution duct work with acoustic lining, attenuators and motorized fire dampers.

Air handling units shall have working and safety controls including emergency stop push buttons and local electrical supply isolator for maintenance. Extract ventilation shall be provided by means of wall mounted fans that discharge to the atmosphere. Individual extract fans shall be provided for toilets.

Roof Extract Fans (if required/applicable) shall be of the propeller flameproof type as specified, they shall be wall mounted, complete with fixed aluminium shutter inclined at 45 degrees and shall operate at 220 volts single phase, 50Hz current. Extract fans shall be interlocked with the air-handling units as system operates on 100% fresh air. Toilet extract ventilation shall be provided by surface mounted extractor fan. Supply air shall not be ducted directly to toilet but shall be delivered into an adjacent area and drawn in through transfer grille in toilet door, ducting for Battery Room shall be corrosion resistant, and the fans, fans motors shall be explosion proof.

30.5 BASIS FOR DESIGN:

The system shall be designed and the equipment to be selected to meet the following design conditions.

30.5.1 External Design Conditions

The mean maximum and minimum values of the external conditions for the calculation of duties for the mechanical services plants are: -

- Summer (max) (55) ºC DB
- Summer (max) RH (35) %
- Winter (min) (0) ºC

All items of plant and equipment for all building services shall be designed to operate without malfunction up to a maximum ambient condition of 55ºC DB and a minimum ambient condition of (0) ºC DB, with instances of 100% RH. All plant and equipment installed externally, or which can be affected by external conditions, shall be capable of withstanding without damage of deterioration the effects of solar radiation, rain, wind, dust, sand storms or other weather phenomena prevalent in the area in which any particular building is located.

30.5.2 Internal Design Conditions

The Air Conditioning system shall be capable of maintaining internal conditions in air-conditioned areas as below: -

- Summer (max) (23) ºC DB
- Winter (23) ºC DB
- RH Not to exceed (50)%

The air conditioning system shall be arranged to introduce a fresh air quantity equivalent to 10% of the total air volume handled. Supply Ventilation system shall be 100% fresh air; toilet extract system shall maintain a small negative pressure within toilet areas. In other mechanically ventilated area extract system shall extract 80% of the supply air volume to maintain a positive pressure internally except for the battery room where the ventilation system shall maintain a negative pressure.

The following air change rates / hour shall be provided in mechanically ventilated areas:

- Store and Workshop 12
- Toilets and wash room 12 (extract only)
- Diesel generator house 12

(or as required by the diesel generator manufacturer if higher value is required)

- Pump House 12

The air conditioning system shall be designed for continuous operation. Plant shall be arranged to facilitate maintenance and future replacement of equipment. The Contractor may use computer programs for calculation of cooling loads provided full details shall be provided to the Employer for approval.

Supply and extract ductwork shall be installed above false ceilings unless otherwise agreed in writing by the engineer and as shown on drawings. Air diffusers or grilles shall be at high level and where practicable fitted into false ceilings.

The Contractor shall calculate heat gains and losses under the specified conditions for each part of each building taking into account solar radiation, thermal transmittance through roofs, walls, floors and windows, fresh air requirements, heat emission from installed electrical equipment and lighting, personnel, infiltration and any other sources. The Contractor shall be responsible for determining the heat transfer coefficients for all materials used in building construction. In the event of any change in materials, design or method of building construction, the Contractor shall at all-time be responsible for rechecking the design of all systems to ensure that they are capable of meeting the specified design requirements.

The Contractor shall prepare all detailed calculations and working drawings for each system, which shall be subject to review by the Engineer. Calculations shall be submitted with descriptions and calculations under the following paragraph headings:

- Concept of each system
- Method of calculation & Method of statement for all installations
- Design criteria and formula for each type of calculation
- Calculations: including hydraulic and equipment sizing calculations.

The Contractor shall provide the following calculations necessary for the selection of plant and equipment which shall be subject to review and approval by the Engineer before commencement of work.

Overall pressure loss of each system, ducts and accessories

Determination of design sensible and latent cooling capacities of each cooling coil supported by complete process line on the psychometric chart.

Determination of air on-coil and off-coil conditions at each cooling coil and heater batteries.

Plant and equipment capacity including fan performance curves & characteristic curves for all equipment where it must be based on the system design(hydraulic) calculations.

Noise control measures, silencer, sound attenuator for both supply and return duct, in addition to applying duct acoustic lining for first 5 meters of supply and return ducts

Any other relevant supplementary calculations.

30.5.3 Internal Sound Levels

The maximum acceptable power sound levels in the various areas of each building are:

- Control and Relay Room 45 db (A)
- L.V.A.C Room 45 db (A)
- Telecoms Room 45 db (A)
- Offices 45 db (A)
- Store and Workshop 50 db (A)
- Toilet 50 db (A)
- Battery Room 48 db (A)
- Tariff metering room 45 db (A)
- Capacitor building 48 db (A)
- Switch gear room 45 db (A)

All plant and equipment shall be suitably selected and installed to ensure that the maximum sound levels stated are not exceeded and where necessary attenuating devices shall be incorporated.

30.6 Air Cooled Roof Top Package Units (for the switch gear rooms where applied)

The technical specifications outlined in section 27.3.1 and the technical specifications for air cooled condensing unit (section 27.7) and for the air handling unit (section 27.11) shall be applicable to the air-cooled roof top package unit except those which are reluctant to specifications listed below:

- The unit shall be of the fully packaged type requiring only site duct work, isolate electrical supply and input from the control systems.
- The supply air fan shall be mounted for bottom air discharge and return.
- All unit section shall have access doors (filters, coil, fans, electrical heater humidifier, supply and return plenum). all access doors are double wall construction and shall have additional tool latched type handle.
- The unit shall be weather proof panted and suitable to be used for outdoor operation.
- The unit shall be equipped with charging points accessed from outside unit.
- All sections shall have a factory installed bulk heat light.
- The unit shall have a factory installed microprocessor controller with a backlit LCD display.
- Fresh air dampers shall be furnished with a rain hood aluminum moisture mesh, and drain lip all around the hood perimeter, the hoods shall be sized for a face velocity not exceeding 600 FPM to eliminate any possible carry over of water inside unit.
- Insect screen and pre aluminum filter shall be installed on the fresh air opening.
- The dampers material is galvanized steel anticorrosion
- The minimum thickness for the air handling unit outer panel shall be 1.2 mm and for the Inner panel the minimum thickness shall be 0.7 mm.

30.7 Air Cooled Condensing Units

The cooling medium for the air conditioning shall be direct expansion refrigeration provided by an air cooled condensing unit located externally.

The condensing unit shall be of the fully packaged type requiring only site connection of refrigeration pipe work, isolate electrical supply and input from the control systems.

The individual items of regenerate equipment shall be matched such that the required performance of the evaporator is achieved concurrently with the satisfactory operation of the compressor and adequate heat rejection at the condenser. The system as a whole shall maintain the correct duty at the design ambient and operate at the maximum ambient conditions stated without exceeding the safe operational limits of any individual item of equipment and without causing any safety device to operate.

All electrical equipment, controls, magnetic coils and solenoids shall be manufactured specifically for operation at the electrical characteristics specified herein and such items designed for any other characteristics shall not be used. The air cooled condensing unit and air handling unit that are interconnected on site with refrigerant piping shall all be supplied by the same manufacturer.

The casing of the condensing unit shall be weatherproof and shall incorporate adequate access and inspection panels secured in place by rustproof fasteners.

The whole of the casing shall be treated for corrosion and weather resistance and non-galvanised mild steel shall not be used (even if painted). The unit shall be finished in not less than two coats of weather resistant finish such as baked enamel of a light reflective colour.

The access panels shall be adequately sized for the service and removal of all working parts of the unit. All panels shall be stiffened and supported to prevent flexing and drumming.

Electrical equipment shall be contained in a fully weatherproofed enclosure with internal division between the power connections and equipment and the control connections and equipment.

The air cooled condenser shall comprise finned tube heat exchangers cooled by ambient air drawn through the heat exchangers by means of axial flow fans.

The condenser coil shall be of a V-shape configuration.

The unit casing and mounting legs shall be arranged to ensure that the required quantity of ambient air flow passes through the heat exchanger from inlet to outlet.
The fans shall be mounted for vertical air discharge wherever possible and wind shields shall be used where fans are mounted for horizontal air flow. Adequate the unit casing and mounting legs shall be arranged to ensure that the required quantity of ambient air flow passes through the heat exchanger from inlet to outlet. The fans shall be mounted for vertical air discharge wherever possible and wind shields shall be used where fans are mounted for horizontal air flow. Adequate openings for sand fall-out shall be provided.
The heat exchanger shall comprise refrigeration quality copper tubes to BS 2871 or equivalent mechanically expanded onto copper plate fins of not less than 2.0 mm minimum thickness. The tubes shall be brazed into properly sized copper tube refrigerant headers and refrigerant connections shall be refrigeration quality copper tube tails. The heat exchanger shall be internally cleaned, dehydrated and leak tested at 10.5 bar and pressure tested to 34.0 bar.
The condenser heat exchanger delivered to site independently shall have a holding charge of the refrigerant to be used in the refrigerant system introduced after pressure testing and the refrigerant connections hermetically sealed before despatch. The refrigerating system shall be of the multiple compressors and multi circuited with duties to match the system duties. Dual circuit as a minimum could be accepted with each circuit capacity equals to 65% of the system design load @ outdoor temperature of 50°C DB, . The type of compressors shall be semi-hermetic reciprocating type.
The temperature and pressure gages shall be installed on compressors suction line and discharge line for each circuit. The casing of air cooled condenser fitted to packaged equipment by the manufacturer shall have a uniform appearance with the package unit. The casing shall incorporate adequate access panels to permit easy cleaning of the condenser coil block. The ends of the casing shall be fitted with a sheet metal cover plate to protect the refrigerant connections and return bends.
The condenser shall be supported on mild steel legs to provide air inlets in accordance with the manufacturer's requirements. A minimum of 2 fans shall be used to provide air flow. Fans shall be axial flow propeller or aerofoil type running at not more than 16 rev/s. Galvanised mild steel wire guards shall protect the fan blades. The fan/motor assembly shall be mounted on a horizontal mounting deck incorporating an orifice ring and the supporting system for the fan/motor shall incorporate anti-vibration to eliminate vibration transmission.
The condenser fans shall be individually connected to separate electrical circuits. In case of a failure in any or its circuit, the remaining fans shall continue to operate normally without interruption. This arrangement ensures the continuous and reliable operation of the air conditioning unit, maintaining proper system performance and preventing a complete shutdown due to a single fan malfunction.

30.8 Refrigeration Pipe work Insulation

Liquid lines shall be insulated where they are in direct sunlight or where they pass through non-air conditioned areas. Suction lines shall be insulated over their entire length.
All insulation to refrigeration pipe work shall be flexible closed cell foam phenolic rubber type with a temperature range of –40 °C to +150 °C and having a thermal conductivity of 0.0375 W/m °C at 21 °C and a water vapour transmission of less than 6.0 ng/Ns. The thickness of insulation shall be in accordance with the following tables:-

Suction Lines

Location	Insulation thickness for OD Pipe Size Range			
	6mm to 10mm	12mm to 22mm	28mm to 41mm	54mm upwards
Exposed to weather	13mzm	13 mm	19 mm	19mm
In ducts and voids	9 mm	9 mm	13 mm	19 mm
In air conditioned spaces	9 mm	9 mm	9 mm	9 mm
In non-air conditioned spaces	9 mm	9 mm	13 mm	19 mm

All bends in insulation of sizes above 22 mm OD piping shall be formed by means of mitred sections. Wherever possible the insulation shall be applied without cutting or sitting and where this is unavoidable the insulation shall be released using an adhesive approved by the manufacturer of the insulation material. All valve bodies shall be insulated using sheets of the same insulation material as the pipe work insulation.

Charging of Refrigeration System

The refrigerant used shall conform to BS 4434 Group 1 or equivalent and shall be non-explosive, non-combustible, non-toxic and non-irritating. Packing air conditioning plant items requiring interconnection with refrigeration piping on site shall be leak tested by the manufacturers and delivered to site with a holding charge of refrigerant.

30.9 DUCTWORK

30.9.1 General

All sheet metal ducting shall be fabricated of galvanised steel and erected as shown on the drawings and in accordance with the institution of Heating and Ventilation Engineers Guide to Current Practice Section B16, the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHERE) and the sheet Metal Manual published by the sheet Metal and Air Conditioning Contractors National Association (SMACNA) or the Heating and Ventilating Contractors Association of the United Kingdom Specification DW/121 or equivalent international standards for sheet metal ductwork for low velocity low pressure air systems with air velocity of up to 5.5m/s.

If it is deemed advisable by the Contractor to change the general location of any duct or the general dimensions thereof from that shown in the drawings, the proposed changes shall be submitted to the engineer and his approval received before any changes are made.

The Duct work shall be with insulation and complete with canvas, support, hangers, automatic motorized fire dampers, volume dampers, splitters, turning vanes, acoustic lining and sound attenuators to cover the air-conditioning systems in all air conditioned rooms, including two temperature glass for inlet and outlet ducts. The duct covers the supply and return, and shall include all required Grills, diffusers, houses, dampers, louvers, foster sealant insulation for outdoor ducts & Aluminium / Stainless steel cladding and proper metal sunshade to cover the air duct systems on the roof or the outdoor areas.

In the areas where a ventilation system is required (i.e no air conditioning is required) duct work without insulation complete with canvas, support hangers, volume dampers, automatic motorized fire damper, turning vanes, acoustic, sound attenuators, acoustic lining, foster sealant insulation & Aluminium/ Stainless steel cladding to cover the ventilation systems and proper metal sunshade to cover the ventilation unit and external duct from direct sun and rain, and all required Grills, diffusers, houses, dampers, louvers, for ventilation systems in the substation buildings.

A mandatory dedicated skylight duct riser shall be utilized to facilitate the duct run passage from central air conditioning units on roof and down to the air-conditioned/ventilated zones in buildings.

30.9.2 Construction

Ductwork for all rooms shall be fabricated of hot dipped galvanised steel sheet, in accordance with ASTM A525, coating designation G90 with minimum zinc coating thickness of 275 G/m2 sheet steel, zinc coated by the hot dip process, general requirements and A527, sheet steel zinc coated by the hot dip process – lock forming quality, US standard gauges as specified. Ductwork shall be substantially airtight with joints neatly formed and finished and of sufficient strength to resist deformation. The inside surfaces of all ducts shall be smooth and free from pockets, burrs and projections. Pittsburgh lock longitudinal corner seaming and double seaming on the sides shall be used. Duct sections shall be connected as scheduled herein.

Companion angles and bracing joints shall be mild steel. Companion angles shall be fabricated in accordance with SMACNA Fig. 4-10, High Pressure Standards, using gaskets. Riveting shall be a maximum of 300 mm (12 in) on centres; bolting shall be a maximum of 100 mm (4 in) on centre with a minimum of 8 mm (5/16 in) bolts. Insulation shall be applied to all air conditioning ductwork i.e., to both the supply, return, and outside ducts. (fibreglass, Manville 800 series span-glass type 814 with FSK foil, or equal).

All ductwork installed inside the battery room shall be constructed from hot dipped galvanised steel sheet and shall be coated with a chemical-resistant and acid-resistant paint suitable for protection against battery vapors and corrosive gases

30.9.3 Schedule Of Rectangular Ductwork

Galvanised Steel		Maximum Side, Top and Bottom	Mild Steel Type of Transverse Joint	Mild Steel Side, Top and Bottom Bracing
mm	(Gauge)	Mm (in)	Connections	Bottom Bracing
0.7	(22)	Up to 450 (up to 18)	Double S Slip	None
0.9	(22)	480 to 750 (19 – 30)	40 x 40 x 3 mm (1 ½ x 1 ½ x 1/8 in) Angle Companion Flanges	40 x 40 x 3 mm (1 ½ x 1 ½ x 1/8 in) Welded Angle Bracing on Duct , 1,200 mm (48 in) on Centre, Max
0.9	(20)	780 to 1140 (31 to 45)	40 x 40 x 5 mm (1 ½ x 1 ½ x 3/16 in) Angle Companion Flanges	40 x 40 x 5 mm (1 ½ x 1 ½ x 3/16 in) Welded Angle Bracing on Duct 1,200 mm (48 inc) on centre, max
1.2	(18)	1,170 to 1,500	50 x 50 x 5 mm (2 x 2 x 3/16 in) Angle Companion Flanges	50 x 50 x 5 mm (2 x 2 x 3/16 in) Welded Angle Bracing on Duct, 1200 mm (48 in) on Centre, Max
1.5	(16)	1550 and over (61 and over)	65 x 65 x 5 mm (2 ½ x 2 ½ x 3/16 in) Angle Companion Flanges	65 x 65 x 5 mm (2 ½ x 2 ½ x 3/16 in) Welded Angle Bracing on Duct, 750 mm (30 in) on Centre, Max

30.9.4 Duct Supports

All ductwork shall be rigidly supported and bolted to substantial section so the building structure using cast in place inserts in beam clamps, reinforced and braced to be free from vibration, rattle and noise. Angle supports and hanger rods shall be fabricated from mild steel, shop painted with an aluminium primer per section 9A of these specifications. Where angle supports and hanger rods are field cut, all edges shall be painted as above. The lower ends of the mild steel hanger rods shall be threaded for sufficient length to allow for adequate vertical adjustment. Lock nuts shall be applied to the end of each hanger rod.

Ducts up to 450 mm (18 in) shall be supported by 25 x 3 mm (1 x 1/8 in) mild steel band hangers, painted as above, at intervals of not less than 3,000 mm (10 ft).

Ducts 480 to 900 mm (19 to 36 in) shall be supported by 13 mm (1/2 in) diameter steel rods or 40 x 40 x 3 mm (1 ½ x 1 ½ x 1/8 in) mild steel angles on each side of the duct passing through or bolted to 40 x 40 x 5 mm (1 ½ x 1 ½ x 3/16 inc) angles running along the underside of the duct at intervals of not less than 1800 mm (6 ft).

Ducts 900 to 1800 shall be supported to approval of the Employer.

30.9.5 Elbows. Offsets and branching

Changes in direction and offsets shall be made in a gradual manner to facilitate streamline flow of air. Elbows shall have a centreline radius of not less than 1 ½ times the width of the duct. Where abrupt turns exist, and elbows of the proper radius cannot be installed, vanned elbows only will be acceptable for duct width greater than 400mm. Branch connections shall be made at a 45 degree angle to facilitate the flow of air, and shoe branch/curved boot shall not be accepted

30.9.6 Turning Vanes

Turning vanes shall be of the airfoil type. The radius of the vanes shall be a minimum of 50 mm (2 in) for ducts up to and including 890mm (35in) and 115mm (4 ½ in) for ducts 900 mm (36 in) and over. Turning vanes shall be fabricated of the same material as the ducts in which they are installed. Vanes shall be installed in the ductwork in such a way as to be quiet and free from vibration when the system is in operation.

30.9.7 Flexible Connections

Flexible connections shall be provided where required. Flexible connections shall be made of 0.5kg (16 oz) neoprene, fibreglass reinforced, with all necessary angles, slips, bolts and other fasteners for securing them to the fan housing and adjoining ducts. A minimum 100 mm (4 in) space shall be maintained between the duct and fan connections but flexible connections shall not be stretched tight. Connections used shall be UL approved. All necessary angles, slips, bolts and other fasteners shall be of mild steel. All fasteners exposed to the weather shall be stainless steel.

30.9.8 Access Doors

Access doors shall be provided where required. Doors shall be 300 x 300 mm (12 x 12 in) unless otherwise noted and shall consist of hinges, sash type latches and handles. All hardware shall be chrome-plated steel. Access doors shall be galvanised steel not less than 1.6 mm (.0064 in) thick. All doors shall be provided with neoprene gaskets so as to be substantially airtight. Doors shall be the insulated type when installed in insulated ductwork.

30.9.9 Caulking

The Contractor shall furnish all materials and perform all caulking operations to achieve weather tight construction. Caulking shall be Silicone No. 1200 as manufactured by General Electric Co., or Engineer approved equal, and shall be in accordance with Spec. No. TT-S-00230 and No. TT-S-D01543. Depth of caulking shall not exceed width of joint. All caulking shall be primed.

30.9.10 Flashing

Flashing shall be provided where ducts penetrate concrete floors, platforms and roofs. Flashing shall be of the same material as ductwork and of the same gauge as the duct being flashed. Flashing shall be attached to the duct with sufficient gasket material or caulking compound inserted between the flashing and the duct to make the flashing watertight.

30.9.11 Cleaning

Before the duct systems are tested and balanced, the interior of all ducts shall be thoroughly cleaned so that no dirt, dust or other foreign matter can be deposited in or carried through the systems or discharged through the outlets. Cheesecloth shall be secured over each opening to entrain such particles during cleaning.

30.9.12 Dampers (Manually Operated)

Manually operated volume dampers shall be provided in all branch ducts to regulate volume of air. All dampers shall be of rigid construction to prevent fluttering of the blades and mechanism. Air flow leakage past a damper when fully closed shall not exceed 5% of the maximum design air flow at the maximum system static pressure difference.

All manually adjustable dampers shall be fitted with a quadrant type operator with a locking device and the position of the primary dampers as set after regulation shall be clearly and indelibly marked on the damper quadrant by means of non-corrodible label approximately 25mm x 50mm stating the actual flow in that section of ducting in cubic meters/second.

Blades of primary dampers shall be of aerodynamic cross section and manufactured from two sheets of the same material as the duct to which they are connected. The blades shall be securely fixed to spindles which shall have both ends housed in nylon or soft metal sleeved bearings. Dampers shall have an opposed blade action.

30.9.13 Fire Dampers

Fire dampers shall be provided in all buildings for ducting systems where ducting passes through a wall or floor forming a fire zone or barrier.

Fire dampers shall be constructed with fire resistance measured in accordance with BS476 Part 8 or equivalent and shall be approved.

Damper casings shall be completely airtight and constructed from galvanised sheet steel of not less than 1.6mm thickness with continuously welded corners. Inlet and outlet connections shall be spigots formed as an integral part of the construction.

Any damper blade or shutter shall be constructed so as not to distort in use and shall be made from either stainless steel or galvanised mild steel such that it shall not corrode or rust. Damper blades shall close against a steel stop around, the whole periphery of the blade and the sides of the duct shall be at least 0.01mm of damper diameter or length of side. Multi leaf damper blades shall overlap by at least 20 mm. The stainless steel shutter type shall be sealed by means of a stainless steel edge gasket. Each damper shall be held open by means of a fusible link set to close the damper at duct temperatures exceeding 72 °C.

An access door shall be provided adjacent to each fire damper for service inspection and resetting of the fusible links. Where the damper is fitted to a wall or floor the damper casing shall be fitted with building in lugs.

30.9.14 Automatic Motorized Fire Dampers

Fire dampers shall be provided in the control building ducting systems where ducting passes through a wall or floor forming a clean agent fire protection zone or barrier. The damper shall be of the dynamic airflow closure rated. Fire dampers shall be constructed with fire resistance rating of 3 hours . The fire damper actuator shall be controlled by a heat or fire alarm signal. Dampers shall be of leakage class 1, and the elevated temperature shall be 121 °C.

Damper casings shall be completely airtight and constructed from galvanised sheet steel of not less than 1.6mm thickness with continuously welded corners. Inlet and outlet connections shall be spigots formed as an integral part of the construction.

Any damper blade or shutter shall be constructed so as not to distort in use and shall be made from either stainless steel or galvanised mild steel such that it shall not corrode or rust.

Damper blades shall close against a steel stop around, the whole periphery of the blade and the sides of the duct shall be at least 0.01mm of damper diameter or length of side. Multi leaf damper blades shall overlap by at least 20mm. The stainless steel shutter type shall be sealed by means of a stainless steel edge gasket.

An access door shall be provided adjacent to each fire damper for service inspection. However a factory mounted access door is preferable. Where the damper is fitted to a wall or floor the damper casing shall be fitted with building in lugs. Each damper shall be manually reset by button.

The dampers shall be motorized with electric actuator, and the actuator shall be furnished factory – installed by the damper manufacturer. The dampers and their installed actuator shall be rated for a maximum airflow rate through the open damper and a maximum pressure across the closed damper; the installed actuator must operate the damper open and close against these rated velocities pressures. The actuator shall be installed at the outer surface of the damper housing. All actuators shall be wired to the HVAC electrical distribution panel located in the air conditioning room.

Each damper shall be equipped with open-close indicator, this option provides two switches, one set to close when the damper blades are at their open position and the other set to close when the damper blades are at their closed position, these switches shall be wired to the HVAC electrical distribution panel, located in the air-conditioning room to indicate lights regarding the damper status. The damper shall be furnished with test switch to provide an easy way to perform testing and maintenance of motorized dampers. The motorized fire damper shall be UL listed & FM approved.

30.9.15 Acoustic Attenuator

The sound attenuator and acoustic lining shall be supplied and installed in the air conditioning and ventilation systems to reduce noise levels in the rooms to those specified.

Purpose made attenuators and sound absorbent material shall be so designed and installed in the ductwork that they offer low resistance to air flow, have adequate strength and cohesion to resist erosion by air flow and do not produce dust. They shall be free from odour and proof against rot, damp and vermin. Adhesives shall be compatible with the sound absorbent material and shall be non-flammable.

Where sound absorbent material and/or special attenuators are indicated they shall reduce the sound level in the space served, due to the equipment, to the specified value.

Outer casings of rectangular silencers shall be constructed in accordance with the previous specification for ductwork manufacture. Seams shall be lock-formed and mastic filled.

Filter material shall be of inorganic mineral or glass fibre of a density sufficient to obtain the specified acoustic performance and packed under not less than 5% compression to eliminate voids due to vibration and setting. Material shall be inert, vermin and moisture proof.

Combustion ratings for the silencer acoustic fill shall not be less than the following, when tested in accordance with ASTM E84, NFPA Standard 255 or UL No 723.

- Flame spread classification 20
- Smoke development rating 20
- Fuel Contributed 15 – 30

Airtight construction shall be provided by use of a duct sealing compound at the site, with material and labour furnished by the Contractor. Silencers shall not fail structurally when subjected to a differential air pressure of 203 mm w.g. inside to outside.

30.9.16 Thermal Insulation

All thermal insulation works shall be carried out in accordance with BS Code of Practice 3005 or equivalent international standards. Thermal insulation materials and finishes shall be proof against rotting, mould growth and vermin and shall be suitable for the ambient temperature and conditions prevailing. No insulation shall be applied to pipework or duct work until hydraulic tests, approved by the Engineer have been carried out.

Thermal insulation shall be applied to all supply and return air ductwork, fans, heater and cooling casings carrying conditioned air whether heated, cooled, humidified or dehumidified. Thermal insulation shall be applied to fresh air intake ducting only where it passes through enclosed spaces where the duct surface temperature is equal to or lower than the air dew point temperature and where it is exposed to the weather.

Rectangular ducting shall be insulated with rigid glass fibre or mineral wool sheets secured to the ducting by means of non-flammable adhesive. Thermal insulation thickness, densities and finishes shall be in accordance with the following table.

Insulated Service	Ductwork Inside Buildings	Density in kg/m^3	Ductwork Exposed to Weather
Supply air ductwork	38 mm	Minimum 40 kg/m3	50 mm
Return air ductwork	25 mm	Minimum 40 kg/m3	50 mm

All ductwork carrying air which is below the maximum dew point of the air in the space through which the duct passes shall have a vapour barrier finish comprising 1 coat PVC solution and 2 coats vinyl based vapour barrier.

Insulation shall be applied to access panels in the form of tightly fitting slabs of rigid glass fibre of the appropriate thickness fixed into place by means of non-setting mastic compound and a galvanised mild steel sheet outer cover plate fixed into position by screwed studs and wing nuts.

Thermal insulation exposed to weather and solar effect shall be additionally protected against the weather by means of an external coating (foster sealant) and by mean of applying cladding of Aluminium or GI steel sheet at least 0.8 mm thick pop-riveted into position and sealed at the joints with non-setting sealing compound.

This Aluminium cladding(or GI steel sheet cladding) shall be applied over the vapour barrier and over then outdoor exposed ducts where applicable. Where insulated ducts or pipes enter a building through a roof or wall the insulation shall be included within the weathering flashings and sealed between the insulation and the flashing by means of non-setting sealing compound.

The installation Duct thermal insulation shall include fixation of insulation by the means of non-flammable adhesive or mechanical fasteners (washers and clips and pins) addition to zip-ties and duct tape.

30.10 Ventilating Units

The ventilating units shall be of modular packaged double skinned type.

The ventilating units shall be factory assembled draw-through units consisting of a centrifugal fan, insect screen & sand trap louver, primary aluminium flat filters, secondary bag filters from synthetic material, all mounted in a unit housing suitable for roof mounting or being located within an equipment room, as applicable.

Ventilating unit housings shall be fabricated from 2.78 mm minimum carbon steel with reinforcing self-forming flanges and other necessary stiffeners and baffles (to prevent air bypass), as required. Each housing shall have a 600 (wide) x 1,800 mm high access door (hinged door with handle) with locking latch and dust tight seals. The clean air fan and drive shall be provided.

Three (3) stages of filtering are required in the ventilating units. The first stage shall be the inertial spin or blade type; the second stage shall be permanent, cleanable, as specified for the air conditioning units. The third stage shall be disposable bag type also as specified for the air conditioning units. Inlet bird screens shall be 12.7 x 12.7mm galvanised wire furnished with painted steel frames. All exposed parts of the assembly shall be finished as specified elsewhere in the specifications. Inertial filter exhaust fans shall be direct drive, centrifugal type, complete with motor, access door, drain connection, predrilled inlet and outlet flange, exhaust duct and discharge screen. Fans shall be of the, arrangement 4, industrial extra heavy-duty type, and shall be constructed throughout of carbon steel. Fan blades shall be welded to the flange and back plate and shall be accurately balanced both statically and dynamically and shall be free from objectionable vibration and noise. Fan casings shall be 4.37mm carbon steel. Motor supports and side plates shall be 4.37mm carbon steel. Motors shall be TEFC and shall be as specified in the Electrical Section of these specifications.

30.10.1 Ventilating Unit Controls

Controls shall be furnished as a part of the unit, located in a rain and dust proof cabinet with remote status panel indicating fan operation, filter service and function switch labelled “on-off”. Provisions shall be made for phase failure detection and interlocking of unit operation with area exhaust fans.

30.11 AIR HANDLING UNITS

Air handling units shall be of modular packaged double skinned type delivered to site in sections for bolting together on site or as fully packaged units. All individual components shall be in accordance with the following sections of this specification.

Fans and motors shall be resiliently mounted on anti-vibration mountings and the outlet connections to any fan shall be fitted with flexible couplings. All air handling units shall be erected on concrete plinths or steel supports to provide adequate mass for anti-vibration purposes and to enable drain connection traps to be properly formed and serviced.

Cooling coils for air cooling and dehumidification shall be fine tube heat exchangers using refrigerant as the cooling medium. The heat exchangers shall be of the duties required to maintain specified design conditions. Casings shall be galvanised sheet suitable for mounting in air handling equipment and shall form a sliding fit in the air handling casings.

The bottom section of the casings shall form a watertight drip tray complete with a drain connection. The drip tray shall be insulated on the inside with 12 mm thickness polyurethane foam waterproofed with a heavy coating of bitumastic or plastic water sealing compound. The drain tray shall have a connection for every 1.2 m width of tray.

The heat exchanger shall be constructed of seamless copper tubes to BS2871 or equivalent. The fins shall incorporate collars to give regular fin spacing.

Copper tubes shall have brazed in return bends and shall be belled out and brazed into copper flow and return headers. All brazing of copper tubes shall be carried out using high temperature brazing materials. The end of each header shall be fitted with a copper blank with an air vent cock and a drain cock.

Each section of the cooling coil shall be fitted with a properly sized refrigerant distributor tubes selected to ensure even flow of refrigerant over the coil.

The suction connections and headers shall be arranged to ensure complete drainage of oil.

The maximum air- flow face velocity shall not exceed 3.0 m/s and the air flow pressure drop shall not exceed 250 N/m2. Each water drain tray shall be fitted with an independent drain with a drain system capable of discharging all of the condensate without backfilling the tray. The material of

the drain pan shall be stainless steel. Condensate drain piping shall be insulated in accordance with the relevant section of this specification.

The AHU shall comprise a sufficient number of access doors to utilize maintenance; each access door shall be equipped with hinged door and rigid handle, locking latch and dust tight seal.

30.12 FANS

30.12.1 General

This clause of the Specification deals with fans of all types as used in air conditioning and ventilation systems of the packaged or site assembled type.

The performance of fans shall be determined by the manufacturer in accordance with the procedures specified in BS848 Part 1 and BS848 Part 2 or equivalent for noise testing. Test certificates shall be submitted to the Engineer.

Fans shall be capable of the duties required to fulfil the specified design conditions. The Contractor shall calculate the system resistance using the frictional resistance of items of plant offered and/or duct runs as installed and shall be responsible for ensuring that the installed fan is capable of the required duty without exceeding the specified noise levels or driving capacity of the motor and drive. Fans shall be direct or belt driven but direct drive shall not be used on centrifugal fans above 1.0 kW motor input power. The impellers of direct drive fans shall be keyed onto the motor shaft by machined keyways and keys securely fixed into position.

Belt driven fans shall be fitted with pulleys for V-belts, which shall be of suitable grade and size for transmitting the drive without excessive slip or wear. Multiple pulleys and belts shall be used where necessary. Taper lock fixing and special adjustable pulleys shall be permitted for use on fans up to 50kw input. Above this size pulleys shall be non-adjustable type secured to the fan and motor shafts by machined keys and keyways. Keys shall be easily accessible for tightening or withdrawal and shall not extend beyond the end of the shaft when fitted.

30.12.2 Centrifugal Fans

Forward curve centrifugal fans shall be used on low pressure systems only and shall not be run in excess of 20 rev/s.

Backward curved centrifugal fans with aerofoil section blades shall be used on all systems requiring a total fan static pressure in excess of 1.0 kN/m².

Centrifugal fans scrolls shall be constructed of zinc coated or galvanised mild steel with angle stiffeners and base angles to ensure freedom from drumming. The construction shall be suitable for continuous operation at the maximum ratings published by the manufacturer.

Lubrication of bearings shall be in accordance with the manufacturer recommendations and bearings requiring regular lubrication service shall have lubrication nipples extended to a convenient location outside the fan casing and shall incorporate an oil reservoir where applicable. All bearings must be checked for satisfactory lubrication before any item of plant is put in operation.

30.12.3 Axial Flow Fans

Axial flow fans shall be of the single or multi-stage contra rotating types.

Axial fan casings shall be of continuously welded mild steel construction hot dip galvanised after manufacture. The lengths or the casings shall be sufficient to allow removal of the fan without disturbing the connected ductwork.

The motor/impeller assemblies shall be fixed to the casings by mild steel threaded rods, which shall be directly fixed to motor casings for motors up to 25 kW.

Axial flow fan impeller blades shall be of aerofoil section constructed from cast aluminium. The hub shall incorporate a cast iron blade fixing plate with keyed slots for the blades. The keyed slots shall permit the removal and readjustment of the blade pitch angle. The fan shall be clearly marked with the factory-set pitch angle and the maximum permissible pitch angle available with the motor fitted. The motor shall be mounted downstream of the impeller and the fan shall be suitable for running with the motor shaft vertical, horizontal or at an angle.

Axial fan casings of 150 mm diameter and above shall be fitted with an airtight inspection door. The fan casings shall be fitted with galvanised mild steel mating flanges, bolted mounting feet, coned inlets and upstream guide banes as necessary. Upstream guide vanes shall be used where necessary to improve the pressure development of the fan to that required by the system it serves. The guide vanes shall be of aerofoil section galvanised mild steel construction, design to impart a rotation to the inlet air to the impeller.

Electrical connections to the fan motor shall be taken to a terminal block enclosed in a terminal box welded to the fan casing. The terminal box lid shall be watertight.

30.12.4 Propeller Fans

Propeller fans shall be diaphragm mounted. Where a propeller fan is used in ducting the fan shall be diaphragm mounted in a galvanised steel casing with flanges at inlet and outlet to facilitate removal from the system without disturbing the attached ducting.

The tip speed of a propeller fan shall not exceed 20 m/s.

The motor/impeller shall be attached to the diaphragm by means of rigid fixing legs incorporating a rubber insert where the legs join the diaphragm to isolate the fan from the diaphragm.
The impeller shall have aluminium or steel blades protected from corrosion by hot dip galvanising or painting with one coat of epoxy resin paint on a suitable primer. The blades shall be bolted, riveted or welded to a steel hub that shall be securely fixed to the motor shaft by means of flush fixing grub screws.
Belt driven axial flow fans shall not be used without prior permission of the Engineer.
All fans shall be statically and dynamically balanced both before and after the driving pulley is fitted.

30.12.5 Inline extracted fan

Duct mounted exhaust fans shall be of centrifugal belt driven in-line type. The fan housing shall be of the square design constructed of heavy gauge galvanized steel and shall include square duct mounting collars. Easy access for inspection and service is provided by removable side panels
Fan construction shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components. The fan wheel shall be centrifugal backward inclined, constructed of aluminium and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
Motors shall be heavy duty ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted out of the air stream.
Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum catalogued operating speed.
Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
Motor pulleys shall be adjustable for system balancing. A NEMA 1 disconnect switch shall be provided as standard, except with explosion resistant motors, where disconnects are optional. Factory wiring shall be provided from motor to the handy box.
All fans shall bear the AMCA Certified Ratings Seal for both sound and air performance.
Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.
Inlet and discharge duct collars are provided for easy duct connection.

30.12.6 Extract Ventilation Units

The impeller shall have aluminium or steel blades protected from corrosion by hot dip galvanising or painting with one coat of epoxy resin paint on a suitable primer. The blades shall be bolted, riveted or welded to a steel hub that shall be securely fixed to the motor shaft by means of flush fixing grub screws.
Belt driven axial flow fans shall not be used without prior permission of the Engineer.
All fans shall be statically and dynamically balanced both before and after the driving pulley is fitted and in plant rooms, incorporate propeller, centrifugal or hybrid type fans that shall be constructed in accordance with the relevant sections of this Specification.
Lubricating points shall be extended to a convenient access point.
Stainless steel nuts, bolts and washers shall be used for all fixings exposed to the weather.

30.12.7 Toilet Extract Units

Toilet extract fan shall be axial type, direct driven. Fan outlets shall be fitted with counterweight shutters to prevent back draught and recirculation through the standby fan.
Toilet extract units for indoor mounting shall be wall, ceiling void mounted as necessary and where exposed to view shall be fitted with a white ABS plastic or enamel finish sheet metal casing. Toilet extract units serving a single internal toilet shall incorporate an automatic timing device connected to the lighting circuit and arranged such that the unit runs for twenty minutes after the roof lighting has been switched off.

30.13 AIR FILTERS

30.13.1 General

Air filters shall be of the types indicated elsewhere in this Specification for the different items of plant. All filter media shall be properly bonded and protected against filter fibre or particle migration. The direction of airflow shall be clearly marked on all filter panels and on installation frames. Access to filters shall be through removable panels fitted with quick release fastener and rubber sealing gaskets.
Each disposable panel filter system shall be provided with 2 complete spare sets for use during the commissioning period. Each disposable bag filter system shall be provided with 4 complete spare sets for use during the commissioning period. These sets shall be in additional to any filter cells supplied as spares in accordance with the general clauses of this Specification.
Filter draft gauges shall be furnished and installed at all filter banks for measuring the resistance to air flow through the filters. Gauges shall be diaphragm actuated dial type (magnetic) consisting of

100 mm diameter white dial with black figures and pointer zero adjustments. Gauges shall be provided with two (2) static pressure tips and necessary copper tubing.
Gauges shall read from 0 to 500 Newton per square meter or equivalent metric unit.
Filter performance shall, unless otherwise noted, be taken to mean the Overall Gravimetric Efficiency against BS2831 Test Dust No. 2 or equivalent.
The framework for adapting filter installation panels to the ducting air handling plant or packaged unit shall be constructed of sheet mild steel angles and all joints in the framing and duct connection shall be sealed with non-setting mastic compound. Filter media of all types and sizes shall be supported in rigid peripheral frames with internal or external wire support of the media to ensure that the media shall not collapse under air flow. The holding frames shall incorporate accurately sized channel sections to provide a good sliding fit for the filters.

30.13.2 Washable Panel Filters

Washable panel filters shall be manufactured from layers of expanded aluminium mesh enclosed in an aluminium frame together to a total of 2inches thickness. The medium shall be suitable for operation in air temperatures up to 90 °C, shall contain a flame retardant and shall be unaffected by oils, solvents and grease at normal operating temperatures.
The filters shall be installed within the unit via dedicated slide-in tracks, constructed from either aluminium or galvanized steel. The track design must allow for smooth and easy insertion and removal of the filter without the need for any special tools. Filter panels shall have a face velocity not exceeding 1.6m/s. Washable filters shall have an air pressure drop when clean not exceeding 33 N/m² when dirty and the dust holding capacity shall not be less than 7.0 kg per m² filter face area. The washable panel filters shall have a gravimetric efficiency of not less than 75%.

30.13.3 Bag Filters

Bag filters shall be of the multi-layer media type. The filter media shall provide a graduated density inlet layer, a fine secondary layer and scram cloth anti-migration finish. Each bas shall have a stiffened cuff to provide leak proof attachment to the retaining frame.
The bag filter system shall have an air pressure drop not exceeding 60 N/m2 when clean and 180/m2 when dirty, and dust holding capacity shall be not less than 20 kg per square meter of cross-sectional area of the inlet face of the filter.
The filters shall be installed within the unit via dedicated slide-in tracks, constructed from either aluminium or galvanized steel. The track design must allow for smooth and easy insertion and removal of the filter without the need for any special tools.
Bag filter systems shall give a gravimetric filtration efficiency of not less than 90%.
The depth of the bag filters (pocket length) shall be 20-22 inches.

30.13.4 Disposable Panel Filters

Disposable panel filters shall be of a resin bonded continuous filament glass fibre medium enclosed in a rigid cardboard frame. The filter medium shall be of graduated density and the filter panels shall be in manufacturers standard sizes. Panel filter systems shall be in V or flat formation, arranged to give a face velocity over the panels of not more than 2.0 m/s. The resistance to air flow shall not exceed 50 N/m² when clean and 200 N/m² when dirty and the dust holding capacity shall be not less than 2.3 kg per (m²) filter area. Disposable panel filter systems shall have a mean gravimetric efficiency of not less than 90%.

30.14 Air Heaters - Electric

This clause deals with electric resistance type air heaters for use in site erected air conditioning plant and fresh air inlet ventilation. Air heater casings shall be manufactured from galvanised sheet steel not less than 2 mm thick and shall be suitable for sliding insertion into packaged air handling unit casings or shall be supplied with flanges at inlet and outlet for duct mounting as required. The air velocity through electric heating batteries shall not exceed 6 m/s and the air pressure drop shall not exceed 25 N/m².
The heater elements shall be for single phase or 3-phase connection, as required, and steps of control shall be arranged to maintain balanced operation across the phases.
The electric heater elements shall be of the finned encased type fixed into the end plate by means of split brass collars and back-nuts. The elements shall be manufactured form 80/20 Nickel Chromium resistance wire centred in a copper tube sheath by means of compressed magnesium oxide. The fins shall be tinned copper or stainless steel metal section wound onto the encased element. The internal wiring shall terminate in a terminal block and a wiring diagram of the heater showing the terminal and the element connections shall be provided in the terminal box cover. The terminal box shall be fitted with a gland for electric cable connection. Each electric heater shall be fitted with a high temperature cut out thermostat with an insertion probe of at least half the heater width. The cut-out shall be set to limit the surface temperature of the elements to 100°C. The heater elements shall be restricted in load density to 3 * 104 W/m².

30.15 Grills, Diffusers and Louvers

Grills and diffusers shall be of aluminium construction and shall be fixed by means of sub-frames with spring clips or screw fixings. Spring clip fixings shall not be used for ceiling mounted grilles and diffusers. The corners of front flanges of grilles, diffusers and sub-frames shall be mitred and jointed to produce a clean unbroken appearance and all visible aluminium sections shall be free from extrusion marks. Front flanges shall be at least 30mm wide and shall incorporate a lip of at least 4.5mm and a plastic fixing gasket. Grill and diffuser blades shall be fixed at even centres with intermediate mullions giving supports for blades of more than 550mm long. Grill and diffuser finishes shall be anodised natural aluminium colour except where otherwise indicated.

All grills and diffusers shall be fitted with an opposed blade damper for regulation purposes. Grills and diffusers shall be fitted with acoustically lined inlet plenums where necessary in order to comply with the acoustic limits of this Specification. Double deflection supply grills, they shall be fitted with two sets of adjustable blades to give vertical and horizontal deflection of the air flow. The blades shall be aerofoil section extruded aluminium set-in nylon bearings at not more than 20mm centres with horizontal blades at the front and vertical blades at the back.

Ceiling diffusers shall be of the square pattern and shall be adjustable to enable the air flow patterns to be varied. All diffusers and grills total flow rate shall be not be more than 450 CFM per grill. Outdoor air louvers shall be of all extruded aluminium construction, sand trap type, fitted with opposed blade dampers in the connected ducting where necessary for air flow regulation. Moveable blade louvers shall not be used.

Louvers shall be weatherproof and shall incorporate an aluminium wire mesh screen on the inside surface. Sand trap louvers shall have an efficiency of 80% on AC coarse (20.200 microns) and 50% on the AC fine (1-70 microns) test dust.

The dimensions of louvers for mounting in the building structure shall suit the concrete block or brick modules and shall be fixed to a hardwood frame.

30.16 CONTROL EQUIPMENT

The control system shall be of the electronic type capable of providing the degree of temperature and/or humidity control specified. The Contractor shall provide full wiring diagrams of all control circuits giving terminal connection references.

The control system shall incorporate all necessary safety interlocks for the successful operation of the mechanical plants and systems.

All the individual control elements shall be provided by the same manufacturer.

Details of all room mounted equipment shall be provided for approval of the Engineer.

Set point potentiometers shall be housed in a robust casing of high impact plastic suitable for the décor of the area in which they are mounted. The control knobs shall have markings in degrees over the band specified and the knob shall be removable enabling the setting to be fixed and enclosed under a dummy knob, rendering it tamper proof.

The control box and set point potentiometer, where combined in a single unit for room mounting, shall not exceed 150mm x 75mm x 50mm deep in overall dimensions.

Temperatures sensor shall be of the resistance type using nickel based element and shall be accurate to +/-1.0°C over the range of 0°C to 30°C. The sensor resistance shall be compatible with the measurement bridge of the matching control box. Room sensors shall be enclosed in a robust high impact plastic housing not larger than 90mm x 90mmx25mm.

Duct sensors shall incorporate a 200mm long non-corrodible tube with the sensing element mounted in a protective housing at the end of the tube.

Step controllers shall provide the required number of operational steps and shall comprise a series of cam operated micro switches operated by means of an electric motor or shall comprise the required number of voltage dependent relays switching in sequence with the output voltage signal from the control box. The cut in points and switching differentials shall be fixed at equal proportions of the operating range. When the load exceeds the switching capacity of the controller, compatible electrical contractors shall be incorporated in the system. Motorised step controllers shall be incorporated in the system. Motorised step controllers shall incorporate a recycling relay or device to return the controller to the non-load position after loss of power to the system. Step controllers shall have external visible indication of controller position.

30.17 Belt Drives and Guards

V-belt drives shall comply with BS 3790 and BS 1140 or equivalent.

All pulleys shall be accurately aligned and V-belt tension adjusted in accordance with the equipment manufacturer's installation instructions before starting the motor. The belt tension shall be ascertained by measuring belt deflection under a given load in accordance with the manufacturer's instruction. Motors shall be provided with means of adjusting their position in order to assemble, adjust or remove the V-belt drive. Holding down bolts shall be fully tightened before starting the motor when anti-vibration mounts are fitted, the motor and the driven component shall share a common set of anti-vibration mounts.

Pulleys shall be manufactured from cast iron or aluminium and shall be securely fixed to motor and driven shafts by means of machined keys and shaft keyways to BS 46 or equivalent.
Variable pitch pulleys shall be permitted on fan drives up to 5 kW maximum input.
A table shall be provided showing the pitch diameters and speed change for each half-turn of the outer flange of the pulley and the fan absorbed power at the highest speed possible. The limits of adjustment of variable pitch pulleys shall not permit the power consumption to exceed that of the driving motor capacity. Safety guards shall be provided for all unprotected intakes to and outlets from fans, (unless the fan is enclosed by in a separate casing) to all V-belt drive, to all drive couplings and elsewhere contact with moving, hot or dangerous plant is possible.
Guards shall be manufactured from at least 2.5mm galvanised steel wire or equivalent to a mesh of not greater than 25mm holes. The mesh shall be supported on a galvanised framework, at least 10mm thick, stiffened as necessary to produce a rigid enclosure.
All guards shall be securely fixed in position with bolts, captive nuts and washers and shall be easily removable for service and maintenance. Access panels shall be provided at the ends of shafts for tachometer readings.

30.18 Electrical Control

Each item of plant shall be provided with local isolation and/or emergency stop buttons to facilitate maintenance, inspection and emergency operation. Where items of plant are monitored and controlled from a control panel or console, remote stop/start facilities shall be provided for each item. Air conditioning unit shall be furnished with a complete factory installed and tested electronic control system to provide all temperature control functions through all operating modes of the unit.
Those devices, which by nature must be installed in the field, shall be tested prior to shipment by the unit manufacturer and then shipped loose with the unit for installation in the field. Each unit shall be furnished with the appropriate field and internal wiring diagrams for use in checking, testing and starting and for regular maintenance and troubleshooting.
Air conditioning unit shall be furnished with a remote status panel with function switch sub-base. Status panels shall indicate the fan operation, filter service, crankcase heater failure, normal cooling pump down and cooling "off" for each compressor; function switches shall be furnished to select the mode of operation and be labelled "Off-Cooling-fan". The status panel shall include an outdoor air minimum controller to set the desired minimum outside air percentage. Controller shall be set at a fixed position after the systems are balanced.
A space thermostat with a range of 15 °C to 32 °C shall be shipped loose with each unit for field mounting. The controls shall include provisions for interlocking the supply air fan in the inertial filter housing and the system exhaust fan(s) where applicable with the air conditioning unit.

30.19 Electrical Connections

All electrical power, control cable and wiring associated with the air conditioning system including all connections between control panels, valves, thermostats, sensing probes and other like items shall be supplied, installed and connected up as part of the Contract.
The cabling and wiring systems shall comply with the requirements of the relevant clauses of this Specification and be either surface or flush installation as appropriate.
Cables and wiring shall comprise either copper cored PVC or XLPE insulated cables, laid in cleats or trenches, copper cored PVC or XLPE insulated wire or drawn into galvanised conduits and turnkeys. Final connections to electric motors and all other items of plant subject to movement and vibration shall comprise flexible cable in flexible conduit.
The Contractor shall provide, with his submission, illustrated technical literature covering all plant and equipment offered.

30.20 MISCELLANEOUS PRESCRIPTIONS

30.20.1 Manufacture

Wherever possible all air conditioning and ventilating plant shall be selected from a single manufacturer's product range and origin; where this is not possible, because of practical or technical construction, then the number of different sources of origin shall be kept to a minimum. The Bidder shall provide, with his Bid, illustrated technical literature covering all plant and equipment offered.

30.20.2 Approvals

The Contractor shall submit to the Engineer for approval copies of all his calculations forming the basis for the selection of air conditioning plant, plant selection details and full working drawings. Such approval shall not, however, relieve the Contractor of his contractual responsibilities.

30.20.3 Maintenance

The Contractor shall be responsible for the maintenance of all installations covered by this section of the Specification for the period of (two) years. The Contractor shall submit to the Engineer for approval copies of maintenance, operation and spare parts manuals for air conditioning installation.

30.20.4 Tagging

Each piece of factory supplied equipment shall be provided with engraved phenol nameplate, engraved with 6.35mm (1/4in.) minimum letters and mounted with rustproof, self-tapping machine screws. Nameplate shall contain the component name and number as they appear on the equipment schedules. Nameplates shall have white lettering on a black background.

30.21 Testing and Balancing

Prior to adjusting and balancing, fans, filters, interior of ductwork and equipment shall be cleaned of dust and debris accumulated during the course of construction.

The Contractor shall provide the services of field engineer to supervise the field testing (after installation) of all equipment furnished under this section. The Contractor shall submit test procedures to the Owner for approval before testing. The Contractor shall supply Labour and equipment required for the field test program. Valid calibration certificates for all test equipment to be used shall be made available before the commencement of any testing.

Equipment that fails to meet test requirements shall be corrected and retested until satisfactory results are obtained. The Contractor shall repair and replace at his expense (including field labour, materials and equipment) all equipment that fails to meet the requirements of this Specification. Tests of all fans shall be made in accordance with the standards of the AMCA. All units shall bear the AMCA certified rating seal. Tests of sound levels produced at the fan outlet shall be conducted when the fan is operating at design conditions, in accordance with AMCA.

After installation, further tests shall be made by the Contractor under the specified field conditions and final acceptance will be subjected to the results of these tests.

The Contractor shall adjust balance and test all heating and air conditioning systems and shall submit test data to the Owner in accordance with the instructions listed below.

Prior to balancing, the Contractor shall complete installation of air handling systems with all components and successfully perform an air leakage (drop test) prior to operational tests. Controls shall be operative and calibrated. Before balancing, check fan wheels for uniform clearance between wheel and inlet cones, concentricity with inlet cones and parallelism with scrolls check alignment of fan and motor sheaves and check drives for proper and uniform tension. Open all duct and air outlet volume dampers.

Obtain copies of fan pressure-volume power characteristics at rated speed and prepare line drawings of systems with identifying designations for each section of the distribution system and all outlets. Set all fans at rated speeds for design volumes and pressure.

Simultaneously operate all supply and exhaust systems servicing common areas on 100% outside air or full recirculation throughout the balancing period.

Measure flow and pressure in ducts by means of pitot tube and a manometer or U-gauge having a minimum sensitivity of 0.5mm of water. Measure fan and motor speeds with a direct reading tachometer or strobo tachometer. Measure current and voltage with direct connected or clamp instruments. Measure flow at air outlets with an Anemometer in accordance with the manufacturer's instructions. Determine actual volume delivery of all fans by measuring the fan performance and by measuring the fan performance and by measuring air flow.

After all fans have been adjusted, proceed with the balancing of systems as follows:

Adjust the outside air quantities by temperature of outside air, recirculated air and mixture. Maximum and minimum air volumes through outdoor return and exhaust air combination shall be adjusted in conjunction with the automatic controls manufacturers by means of linkage stops on damper motors.

Balance systems to the following tolerances:

- Fans Design volume plus 5%
- Outlet Design volume plus 5%
- Leakage 3%

The following test data, arranged by system as follows, shall be submitted to the Engineer:

- Fan Data:
  Design capacity
  Actual capacity
  RPM
  Inlet static pressure
  Discharge static pressure
  Fan curves showing variation of air flow with static pressure at operating rpm and motor loading and overall efficiency for operating conditions from no load to 130% rated load.
- Motor data
  Manufacturer and model number
  Rating, kW
  Phase
  Frequency
  Rated volts

Actual volts
Rated amperes
Actual amperes
Locked rotor amperes

- Starter data
  Manufacturer and model number
  Heater size
  Line voltage
  Ampere rating
  Control voltage
  Frequency
- Air outlet data
  Sketch showing all air outlet locations and number assigned to outlets for purpose of test
  Manufacturer and model number
  Sizes
  Actual free area
  Manufacturer's test factor
  Measured velocity
  Design capacity
  Actual capacity
  Capacity, percentage above or below design
- Outdoor air data
  Size of inlet
  Actual free area
  Manufacturer's test factor
  Measured velocity
  Outdoor air temperature
  Return air temperature
  Mixed air temperature with average traverse reading

When requested by the Owner, the Contractor shall test outlets for performance by means of smoke, air velocity pattern, air temperature pattern and noise levels.

The Contractor shall test all fire dampers for ease of operation by removing the fusible link. After testing, replace the fusible link and reset damper.

30.22 Duct Leakage Tests

The Contractor shall pressure test all ductwork to ensure minimum leakage and the integrity of the system installed duct system. The Contractor shall furnish all labour and equipment such as blowers, orifices. Close-off devices for all duct openings etc. required to successfully perform the tests. The test shall be performed in accordance with the HAVC Air Duct Leakage Test Manual (SMACNA) 1985 and as follows: -

Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a flexible duct.

Start the blower with its control damper closed.

Gradually open the damper until the pressure in the duct reads 150mm WG.

Survey all joints for audible leaks. When all audible leaks have been identified, shut down the blower, repair all leaks, and let sealant set. Retest system as above.

After all audible leaks have been repaired the remaining leakage shall be measured with the orifice section of the apparatus as follows:

Start the blower and open damper until pressure in duct reaches 125mm WG.

Read the differential pressure across the calibrated orifice and read leakage rate in m3/h.

If no leakage exists, the test shall be deemed complete.

If a small leakage is detected, the test shall be deemed complete if the leakage rate is less than 5% of air volume content of the duct section under test.

If the leakage is above 10% of the duct volume the duct shall be rechecked by more carefully listening or feeling along duct joints until all leaks have been identified.

30.23 Performance Guarantees

The Contractor shall guarantee that the equipment shall perform and maintain space conditions in accordance with general and detail design.

All electromechanical works related to the electrical distribution panels shall be electrically supplied from the LVAC room only.

31.0 FIRE PROTECTION AND DETECTION SYSTEMS

31.1 Fire protection system (Clean agent fire suppress system)

The supply shall include:

- A total flood system shall be both UL and FM listed/approved clean agent fire suppression system with automatic addressable detection and control system (including a combination of

both a photoelectric detector and ASD system) for the control building rooms (except for the workshop, office, kitchen rooms and corridor which shall be protected by a UL and FM listed addressable fire detection system).

For the detailed design of the fire protection system, reference shall be made to NEPCO specification for clean agent fire suppression system and as follows:

31.1.1 Scope

This specification outlines the requirements for a "Total Flood" UL and FM listed Clean Agent Fire Suppression System with automatic detection and control. The work described in this specification includes all engineering, labour, materials, equipment and services necessary, and required, to complete and test the suppression system. The fire alarm and firefighting systems shall be approved from civil defence for drawings and material before erection and the system should include but not limited the following items:

1- The firefighting system (including fire alarm) using the clean agent shall cover the following rooms
2- Control and Relay Rooms & control buildings including room void, cable trenches, raised floor and above false ceiling.
3- 132 kv Control and Relay Room including room void, cable trenches, raised floor and above false ceiling
4- Battery room including room void, cable trenches, raised floor
5- LVAC room including room void, cable trenches, raised floor and above false ceiling.
6- Tariff room including room void, cable trenches, raised floor and above false ceiling.
7- PLC/Telecom room including room void, cable trenches, raised floor and above false ceiling.
8- 33 kv Switch gear rooms. room void, cable trenches, raised floor
9- Switch gear tunnel
10- 132 KV GIS switchgear room room void, cable trenches, raised floor/basement
11- 400 KV switchgear room room void, cable trenches, raised floor/basement

The fire alarm system shall cover the remaining rooms

1-office
2-Air conditioning room
3-corrodor
4-Kitchen
5-Workshop/Store
6-Diesel generator room
7-Pump house
8-Capacitor building
9-CCTV Room

The fire alarm and firefighting system shall include but not limited to the following items

- Photoelectric addressable smokes detector.
- Complete aspirating smoke detectors with (pipes, sampling points, end caps, ..etc.)
- Strobes/Horn.
- Manual releases station.
- Abort switch (station).
- Warning sign.
- Spray nozzles as per specification design.
- Digital timers.
- Bells 6".
- Pipes network
- Addressable Control and monitor devices (modules), all addressable items shall be addressed by means of rotary decimal addressing device
- Charged cylinders with clean agent. Where each cylinder weight shall not exceed 300kg, in case more weight of the agent is required then cylinder shall be divided to not exceed the 300 kg per cylinder criterion.
- Pipes, values, supports … etc.
- A decorative glass box to cover the release station flush with wall, with thickness 6mm secured type.
- A plastic hammer inside a wall mounted box flush with the wall with glass door and key.
- UL listed Fire stop material to seal all holes, penetrations and openings in the trenches, walls, roof and ceilings.

31.1.2 Applicable standards and publications

The design, equipment, installation, testing and maintenance of the Clean Agent Suppression System shall be in accordance with the applicable requirements set forth in the latest edition of the following codes and standards:

1) NFPA No. 2001 - Clean Agent Fire Extinguishing Systems
2) NFPA No. 70 - National Electrical Code
3) NFPA No. 72 - Standard For Protective Signalling

4) Factory Mutual Approval Guide
5) U.L Listings
6) Requirements of civil defence department in Jordan, as the Authority Having Jurisdiction (AHJ)
7) All firefighting items shall be UL listed & FM approved

The standards listed, as well as all other applicable codes and standards shall be used as "minimum" design standards. Also to be considered are the requirements of the "Authority Having Jurisdiction" and good engineering practices.

31.1.3 Requirements:

The Suppression System installation shall be made in accordance with the drawings, specifications and applicable standards. Should a conflict occur between the drawings and specifications, the specifications shall prevail.

31.1.4 QUALITY ASSURANCE

31.1.4.1 Manufacturer responsibilities

1) The manufacturer of the Suppression System hardware and detection components shall have a minimum of (5) years' experience in the design and manufacture of similar types of suppression systems and who refer to similar installations providing satisfactory service.
2) The name of the manufacturer, part numbers and serial numbers shall appear on all major components.
3) All devices, components and equipment shall be the products of the same manufacturer.
4) All devices, components and equipment shall be new, standard products of the manufacturer's latest design and suitable to perform the functions intended.
5) All devices and equipment shall be U.L and FM listed.
6) Locks for all cabinets shall be keyed.

31.1.4.2 Installer responsibilities

1) The installing contractor shall be trained by the supplier (The local manufacturer's authorized distributor in Jordan) who must be authorized, factory trained to design, install, test and maintain Suppression Systems., also the supplier must submit on request all required documents the manufacture's authorization to supply, test, commissioning. Also, the supplier shall indicate documents, that he is able to provide spare parts may require in future.
2) The installing contractor shall be an experienced firm regularly engaged in the installation of automatic Clean Agent, or similar, fire suppression systems in strict accordance with all applicable standards.
3) The installing contractor must have a minimum of three (2) years' experience in the design, installation and testing of Clean Agent, or similar, fire suppression systems. A list of systems of a similar nature and scope must be provided on request.
4) The installing contractor shall be an authorized stocking distributor of the Clean Agent system equipment so that immediate replacement parts are available from inventory.
5) The installing contractor shall show proof of emergency service available on a twenty-four hour, seven-day-a-week basis.

31.1.4.3 Submittals

The installing contractor shall submit the following design information and drawings for approval prior to starting work on this project:

a) Field installation layout drawings having a scale of not less than 1:1000m detailing the location of all agent storage tanks, pipe runs including pipe sizes and lengths, addressable control panel(s),detectors, manual pull stations, abort stations, audible and visual alarms, etc.
b) Auxiliary details and information such as maintenance panels, door holders, special sealing requirements and equipment shutdowns.
c) Separate layouts, or drawings, shall be provided for each level, (i.e.; room, under floor, and above ceiling) and for mechanical and electrical work.
d) A separate layout or drawing, shall show isometric details of agent storage containers, mounting details and proposed pipe runs and sizes.
e) Electrical layout drawings shall show the location of all devices and include point-to-point conduit runs and a description of the method(s) used for detector mounting.
f) Provide an internal addressable control panel wiring diagram which shall include power supply requirements and field wiring termination points.
g) Graphic Enunciator wiring schematics and dimensioned display panel illustration shall be provided. (Optional device)
h) Complete hydraulic flow calculations, from a U.L. listed computer program, shall be provided for all engineered Clean Agent systems. Calculation sheet(s) must include the manufacturers name and U.L. listing number for verification. The individual sections of pipe and each fitting to be used, as shown on the isometrics, must be identified and included in the calculation. Total agent discharge time must be shown and detailed by zone.

i) Provide calculations for the battery stand-by power supply taking into consideration the power requirements of all alarms, initiating devices and auxiliary components under full load conditions.
j) A complete sequence of operation shall be submitted detailing all alarm devices, shutdown functions, remote signalling, damper operation, time delay and agent discharge for each zone or system.

Submit drawings, calculations and system component data sheets for approval to the local Fire Prevention Agency, owners Insurance Underwriter and all other Authorities Having Jurisdiction before starting installation. Submit approved plans to the Architect/Engineer for record.

31.1.5 CLEAN AGENT REQUIREMENTS

31.1.5.1 System description and operation

a) The Total Flood system shall be as per NFPA genetic name HFC-227ea Suppression System.
b) The system shall provide an HFC-227ea minimum design concentration of 7%, by volume, in all areas and/or protected spaces, at the minimum anticipated temperature within the protected area. System design shall not exceed the NOAEL value of 9.0%, adjusted for maximum space temperature anticipated, unless provisions for room evacuation, before agent release, are provided.
c) The system shall be complete in all ways. It shall include all mechanical and electrical installation, all detection and control equipment, agent storage containers, HFC-227ea agent, discharge nozzles, pipe and fittings, manual release and abort stations, audible and visual alarm devices, auxiliary devices and controls, shutdowns, alarm interface, caution/ advisory signs, functional checkout and testing, training and all other operations necessary for a functional, U.L. Listed.
d) Provide two (2) inspections during the first year of service. Inspections shall be made at (6) month intervals commencing when the system is first placed into normal service.
e) The general contractor shall be responsible for sealing and securing the protected spaces against agent loss and/or leakage during the 10 minute "hold" period.
f) The system(s) shall be actuated by a combination of aspirating and photoelectric detectors installed at a maximum spacing of 250 sq. ft. (23.2 sq. mtr) per detector, in both the room, underfloor and above ceiling protected spaces. If the air flow is one air change per minute, photoelectric detectors only shall be installed at a spacing not to exceed 125 sq. ft. (11.6 sq.mtr) per detector. (Ref. NFPA No. 72 - Chapter 5 - 1993 edition).
g) Detectors shall be wired in "Sequential Detection" method of operation, standard Cross-Zoned detection, or single detector release, using either a Class "A" or Class "B" wiring arrangement. No other detection / wiring arrangements will be acceptable.
h) Automatic operation of each protected area shall be as follows:
   1) Actuation of one (1) detector, within the system, shall:
      a) Illuminate the "ALARM" lamp on the addressable control panel face.
      b) Energize an alarm bell and/or an optional visual indicator.
      c) Transfer sets of 5 Amp rated auxiliary contacts which can perform auxiliary system functions such as:
         1) Operate door holder/closures on access doors.
         2) Shutdown HVAC equipment.
      d) Light an individual lamp on an optional graphic annunciator.
   2) Actuation of a 2nd detector, within the system, shall:
      a) Illuminate the "PRE-DISCHARGE" lamp on the addressable control panel face.
      b) Energize a pre-discharge horn or horn/strobe device.
      c) Shut down the HVAC system and/or close dampers.
      d) Start time-delay sequence (not to exceed 60 seconds).
      e) System abort sequence is enabled at this time.
      f) Light an individual lamp on an optional graphic annunciator.
   3) After completion of the time-delay sequence, the HFC-227ea Clean Agent system shall discharge and the following shall occur:
      a) Illuminate a "SYSTEM FIRED" lamp on the addressable control panel face.
      b) Shutdown of all power to high-voltage equipment
      c) Energize a visual indicator(s) outside the hazard in which the discharge occurred.
      d) Energize a "System Fired" audible device. (Optional)
   4) The system shall be capable of being actuated by manual discharge devices located at each hazard exit. Operation of a manual device shall duplicate the sequence description above except that the time delay and abort functions SHALL be bypassed. The manual discharge station shall be of the electrical actuation type and shall be supervised at the main addressable control panel.
   5) All protected spaces shall be 100% sealed i.e a fire stop material (UL listed and FM approved) and shall be applied at all trenches openings and sleesves pipes between:

1-the adjacent protected rooms
2-the protected rooms and unprotected rooms and corridors.
3-the protected rooms and the outdoor areas

31.1.6 MATERIALS AND EQUIPMENT

31.1.6.1 General requirements

The HFC-227ea Clean Agent System materials and equipment shall be standard products of the supplier's latest design and suitable to perform the functions intended. When one or more pieces of equipment must perform the same function(s), they shall be duplicates produced by one manufacturer.

1) All devices and equipment shall be U.L Listed and FM approved.

31.1.6.2 HFC-227ea storage and distribution

Each system shall have its own supply of clean agent.

1) The system design can be modular, central storage, or a combination of both design criteria.
2) Systems shall be designed in accordance with the manufacturer's guidelines.
3) Each supply shall be located within the hazard area, or as near as possible, to reduce the amount of pipe and fittings required to install the system.
4) The clean agent shall be stored in Agent Storage Containers. Containers shall be super-pressurized, with dry Nitrogen, to an operating pressure of 360psi @ 70 °F. (2500 kPa at 20 °C). Containers shall be of high-strength alloy steel construction and conform to NFPA 2001.
5) Containers shall be actuated by parallel wired initiators through an Agent Release Module, located at each agent container.
6) Each container shall have a pressure gauge and low-pressure switch to provide visual and electrical supervision of the container pressure The low-pressure switch shall be wired to the addressable control panel to provide an audible and visual "Trouble" alarm in the event the container pressure drops below 288 psi (1986 kpa). he pressure gauge shall be colour coded to provide an easy, visual indication of container pressure.
7) Each container shall have a pressure relief provision that automatically operates when the internal temperature exceeds 150 °F. (66 °C).
8) Each container shall be provided with a liquid level indicator of the magnetic or float -type design or ultrasonic type, the device shall be factory -mounted, calibrated and tested by the system manufacturer (if float -type design will be offered), or it shall be expressly approved or recommended by the firefighting system manufacturer (if ultrasonic type to be offered).
9) Engineered discharge nozzles shall be provided, within the manufacturer’s guidelines, to distribute the HFC-227ea agent throughout the protected spaces. The nozzles shall be designed to provide proper agent quantity and distribution.
    a) Nozzles shall be available in pipe sizes 3/8” thru 2.0” (BPS 10mm thru 50mm) Each size shall be available in 180° and 360° distribution patterns.
    b) Ceiling plates, can be used with the nozzles to conceal pipe entry holes through ceiling tiles.
10) Distribution piping, and fittings, shall be installed in accordance with the manufacturer's requirements, NFPA 2001 and approved piping standards and guidelines. All distribution piping shall be installed by qualified individuals using good, accepted practices and quality procedures. All piping shall be adequately supported and anchored at all directional changes and nozzle locations.
    a) All piping shall be reamed, blown clear and swabbed with suitable solvents to remove burrs, mill varnish and cutting oils before assembly.
    b) All pipe threads shall be sealed with Teflon tape pipe sealant applied to the male thread ONLY.
11) Separate nozzles shall be installed between any two obstacles or drop beams where the depth of the obstacles or drop beam exceeds (30 cm (12 inches). Each space formed between two such obstacles shall be treated as an independent area in terms of nozzle coverage to ensure proper gas distribution, maintain proper concentration level, and achieve effective system performance during discharge.
12) All parts, components and accessories of the firefighting system shall be factory-manufactured, original and shall have identifiable manufacturer’s part numbers, the part numbers shall strictly correspond to the manufacturer’s official catalogues and documentation. locally fabricated components shall not be accepted under any circumstances, including but not limited to adapters, flexible connections, and similar items.
13) in any case a clean agent protected room ceiling height exceeds 5 meters, there shall be multi-tier clean agent nozzles network constituting of 5 meters high each where the first tier covers 5 meters height and the additional height shall be covered by next level of nozzles.

31.1.7 ELECTRICAL REQUIREMENTS

31.1.7.1 Addressable control panel

The addressable control panel must be a listed device that has a releasing circuit and is listed for use with the Agent Release Module, each protected clean agent building shall have its own dedicated addressable firefighting panel.

31.1.7.2 Detectors

The detectors shall be spaced and installed in accordance with the manufacturer's specifications and the guidelines of NFPA No. 72 - 1993 edition.

1) Complete aspirating smoke detector with it is (pipes, sampling points, end caps, ..etc.).
2) The Photoelectric detector shall be with a 4" (10mm) base, or 6" (15mm) base.

31.1.7.3 Manual release (electric):

The electric manual release switch shall be a dual action device which provides a means of manually discharging the Suppression System when used in conjunction with the Control System.

1) The Manual Release switch with dual action device requiring two distinct operations to initiate a system actuation.
2) Manual actuation shall bypass the time delay and abort functions shall cause the system to discharge and shall cause all release and shutdown devices to operate in the same manner as if the system had operated automatically.
3) A Manual Release switch shall be located at each exit from the protected hazard and shall have an advisory sign, provided at each location.

31.1.7.4 Abort station:

The Abort Station shall be the "Dead Man" type and shall be located next to each manual switch.

1) The Abort Station shall be supervised and shall indicate a trouble condition at the Addressable control panel, if depressed, and no alarm condition exists.
2) "Locking" or "Keyed" abort stations shall not be permitted.
3) The Abort Station shall be located adjacent to each manual station and can be furnished in combination with a Manual Release Switch or in combination with a Manual Release Switch and Digital Countdown Timer indicating remaining discharge time.

31.1.7.5 Audible and visual alarms

Alarm audibles and visual signal devices shall operate from the Addressable control panel.

1) The Alarm Bell, Alarm Horn and Horn/Strobe devices shall have an HFC-227ea label shall be attached to the strobe lens when required.
2) The visual alarm unit shall be Vertical Strobe device with HFC-227ea label shall be attached to the strobe lens when required.
3) A Strobe device shall be placed outside, and above, each exit door from the protected space. Provide an advisory sign, at each light location.

31.1.7.6 Caution and advisory signs

Provide signs, as required, to comply with NFPA 2001 and the recommendations of the HFC-227ea equipment supplier:

1) Entrance sign: (1) required at each entrance to a protected space.
2) Manual Discharge sign: (1) required at each manual discharge station.
3) Flashing Light sign: (1) required at each flashing light over each exit from a protected space.

31.1.7.7 System and control wiring

All system wiring shall be furnished and installed by the contractor.

1) All wiring shall be installed in rigid PVC conduit, and must be installed and kept separate from all other building wiring.
2) All system components shall be securely supported independent of the wiring. Runs of conduit and wiring shall be straight, neatly arranged, properly supported, installed parallel and perpendicular to walls and partitions.
3) The sizes of the conductors shall be those specified by the manufacturer. Colour coded wire shall be used. All wires shall be tagged at all junction points and shall be free from shorts, earth connections (unless so noted on the system drawings), and crosses between conductors. Final terminations between the Addressable control panel and the system field wiring hall be made under the direct supervision of a factory trained representative.
4) All wiring shall be installed by qualified individuals, in a neat and workmanlike manner, to conform to the National Electrical Code, Article 725 and Article 760, except as otherwise permitted for limited energy circuits, as described in NFPA 72 -1993 edition. Wiring installation shall meet all local, state, province and/or country codes.
5) The complete system electrical installation, and all auxiliary components, shall be connected to earth ground in accordance with the National Electrical Code.

31.1.8 SYSTEM INSPECTION AND CHECKOUT

After the system installation has been completed, the entire system shall be checked out, inspected and functionally tested by qualified, trained personnel, in accordance with the manufacturer's recommended procedures and NFPA standards.

1) All containers and distribution piping shall be checked for proper mounting and installation.
2) All electrical wiring shall be tested for proper connection, continuity and resistance to earth.
3) The complete system shall be functionally tested, in the presence of the owner or his representative, and all functions, including system and equipment interlocks, must be operational at least five (5) days prior to the final acceptance tests.
    a) Each detector shall be tested in accordance with the manufacturer's recommended procedures, and test values recorded.
    b) All system and equipment interlocks, such as door release devices, audible and visual devices, equipment shutdowns, local and remote alarms, etc. shall function as required and designed.
    c) Each Addressable control panel circuit shall be tested for trouble by inducing a trouble condition into the system.

31.1.9 MISCELLANEOUS PRESCRIPTIONS

31.1.9.1 Training requirements

Prior to final acceptance, the installing contractor shall provide operational training to each shift of the owner’s personnel. Each training session shall include Addressable control panel operation, manual release and abort station functions, trouble procedures, supervisory procedures, auxiliary functions and emergency procedures.

31.1.9.2 Operation and maintenance

Prior to final acceptance, the installing contractor shall provide complete operation and maintenance instruction manuals, four (4) copies for each system, to the owner. All aspects of system operation and maintenance shall be detailed, including piping isometrics, wiring diagrams of all circuits, a written description of the system design, sequence of operation and drawing(s) illustrating control logic and equipment used in the system. Checklists and procedures for emergency situations, troubleshooting techniques, maintenance operations and procedures shall be included in the manual.

31.1.9.3 As built drawings

Upon completion of each system, the installing contractor shall provide four (4) copies of system "As-Built" drawings to the owner. The drawings shall show actual installation details including all equipment locations (i.e.: addressable control panel(s), agent container(s), detectors, alarms, manuals and aborts, etc.) as well as piping and conduit routing details. Show all room or facilities modifications, including door and/or damper installations completed. One (1) copy of reproducible engineering drawings shall be provided reflecting all actual installation details.

31.1.9.4 Acceptance tests

1) At the time "As-Built" drawings and maintenance/operations manuals are submitted, the installing contractor shall submit a "Test Plan" describing procedures to be used to test the control system(s). The Test Plan shall include a step-by-step description of all tests to be performed and shall indicate the type and location of test apparatus to be employed.
   The tests shall demonstrate that the operational and installation requirements of this specification have been met. All tests shall be conducted in the presence of the owner and shall not be conducted until the Test Plan has been approved.
2) The tests shall demonstrate that the entire control system functions as designed and intended. All circuits shall be tested: automatic actuation, solenoid and manual actuation, HVAC and power shutdowns, audible and visual alarm devices and manual override of abort functions. Supervision of all panel circuits, including AC power and battery power supplies, shall be tested and qualified
3) Upon acceptance by the owner, the completed system(s) shall be placed into service.

31.1.9.5 System inspections

1) The installing contractor shall provide two (2) inspections of each system, installed under this contract, during full warranty period. The first inspection shall be at the six-month interval, and the second inspection at the 12-month interval, after system acceptance. Inspections shall be conducted in accordance with the manufacturer's guidelines and the recommendations of NFPA 2001.
2) Documents certifying satisfactory system(s) operation shall be submitted to the owner upon completion of each inspection.

31.1.10 Warranty

All system components furnished, and installed under this contract, shall be guaranteed against defects in design, materials and workmanship for the full warranty period which is standard with the manufacturer, but in no case less than (5) year from the date of system acceptance.

31.1.11 ASD system

31.1.11.1 GENERAL

I) SCOPE

This document provides specification details for Fire Alarm Aspiration Smoke detection (ASD) detector. All items under this specification shall comply with all applicable code requirements and manufacturer's recommendations.

II) APPROVALS

a. The Aspirating Smoke Detector shall be tested, approved and/or listed by:

1- Underwriters Laboratories (UL) S911
2- Underwriters Laboratories Canada (ULC)
3- Factory Mutual (FM)

III) CODE, STANDARDS, AND REGULATION

a. The aspirating smoke detector shall be installed per manufacturer's instructions, including pipe network, programming, and power requirements, and shall comply with one or more of the following codes and standards:

1- National Fire Protection Association (NFPA)
2- British Fire Protection Association (EN-54)
3- The process from design through preparing shop drawings and finally obtaining The approvals & stamps of the complete and operational firefighting system (Clean agent & automatic fixed water & fire hydrants and hose cabinets) from general directorate of Jordan civil defense and any related efforts& costs in process shall solely be the responsibility of the contractor.

IV) SYSTEM REQUIREMENTS

a. The Aspirating Smoke Detector (ASD) shall offer various classifications to include Very Early Warning Smoke Detection (VEWFD), Early Warning Smoke Detection (EWFD), and Standard Smoke Detection (SFD) settings as identified per the requirements of NFPA.

b. The ASD shall be self-contained and monitored by a display featuring LEDs and/or LCD to include a control system utilizing microprocessor-based technology with all functions fully programmable, LED displays, alarm indications, airflow and detector faults.

c. The system shall constantly sample air from the environment. In operation, air shall be drawn from the air sampling piping network, through a particle separator and a 30-micron filter assembly being pulled through the detection chamber by the aspirator. The system shall not rely on air currents to bring smoke to the detector. Inside the smoke detection chamber, air shall be exposed to a blue LED and infrared laser light source. Light scattered by smoke particles shall flow through the chamber and be detected by solid state receivers, which shall convert the light to an electronic signal.

d. The ASD shall incorporate a dual light source technology system for the automatic discrimination of signals from non-fire related sources, such as dust. The system shall automatically compensate for changes in environmental conditions and the negative effect of filter contamination.

e. The ASD shall display a series of LEDs or be visible via an interactive LCD. The ASD shall include a Reset, Isolate, and Test functions on the front of the panel.

f. The program shall allow the ASD firmware to be updated in the field by system installers and maintainers.

g. The ASD shall have the capability to connect to the building automation/management system via Modbus Protocol utilizing a TCP server or serial connection using RS-485.

h. Detector Performance Requirements: -

1- Detectors shall be approved to monitor up to five alarm levels. Each level shall be programmable and able to select desired sensitivity.
2- Detectors shall report alarms and faults using fault relays or direct connection via the SLC loop, if applicable.
3- Detectors shall include a field-replaceable filter and an internal particle separator to reduce the amount of non-combustible materials reaching the detection chamber.
4- The software shall provide pipe design, system configuration, and system monitoring in a single software program. It shall store up to 18,000 events. Events shall include smoke levels, alarm conditions, operator actions, and faults. The date and time of each event shall be recorded.
5- The front panel of the detector shall indicate flow faults, configuration, external monitor, time, communication, trouble, filter, isolation, voltage, and high flow faults via dedicated LEDs or an LCD display.
6- The ASD shall use ultrasonic sensors to confirm proper air flow through the pipe network and produce a fault when there is a change of a user-settable percentage from nominal air flow.

7- The ASD shall store vital statistics including airflow, obscuration signal level, alarm levels, fan speed, and temperature. The frequency with which these statistics are stored shall be adjustable.

V) SUBMITTALS

a. System shall be complete in all ways and shall include all engineering and electrical installation, all detection and control equipment, auxiliary devices and controls, alarm interfaces, functional testing, training, and all other operations necessary for a functional, UL Listed, and FM Approved system.

b. Prepare product data and site drawings indicating the system layout, including location of modules, detection/aspiration unit, air intake ports, flow calculations, transport times, power requirements, and sample hole obscuration sensitivity level calculations.

c. Show method and spacing of hanger supports on aspirating tube to the building structure.

d. System commissioning data shall be supplied as recommended per manufacturer's instructions within 30 days of installation.

e. As-Built Drawings:

1- Upon completion of the installation, the Contractor shall revise aspirating detection system design files, calculations, manuals, and operating instructions to agree with on-site conditions.

2- Submit a copy of the manufacturer's installation, operation, and maintenance manuals.

3- Final construction drawings shall be stamped/sealed by a licensed Professional Engineer in the state where the work is being constructed, or a NICET level III or higher certified fire alarm technician.

VI) QUALITY ASSURANCE

a. Manufacturer.

b. Detector Requirements:

1- The ASD shall operate in air flows from 0-4000 ft/min (0-1,219 m/min). The system software shall provide pipe design, system configuration, and system monitoring in a single software program.

2- The ASD shall offer Very Early Warning Smoke Detection, Early Warning Smoke Detection, and Standard Smoke Detection settings. The ASD shall offer a wide range of sensitivity.

c. Installer: The equipment installer shall be authorized and trained by the manufacturer and shall have the ability to design a system based on code requirements. The installer shall be capable of providing calculations, design, and testing documents upon request.

31.1.11.2 PRODUCT

I) ASPIRATING SMOKE DETECTOR

A- The ASD shall allow up to 5 programmable alarm levels with time delays.

B. The ASD shall provide up to 8 form C, programmable, latching or non-latching relays or the ability to connect directly to the FACP via the SLC. It shall include a field-replaceable filter and an internal particle separator to reduce the amount of non-combustible materials reaching the detection chamber. The unit shall use ultrasonic sensors to confirm proper air flow through the pipe network and store up to 18,000 events. Events shall include smoke levels, alarm conditions, operator actions, and faults. The date and time of each event shall be recorded.

II) DESIGN PARAMETERS

A- The ASD design shall comply with all national and local code requirements and UL and FM approved listings. The ASD shall be designed with VEWFD design basis with the following parameters, other design basis may be accepted as per NEPCO engineer's approval:

1- NFPA Classifications:

a. **VEWFD**: Very Early Warning Fire Detection. The sample port spacing shall not exceed 200 sq. ft. (18.5 sq. m) and shall initiate an alarm/alert in less than 60 seconds from the furthest sample port. The detector shall be programmed to pre-alarm at .2% obscuration per foot and alarm at 1% obscuration per foot at the sample port.

b. **EWFD**: Early Warning Fire Detection. The sample port spacing shall not exceed 400sq. ft. (37.1 sq. m) and shall initiate an alarm/alert in less than 90 seconds from the furthest sample port. The detector shall be programmed to alarm at 1.5% obscuration per foot at the sample port.

c. **SFD**: Standard Fire Detection. The sample port spacing shall not exceed 900 sq. ft. (83.7 sq. m) and shall initiate an alarm/alert in less than 120 seconds from the furthest sample port. The detector shall be programmed to alarm at 3.2% obscuration per foot at the sample port.

2-Sampling point flow and pressure requirements:

3-Minimum Flow: 2 L/min.

4-Minimum Pressure: 25 Pa

B. A test port shall be provided at each pipe run located at 18" above the finished floor for under floor systems, or 5ft above the finished floor when pipe network is above the ceiling. The test port shall be constructed using a vented end cap. Provide a decal indicating the install date, detector zone, pipe number, test point ID, transport time and suction pressure (Pa).

III) MONITORING:

A- The ASD shall provide up to three Fault types to indicate the priority of faults generated in the system. Fault indication shall be provided for the following:

1- Low flow – If the device has decreased in air flow, a Fault shall be generated at a user-settable decrease in air flow.
2- High flow – If the device has increased in air flow, a Fault shall be generated at a user-settable increase in air flow
3- Configuration – Device configuration failure. A Fault shall be generated if a configuration update did not transfer.
4- Sensor – If the particulate sensor is not operating properly and needs immediate replacement, a Fault shall be generated.
5- External Monitor – If the external monitor detects an open a Fault shall be generated.
6- Time – If the internal time base needs to be updated, a Fault shall be generated.
7- Communication – If the device fails to communicate to one of its peripherals and cannot function properly, a Fault shall be generated.
8- Aspiration – If the aspirator is not working and requires immediate attention, an Fault shall be generated.
9- Filter – As the filter approaches a pre-set threshold, an initial warning shall be given to change the filter and a Fault shall be generated.
10- Isolate – If the device is put into the Isolate mode, an Isolation fault shall be generated.

IV) DISPLAYS:

A- The system shall provide a user interface at the front of the detector with the following displays:

1- Air Flow/Fault Display – The air flow/fault display shall consist of 10 bicolor LEDs and operate in one of two modes: air flow or fault indication. Green segments shall indicate how close the current air flow is to the high or low air flow threshold. The default threshold for a fault condition is + or – 20% from the airflow baseline. During normal operation two adjacent indicators shall be green and correspond to the current airflow entering the detector. When airflow is at a balanced level, the two green segments shall be centered on the graph. As airflow rises and falls, the green segments shall move right and left accordingly. If a fault is activated on the device, the corresponding LEDs shall illuminate in amber and an additional "fault" LED shall be triggered to signal a fault has been generated. All 10 faults shall be indicated on the User Interface.
2- 10 particulate levels – The particulate level display shall consist of ten amber LEDs that correspond to the current level of the particulate detected. The LEDs shall illuminate in order from Level 1 to Level 10, starting from the bottom of the display and moving up as the particulate level increases. Each LED shall represent a 10% increase in the particulate level necessary to reach the Alert Alarm level.
3- (3) 5 alarm levels – All (3) 5 Alarm levels shall be indicated on the User Interface. The Alarm Level Display shall consist of (3) 5 red LEDs that correspond to the current alarm level. These LEDs shall be located directly above the Particulate Level LEDs. They shall illuminate sequentially upward as the severity of the alarm increases.
4- On/Off indication
5- Low Voltage indication

B- The user interface shall offer an interactive panel. The panel shall have a security passcode system to prevent unauthorized access if chosen. The panel shall allow the following features to be activated at the device:

1- Test.
2- Reset.
3- Isolate.

V) SOFTWARE

A- The software shall be based on a single program, PipeIQ, which provides pipe network design, ASD configuration, and system monitoring. The software shall provide the ability to remotely monitor the system and provide the following functions:

1- Test, reset, and isolate functions from remote locations.
2- Bill of Materials for the pipe network.
3- Pipe layout of the pipe network.

4- Generate transportation time from the sampling holes to the detector and sampling hole pressure.
5- Live event monitoring.
6- Historic event retrieval.
7- Custom message function to input messages about a device or site.
8- Configuration settings
9- Network settings
10- Trend graph reflecting obscuration over time
11- Shall support up to 255 devices.

VI) SAMPLE PIPE NETWORK

A- The ASD shall consist of a pipe network to transport air to the detection system supported by calculations from a computer-based design modeling tool.

1- The internal pipe diameter of the network may range from 0.59 inches to 1.03 inches (15-26 mm) with a smooth bore internal surface.
2- The ASD shall accept both nominal 3/4 inch and 25 mm pipe diameters.
3- Inflow and Exhaust pipes shall enter the device from either the top or the bottom of the unit so that the unit does not have to be inverted.
4- The system exhaust must be located back into the room being monitored. If the ASD is located within the same room being monitored, no exhaust pipe is required to be connected to the ASD.
5- Material for pipe and fittings shall be orange chlorinated polyvinyl chloride (CPVC) PIPE. The pipe shall be UL Listed as an accessory for plenum use as per UL 1887 standard.
6- The pipe shall be identified as “Smoke Detector Sampling Tube” along its entire length, in requirements per local codes and standards and manufacturer’s recommendations.
7- Pipe material substitution may be acceptable to accommodate environments where pipe network will be installed but must be approved by the specifying engineer and authority having jurisdiction, and if applicable, insurance underwriters.
8- The substitution pipe must comply with both inner and outer pipe diameter requirements.
9- All joints and sampling pipes must be glued and connected, free of any air gaps using solving cement throughout the pipe network, with the exception of the pipe connected to detector.

VII) SAMPLING PORT:

A- Sample port spacing shall comply with the requirements of NFPA classifications and manufacturer’s recommendations.
B- The minimum sample port diameter must not be less than 5/64” and shall not exceed a diameter larger than 1/4".
C- All sample ports must be identified in accordance with NFPA.
D- In areas with a suspended ceiling the pipe network shall be installed above the ceiling utilizing a 3/8 inch diameter, flexible capillary tubing attached to an approved manufacturer’s capillary sample port supported by the ceiling.
E- The size of sample ports shall be verified and confirmed with PipeIQ calculations software.

VIII) SYSTEM OPERATING POWER

A- The contractor must provide power supply/charger as requied to convert 230VAC/50Hz input into a single 12 VDC or 24 VDC Class 2 Rated power limited output, with UL listing UL1481.
B- Power supply shall be provided with appropriately sized batteries to accommodate the system’s power requirements in the event main AC power is interrupted.
C- Upon loss of AC power, the external battery shall have sufficient capacity to power the fire alarm system for not less than 24 hours plus 5 minutes of alarm.

IX) FILTER ASSEMBLY

A- Internal non-replaceable particle separator shall remove larger contaminates before entering the detection chamber and filter.
B- Multi-stage 30 micron field-replaceable filter. A fault shall be generated when the filter needs replacement due to a reduction of air of more than 20%.

X) **WIRING:** Wire gauge shall range from 24 to 12 AWG (0.5-2.05 mm). Wire or conduit shall enter the detector from either the top or the bottom of the device. Pluggable terminals shall be used to wire the detector.

31.1.11.3 EXECUTION

I) EQUIPMENT INSTALLATION

A. **The entire system shall be installed in accordance** with national and local codes and per the manufacturer’s installation manual.

B. Aspirating Smoke Detector Installation:

1. ASD shall be mounted on a secured wall at a height of approximately 36 to 60 inches (0.9- 1.5 m) above the finished floor.
2. ASD shall be located in an unobstructed location and shall maintain 36 inches (0.9m) clearance in front of the unit.
3. Any exposed wiring shall by carried out using a galvanized conduits and shall be of a fire-resistant cable, however, any exposed wiring shall not be allowed without prior approval by engineer.
4. Any CPVC pipe for sampling parts in trenches must be well supported and protected by suitable materials accepted by owner.
5. Any required penetration to the wall or ceiling must be done through PVC sleeve.
6. No penetration accepted for any movable cover like trenches galvanized cover.

C. Sampling Pipe Network

1. Sampling pipe network shall be installed and designed so that the transport times from the most remote sample port location complies with the classifications of NFPA.
2. Sampling pipe shall be installed within 4 to 12 inches (0.1-0.3 m) from the ceiling in smooth ceiling applications.
3. All pipes shall be supported by mechanical hangers attached to the structure of the building, at no greater than five-foot centers.
4. All pipes must be labeled throughout its entire length, as required per NFPA.
5. Piping network(s) shall be installed/design to provide detection points and spacing as indicated on the drawings (or as required). All changes to the direction of the pipe shall be made with standard elbows or tees. Piping shall be verified per manufacturer's modeling software.

D. Sampling Port

1. Sample port spacing shall comply with the requirements of NFPA classifications and manufacturer’s recommendations.
2. All sample ports shall be drilled directly at the bottom of the pipe and equal the diameter as indicated per the PipeIQ reports.

II) SYSTEM INSPECTION:

1. Perform a visual inspection of the physical installation, checking adequate size batteries are used, piping is securely connected and installed, and all sample ports comply with the design.
2. Verify ASD communicates to fire alarm control, and if applicable, has the ability to network via a dedicated IP address and Modbus protocol.
3. Check the controller to ensure the following functions are operational and programmed in accordance with the specification:

Alarm Levels and Indicators
Time Delays
Particulate Level Display
Detector Fault Test Indicator
Detector Test and Indicator
Isolate/Reset Function
Air Flow Fault Indicators
Configuration Fault
Sensor Fault
External Monitor Fault
Time Fault
Communication Fault
Aspirator Fault
Filter Fault

III) COMMISSIONING

A. The system shall be commissioned in the presence of the manufacturer or installing contractor representative and client representative. The contractor shall provide the following necessary instrumentation, equipment, materials, and labor for the test:

1. PipeIQ Pipe Layout Report
2. Aerosol smoke (Home Safeguard Industries Model 25S or equivalent)
3. Stopwatch capable of measuring 1 second intervals
4. A total of two (2) qualified personals when testing is being performed

B. Acceptance testing shall be conducted in front of specifying engineer or client representative, and if required, in front of the Authority Having Jurisdiction using the following testing methods:

1. Introduce canned smoke (Home Safeguard Industries Model 25S or equivalent) directly into the sampling hole in to farthest sample hole for a duration of 2 seconds at a distance of 6 inches from the sample hole. Start the timer once the smoke has been introduced.
2. Stop the timer once the first particulate bar is illuminated on the front of the device, above what was displayed during normal device operation. The device need not go into alarm to verify the transport time – an increase on the particulate meter is a successful measurement of transport time.
3. Compare the observed transport time with the results on the Pipe Layout report from PipeIQ. If there is more than a 20% discrepancy, verify the sample hole quantity, sizes, location, and the integrity of pipe and that the installed pipe network is identical to the PipeIQ Pipe Layout report.
4. Once transport times for the farthest sample points are verified, test the remaining holes for airflow by introducing smoke into each hole and verifying a response at the device or panel. Transport times are not required on each of the remaining holes, only a verification that air is flowing.
5. Document test results as required per NFPA to include the client's contact information, transport times, and sensitivity levels.
6. Upon completion of a successful test, installer shall so certify the system in writing to Owner's Representative.

IV) WARRANTY:

The manufacturer shall guarantee the product by warranty for a period of five years. All components of the detector shall be replaced with the exception of regular maintenance accessories: replaceable micron filter. The installation and programming of the ASD shall be completed by factory-trained installer.

V) TRAINING

A. The contractor shall provide complete training to the Owner by factory-trained technicians.

31.2 Fire detection system

In order for an outbreak of fire to be rapidly discovered, the substation is to be equipped with an automatic addressable fire detection system. The fire alarm system is to monitor all spaces in the buildings concerned.

In the event of an outbreak being discovered, a fire alarm warning is to be sounded locally and a signal transmitted to the National Control Centre.

The fire detection device must be designed in such a way that:

- It operates automatically, i.e. it itself discovers and indicates a fire.
- It is self-monitoring, i.e. important functions are monitored in such a way that a fault affecting the functioning of the installation triggers off a fault alarm which is sounded locally and a signal is transmitted to the National Control Centre.
- HVAC systems shall be controlled.

31.2.1 SYSTEM DESCRIPTION

- Provide an addressable fire alarm system including fire alarm panel, controllers, power supply unit, manual call stations, heat detectors, smoke detectors, sounders, strobes, initiating and indicating device circuits, fully supervised as shown on the drawings.
- System to operate with manual stations and detectors, circuits as follows:
  1. Actuate control panel to cause alarm signal continuously throughout building.
  2. Indicate alarm origin.
  3. Indicate origin of signal.

31.2.2 SUMMARY:

This section specifies the furnishing, installation, connection and testing of a complete, operative and coordinated 24 Volt, fire alarm system. The system shall include but not be limited to, alarm initiating devices, alarm notification appliances, Fire Alarm Control Panels (FACP), auxiliary control devices, and wiring as shown on the drawings and specified herein.

31.2.3 REFRENCE STANDARDS:

1. The fire alarm system shall comply with requirements of NFPA 72, the system shall be electrically supervised and monitor the integrity of all conductors.
2. The fire alarm system shall be manufactured by an ISO 9001 certified company.
3. The FACP and peripheral devices shall be manufactured 100% by a single manufacturer (or division thereof).
4. The system and its components shall be listed by Underwriters Laboratories of USA, Factory Mutual FM, Inc. listed under the appropriate UL, ULC & FM testing standard as listed herein for fire alarm applications and shall be in compliance with those listings & approval.
5. The LPCB standard.

31.2.4 SUBMITTALS

A. General:

All substitute equipment proposed as equal to the equipment specified herein, shall meet or exceed the above standards. For equipment other than that specified, the contractor shall supply proof that such substitute equipment does in fact equal or exceed the features, functions, performance, and quality of the specified equipment.

B. **Shop Drawings**:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.

2. Include the following information in the equipment submittal:

A. Power calculations, voltage drop calculations for wiring runs in worst case condition.

B. Complete manufacturer's catalog data including supervisory power usage, alarm.

3. Submit the as built drawings for the system including the followings:

a. General plans showing all initiating, end of line, supervisory, indicating appliances, and output control devices; including circuit interface panels, enunciators, Control panel location.

b. Indicate ambient sound levels used by the system layout designer for sound level calculations and mathematical justification for signal placement to meet the code required 15 dBA above ambient for audible warning signals

c. Wiring diagrams showing points of connection and terminals used for all electrical connections to the system devices and panel.

d. Complete single-line riser diagram showing all equipment.

e. Fire detection system shall be intelligent device addressable, analogue detecting, low voltage and voice evacuation alarm system in full compliance with all applicable codes and standards, Including, but not limited to the followings:

1. Main system including all fire detection.

2. Voice evacuation alarm/notification and communication system.

3. Circuit interface panels including all modules.

4. Power supplies, batteries and battery chargers.

5. Equipment enclosures.

6. Intelligent addressable manual pull stations, heat detectors, analogue smoke detectors, strobe lights both internal and external alarm monitoring modules, and supervised control modules.

7. Audible and visual evacuation signals.

8. Software as required providing a complete functioning system.

9. Wiring including sleeves diameter 20mm pvc at least.

10. Installation, operation and testing.

4. Show annunciator layout and main control panel module layout, configurations and terminations.

C. **Manuals**:

1. Submit simultaneously with the shop drawings, complete operating and maintenance manuals listing the manufacturer's name(s) including technical data sheets.
2. Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnections between the items of equipment.
3. Provide a clear and concise description of operation which gives the information required to properly operate the equipment and system.

D. Software Modifications

Provide the services to perform all system software modifications, upgrades or changes by the owner through the FACP. Response time of the technician to the site shall not exceed one day (24 hours).

E.Certifications:

Together with the shop drawing submittal, submit a certification from the equipment manufacturer indicating that the proposed supervisor of installation and the proposed performer of contract maintenance is an authorized representative of the equipment manufacturer and trained on network applications.

31.2.5 GUARANTEE:

All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least Two (2) years from the date of acceptance. The full cost of maintenance, labor and materials required to correct any defect during these Two years period shall be included in the submittal bid.

31.2.6 APPLICABLE PUBLICATIONS:

The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only.

A. The fire alarm system shall comply with requirements of NFPA 72 for protected premises signaling systems except as modified and supplemented by this specification. The system field wiring shall be supervised either electrically or by software-directed polling of field devices.

B. Local and State Building Codes.

C. All requirements of Civil Defense Directorate of Jordan as a Sole Authority Having Jurisdiction (AHJ).

31.2.7 APPROVALS:

The system must have proper listing and/or approval from the following nationally recognized agencies:

UL Underwriters Laboratories Inc
ULC Underwriters Laboratories Inc of Canada
FM Factory Mutual
MEA Material Equipment Acceptance (NYC)
LBC & standared
Local Civil Defense Authority.

31.2.8 EQUIPMENT AND MATERIAL:

A. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system. The authorized representative of the manufacturer of the equipment, shall be responsible for the satisfactory installation of the complete system.

B. All equipment and components shall be installed in strict compliance with manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc. before beginning system installation. Refer to the riser/connection diagram for all specific system installation/termination/wiring data.

C. All equipment shall be attached to walls and ceiling assemblies and shall be held firmly in place. (e.g., detectors shall be supported by suspended ceilings).

31.2.9 CONDUIT AND WIRE:

A. Conduit:

1. Conduit shall be in accordance with the National Electrical Code (NEC) and local requirements. All wiring shall be installed in conduit. Conduit fill shall not exceed 40 percent of interior cross-sectional area where three or more cables are contained within a single conduit.
2. Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760-29.
3. Conduit shall not enter any FACP, or any other remotely mounted control panel equipment or back boxes, except where conduit entry is specified by the FACP manufacturer.
4. Conduit shall be 3/4 inch (19.1 mm) as a minimum size.

B. Wire:

1. All fire alarm system wiring must be new, unless specified herein.
2. Wiring shall be in accordance with local and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer.
3. All wire and cable shall be listed and approved by a recognized testing agency for use with a protective signaling system.
4. Wire and cable shall have a heat rating suitable for the installation as indicated in NFPA 70 (e.g., 105ºC).
5. Wiring used for the signaling line circuit (SLC) multiplex communication loop shall be twisted and shielded and installed in conduit unless specifically excepted by the fire alarm equipment manufacturer.
6. All field wiring shall be completely supervised.

C. Terminal Boxes, Junction Boxes and Cabinets:

All boxes and cabinets shall be UL listed for their intended purpose.

D. Initiating circuits shall be arranged to serve like categories (manual, smoke… etc). Mixed category circuitry shall not be permitted except on signaling line circuits connected to intelligent reporting devices.

E. Trouble and Supervisory connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution Panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 4 mm². The FACP cabinet shall be grounded securely to grounding rod.

31.2.10 FIRE ALARM CONTROL PANEL:

A. The Power Supply /Batteries/Charger shall use one unit space in the cabinet and provides the means of automatically supplying 24 V DC operating and emergency power to the system. Provide analogue addressable fire alarm control panel with not less than two active detection loops. Each loop shall be capable of driving the number of analogue addressable devices as shown on the drawings.

B. The fire detection system shall consist of the following:

1. Network capability of up to manufacturing recommended.
2. Touch screen color graphics capability
3. Standalone capability of each control unit on loss of data channel
4. Conventional and Analog Devices
5. It shall incorporate a real time clock to enable events to be accurately referenced against time and date. The panel shall comprise separate processors; cross-monitoring each other's correct operation, for the major functions of the systems. In particular different processors must be used for the main control

function, the detection input and alarm output functions and the display and control function. No more than 200 addressable input or output points shall be controlled by a single processor.

6. The panel shall incorporate a key switch to prevent unauthorized use of the manual controls. The panel shall be capable of operating with analogue addressable detectors and addressable ancillary equipment.
7. Provision shall be made for each addressable loop to be sub-divided into geographical zones. The section of wiring corresponding to each zone circuit shall be protected from faults in other sections by line isolator modules. In order to facilitate re-configuration and system extension, the allocation of addresses to devices shall be independent of their physical arrangement on the loops.
8. The panel shall have provision to house the AC Main power supply and batteries.
9. The panel shall monitor the status of all devices on the addressable loops for fire, short-circuit fault, open-circuit fault, incorrect addressing, unauthorized device removal or exchange, pre alarm condition and contaminated sensor condition.
10. All internal connection and interfaces including charger, battery and remote signaling functions shall also be monitored.
11. The following discrete visual indications shall be provided: -
    POWER ON green LED indicator, FIRE ALARM dual red LED indicator
    FAULT yellow LED indicator, DISABLED / ISOLATED yellow LED indicator
    FIRE ZONES red LED indicator per zone
12. Field programmable
13. The panels shall have an integral LCD alphanumeric display. In order to provide an easy identification of different information, the LCD display shall be arranged to display the following:
    Event type, Zone message, Addressable point message
    Circuit identifier / Point number / Zone number and Number of events in the system.
14. Individual ground fault detection and annunciation per circuit
15. The panel shall provide a set of push button controls to enable an authorized operator to perform the following:
    EVACUATE (actuates ALL alarm sounders in the system)
    SILENCE (stops all currently actuated alarm sounders)
    RESET (returns the panels to quiescent condition)
16. A facility to manually check all the discrete LED indicators shall be available. This shall be clearly marked 'LAMPTEST' and be accessible at all time.
17. The panel shall have a simple to operate keypad to enable a user, interacting with the information displayed on the LCD, to access the various built-in functions. A customer configurable pass code facility for two levels.
18. The panel shall provide volt-free contact facilities for remote signaling the following system conditions:
    Alarm, Pre-alarm, Fault, Zone Isolated
19. The panel shall be capable of monitoring and controlling remote devices, such as relays for the control mechanical equipment directly from the addressable loops
20. The panel shall interrogate each addressable device at least once every 2 seconds and shall incorporate fire decision algorithms specifically adapted to the response characteristic of the analogue addressable detectors employed. The algorithms shall perform a trend analyst of the signal received from the analogue addressable detectors in order that non-fire events may be differential.
21. A special scanning sequence must be provided so that designated manual call points provide alarm indication and warning within 1 second of operation shall be provided
22. The panel shall have the ability to annunciate a pre-alarm condition designed to give the earliest possible warning of a potential fire condition without raising the full alarm condition.
23. The panel shall have the ability to automatically adjust the alarm and pre-alarm threshold levels to compensate for changes in detector sensitivity due to contamination over a period of time. The panel shall have the ability to provide automatic warning that a detector has reached a level of contamination, which requires that it be replaced or serviced. The panel shall be capable of providing a two-stage sounder facility that can be programmed, either on a zone basis or common system basis.
    The panel shall have the facility to change the sound output dependent upon whether the source of alarm is an automatic sensor, a manual call point or an EVACUATE command.
24. The panel shall be capable of generating customer definable time delay sequences to upgrade, without the need for external timers, alarm sounded responses as follows:
    Silent to Alert, Alert to Evacuate, Silent to user defined tone
25. The panel shall monitor all critical system components and interconnections, internal and external, such that failure, which would prevent the correct operation of the alarm functions, causes the FAULT indicator to light and a message to be given on the alphanumeric display. The following faults shall be reported:
    Loop Short Circuit
    Loop Open Circuit
    Unconfigured Device
    Addressable Device Failure

Device Not Responding
Incorrectly Configured Device
Detector Condition Monitoring Device
Call Point wiring Open Circuit
Call Point Wiring Short Circuit
Detector Circuit Wiring Fault
Power Supply Unit Fault
Charger Fault
Battery Fault
Battery Critical
Mains Failure
Relay Output Stuck
Signaling Fault
Sounder Wiring Open Circuit
Sounder Wiring Short Circuit

The panel shall provide text messages to indicate the precise location of where a fault has occurred in the system. The panel shall incorporate the following system management facilities:

Isolate/re-connect a particular addressable point
Isolate/re-connect a particular detector zone
Isolate/re-connect a particular sounder zone
View the number of alarms since power up
View the number of software initialization since power up
View common alarm status
View common fault status
View common disabled status
View zone alarm status
View zone fault status
View zone isolated status
View point address status

Events shall be displayed in chronological order in any of the following three options:

Newest event first, Oldest event first, Highest priority event first

All intelligent analogue sensors shall be interchangeable, ceiling mountable and shall use common twist-lock bases

C. The system shall permit expansion of both capacity and functionality through the addition of units, modules, addressable devices and detectors.

D. High-speed data transfer rates for alarm reporting, quick report generation from multiple systems/transponders and upload/download capability between network systems. The maximum response time shall be 5 seconds between initiation of alarm and signal output.

E. Each unit shall have sufficient memory to support its own operating system and databases including:

1. Fire Management
2. Alarm Management
3. Historical/Trend Data
4. Maintenance Support Applications
5. Custom Processes
6. Operator I/O

F. Expandability: The system shall be expandable in nature and shall permit easy expansion through the addition of software applications, additional units and devices.

G. Serial Communication Ports: provide data communication ports for simultaneous operation of devices such as industry standard printers, programming terminal, personal computer, and transponder and annunciate.

H. Integrated on-line Diagnostics: Each unit shall continuously perform self- diagnostics, communication diagnostics and diagnostics on all subsidiary equipment.

I. Surge and Transient Protection: Each unit shall provide isolation and transient protection at all network zerminations and all field point terminations to suppress induced voltage transients where required.

31.2.11 FACP Power Supplies:

1. Main power supplies shall operate on 230 VAC, 50Hz.
2. Each main supply shall provide 3.0 amps of usable notification appliance power, using a switching 24 VDC regulator.
3. The supply shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults.
4. It shall provide meters to indicate battery voltage and charging current.

31.2.12 BATTERIES AND EXTERNAL CHARGER:

Battery:

1. Batteries shall be 12 volt, Gall -Cell Rechargeable Lead Acid type.

2. The battery shall have sufficient capacity to power the fire alarm system for not less than 24 hours plus 5 minutes of alarm upon a normal AC power failure.
3. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills and leakage shall not be required.

Enclosures:

1. Control panels shall be housed in UL-listed cabinets suitable for surface or semi-flush mounting. Cabinets shall be corrosion protected, given a rust-resistant prime coat, and the manufacturer's standard finish.
2. The back box and door shall be constructed of 0.060 steel with provisions for electrical conduit connections into the sides and top.
3. The door shall provide a key lock and include a transparent opening for viewing all indicators. For convenience, the door shall have the ability to be hinged on either the right or left-hand side.
4. The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.

31.2.13 SYSTEM COMPONENTS, INTELLIGENT:

A- Addressable Devices - General

1. Addressable devices shall use simple to install and maintain decade (numbered 0 to 9) type address switches or a binary address setting method.
2. Detectors shall be analog and addressable, and shall connect with two wires to the FACP signaling line circuit.
3. Addressable smoke and thermal detectors shall provide dual alarm and power/polling LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the LED flash shall have the ability to be removed from the system program. An output connection shall also be provided in the base to connect an external remote alarm LED.
4. The fire alarm control panel shall permit detector sensitivity adjustment through field programming. Sensitivity shall be automatically adjusted by the panel on a time-of-day basis.
5. Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA 72, Chapter
6. The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature.
7. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
8. Addressable devices shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. LED(s) shall be provided that shall flash under normal conditions, indicating that the device is operational and is in regular communication with the control panel.
9. A magnetic test switch shall be provided to test detectors and modules. Detectors shall report an indication of an analog value reaching 100% of the alarm threshold.

B- Intelligent Photoelectric Sensor

The Intelligent Photoelectric Sensor shall connect with heat resistance 2 wires to the control panel. The sensor shall be easy to install into the base. The sensor shall incorporate a built in type identification so the system can identify the type of sensor. The sensor shall be continually monitored to measure any change in their sensitivity because of the environment (dirt, smoke, temperature, humidity, etc.).

The sensor shall use the photoelectric principle to measure smoke density and shall on command from the control panel send data to the panel representing the analog value of the smoke density. The sensor shall provide advanced indication of the analog value of the level of smoke density to the panel that maintenance is required, reducing the maintenance required to inspect routinely all sensors in order to ensure normal operation. The sensor's sensitivity shall be adjustable by device.

C- Intelligent Thermal/Heat Sensor

The Intelligent Analog Thermal/Heat Sensor shall connect with heat resistance 2 wires to the control panel. The sensor shall be easy to install into the base. The sensor shall incorporate a built-in type identification so the system can identify the type of sensor. The sensor shall be continually monitored to measure any change in their sensitivity, because of the environment (dirt, temperature, humidity, etc.). The sensor shall use dual solid state to monitor rate of heat rise from 10^{o}C, to +60^{o}C and provide a fast response to rapid increases in temperature. The sensor on command from the control panel shall send data to the panel representing the analogue value of the ambient temperature.

D- Intelligent Monitor Module

The Intelligent Monitor Module shall be used to connect a supervised conventional initiating device or zone of supervised conventional initiating devices (manual pull stations 4 wire smoke detectors conventional ... etc. to one of the 2 wire intelligent analog loop cards.

The module shall mount in an electrical box and shall be capable of Class "A" supervised wiring to the initiating device. In order to maintain proper supervision there shall be no T-taps allowed on Class "A" lines. The Monitor Module shall provide internal identifying code which the control panel shall use to identify the type of device. The Monitor Module shall contain an integral LED that flashes each time the monitor module is polled.

E- Intelligent Control Module

The Intelligent Control Module shall be used to connect and supervise conventional indicating device or zone of indicating devices that require an external power supply, such as horns, strobes, bells, to one of the 2 wire intelligent analog loop (Class "A". The control Module shall be capable of operating as a relay (dry contact form C), to control Door Holders. The module shall mount in an electrical box supervised wiring to the indicating or control device. The Control Module shall provide an internal identifying code which the control panel shall use to identify the type of device.

The control module shall mount in a standard 4-inch square (101.6 mm square).

F- Isolating Module

The Isolating Module shall be an automatic switch, which will open when the intelligent loop voltage drops below 4Volts. The Isolator Module shall be placed between groups of sensors/intelligent modules on the loop in order to protect the intelligent loop if a short should occur. If a short occurs between any two isolators, then both isolators switch to open circuit conditions and isolate the group of sensors/modules between them. The remaining devices on the intelligent loop shall continue to operate and communicate normally. The number of devices between isolators shall be as recommended by manufacturer or less. The Isolator shall be designed to mount in an electrical box.

J- Addressable Pull Box (manual station)

1. Addressable pull boxes shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by **the use of a key.**
2. All operated stations shall have a positive, visual indication of operation and utilize a key type reset.
3. Manual stations shall be constructed of Lexan with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches (44mm) or larger.

31.2.14 TEST:

The service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment shall be provided to technically supervise and participate during all of the adjustments and tests for the system.

A. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
B. Verify proper supervisory alarm at the FACP.
C. Open initiating device circuits and verify that the trouble signal actuates.
D. Open signaling line circuits and verify that the trouble signal actuates.
E. Open and short notification appliance circuits and verify that trouble signal actuates.
F. Ground initiating device circuits and verify response of trouble signals.
G. Ground signaling line circuits and verify response of trouble signals.
H. Ground notification appliance circuits and verify response of trouble signals.
I. Check alert tone and prerecorded voice message to all alarm notification devices.
J. Check installation, supervision, and operation of all intelligent smoke detectors using walk test.
K. Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and the proper processing of the signal at the FACP and the correct activation of the control points.
L. When the system is equipped with optional features, the manufacturer's manual should be consulted to determine the proper testing procedures. This is intended to address such items as verifying controls performed by individually addressed or grouped devices, sensitivity monitoring, verification functionality and similar.

320 PORTABLE FIRE EXINGUISHERS:-

32.1 Portable Fire Fighting Equipment

The portable apparatus provided under this contract is to be used for dealing with outbreak of fire in areas where oil filled transformers and switchgears are protected by fixed installations as well as in electrical equipment in control & relay, battery and office rooms, telecom, LVAC, Workshop, Store and air-condition rooms. All apparatus shall be of suitable type for operation by one person and shall

easily be recharged. The content of extinguishers shall be non-corrosive and free of chemicals or toxic gases when heated.

Equipment for dealing with oil fires shall be of foam generating type and for other electrical fires CO2 and powder type shall be used.

The contract shall include provisions for the supply and installation of all wall brackets and fittings for small units as well as provisions of wheeled trolleys for units which cannot be carried easily. Portable wall mounted, hand-held extinguishers shall be 6 kg size charge with CO2 and a 12kg &50kg size multipurpose powder of ABC rating, in addition to 50 litre size foam type fire extinguishers.

32.2 Marking: All extinguishers shall be painted and marked in the Arabic and English languages with clear instruction for use.

32.3 Installation

Where extinguishers are provided internally, they shall be wall mounted and attached in a manner affording quick release from the supporting bracket. The positions of the extinguishers are subject to the Employer's approval.

For outdoor installations, the fire extinguishers shall be installed under a dedicated protective canopy or enclosure to shield them from the direct weather conditions, the canopy shall be fabricated from red color painted galvanized steel sheet of minimum thickness 2 mm. each canopy shall be securely fixed to the ground using suitable anchors or base supports to prevent movement.

The preliminary positions of the portable fire extinguishers shall be as per the following table:

	Powder 50 kg	**Powder 12 kg**	**CO2 6 kg**	**Foam 50 l**
For each electrical room in the control building (except office)			2	
For switch gear rooms	2 (Trolley)		4 (wall mounted)	
For the office rooms & kitchen		1 (each zone)		
For the corridors		2	2 (wall mounted)	
For capacitor buildings & GIS's	2 (Trolley each)		2 (wall mounted each)	
For the switchyard areas				2
For each apartment in the service building		1	1	

33. Special Technical Specifications for Sanitary Works

33.1 Introduction

The specifications to be considered as complementary to the General Technical Specifications issued by the Ministry of Public Works in 1985, in its three parts of mechanical works or any other appendices for all the works required in this Contract, including the latest editions of the Jordanian National Codes whichever is more stringent.

33.2 General

The works of this Contract include the supply, installation and commissioning of materials, equipment, services, operational checks and tests necessary to complete the required mechanical work to the fullest extent as shown on the tender's drawings, specifications, BOQs (if available) in addition to the instructions of the National Electric Power Company.

33.3 Required Works

Mechanical works include the following:

1- Hot and cold-water networks work.
2- Sanitary works for washbasins, sinks, toilets, showers, eyewashes ... etc.
3- Sanitary drainage.
4- Rainwater drainage.

33.4 Civil and Architectural Works

It includes all civil and architectural works related to and necessary for mechanical works such as: supports for devices, fasteners, pipe penetration through walls, floors, roofs, nodes, pipe sleeves, excavations, desilting, cleaning, painting, protection and waterproofing.

33.5 Electrical Works

It includes all electrical works necessary for mechanical works in terms of electrical wiring such as cables and wires and their connections to mechanical devices and operating panels.

33.6 General Requirements

A. Shop Drawings:

- The Contractor shall submit three copies of the Shop Drawings.
- The Shop Drawings shall be submitted prior to execution of the mechanical works and the Contractor is not entitled to carry out any work without the written approval of the Client.
- The drawings shall include the full details of the devices and piping networks, the method of their application, location of the sleeves, and so on, to contain the dimensions and sizes of the devices, pipes and their locations, with full coordination between the electrical, structural and architectural works.
- Scale of the drawings shall be 1:50 and 1:25 for details.
- The Contractor shall attach the data sheets of all the devices that will be incorporated in the project, based on which the price was formed

B. As Built Drawings:

1. The Contractor shall submit three copies of the drawings to the Client, which are in accordance with the executed works, after the completion of the works required under the terms of the Contract.
2. These drawings shall include all changes and modifications of the shop drawings, approved during the execution of the works, with indication of valves, pipes and devices numbering and their types and capabilities.

C. Operation and maintenance instructions:

The Contractor shall provide three copies of the operation and maintenance instructions in an envelope including the following:

1- A brief description of each mechanical system: air conditioning system, regular water system, sewage network system, with description of the devices and their operating methods.
2- Data sheets for devices and materials including the manufacturer's name, model and capacity of each device.
3- Maintenance and operation schedules.
4- A list of the parts and components of each device with the number and the technical and commercial name of each piece.

D. Maintenance:

The Contractor must perform the necessary maintenance operations of the mechanical systems during the two-years maintenance period from the delivery date of the mechanical works.

33.7 Equipment, Materials, Workmanship & Works

- All devices and materials must be new, without any manufacturing defects, in accordance with special and general materials, clearly stamped with the name of the manufacturer, model, date of manufacture and with a certificate of origin.
- The work must be completed with a high degree of efficiency and accuracy and in accordance with the Client's specifications and instructions.
- The Client's approval of the execution plans, equipment and materials does not release the Contractor from the responsibility to complete the works in accordance with the specifications and plans to the fullest extent
- The Contractor shall provide samples of the materials to be used for Client's approval, before installation, in terms of the unit price. These samples will be costed at the Contractor's expense and without additional costs.

33.8 Pipe Works:

In addition to the General Technical Specifications issued by the Ministry of Public Works in 1985 (Volume 1 and 2) and the latest editions of the Jordanian National Codes the following must be taken into account:

1- Galvanized steel pipes are connected by threaded connections only.
2- All plumbing systems are hydraulically tested by filling them with water at a pressure of one and a half times the design pressure of the network, provided that the pressure used in the test is not less than six (6) bar for twenty-four (24) hours continuously under this pressure.
3- Hydraulic testing is repeated in case of any defects during the first inspection and after repair.
4- Hydraulic testing of any underground submerged network shall be carried out before they are being isolated and silted.
5- Hydraulic testing of any insulated network shall be carried out prior to insulation works.
6- Submerged underground pipes shall be insulated by a layer of bitumen, then a layer of bitumen-saturated burlap, and then a final layer of bitumen, in accordance with the drawings.
7- Hot water pipes are thermally insulated using a layer of pre-fabricated thermal insulation after being painted with two layers of the primer paint, provided that it is finally wrapped with a layer of aluminum foil and according to the plans.
8- Sanitary drainage pipes (UPVC) are connected using the parts manufactured for that. It is forbidden to use the connection method with fire heating.
9- Underground submerged pipes shall be installed at depth of at least fifty (50) cm. A flat compacted layer of soil ten (10)cm thick below the pipes and a similar compacted layer above the pipes shall be provided.

33.9 Types of pipes:

1- Galvanized steel pipes of class B for the main distribution pipes for hot and cold water networks.
2- PPR pipes conforming to BS EN ISO 15874
3- PEX pipes (Cross-linked polyethylene) conforming to BS EN ISO 15875
4- CPVC pipes conforming to BS EN ISO 15877
5- High-pressure UPVC pipes conforming to BS 4514/1696, 5255/1976.
6- Rainwater drainage pipes in accordance with the description in the BoQ.

34. FIRE FIGHTING SYSTEM FOR transformer and reactor

34.1 General

34.1.1 Objectives and application field

This specification establishes technical characteristics and purchase requirements to be met by Water Spray Fixed System for all power transformers fire protection. The goal of the firefighting system is to detect and extinguish fire, minimizing damages to transformers and close areas.

34.1.2 CONTRACTORS RESPONSIBILITIES

The Contractor is responsible for the quality and the satisfactory operation of the installations entrusted to him, as well as for compliance with the performance stipulated in this document. Consequently, for his own account and under his own responsibility, he must carry out all calculations and select the necessary materials and equipment, which in turn shall be subjected to the client approval and the AHJ approval

Apart from the required performance definitions, this document and the relevant drawings also provide many indications resulting from the studies carried out by the Engineer.

The Contractor shall review these studies and check the corresponding indications.

The same applies to equipment selection, for which the information given in this document must be deemed as indicative and defines only the minimum requirements.

34.1.3 Applicable standards

- Jordanian National Codes
- Requirements of civil defence department in Jordan, as the Authority Having Jurisdiction (AHJ)
- ASME Section VIII DIV I-2007: Rules for Construction of Pressure Vessels.
- ASME Section.IX-2010: Qualification Standard for Welding and Brazing. Procedures, Welders, Brazers, and Welding and Brazing Operators.
- ASTM A27/A27M-08: Standard Specification for Steel Castings, Carbon, for General Application.
- ASTM A31-04 (2009): Standard Specification for Steel Rivets and Bars for Rivets, Pressure Vessels.
- ASTM A36/A36M-02 (2001): Standard Specification for Structural Steel.
- ASTM A53/A53M-07 (2007): Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.
- ASTM B75–02: Standard Specification for Seamless Copper Tube.
- ASTM B88–09: Standard Specification for Seamless Copper Water Tube.
- ASTM A105/A105 M-10: Standard Specification for Forgings, Carbon Steel for Piping Components.
- ASTM A126- 04(2009): Standard Specification for Gray Iron Castings for Valves. Flanges and Pipe Fittings.
- ASTM A131/A131M–08: Standard Specification for Structural Steel for Ships.
- ASTM A135/A135M– 09: Standard Specification for Electric-Resistance-Welded Steel Pipe.
- ASTM A139/A139 M-04 (2010): Standard Specification for Electric-fusion (Arc)- Welded Steel Pipe.
- ASME/ANSI B36.10/19: Carbon, alloy and stainless pipes.
- ASTM A181/A181M-06: Standard Specification for Forgings, Carbon Steel for General Purpose Piping.
- ASTM A234/A234-10M: Standard Specification for Piping, Fitting of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
- ASTM B251-02e1: Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube.
- ASTM A285 / A285M – 03 (2007): Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength.
- ASTM A307-04e1 (2004): Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
- ASTM A434 - 06 Standard Specifications for Steel Bars, Alloy, Hot-Wrought or Cold-Finished, Quenched and Tempered.
- ASTM A453 / A453M–10: Standard Specification for High-Temperature Bolting, with Expansion Coefficients Comparable to Austenitic Stainless Steels.
- ASTM A615/A615M-09b: Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
- ASTM A516 / A516M – 06: Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
- ASTM A668/A668M-04 (2009): Standard Specification for Steel Forgings, Carbon and alloy, for General Industrial Use.
- ASTM A795 / A795M – 08: Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use.
- ASTM B61-08 (2008): Standard Specification for Steam or Valve Bronze Castings.
- ANSI/AWWA D100-05 (2006): Welded Steel Tanks for Water Storage AWS.
- AWWA D102-03 (2003)*:* Painting Steel Water Storage Tanks.
- ANSI/AWWA D103-09 (2009): Factor-Coated Bolted Steel Tanks for Water Storage.
- ASME/ANSI B16.1 (1998): Cast Iron Pipe Flanges and Flanged Fittings.
- ASME B16.3 (2006): Malleable Iron Threaded Fittings.
- ANSI/ASME B16.4 (2006): Gray Iron Threaded Fittings.
- ANSI B16.42 (2005): Cast Iron Pipe Flanges and Flanged Fillings.
- ASME B16.5 (2003): Pipe Flanges and Flanged Fittings.
- ANSI B16.18 (2001): Cast Copper Alloy Solder Joint Pressure Fittings.
- ANSI/ASME B16.9 (2007): Factory-Made Wrought Buttwelding Fillings.

- ANSI B16.22-2001 (R2005): Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- ANSI B16.25 (2007): Bullwelding Ends.
- ANSI/ASME B16.4 (2006): Gray Iron Threaded Fittings, Classes 125 and 250.
- ANSI/ASME B31.1 (2010): Power Piping.
- AWS 010.9-69: Qualification of Welding Procedures and Welders for Piping and Tubing.
- ANSI/AWS B2.1/B2.1M (2009): Specification for Welding Procedure and Performance Qualification.
- ANSI/IEEE C2 (2007): National Electrical Safety Code.
- MSS SP-58-(2009): Pipe Hangers and Supports-Material, Design, Manufacture, Selection, Application, and Installation.
- NEMA ICS-6-1993 (R2001, R2006): Enclosure.
- NEMA MG1-(2009 Rev 1-2010): Motors and Generators.
- NFPA-12- (2008): Standard on Carbon Dioxide Extinguishing Systems.
- NFPA-13- (2010): Standard for the Installation of Sprinkler Systems.
- NFPA-14- (2010): Standard for the Installation of Standpipe and Hose Systems.
- NFPA-15- (2007): Standard for Water Spray Fixed Systems for Fire Protection.
- NFPA-20- (2000): Standard for the Installation of stationary pumps for Fire Pumps.
- NFPA-22- (2008): Standard for Water Tanks for Private Fire Protection.
- NFPA-24- (2010): Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
- NFPA-25, Standard for Inspection, Testing, and Maintenance of Water Based Fire Protection Systems.
- NFPA-37- (2010): Standard for the Installation and use of Stationary Combustion Engines and Gas Turbines.
- NFPA-70- Ed. 2008 (2011): National Electric Code.
- NFPA-72-(1999): National Fire Alarm and Signaling.
- NFPA-72E-(1997): Standard for Automatic Fire Detectors.
- NFPA-221, Standard for Fire Walls and Fire Barrier Walls.
- NFPA-780- (19979: Installation for lightning protection.
- NFPA-1901- (2009): Standard for automotive fire apparatus.
- NFPA-1963-(2009): Standard for Fire Hose Connections.
- NFPA 5000, Building Construction & Safety Code.
- OSHA, Code of federal regulations, Title 29, Part 1926.
- BS EN 671-1 for fixed firefighting system.
- BS 5041-3 for dry riser inlet.
- BS EN 54 Standard for installation of Fire Alarm System.

34.1.4 QUALITY ASSURANCE:

A) MANUFACTURER:

1) The manufacturer of the deluge system components and equipment shall have a minimum of (10) years' experience in the design and manufacture of similar types of firefighting systems and who refer to similar installations providing satisfactory service.
2) The name of the manufacturer, part numbers and serial numbers shall appear on all major components
3) All devices, components and equipment shall be the products of the same manufacturer as long as possible.
4) All devices, components and equipment shall be new, standard products of the manufacturer's latest design and suitable to perform the functions intended.
5) All devices and equipment shall be U.L listed and/or FM approved.
6) Locks for all cabinets shall be keyed alike.

B. INSTALLER:

1) The installing contractor shall be trained by the supplier (The local manufacturer's authorized distributor in Jordan) who must be authorized, factory trained to design, install, test and maintain fixed spray system, also the supplier must submit on request all required documents the manufacture's authorization to supply, test, commissioning. Also, the supplier shall indicate documents, that he is able to provide spare parts may require in future.
2) The installing contractor shall be an experienced firm regularly engaged in the installation of deluge system in strict accordance with all applicable standards.
3) The installing contractor shall be authorized by the Civil Defense to carry out fire protection system installation Works.
4) The installing contractor must have a minimum of ten (10) years' experience in the design, installation and testing of fixed spray system. A list of systems of a similar nature and scope must be provided on request.
5) The installing contractor shall be an authorized stocking distributor of the fixed spray system equipment so that immediate replacement parts are available from inventory.

6) The installing contractor shall show proof of emergency service available on a twenty-four hour, seven-day-a-week basis

34.2 SCOPE DESCRIPTION

The contractor shall furnish all Design, labour, materials, tools, supplies, equipment, transportation, supervision, technical, professional and other services, and shall perform all operations necessary and required to satisfactorily complete all the necessary engineering, procurement services, construction work and commissioning for the fire protection system and equipment for the project.

34.2.1 Scope of supply and work

Equipment, accessories and services making up the scope of supply of the present specification are as follows.This specification covers the Design, supply, delivery and complete installation, testing and commissioning on site and in full working order of the equipment specified in this document and/or shown on the drawing.

Any deviations from the specification must be fully and clearly indicated in the tender submission schedules. The Contractor shall supply all materials necessary to make up effective and operable fire protection, detection and alarm systems for the transformers indicated in the drawings and according to specification, and particularly:

- All the necessary pipe work, valves, equipment and instrumentation required for the facilities.
- All electrical cable between panels, junction boxes, sensors, call points, pressure switches, alarm bells, flashing lights, and generally all the cable (and their supports) required for the facilities.
- Local alarms indicating actuation of the systems.
- All detectors, fire signaling and alarm cabling shall be installed by the Contractor using materials in accordance with international standards.

The main electrical supply to the Contractor's equipment will available in the LVAC room located inside the control building.

All instrumentation and electrical equipment will be enclosed to suit the Hazard Class of the area.

Hazardous Area Certificate will be required for each item supplied within the Hazardous Area.

The Contractor shall define in the quotation the full specification of every system proposed (pipe work, cables, equipment, …etc.).

Tubes and all items of equipment shall be delivered, stored and maintained in closed storage with their open ends effectively plugged, capped or sealed. All fittings, valves and sundry items shall be stored in clean bins or bagged and stowed in suitable racks.

All such stored items shall be maintained under weatherproofed cover to be supplied by the contractor until they are ready for incorporation in the works. Particular care shall be taken to ensure that electrical equipment and components are kept clean and dry.

Before installations are handed over or subjected to the inspection and tests, the entire installation shall be thoroughly cleaned, both internally and externally.

All fire protection installations shall be flushed out with clean water. During the flushing out, provision shall be made to exclude any items of plant, which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Engineer.

The Contractor shall also provide and install:

- The complete fire pumping station, including firewater pumps (pumps, diesel engines drive "if required", pump controllers, skid & pump), jockey pump (pumps, electric drive, electric drive controllers), piping & hanging, valves, check-valves, relief valves, fittings, instrumentation, storage fire water tanks and feeding controllers (valves & controllers).
- The firewater mains (open nozzles, sprinkler, standpipe & hydrant), including piping, fittings, hanging, block-valves & hydrants, fire department (Siamese) connections.
- The fixed spray (deluge) system, including the control valves, piping, hanging, heads and instrumentation.
- The hose reels (standpipes, hose connections, external hose streams).
- The marking of all the safety equipment. The Contractor shall be responsible for all aspects of the provided systems.
- The checking of the tender drawings and any calculations "if available" supplied with the drawings. The Contractor shall check each drawing and satisfy himself that his design is correct for the equipment offered and will meet all applicable rules and regulations.
- The provision of any additional information required by the Contractor's installation engineers which are particular to the equipment being supplied, e.g. fabrication drawings, equipment data sheets, commissioning instructions etc.
- The provision of drawings and equipment data related to the systems as required by the Engineer.
- The supply of all required equipment and other fixtures associated with the systems.
- Shop testing of equipment and provision of inspection facilities.
- The provision and fittings of suitable wall boxes, transits and plates where pipe work or cable passes through walls, etc...as well as fire rating reinstatement materials.
- The supply of as built drawings and as built calculations.

- The provision of scaffolding, ramps and any other equipment required to enable the systems to be installed, tested and commissioned correctly.
- A demonstration to key personnel in the use and testing of the systems and equipment supplied.
- Operating and maintenance manuals.

34.3 Supplies included

34.3.1 General supplies

The supplier must provide the following, except where this is otherwise indicated by NEPCO:

a) Equipment and accessories, as detailed in paragraphs 3.2.1 to 3.2.9.
b) Engineering and technical support.
c) Design, manufacturing isometric drawings for piping ,supports & all system components, in addition to calculations and list of materials.
d) Anticorrosive paint and coatings.
e) Data plate for each system components.
f) Electrical and control wiring diagrams.
g) Installation, operation and maintenance manuals.
h) Factory tests.
i) Spare parts and special tools tests.
j) Assembly Service.
k) Assembly supervision and final commissioning tests.

34.3.2 Fixed water spray system

34.3.2.1 Steel suction tank

The steel suction tank must be above ground installation at floor level, the Qc/QA shall be the responsibility of the contractor including Non-destructive tests such as: penetrant tests, Ultrasonic tests and Radiographic tests where these tests shall be witnessed by NEPCO engineer and QA/QC documents shall be submitted after finishing tests and. Moreover, the filling test for tank and delivering tank filled with potent water shall be the responsibility of the contractor. the the steel suction tank shall include but not limited to the following:

a) External stair from hot -dip galvanized steel
b) Internal stair from stainless steel.
c) Hatch for access to the interior.
d) Valves room.
e) Discharge pipe with gate valve (Outside Screw and Yoke, OS & Y).
f) Filling Water Pipe.
g) Recirculation pipe
h) Level gauges
i) Glass water level indicator with proper weather proof housing.
j) Overflow pipe.
k) Ventilation.
l) Cathodic protection.
m) Inner and exterior anticorrosive painting.
n) Recirculation pipe for testing purpose.
o) Level switches.
p) Anti-vortex plate.

34.3.2.2 Water pumping system

a) Main fire pump driven by electric motor, including the automatic controller equipment.
b) Secondary fire pump, driven by internal combustion engine, or driven by electric motor.
c) Pressurizing pump water (Jockey pump), including the starter and automatic control.
d) Design and construction drawings of water supply system for fire fighting pumps.
e) Pumps accessories and auxiliaries:
    - Strainers on pumps suction
    - Shutoff valves.
    - Check valves
    - Safety and relief valves
    - Return valves,
    - Relief valves
    - Air release valves.
    - Manometers.
    - Pressure gauges
f) Fire hose coupling for pump test, and other accessories that make up the pumping system.
g) Hose valve head for pump testing, including water and hoses spending measuring devices.
h) Measuring instruments and control switches.
i) Special Tools for Maintenance
j) Spare parts.

34.3.2.3Water pipes and spraying nozzles heads

a) Water main pipe and its accessories.
b) Rising main pipe to spray systems.
c) Spray nozzles pipes.
d) Structures and piping supports.
e) Reinforced concrete bases around the transformer to ensure the stability and proper support of the supporting and piping system.
f) Control valves.
g) Deluge valve complete with all necessary trimming, and including fast operation devices.
h) Fire rated wall to provide protection for the deluge valve set.

34.3.2.4 Pressure Tank (optional)

The pressure tank to supply pressurized water to spray systems should include the following:

a) Level indicator.
b) Manometer indicator.
c) Water filling pump.
d) Air compressor.
e) Discharge pipes, (check) retaining and control valves.
f) Relief valve.
g) Access chamber. (Checking manhole).
h) Emergency drain valve.
i) SCADA (Supervisory Control and Data Acquisition) System Alarm and supervisory service.

34.3.2.5 Fire Department connections to water supplying Public Service

Fire Department connections with water Public Service supply to combine the water supply pressure with the principal pipe:

a) "T" Pipe derivation in connection with water main pipe.
b) Hoses connections with fire department from water public service.
c) Check valves on each connection.

34.3.2.6 Water pipe system.

The water pipe system consists of, main pipe and upstream pipes to water nozzles. It shall include:

a) Indicating control valves.
b) Check valves.
c) Relief valve.
d) Pressure-reducing valves.
e) Pipe supports.
f) Water flow detectors (Indicates alarm only, not to start the pump).
g) Alarms.
h) Thermal insulation with aluminum cladding for all exposed pipe.

34.3.2.7 Water spray system

a) Water spray system for transformers fire protection
b) Water spray system for protection of neighboring areas through water screens (optional).

34.3.2.8 Automatic Fire Detection System

a) The system activation based on detecting the fire by receiving two signals one from weather proof-explosion proof **spot type heat detector** and the second from hydraulic signal from a separate pilot pipe line.
b) Automatic start controls of fire protection system.
c) Air compressor and accessories (if applicable).

34.3.2.9 Control system, Alarm and Supervision service.

a) Substation control room. Central control unit, consisting of the following principal elements:
   - Automatic / manual starting control circuits of fire protection system.
   - Visible indications of supervision service,
   - Visible lights and audible alarms,
   - Power supply for AC / DC control, including battery bank and automatic charger.
   - The control system will be connected to the panel PCI general control of the substation.
b) Pumps house. Local control units of pumping equipment, and shall have the following elements:
   - Manual starting controller of main fire pump (electric motor)
   - Automatic/ manual starting controller of emergency fire pump (diesel motor or electric motor).
   - Power supply for AC / DC control, emergency battery bank for control, supervision and alarms service, including its battery charger.
   - Automatic / manual starter of pressurizing pump (Jockey pump).
   - Automatic / manual starter of air compressor. (if applicable).

34.3.2.10 Civil work equipment in the pump house

Based on the installation drawings of equipment, to be provided by the supplier & the instructions of the client, the contractor shall be fully responsible for carrying out all necessary works in the pump house to

ensure the proper installation of the firefighting system and the connection of the pipes to the water tank and to the pipe network. This includes but not limited to providing all civil works related to the following:

a) Connecting Pumps suction pipes to the water tank and connecting the discharge line to the firefighting system downstream pipe network.
b) Foundations and anchor bolts and pipe equipment.
c) Drainage system.
d) Installing the recirculation (testing) line.
e) Connecting the Siamese pipe to the system.
f) Supporting system.
g) Sleeves/trenches for the power cables and control/signals cables.

And any other required works to ensure the proper operation of the system.

34.3.2.11 Installation of equipment

Based on drawings and installation instructions that are proposed by the supplier & the instruction of the client, the following work will be carried out:

a) Installation of pumps and other equipment to be installed in the pump house.
b) Installation of equipment and control stations, electrical wiring, including AC power supply.
c) Installation of water pipes including all necessary components and accessories, and including pipes spray nozzles heads.
d) Installation and connection of automatic fire detectors.
e) Support system.

34.3.2.12 Local communication system

a) Local intercom, between central control station & NCC, pump house and transformer bay.
b) Transmission of alarm and problem signals to local station.

34.3.2.13 Electricity

The contractor shall provide AC Power supply to the firefighting system from low voltage room inside the substations control building.

34.3.2.14 Transmission of alarm and faults of the firefighting system to the telecommunication room or the PLC room.

The contractor shall provide all means to transmit alarm and fault signals of the firefighting system to the telecommunication room in the control building (RTU panels).

34.3.3 Supplies not included

34.3.3.1 Remote communication system from substation telecom room to the Nepco's National Control center**.**

34.3.4 Quality of Materials

Only materials/equipment meeting quality guidelines mentioned specifically for the products shall be subject to the approval of the Authorized Engineer. Wherever applicable, the system and material is to comply with the relevant International Standards such as NFPA, British Standards/Vds. All Materials and equipment should have at least been certified by two independent Certification Organizations from International Testing Laboratories & Accredited Certification Bodies, one of these Certification Organizations shall be UL listed and/or FM approved and the other shall be LPCB/ BSI Kitemark/Vds.

34.3.4.1 APPROVAL LISTING OF MATERIALS

The material/equipment shall have been tested and, where applicable, shall have been granted a certificate of approval or listing for the intended service. UL listed, FM approved, BSI Kitemark,Vds approved equipment shall be used.

The Contractor shall supply only proven and established material/equipment which is suitable for the duty. The Employer reserves the right to call for either substitute or alternative units, or to nominate manufacturers or models for any class of material/equipment.

34.4. General features and design criteria

34.4.1. Generals

34.4.1.1 Conformation of fixed water spray system

The firefighting water spray system for protection of transformers in outdoor facilities, shall consist of a piping system and a double (interlock) knock deluge fixed spray system based on the supply of pressurized water by pumps up to the automatic control valves, to which the open-type spray nozzle header pipes are connected. In response to signals from the automatic fire detection system and the pressure switches, the automatic control valves shall open, discharging water through all nozzles simultaneously and fully covering the transformer being protected.

34.4.1.2. Specifications for system design

The systems and equipment covered by these specifications shall be designed and built under the conditions indicated in Chapter 5, components of spray system and their specific design, as well as the Particular Specifications defined by NEPCO.

34.4.2 Design general features

Based on the requirements for the water spray extinguishing system indicated in chapter 4.1.2., the general features of the spray system shall:

a) Detect fire quickly and accurately.
b) Be capable of starting the extinguishing system quickly and automatically and manually, in order to extinguish the fire during its initial phase.
c) Be reliable in startup response, and provide stable spray characteristics.
d) Offer high fire extinguishing and fire intensity control features in all environmental conditions, especially under strong wind.
e) Prevent secondary damage to equipment and adjacent facilities, through the heat-prevention barriers.
f) Offer high security when sprinkling water to electrically energized parts.

34.4.3. Design general criteria

34.4.3.1 General arrangement of transformers bays

The design of the water spray system shall take into account the following facilities in the transformer bays, the details of which are indicated in the Particular Specifications drawings:

a) Firefighting walls, which separate transformers from each other to prevent a fire in one transformer extending to the one next to it also the fire wall will separate the transformer from the buildings.
b) The transformer bench, concrete basin and tank, to collect possible oil and water spills.
c) Gravel backfilling in transformer basins.

34.4.3.2. Main transformer protection and fixed water spray capacity

The capacity of extinguishing or water spray systems for protecting transformers shall be determined based on that required by the larger demand transformer unit installed in the protected area, considering it as the main design object.

34.4.3.2. Protection of auxiliary transformers and other equipment under protected area

The water spray extinguishing system shall be designed for the largest transformer unit and shall be made extensive to protect other areas with fire loads (wire tunnel, fuel tank, etc…) within the same substation.
Smaller fire risk areas to be protected shall be indicated by Nepco in the Particular Specifications.

34.4.3.4. Water spray unit area

Water spray shall be limited to each transformer unit, considered as a unit in the area to protect.

34.4.3.5. Protection of adjacent areas

The protection of adjacent equipment and facilities shall be considered, using the criteria for establishing well defined fire protection areas, including the protection against secondary damage and fire propagation.

34.4.3.6 Water spray system protection levels

Fire protection using water spray shall cover the following protection levels.

a) Fire extinguishing. (Transformer protection)
b) Fire intensity control. (Transformer protection)
c) Protection of exposed surfaces. (Transformer protection)
d) Protection of exposed surfaces. (Protection of adjacent equipment and facilities).
e) Protection of adjacent areas using heat radiation barriers. (Protection of equipment and facilities in adjacent areas).

34.4.3.7 Submittals

The installing contractor shall submit the following design information and drawing for approval prior to starting work on this project.

34.4.3.8 Product Data

Calculation sheets in addition to field installation layout drawings having a scale of not less than 1:100 m detailing the location of all equipment, pipe runs including pipe sizes and lengths, controls and other accessories, Auxiliary details and information such as maintenance panels, door holders, special sealing requirements and equipment shutdown.
Separate layouts, or drawings, shall be provided for each transformer for mechanical and electrical work.
A separate layout or drawing, shall show isometric details of piping system supporting details and proposed pipe runs and sizes.
A detailed 3D drawing of the system.
Electrical layout drawings shall show the location of all devices and include point-to point conduit runs and a description of the method(s) used for detector mounting.
A complete sequence of operation shall be submitted detailing all alarm devices, shutdown functions, remote signaling, and water spray pattern for each system.
Submit drawings, calculations and system component data sheets for approval to the Local Fire Prevention Agency, and all other Authorities having jurisdiction before starting installation. Submit approved plans to the Engineer for record.

34.4.3.9 Drawings:

34.4.3.9.1 Shop drawings

The Contractor shall provide shop drawings for each system floorwise in detail as required by the engineer in charge and Authority having jurisdiction. It is the contractor responsibility to co-ordinate with other services while preparing the shop drawings and obtain approval from the engineer in charge.

34.4.3.9.2 AS BUILT DRAWINGS

Upon completion of each system, the installing contractor shall provide four (4) copies of system "As-Built" drawings and one softcopy (CD) to the owner. The drawings shall show actual installation details including all equipment locations as well as piping and conduit routing details. Show all room or facilities modifications, including details of the pump house. One (1) copy of reproducible engineering drawings shall be provided reflecting all actual installation details. These drawings shall be as accurate and complete as possible.

34.4.3.10 COMMISSIONING AND TESTING

Performance tests shall be carried out at site in the presence of Civil Defense personnel. All tests shall be carried out in the presence of the Employer's, insurers or their nominated representatives. The Contractor shall provide all the necessary tools and equipment for testing and commissioning activities.

34.4.3.11 PROTECTION SYSTEMS APPROVAL

It is the responsibility of the Contractor to submit the fire protection systems design, to obtain the Authority approval prior to the commencement of work and to implement the Authority requirements. The Contractor shall also submit the 'As Built' drawings to the Authority and make necessary arrangements for Final Inspection & Testing and obtain the final No Objection Certificate (NOC) and approval from the concern Authorities.

34.5 Components of water spray fixed system and specific design

34.5.1 General

34.5.1.1. Control and Measurement Instruments

a) High quality instruments. All control and measurement instruments used in the fire protection system shall be of a UL listed and FM approved and of recognized brand and quality.
b) Indication of measurement units in accordance with General Measurement System of Units rules for all measurement instruments.

34.5.1.2. Data Plate

The fire protection system and each part of the equipment it comprises shall be provided with a data plate, made of stainless steel, attached to a visible location, providing information regarding the name of the unit, manufacturer, serial number, technical specifications and year of manufacturing.

34.5.1.3. Coatings and finishes

34.5.1.3.1. Electric cabinets, equipment and appliances

All panels and electrical cabinets of equipment, devices and accessories shall have protective coating and finish, as indicated in the NEPCO Particular Specifications or as required by the Engineer.

34.5.1.3.2 Valves and piping

For all valves and piping, pipe supporting structures shall be given an anticorrosive coating.

34.5.1.4 Packing and shipment procedures

The supplier shall prepare and submit the packing and shipment procedures for NEPCO approval.

34.5.2 Water tank

34.5.2.1 Suction steel tank

a) Construction rules. The water suction tank shall comply with provisions in NFPA-22.
b) Welded steel tank. The suction tank shall be preferably made of welded steel, and comply with ANSI/AWWA D100-05 specifications.
c) Bolt-up steel tank. A bolt-up steel tank may be used in special ground level construction scenarios, in which case it shall comply with ANSI/AWWA D103-09 specifications.

34.5.2.1.1. Tank Capacity

Unless otherwise specified by Nepco, the net tank capacity, considered between the overflow pipe and the level of the antivortex suction plate, shall store at least the amount resulting from calculating the required flow rate, for a period of one hour minimum and subjected to the approval of the AHJ.

34.5.2.1.2. Shape of the tank: Shape of tank: The steel suction tank can have any desired shape.

34.5.2.1.3. Materials: The materials to be used in the construction of the suction tank shall comply with the provisions set forth in table 1.

Table 1 Suction tank materials

Concept	Specification
Steel plates	ASTM: 1.- A36/A36M-02, A434 - 06: Grado A, B, C y D. 2.- A131/ A131M – 08, A285 / A285M – 03: Grado A, B y C. 3.- A516 / A516M – 06:Grado 55 y 60.
Structural profiles	ASTM: A36/A36 M-02 and A31-04 :Grado A y B.
Tubular columns	ASTM: A139/A139 M-04 and A53/A53M-07: GradoB.
Bolts, anchoring bolts, rods	ASTM: A 307-04e1: Grado A y B.
Pipe components General usage Pipe components	ASTM: A181/A181A M-6 A668/A668M-04 : Clase 60 y 70 A105/A105 M10: Clase B
Cast parts	ASTM: A27/A27M-08: Grado 60-30, revenido
Reinforced steel parts	ASTM: A615/A615M-09b : Grado 40 ó 60
Contribution electrode rods	AWS: Acero al carbon E60XX o E70XX

34.5.2.1.4. Design Loads

34.5.2.1.4.1. Dead Load

The base unit mass shall be considered as 7.849 Kg/m^2 for steel, and 2.307 Kg/m^2 for concrete.

34.5.2.1.4.2 Live Load

Under normal conditions, the load shall consider the water mass at the point of spillage through the overflow pipe on the upper part of the tank, assuming a unit mass of 1000 Kg/m^2. Should the tank roof have an inclination of less than 30 degrees it shall be designed to withstand a uniform mass of 122 Kg/m^2 in the horizontal projection plane.

34.5.2.1.4.3. Wind Load

Under conditions of up to 162 Km/h, wind load shall be considered at a pressure of 147x10^{2}kPa over the vertical plane or 88x10^2 kPa over projected areas in cylindrical surfaces. In the case of winds above 161 Km/h, load shall be readjusted in proportion to the square of wind velocity.

34.5.2.1.4.4 Seismic load

In suction tank design, the provisions set forth on seismic loads shall be applied.

34.5.2.1.4.5 Loading balcony and stairs

All structures and connections shall be designed to support the following loads:

a) Vertical load of 4454 N for every 0.93 m^2 of the loading balcony or platform.
b) Load of 2227 N for every 0.92 m^2 of balcony and platform projected over the tank roof.
c) Load of 1550 N for every section with load caused by snow.

34.5.2.1.5. Unit effort

34.5.2.1.5.1. Maximum effort

The maximum efforts produced by loads shall not exceed the following values indicated in table 2.

Table 2. Maximum efforts

Stress applied to:	Value
A net section	103.43 MPa
Anchoring bolt	103.43 MPa
Bending applied to:	
Stress over external fibres, except for column seating plates.	103.43 MPa
Column seating plate	137.90 MPa
Compression on extreme fibers of laminated profiles and for plate-web beams and composite elements for values of: (I.d/b.t) not exceeding 600 (I.d/b.t) exceeding 600	 103.43 MPa 62.055 MPa

34.5.2.1.5.2. Stress Increases

When calculating wind load and seismic efforts, the permissible work units may be increased by 25 %, as long as the resulting section is not less than the dead load and live load on its own.

34.5.2.1.6. Design details

5.2.1.6.1 Minimum thickness of steel plates in contact with water.

Tank plates in contact with water shall have a minimum thickness, as specified in table 3.

Table 3. Minimum thickness of plate in contact with water.

	Tank diameter (m)			
	15,24	15.24 to 36.58	36.58 to 60.98	60.98
Base ring	6.2 mm	6.4 mm	7.94 mm	9.5 mm
Upper rings	4.76 mm	6.4 mm	7.94 mm	9.5 mm

34.8.5.2.1.6.2. Additional thickness due to corrosion

If interior bracing is required to support the water content, 1,6 mm additional thickness shall be added to the calculated sections. Tubular sections shall be hermetically sealed to prevent internal corrosion.

These profiles support is those that give rigidity to the tank.

34.5.2.1.6.3. Thickness of the plating tank.

a) Thickness design: Tank plates or sheets shall be designed based on the maximum efforts or under membrane tension, which may be reduced by the efficiency of the joint as indicated in ANSI/AWWA D100.5 standards.
b) Minimum thickness: The thickness of tank base plates shall be such as not to suffer deformation, and in no case shall be less than the values specified in table 4.

Table 4. Minimum thickness of tank base steel plates (mm)

Type of support		Depth of water (m)											
		3.05	3.66	4.27	4.88	5.49	6.10	6.70	7.32	7.92	8.53	9.14	12.19
Distance between Beams (m)	3.66	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	9.5
	4.27	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	9.5	9.5	11.1
	4.88	7.94	7.94	7.94	7.94	7.94	7.94	9.5	9.5	9.5	9.5	9.5	11.1
	5.49	7.94	7.94	7.94	7.94	9.5	9.5	9.5	9.5	11.1	11.1	11.1	12.7
	6.10	7.94	7.94	9.5	9.5	9.5	11.1	11.1	11.1	11.1	11.1	12.7	14.3
	7.32	9.5	9.5	11.1	11.1	11.1	12.7	12.7	12.7	14.3	14.3	14.3	17.5
Slab or flattened earth		6.4	6.4	6.4	6.4	6.4							

34.5.2.1.6.4. Strengthening tank openings

All tank hull openings greater than 102mm in diameter shall be reinforced with flanges and accessories.

34.5.2.1.6.5. Tank top

a) Installation of tank roof. The suction tank shall have its own roof.
b) Design of tank roof supports. Tank roof supports that are not in contact with water shall be designed in compliance with construction specifications.

34.5.2.1.6.6. Folding the steel plates

Steel plates shall be cold formed to provide the tank with suitable curvature, as per table 5.

Table 5. Minimum diameter of steel plate bending

Plate thickness (mm)	Minimum curvature diameter (m)
Less than 9.5	12,2
Between 9.5 and 12.7	18,3
Between 12.7 and 15.9	36,6
15.9 and above	Bending required for all diameters

34.5.2.1.6.7. Anticorrosive coating the bottom plating

The lower side of all tank bottom plates shall be protected against corrosion by one of the following methods:

a) Anticorrosive paint: Apply to coats of anti-corrosive paint after welding is completed.
b) Oil saturated sand: Mount the bottom of the tank over a layer of petroleum-based oily sand, with a thickness of 102 mm.

34.5.2.1.7. Tank connections of pipes and fittings

34.5.2.1.7.1. General

(I) Steel pipe:

a) Standards. Steel pipes shall comply with ASTM A53/A53M , type EFS, grade A or B.
b) Measurements. Pipes in contact with water shall comply with the following:
- Do not use pipes less than 51 mm.
- Extra strong for pipes between 51 and 127 mm.
- Normal mass for pipes greater than 152 mm.

See Table 8, the piping material. Paragraph 5.4.1.3.1. Piping material

(II) Tank pipes connections:

The supplier shall submit for Nepco´s approval information related to the method for connecting pipes to the suction tank. The information shall include:

a) Use and measurements of all pipes.
b) Location
c) Types and sizes of valves

34.5.2.1.7.2 Tank ventilation

a) Effective ventilation: When the steel roof is essentially closed to air passage, effective ventilation shall be arranged above the maximum water level. Cross section of the ventilation pipes shall be equal to the cross section of the discharge pipe.
b) Ventilation screen. A corrosion proof screen or a plate with 9.5 mm drilled holes, shall be installed in the tank ventilation, in order to prevent the entry of birds or other animals, offering a net passage area of 610 mm equal to the ventilation opening.

348.5.2.1.7.3. Roof manhole

a) Manhole: A door or hatch shall be installed on the tank roof, of easy access, provided with a steel cover, and a minimum diameter 610 mm. The cover shall include a retainer latch to maintain it closed.
b) Hatch for extraction fan: An additional hatch or flanged opening shall be provided in the center of the tank or near it, with a removable cover, of a diameter of 610 mm and a neck of 102 mm in height. The opening of the hatch shall be built such as to be able to install an extraction fan, secured with 4 bolts.

34.8.5.2.1.7.4. Stairs

(I) External Stairs:

a) Measurements: The external stairs of the tank shall be fixed, with separation of at least 178 mm between the tank and the centre bar line, rigidly secured with bolts or welding to the corbel or brackets, which in turn shall be welded to the tank plates. The lower support of the ladder shall not be more than 1.8 m above that of the tank, and the ladder shall be extended over the tank's hull and around the roof up to the hatch and tank ventilation, with the last corbel located in front of the balcony, approximately 0.61 m from the hatch.
b) Safety handrail: All ladders shall be equipped with a handrail or other safety device of a type commonly used in ladders.

(II) Interior Stair: The fixed interior stair, intended to get from the hatch to the bottom of the tank, shall not be rigidly connected to the bottom.

34.5.2.1.7.5 Lightning protection

Tanks shall be supplied with lightning rods, and their installation shall comply with provisions set forth in NFPA 780.

34.5.2.1.7.6. Water level meter

a) Level gauge: Suction tanks shall include a level gauge of suitable design, the level gauge shall be made of glass and protected using a weather proof material.
b) Level alarm: An electrical alarm shall be used to indicate high and low level.

34.5.2.1.7.7 Discharge pipe

(**I**) **Measures**: The discharge pipe shall be of a diameter not less than 152 mm, for tanks with a capacity up to 94.63m^3, not less than 203 mm for capacities of 113.55 m^3, and 254 mm for greater capacities.

(**II**) **Pipe materials**: The material of the discharge pipe shall be UL listed and FM approved, and of corrosion resistant material, in compliance with provisions set forth in chapter 5.2.1.8.1.

(**III**) **Rigid connection**: The pipe shall be rigidly connected to the tank, through welding; the upper part of the pipe inside the tank shall project from the tank wall. Outside the tank, the pipe shall be secured with supports.

(**IV**) **Control and retention valve:** he discharges pipe, near the tank, shall include a gate valve (Outside Screw and Yoke, OS & Y), with an indicator, and a horizontal check valve, UL listed and FM approved.

(V) Vortex plate: At the entrance of the discharge pipe, inside the tank, a horizontal plate shall be provided for the control of the vortex; it shall be made of steel, of a size of at least twice the pipe diameter, which shall be mounted at least half a diameter above the entrance of the loading pipe.

34.5.2.1.7.8. Water filling pipe

The suction tank shall be kept full at all times; should not be allowed a level of 0,80 to 1 m below the level of service.

a) Lateral passage line and check valve: Should the suction tank be filled by existing water pressure; the filler pipe shall be preferably a lateral passage of the check valve. The lateral passage line shall be of a measurement such that the tank can be filled in 8 h; in any case it shall not be less than 51 mm. You must have a gate valve (Outside Screw and Yoke, OS & Y), which shall open only when filling.
b) Water filling pump: When the tank is being filled with a pump, the pump and its connections shall have suitable measures for it to be filled in 8 h; in any case they shall not be less than 51 mm. The connection may be direct to the discharge pipe, in which case a gate valve (Outside Screw and Yoke, OS & Y) with fork and worm gear shall be installed on the pump side.
c) Automatic filling: Automatic filling may be used when employing a separate filling pipe direct to the tank.

34.5.2.1.7.9 Overflow pipe:

a) **Capacity**: The capacity of the overflow pipe shall be calculated so that it is, at least, greater than the filling pipe, and in any case not less than 76.2 mm.
b) **Location of pipe entry to the tank:** The entry of the overflow pipe shall be located at the top of the tank, determining the maximum tank capacity.
c) **Pipe discharge:** The overflow pipe shall be extended with a small variation in level to drain to the sump or basin that is nearest to the tank.

34.5.2.1.8 Painting

34.5.2.1.8.1. General Painting

On completing assembly of the tank, all external and internal surfaces shall be painted in compliance with the following scheme:

a) Interior paint:

- General cleaning: All interior steel surface of the tank exposed to water immersion or the area exposed to vapours, shall be cleaned using the blasting procedure SSPc-SP8, and primed as per indications in AWWA DI02 standards.
- Final coating: Any final paint coating for interior surfaces shall be in compliance with AWWA DI02 standards.

b) Exterior paint:

- Cleaning and priming: All tank exterior surfaces shall be prepared by commercial blasting SSPC-SP6 or chemical bathing SSPC-SP8, and primed with a coating of red paint, as per AWWA DI02.
- Final paint. All final exterior paint coating shall be compliant with AWWA DI02 standards.

34.5.2.1.8.2. Cathodic protection

Cathodic protection to be used as an internal anti-corrosion treatment of the tank.

34.5.3 Water pumping system

The pumping system must meet the specifications contained in the NFPA-20.

34.5.3.1 Fire Pumps

The fire water pump shall consist of the following units: pump, driving motor and controller, which shall operate as a complete unit. Fire pump manufacturer shall bear the unit responsibility for the total packaged fire pump set. Major components of fire pump set such as fire pumps, engines and controller shall be manufactured by a single manufacturer. Each pump with its engine or motor shall be assembled at factory. Factory performance test shall be conducted for fire pumps using actual job motor and actual job engine. Factory test shall not be conducted using suction pressure created by other systems. It shall be done at true suction pressure i.e. suction pressure based on water tank level. A certificate showing the results of this performance test shall be submitted for review and approval along with factory test curve. In addition to the performance test a string test should also be

conducted at factory with actual job pumps and actual job drivers along with their actual job controllers as a packaged-unit prior to dispatch. A certificate showing the successful completion of this packaged-unit string test shall also be submitted for review & approval. Fire Pumps should be covered by a warranty of 5 years from the date of the final testing and commissioning (when the system set to work). 12 years spare parts availability should be assured by the fire pump manufacturer.

The scope of work includes design, manufacturing, shop testing and supply of the Fire Pump Set.

The fire pump shall consist of Electric Motor driven pump to act as duty pump, and Electric Motor driven pump to act as secondary standby pump, in addition to Electric motor driven Jockey pump. Fire pumps shall be of UL listed and/or FM approved specifically to be used for fire protection. The fire pumps shall meet the requirements of NFPA 20 (Standard for the Installation of Stationary Pumps for Fire Protection).

The fire pump(s) shall be designed to deliver 150 % of the rated flow capacity at not less than 65% of the rated head in conformance to NFPA 20. Shutoff head shall not exceed 140% of rated head.

34.8.5.3.1.1. Main pump and emergency pump

The primary and secondary pumping system must have two pump units installed in parallel, to discharge onto a single collector, the main pump, which is driven by an electric motor operates under normal conditions and the other pump during an emergency to fulfil the requirements. In case of failure or malfunction of the power supply the switching, cabinet will switch to an essential load distribution board fed by diesel generator.

34.8.5.3.1.2 Pumps, capacity, type and characteristics

34.5.3.1.2.1 Pumps Capacity

Each firefighting pump unit shall be capable of operating at 150 % of its rated capacity; the rated capacity shall be determined by that required by the transformer of greatest capacity installed in the same protected area.

34.5.3.1.2.2. Types of pumps

The type of firefighting pumps shall be selected in accordance with suction conditions. Fire Pumps shall be of either Horizontal Split Case Centrifugal type or End Suction Centrifugal type, in accordance with NFPA 20 requirements, specifically labeled for fire service, capable of delivering the duties required by the fire protection system and suitable for the flooded suction (positive suction) condition where the liquid to be pumped is above the centerline of the pump suction flange:

a- Horizontal Pump: Centrifuge, spiral type, one single step, split casing and horizontal installation, for locations with positive pressure suction. Horizontal pumps shall not be used for cases when suction pumping is needed.

b- Vertical pump: Centrifuge, turbine type, multiple steps, vertical installation, to be used when water suction is located below ground level.

34.5.3.1.2.3. Discharge head-Spending characteristics

The load-discharge flow characteristics of any kind of firefighting pumps shall comply with the following:

a) The Head-discharge flow characteristics are defined by the rated capacity at 100 % flow required by the fire protection system.
b) Pumps shall be capable of operating at not less than 150 % of rated capacity without total load resulting less than 65 % of rated head.
c) Total shut- discharge head (churn) shall not exceed 140 % of rated head.

The supplier shall provide NEPCO with the head-flow, break power-flow, and efficiency-flow characteristic curves obtained during factory tests.

34.5.3.1.3. FIRE PUMP CONSTRUCTION

The pump construction shall be of end suction centrifugal type or horizontal split case centrifugal type.

For end suction pumps the pump casing shall be of extra heavy cast iron, with minimum tensile strength of 30,000 lbs and shall be radially split. Suction nozzle should be on the opposite side of the casing from the stuffing box and have the face of the suction nozzle perpendicular to the longitudinal axis of the shaft. Pump shall be of back pull-out design that permits removal of the bearing bracket, stuffing box and impeller without disturbing the piping. Flanges shall be as per ANSI B 16.1 Class 250, raised face type. For horizontal split case pumps the pump casing shall be of extra heavy cast iron, with minimum tensile strength of 30,000 lbs and shall be split parallel to the shaft. Bearing housing supports, suction and discharge flanges shall be cast, bored and machined integrally with the lower half casing. Upper and lower half casings shall be dowelled and bolted together. Removable upper half casing must permit inspection or removal of the entire rotating assembly without disturbing the piping. Flanges shall be as per ASME B16.1 Class 250, raised face type.

The impeller shall be of Bronze enclosed single or double suction type both statically and hydraulically balanced. The impeller shall be keyed to a steel shaft (Stainless Steel AISI 420 or Alloy steel AISI 4340). The shaft shall be protected by steel sleeve(s) (Stainless Steel AISI 420). An O-ring shall be provided between shaft and sleeve(s) to prevent water leakage. The sleeve(s) shall be positive drive by means of an extended impeller key. The pump shall be equipped with bronze renewable casing wear rings to reduce casing wear and maintenance costs. The casing rings shall be hold by anti-rotational pins to permit easy reinstallation and reduce down time. The rotating element shall be mounted in grease lubricated ball bearings. Heavy cast glands shall be furnished on each stuffing box design for easy removal for packing inspection and maintenance Heavy fabricated steel base to mount the pump and driver shall be furnished. Flexible shaft jaw type coupling shall be furnished to connect the driver and pump. Coupling shall be enclosed in standard coupling guard.

34.5.3.1.4. Pumps accessories and auxiliaries

Firefighting pumps shall include all their accessories and auxiliary devices. The Fire Pumps shall be provided with the following accessories, as required by NFPA 20:

1. Flow Metering Device (One for complete fire pump package unit). It shall be of the Venturi type.
2. Air release valve (for each Horizontal Split Case fire pumps).
3. Suction pressure gauge (for each fire pumps).
4. Discharge pressure gauge (for each fire pumps).
5. Casing circulation relief valve (for electric motor driven fire pumps only).
6. Necessary spare part such as but not limited to bearing, backing, … ect.

34.5.3.1.4.1. Discharge pressure gauge

It must meet 89 mm diameter or greater, with pressure range twice the value to be indicated, in any case, not less than 1380 kPa.

34.5.3.1.4.2. Suction pressure gauge

It must meet 89 mm diameter or greater, with pressure range twice the suction pressure to be indicated, in any case it should be not less than 700 kPa.

34.5.3.1.4.3. Circulation relief valve

Each pump shall have an automatic relief valve listed for the fire pump service installed and set below the shutoff pressure at minimum expected suction pressure. The valve shall be installed on the discharge side of the pump before the discharge check valve. It shall provide flow of sufficient water to prevent the pump from overheating when operating with no discharge. Provisions shall be made for discharge to a drain. Circulation relief valves shall not be tied in with the packing box or drip rim drains. Minimum size of the automatic relief valve shall be 19.0 mm for pumps with a rated capacity not exceeding 9.462 L/min, and 25.4 mm for pumps with a rated capacity of 11,355 to 18,925 L/min.

34.5.3.1.4.4. Automatic air purge

The pumps must have an automatic air purging device, operated float type with a nominal size not less than 12.7 mm.

34.5.3.1.5. Suction pipe and accessories

34.5.3.1.5.1. Pressure capacity

The suction pipe must be rated pressure not less than required by the upstream branch piping installed in the transformers. In the case of two pumps, main and emergency, having in common the same suction pipe, required actions shall be provided in order that each pump receives its water supply proportionally.

34.5.3.1.5.2. Pipe measurement

Suction pipe measurement shall be such that pumps operating at 150% of its rated capacity, the pressure in suction flange must be 0kP, or greater, not exceeding water suction speed the value of 4.57 m / s.

34.5.3.1.5.3. Suction pipe installation

In general, the installation of suction pipe must avoid leakage and formation of air spaces.

Installation in cold weather areas: In case of plants placed in areas with cold weather, the suction pipe must be installed below the underground frost line or should be enclosed in a box for protection against freezing. Use of eccentric conical reduction: When pipe and pump suction flanges are not the same size, they must be connected through an eccentric conical reducer, in such a manner that avoids the formation of air spaces. Use of stress reliever device: When the pump suction and supply are mounted on separate bases and connected with rigid interconnecting piping, the pipe must be fitted with an effective stress reliever. Protection against corrosion inside and outside: The inner of the suction pipe must be galvanized steel, or it must be protected with paint recommended for submerged surfaces. The exterior of the visible pipe above ground installation should be protected with anticorrosive coating.

345.3.1.5.4. Shutoff valve

In suction pipe it must be installed a shutoff valve, Outside Screw and Yoke (OS & Y) gate type with indicator "super vision", no butterfly valves must be installed.

34.5.3.1.5.5. Suction screen filters

The passage of materials in the suction line that could clog the pump shall be obstructed by a system of screens. Double removable intake screens shall be provided at the suction intake. Below minimum water level these screens shall have an effective net area of openings of 645 mm2 for 3.785 L/min at 150 % of rated pump capacity. Screens shall be so arranged that they can be cleaned or repaired without disturbing the suction pipe. A brass, copper, Monel, stainless steel, or other equivalent corrosion-resistant metallic material wire screen of 12.7-mm mesh and No. 10 Brown & Sharpe (B. & S.) gauge wire shall be secured to a metal frame sliding vertically at the entrance to the intake.

The overall area of this particular screen shall be 1.6 times the net screen opening area.

34.5.3.1.5.6. Alarm device at suction pipe

Can be installed on the suction pipe or the supply of stored water, as applicable, appropriate arrangements to activate alarm "low level".

34.5.3.1.5.7. Anti-vortex plate

For pumps that supply water from a suction tank, it must be installed at suction entrance an anti-vortex plate.

34.5.3.1.6. Discharge pipe and accessories

34.5.3.1.6.1 Pressure Capacity

Rated pressure of components in the discharge section shall be suitable for the maximum work pressure they are subjected to, which shall not be less than the rated pressure of the firefighting system. All discharge pipes shall be hydrostatically tested in accordance with provisions set in section 6.

34.5.3.1.6.2. Discharge pipe measurement

The discharge pipe shall be such that, when the pump is operating at 150 % of its rated capacity, the velocity of water in the pipe does not exceed 6.2 m/s.

34.5.3.1.6.3. Check valves and shutoff valve

a- Check valve: A check valve shall be installed in the discharge pipe, UL listed and FM approved.

b- Shutoff valve: A shutoff valve shall be placed in each pump discharge after the non-return valve, supervised gate valve (Outside Screw and Yoke, (OS & Y) must be installed.

34.5.3.1.6.4. Relief valve

In order to prevent pump overheating, a relief valve shall be installed between pump impeller and the non-return valve. Overheating is due to discharge pressure plus static suction pressure exceeding the design working pressure in the event of operating the pump at zero flow (valve closed).

(I) Relief valve type: It may be of the loaded spring type or diaphragm type, operated by the pilot signal, and it must be set to a value that prevents the components of the fire protection system from being subject to a pressure greater than the pressure they can withstand; the valve shall not be less than that specified in table 7.

Pump Rating		Minimum Pipe Sizes (Nominal)						
Gpm	L/min	Suction (in.)	Discharge (in.)	Relief valve(in.)	Relief Valve Discharge(in.)	Meter Derive(in.)	Number And Size of Hose Valves (in.)	Hose header supply(in.)
25	95	1	1	¾	1	$1^{1/4}$	$1\text{-}1^{1/2}$	1
50	189	$1^{1/2}$	$1^{1/2}$	$1^{1/4}$	$1^{1/2}$	2	$1\text{-}1^{1/2}$	$1^{1/2}$
100	379	2	2	$1^{1/2}$	2	$2^{1/2}$	$1\text{-}2^{1/2}$	$2^{1/2}$
150	568	$2^{1/2}$	$2^{1/2}$	2	$2^{1/2}$	3	$1\text{-}2^{1/2}$	$2^{1/2}$
200	757	3	3	2	$2^{1/2}$	3	$1\text{-}2^{1/2}$	$2^{1/2}$
250	946	$3^{1/2}$	3	2	$2^{1/2}$	$3^{1/2}$	$1\text{-}2^{1/2}$	3
300	1,136	4	4	$2^{1/2}$	$2^{1/2}$	$3^{1/2}$	$1\text{-}2^{1/2}$	3
400	1,514	4	4	3	5	4	$2\text{-}2^{1/2}$	4
450	1,703	5	5	3	5	4	$2\text{-}2^{1/2}$	4
500	1,892	5	5	3	5	5	$2\text{-}2^{1/2}$	4
750	2,839	6	6	4	6	5	$3\text{-}2^{1/2}$	6
1.000	3,785	8	6	4	8	6	$4\text{-}2^{1/2}$	6
1,250	4,731	8	8	6	8	6	$6\text{-}2^{1/2}$	8
1,500	5,677	8	8	6	8	8	$6\text{-}2^{1/2}$	8
2,000	7,570	10	10	6	10	8	$6\text{-}2^{1/2}$	8
2,500	9,462	10	10	6	10	8	$8\text{-}2^{1/2}$	10
3,000	11,355	12	12	8	12	8	$12\text{-}2^{1/2}$	10
3,500	13,247	12	12	8	12	10	$12\text{-}2^{1/2}$	12
4,000	15,032	14	12	8	14	10	$16\text{-}2^{1/2}$	12
4,500	17,032	16	14	8	14	10	$16\text{-}2^{1/2}$	12
5,000	18,925	16	14	8	14	10	$20\text{-}2^{1/2}$	12

Table 7

(II) Relief valve free discharge: It shall discharge to an open pipe or inside a cone or funnel; water movement shall be visible. Water shall be guided and discharged outside the pump room through a pipe with a diameter not less than that specified in table 7.

(III) Relief valve location: The relief valve shall be located between the pump and the discharge check valve.

(IV) Relief valve return: When the supply of water to the firefighting pump is taken from a suction tank of limited capacity, the discharge of the relief valve and the pipe shall be of sufficient capacity so as to avoid a counter pressure exceeding the rated working pressure of the components of the fire protection system.

34.5.3.1.7. Water spending meter device

A testing circuit shall be connected to the firefighting pump impulse collector downstream from the cut-off and check valves, returning water to the tank. This test circuit shall be equipped with a volume-meter to measure flow, which allows verifying the characteristic curves of each pump.

34.5.3.1.7.1. Water spending meter

The flow-meter or fixed pipe for measuring the pump flow, as indicated in table 7, shall be capable of measuring not less than 175 % of the pump's rated capacity.

34.5.3.1.7.2. Water spending meter piping

a- Supplier measures: The whole piping in the testing system must be of dimensions as specified by the supplier and it shall not be less than that indicated in table 7.

b- Minimum measures: The pump flow test for positive displacement pumps shall be carried out using a flowmeter installed in a test loop back to the water tank. The flowmeter reading or discharge pressure shall be recorded and shall be in accordance with the pump manufacturer's flow performance data. Flow rates shall be as specified while operating at the system design pressure. Flowmeter should be installed according to manufacturer's instructions.

c- Straight sections: The length of the straight pipe section before and after the flow meter shall be aligned with manufacturer's specifications.

34.5.3.1.7.3 Hose Valves

(I) Types of valves: Hose valves shall be UL listed and FM approved; their number and size being determined as specified in table 7. Hose valves shall be mounted on a pipe header whose measurement shall also comply with table 7, and shall offer an external thread under NH standards as specified in NFPA 1963.

(II) Protection against freezing: In cases in which hose valve headers are located outside the pump house and may be prone to freezing, a gate or butterfly valve with indicator shall be installed, in the header pipe near the pump, and a drainage valve provided to water this section of pipe.

(III) Increased pipe length: If the pipe between pump and header valve is longer than 4.5 m in length, it shall be necessary to use the next pipe size as indicated in table 7.

34.5.3.2 Horizontal pump installation

34.5.3.2.1. Application and type

34.5.3.2.1.1. Horizontal pump application

Centrifuge pumps operate based on the centrifuge principle; in these pumps the motor or any other driving means, turns a propeller with its blades submerged in water and buried in a case. Water enters the case and immediately into the flow at the center of said impeller towards its ends or to the outer part of the case, where it quickly increases load pressure. Horizontal centrifuge pumps shall not be used where it is indicated that static suction needs to be provided.

34.5.3.2.1.2. Pump type

The horizontal pump shall be spiral type, two-part casing, one or more steps, in-line design.

a) The spiral receives the liquid from the impeller and transforms most of the kinetic energy into pressure energy. The transversal section of the spiral increases progressively within the 360 degrees arch described around the impeller.

34.5.3.2.2. Assembly base

The pump and driving motor shall be mounted on a common assembly base and be connected through a joint to absorb vibrations. The base plate shall be safely secured at its solid block, in order to ensure proper alignment between pump and motor.

34.5.3.3. Vertical installation pumps

The vertical centrifuge pump shall be used for cases of water level below ground level, for instance in cases when suctioning from an underground tank, dams and other open surfaces.

34.5.3.4. Pressurizing (Jockey) pump

The purpose of pressurizing (jockey) pumps is to maintain the entire installation pressurized in order to support small demands or leaks, if any should occur. The pump is controlled by a pressure switch, with automatic start and stop. It can also be started in manual mode; this pump is connected in parallel with the firefighting pump and it discharges into the same collector of the firefighting system.

34.5.3.4.1. Pump capacity and pressure

The Jockey pump capacity shall be not less than 1% of that of the fire pumps used in the fire pump unit; and pressure rating shall be equal to that of the same. The jockey pump together with its hidrofort tank shall have a capacity of not less than that required to cover all leaks that may arise. The contractor shall provide the technical data of the hidrofort tank and the pump unit. The discharge pressure shall be, consistent with the fire pump working pressure, the sufficient pressure to maintain the startup and the deluge system prepared for firefighting purposes.

34.5.3.4.2 Jockey Pump type, motor drive and starter

Type of pump: the Jockey pump shall be vertical multi-stage type with stainless steel (S.S. 316) chamber, stainless steel (S.S. 316) shaft, and stainless steel (S.S. 316) impeller and close coupled to a 2900 rpm totally enclosed fan cooled electric motor with class "F":

a) insulation and wound for a 415 volts 3 phase 50 Hz. power supply.

b) Type of motor: The driving electric motor shall be squirrel cage induction type, three-phase, 415 Vac, 50 Hz, external cooling.

c) Type of motor starter: The motor shall be controlled by a magnetic starter, at full voltage.

34.5.3.4.3 Pressure tank and accessories

34.5.3.4.3.1 Pressure Tank

The pressure tank installed in the pump discharge header shall be a vessel accumulating and regulating the pressure continuously exerted in the fire protection system pipe, maintaining it within a pre-established range.

34.5.3.4.3.2 Accessories

The pressure tank shall include the following accessories:

Purge valve, in the upper and lower part of the tank.

Maintenance inspection records log book.

Measurement and control header, including:

1-Indicator pressure gauge of front dial type, connected through 6.5 mm valve with a diameter of not less than 89 mm. The scale range shall be double the working pressure.

2-Safety valve.3-Pressure switches, in sufficient quantity to control the pump and alarm signaling.

34.5.3.4.4. JockeyPump auxiliaries

The pressurized pump shall have the following:

a) One check valve at the pump discharge.

b) Two butterfly or gate valve, with indicator "supervised".

c) Strainer on pump suction

34.5.3.4.5. Jockey pump control

Enclosure rating shall be NEMA 2.

The Jockey Pump Controller shall be listed and shall be relay logic based. Starting type shall be direct on line. Jockey controller shall have the following features:

- Main disconnected switch with rotary handle, sized for disconnecting motor horsepower and voltage.
- Motor Starter rated to motor's horse power, with thermal and short circuit protection.
- Rated motor contactors.
- Circuit breaker for protection of control circuit.
- Selector switch for Hand—Off—Automatic operation.
- Star—Delta starting timer (for controllers above 4 kW).
- Power ON/Healthy indicator/free contact.
- Pump Run indicator/free contact.
- Pump Trip indicator/free contact.
- Adjustable Pressure Switch or Pressure Transducer.
- Controller shall be rated for 415 VAC, 3 Phase, 50 Hz power supply.
- Controller shall be completely wired, assembled, programmed and tested at the factory before shipment, and ready for immediate installation.

Jockey Pump shall run either manually (by turning the selector switch to hand mode) or automatically. In auto mode, the Jockey Pump shall run automatically due to pressure fall in discharge line and it shall stop automatically when the pressure reaches to the set point. Pressure Switches or Pressure Transducers provided inside the jockey controller should be set accordingly.

34.5.3.4.5.1 Operation from central control station

Automatic start and stop: Operate automatically, through pressure switch, within the assigned pressure range, with the pressure switch set to automatic.

Manual start: By actuating on an instant operation switch, with the commuting switch in manual position. Supervision of the commuting switch: Raise the alarm when the commuting switch is in manual position.

34.5.3.4.5.2 Operation from pump hose and test line.

Manual start and stop. Using instant switch. Pump status supervision

34.5.3.5 Fire pumps electric operation

34.5.3.5.1 Electric power supply and conductor lines

The electric power supply to equipment in the pump room shall meet all the requirements indicated in NFPA 20 and NFPA 70.

34.5.3.5.1.1. Substation self-service feeder center

The firefighting system shall be supported by an electrical installation, which shall be designed to supply electricity and control signals, necessary for its proper operation. This installation shall be independent from any other electrical installation. Electricity supply shall be provided by the substation own services. The firefighting system shall include one or more alternative sources for emergencies, which shall automatically transfer and re-transfer between them.

34.5.3.5.1.2. Power conductor line

(I) Electric lines routing to pump house: Electrical conductors that feed pumps shall be physically conveyed through areas that do not have a fire load in the substation. When electrical conductors must run through a building, these shall be High Safety, offering a survival period of 90 minutes.

(II) Electric line drops voltage requirements: Conductors shall have sufficient capacity so that:

Motor voltage drop: Shall not suffer more than 5 % of rated value for motors, when the pump is operated at maximum power and assigned speed and the lines carry maximum load. Voltage drops in controller terminals: Under motor start up conditions, it shall not suffer a drop greater than 10% of controller voltage.

34.5.3.5.1.3 Pump house inner wiring

Any lighting inside the pump room shall be introduced in a metal conduit or in one flexible conduit which is sealed against humidity. The room will offer average lighting levels of 250 lux, at least, in pump areas, electrical switchboards and fire extinguishing system equipment; and 50 lux in the water tank area (if the tank is inside the room). In addition, it shall have emergency lighting that guarantees a level of lighting not less than 5 lux throughout the room, which shall be prepared to enter into operation automatically in the event of a general lighting failure or when its voltage drops below 70 % of its rated value. The installation of this lighting shall be fixed and equipped with own power sources offering an autonomy of 1 hour at least.

34.5.3.5.1.4 Feeder circuit diagram

Power supply to motors shall be configured as indicated in figure 1.

The contractor shall put the calibre of the circuit breaker, on the Nepco panel.

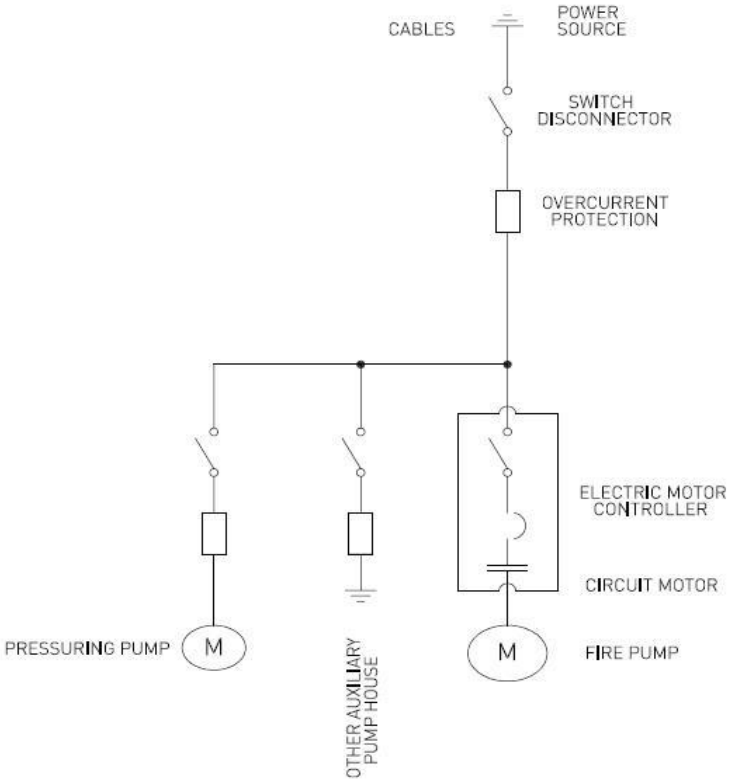


Figure 1

a- Exclusive feeder circuit: The feeder circuit of firefighting pumps shall be independent and exclusive, and shall not be affected by any other circuit or disconnection resources that are not specific of the same circuit.

b- Feeder line protection device: A means of disconnecting shall be provided to the feeder line in the substation auxiliary services cabinet. The means of disconnecting shall be accessible, ensuring it is not possible to disconnect in normal conditions, through the use of some kind of safety lock.
Protections installed in the feeder line shall not open the circuit at a current level equal to the sum of currents of the firefighting pump running at full load, the pressurized pump, the air compressor and other auxiliary services associated to the pumping system.

c- Electric line power rate: The main feeder line, from the source of energy to the firefighting pump motor, shall have a minimum conducting capacity equal to 125 % of the sum of currents at full load of the firefighting pump, the pressurized pump, the air compressor (if installed) and other services associated to the pumping system.

34.5.3.5.2 Fire pump electric motor

On installations where the Fire Pump is to be operated electrically, the electric motor shall be a horizontal, open drip-proof type, UL listed, wound for 415 V, 3 phase, 50 Hz (cycle) current. The motor capacity in horsepower shall be such that the maximum motor current in any phase under any condition of pump load and voltage unbalance shall not exceed the motor-rated full-load current multiplied by the service factor.
Fire pump electric motor ambient temperature rating shall be 40 deg. C and it shall be capable of operating continuously with an overload of 15% without stress or excessive rise in temperature. The locked rotor current shall not exceed the values specified in NFPA 20. Bearings shall be anti-friction ball or roller type.

34.5.3.5.2.1 Voltage and frequency

Asynchronous, in squirrel cage, three-phase 415 Vac, 50 Hz, with normal start up torque. Current of the blocked rotor at rated voltage and frequency shall not exceed values provided by the block codes A-G, as indicated in NFPA-70.

34.5.3.5.2.2 Continuous service: The motor shall have a capacity of continuous service, and its rated voltage and frequency shall not exceed, under any load condition, its current multiplied by the service factor.

34.5.3.5.2.3 Protection and cooling

The motor shall be totally sealed and cooled externally through forced ventilation.

34.5.3.5.2.4 Nameplate: The motor shall include a data plate and terminal identification plate as specified in NFPA 70 and NEMA MG-I.

34.5.3.6 Electric motor controller and accessories

The electric motor controller of the firefighting pump shall be UL listed and FM approved, fully comply with specifications in NFPA 20.
Enclosure rating shall be NEMA 2.
The Main Electric Fire Pump Controller shall be listed for fire protection use as per

NFPA 20 and shall be microprocessor based with star-delta open transition type starter. It shall have the following features:

• Voltage Surge Protector.
• Main disconnecting switch with rotary handle sized for disconnecting motor horsepower and voltage.
• Circuit breaker with shunt trip coil and rotary handle.
• Rated motor contactors.
• Emergency run mechanism to mechanically close motor contactor contacts to start motor in case of emergency.
• Manual start and stop push buttons.
• 20x4 LCD display showing all system parameters and variables.
• Software which would enable user to program all related parameters like timers, pressure, inputs and outputs.
• phase line voltages indication.
• phase line motor currents indication.
• Should indicate real value of discharge pressure.
• Should indicate motor running hours.
• Should indicate ambient temperature.
• Starting delay timer (should be programmable) for sequence multiple pumps starting.
• Automatic or manual shutdown after automatic start (should be selectable).
• Automatic shutdown mode enabled/disabled indicator.
• Power ON/Healthy indicator.
• Automatic mode indicator.
• Manual mode indicator.
• Motor Run indicator/free contact.
• Phase Loss/Failure alarm / indicator / free contact.
• Phase sequence error alarm/indicator / free contact.
• System error alarm / indicator / free contact.
• Fail to start alarm / indicator.
• System error alarm / indicator.
• Push button for alarm silence (should be only for additional alarms).
• Motor locked rotor trip at 600% of FLA, after programmable time delay.
• Programmable automatic weekly test, which should be able to program to start at any desired day, hour and minute in the week.
• Manual test push button.
• 10 additional programmable indicators (LED's).
• 10 additional programmable auxiliary digital inputs.
• 7 additional programmable output relays (free contacts).
• Pressure transducer with analog voltage output.
• Data logging system for pressure and events.
• USB port for saving recorded pressure and events on USB memory, and can be viewed with MS word and Excel.
• Electrically actuated built in discharge solenoid valve.
• Electrical alarm bell.

Controller shall be rated for 415 VAC, 3 Phase, 50 Hz power supply.

Controller shall be completely wired, assembled, programmed and tested at the factory before shipment, and ready for immediate installation

34.5.3.6.1 General

34.5.3.6.1.1 Controller equipment

The controller shall be specially approved for service of the firefighting pump impulse motor, and shall have a short circuit capacity of at least that of the circuit it will be used in.

34.5.3.6.1.2. Controller assembly and tests

All controllers shall be completely assembled, wired and tested by the manufacturer before shipping from factory.

34.5.3.6.1.3. Controller identification

The controller shall have a plate with the words "FIRE PUMP ELECTRICAL CONTROLLER", which shall clearly indicate the name of the manufacturer, identification and total electrical power.

In the event of multiple pumps protecting different areas or parts of the installation, the signs shall be placed close to the controller, indicating the zone or area of the system that controls the pump.

34.5.3.6.2. Contractor responsibility

The Contractor shall be responsible for performing any necessary procedures for controller unit adjustment services, either during installation, testing or the guarantee period.

34.5.3.6.2.1. Installation: All equipment shall be jointly installed in a single support structure.

34.5.3.6.2.2. Controller location: The controller assembly shall be located as close as practically possible to the motor it controls, ensuring direct visibility from the controller.

34.5.3.6.2.3. Controller protection: Controllers shall be placed or protected so that they are not affected by a possible leak from pump or its connections. The electrified controller parts shall be separated by not less than 12 in (305 mm).

34.5.3.6.2.4. Controller free spaces: For maintenance purposes, the controller shall maintain free spaces at the back of not less than 1.1m, and on one of the two sides of not less than 0.61 m.

34.5.3.6.3 Construction

34.5.3.6.3.1. Moisture and dust proof equipment

All controller assemblies shall be suitable for use in areas subject to a moderate degree of humidity. Operation shall not be negatively affected by normal accumulation of dust.

34.5.3.6.3.2. Assembly: All equipment included in the controller shall be firmly and permanently assembled over a simple and incombustible support structure.

34.5.3.6.3.3. Panel

The support structure shall be safely mounted on a panel, self-support, which shall protect equipment against mechanical damage and out of reach of water. The panel shall be made of steel plate, with protection against vertical drops and accessible from a front door with keyless handle, and the corresponding signs and indicators.

34.5.3.6.3.4. Grounding

a) Steel panel: It shall be earthed in accordance with indications in NFPA-70.
b) Devices (Lightning rods) to suppress voltage peaks above rated voltage. These shall be earthed through copper wire of suitable calibre.

34.5.3.6.4 Connections and wiring

34.5.3.6.4.1. Maintenance facilities

All components and electrical connections at the controller shall be easily accessible for maintenance. The controller panel shall not be used as a connections box to branch and feed other equipment.

Interior connection terminals shall offer easy access to all connection elements.

34.5.3.6.4.2. Testing facilities: The controller panel door shall contain measurement equipment, which can be operated without the need to disconnect any ruler cable.

The control panel shall include the following measurement equipment:

a) Amp meter: Reading of intensity absorbed by the primary motor.
b) Volt meter: Equipped with a switch to measure voltage between phases and between phase and neutral.

34.5.3.6.4.3. Continuous service

All components and connections of controller wires shall be designed on the basis of continuous service.

34.5.3.6.5. Operating circuits protection

Circuits for controller operation shall not contain any overcurrent protection devices, as shown on the independent circuit diagram below.

34.5.3.6.6. Controller exterior operation

All equipment of the connection and disconnection control for normal use, or for motor start and stop, shall be manually operable from the outside.

34.5.3.6.7. Wiring diagram and instructions

34.5.3.6.7.1. Wiring diagram and terminals identification

a) Connection scheme. The connection drawings and list of materials shall be placed in permanent form on the outside of the controller panel.
b) Wiring identification. All wires shall be fully identified so that they match those indicated in the connection drawings.
c) All tapping shall be duly numbered in sequence, as indicated in the corresponding diagram, in clear form, with indicators that can be secured to the tapping, made of insulating and self-extinguishing material. Identification numbers shall not be written with a pen, but print shop style.

34.5.3.6.8. Equipment identification.

All characteristic control elements, disconnector or switch, shall have a visible label attached clearly indicting the name of the manufacturer, identification number and rated technical specifications.

34.5.3.6.9. Controller components

34.5.3.6.9.1. Overvoltage suppression device

In order to avoid voltage peaks, a protection device shall be connected for overvoltage to the electricity feed to the controller panel. This protection shall be capable of suppressing voltage peaks that exceed the rated current.

34.5.3.6.9.2. Switch disconnector

The disconnector shall be a circuit switch or moulded box type switch, with capacity for 115 % of current corresponding to the motor at full load; it shall also be suitable for breaking current to the blocked rotor. The disconnector shall be placed in the essential's cabinet. It shall comply with the following:

a) Safety warning. The switch shall have a label stating "Warning. Do not open or close this disconnector while the circuit switch is in the closed position"

b) Safety lock. The manual operation lever of the disconnector shall have a padlock or security mechanism, which shall be secured so that it requires use of the other hand to hold the lock free or secure in order to allow breaking or closing the disconnector.

34.5.3.6.9.3. Short circuit switch

I- Motor circuit protection: The motor circuit shall be protected with a switch, which shall be directly connected to the tapping from the essential services cabinet.

II- Mechanical features: The pump switch shall have the following mechanical specifications:

a) Operated from the outside.
b) Shall provide for free trip.
c) A plate shall be placed outside the closed panel and next to the switch trip with the following label: "Circuit switch, disconnection resource". The size of the letters shall be 10 mm.

III- Electrical features: The pump switch shall have the following mechanical specifications:

a) Rated voltage capacity of not less than 115 % of rated current at full motor load.
b) Provide non thermal overcurrent sensor elements.
c) Provide instant protection against short circuit current.
d) Have breaker capacity equal or greater than short circuit current connected from.
e) The circuit switch shall allow for normal starting of the motor without tripping.
f) Instantaneous trip adjustment shall not be greater than 20 times current at motor full load.

34.5.3.6.9.4. Overcurrent protection for locked rotor

The overcurrent protection for locked rotor, connected between the disconnection resource and firefighting pump motor, shall have the following characteristics:

a) Relay protection. For squirrel cage or coiled rotor induction type motors, the protection device shall:
   - Protection with delay type relay, with a trip time between 8 and 20 s for breaking current with a locked rotor.
   - 300 % adjustment to motor current at full load.
b) It shall be possible to re-establish the protection device immediately after a trip, without modifying its characteristics.

34.5.3.6.9.5. Pump motor star up using a contact: The pump motor is started by a contact, the output contact terminals are connected to the pump and the input contacts are connected to the main line rushing.

The start up contact coil is fed directly from the mains.

34.5.3.6.9.6. Visible indicator of power supply

The door of the controller panel shall include a visible indicator of energy supply; this power shall be connected to the wires coming from the panel tapping. The visible indicator can be a pilot light.

34.5.3.6.9.7. Alarms and signal devices for the central station

The controller shall have auxiliary contacts, normally open and closed, to send alarm signals to the control room and acoustic alarms to the pump room. These alarms shall indicate any of the following:

a) Lack of voltage.
b) Startup sequence.
c) Selector not in automatic
d) Pump running with pressure.
e) Jockey pump in continuous operation. (If the manoeuvre is inside the controller panel)

34.5.3.6.10. Starting and control

34.5.3.6.10.1. Automatic and automatic not controller

a) Automatic controller; it shall start automatically due to voltage drop or flow demand. It may operate as non-automatic controller.
b) Non automatic controller. It shall be possible to operate it on placing the selector in manual position and pressing the electric button on the panel door. It shall be possible to mechanically operate it through manual initiation

34.5.3.6.10.2. Automatic control

I- **Signal control water pressure:** A pressure switch shall be included in the controller circuit, which shall contain independent adjustment elements for high and low pressure. The pressure switch shall be capable of supporting a temporary overpressure of 2760 kPa, without losing accuracy.

The pressure switch shall react to changes in permanent water pressure in the water pipe of the fire protection system. It shall be provided with suitable arrangement to release pressure actuated on the pressure switch for controller operating tests and the pump unit.

a) Individual pressure line. Each controller shall have its own individual pressure sensor line, 12.7mm made of corrosion resistant material (copper, brass, series 300 stainless steel).
b) Connection to pressure line. The connection to the pressure sensor line shall be made at a point between the check valve and the pump discharge control valve.
C) There shall be two check valves installed in the pressure sensing line at least 5ft (1.5m) apart with a 3/32inch (2.4mm) hole drilled in the clapper and as per the NFPA 20.

II- Manual power control from the central control station:

The central control station (PCI cabinet) shall include a manual trip button for each extinguishing zone, for continuous and non-automatic operation of the fire protection pump.

III- Driver manual trigger: The controller shall be wired to manually trigger in the pump room.

34.5.3.6.10.3. Non automatic controller

I- Manual electric controller: The control monitor fitted on the panel door shall have a manually operated switch attached so that, when the motor is started manually, its operation is not affected by the automatic circuit pressure switch. The wiring shall be designed so that the unit remains in operation until manually tripped.

II- Mechanical driver manual: Manual mechanical device. The controller shall be equipped with a manual lever, which when operated mechanically closes the motor circuit switch mechanism. The operation of this lever shall provide for continuous, non-automatic, motor operation, independent from any other electrical control circuit. The lever shall have a padlock of mechanical lock that holds it in its closed position.

Return to disconnect position. The motor starter shall automatically return to the disconnected position in the event the operator releases the starter lever at any time, unless it reaches its final normal operation position

III- Stop methods: The stop shall be executed by the following two methods:

a) Manual stop. This involves the use of an instantaneous stop switch placed outside the controller panel, which, in the event of automatic controller, shall return to its fully automatic position.

b) Automatic stop after automatic start up. If the controller has been configured for automatic trip after startup has reached its normal operation condition, a running period of at least 10 minutes shall be provided with a timer relay, before being put out of service.

34.5.3.7 House of pumps and equipment protection

Before construction of the pump room, the contractor shall submit to NEPCO all necessary information of all equipment for the construction of the pump room, including details of water intake, water recirculation location and distribution of each unit, route of the pipe network and in general all pertinent recommendations based on specific equipment to be installed.

34.5.3.7.1. Protection of equipment against mechanical damage

Any equipment installed in the pump room shall be protected against possible damage caused by an explosion, fire, flooding, earthquakes, insects, freezing and any other adverse conditions, including vandalism.

34.5.3.7.2. Artificial lighting

34.5.3.7.2.1. Normal lighting

The pump room shall have artificial lighting for normal situations. The room shall have minimum average lighting levels of 250 lux in pump, electrical switchboard and equipment of the fire extinguishing system areas; and 50 lux in the water tank area, if located inside the pump room.

34.5.3.7.2.2. Emergency lighting

Emergency lighting shall be provided in the pump room, which shall guarantee a lighting level not less than 5 lux throughout the room, prepared to come on automatically in the event of a fault in general lighting or when its voltage drops to less than 70 % of its rated value. The installation of this lighting shall be fixed and equipped with its own sources of energy offering autonomy of at least 1 hour.

34.5.3.7.3. Internal heating

In the cases of installation in cold climates, the pump room shall be equipped with suitable means to maintain indoor temperature above 5 ºC.

34.5.3.7.4. Measures against excess moisture

34.5.3.7.4.1. Air renewal unit

It shall be necessary to install an air renewal unit in order to avoid condensation in the pump room.

34.5.3.7.4.2. Drain water

The pump room shall be equipped with a drain water network to evacuate water from possible spillages during installation tests and maintenance of the fire fighting pumps, possible leaks from the pipe network and water from the tank (in the event it is inside the room), or from the plumbing installation for filling the water tank.

The network shall comprise several sumps and/or longitudinal drain ducts fitted into the ground and galvanized steel grille, UPVC pipe collectors if fitted and steel otherwise, as well as accessible boxes for the collection and distribution of water.

The drainage network will be connected to the sewer network, directly whenever it is above the sewer network level; in the event of being below this level, water shall be pumped to the network using a pressure pump installed in the collection box of the interior drainage network in the room.

34.5.4 PIPES, FITTINGS AND SUPPORTS

34.5.4.1 General

34.5.4.1.1 PIPES

1. Pipes and fittings shall be in conformance with the following specifications unless specified otherwise by the Authority having jurisdiction. Obtain approval of local Authorities before proceeding with the work.

2. Pipe shall be schedule 40 seamless UL (an equivalent grade HDPE pipes can be accepted) for underground piping, and schedule 40 factory galvanized steel to ASTM A 53 Grade B for above ground installations.
3. When pipes are assembled by screwed fitting or by roll-grooved / cut-grooved, the minimum thickness for a pressure up to 20.7 bar. Diameters: Minimum diameter is DN25
4. Pipes bending:
   Schedule 40 Steel pipes bending is allowed if bending are executed with no defaults, no diameter reduction and no significant deviation in the pipes circle symmetry.
   The bending minimum radius must be:
   - 6 pipe diameters for a diameter < 2“, and
   - 5 pipe diameters for a diameter > 2 ½”.
5. Pipes marking and identification, Firewater pipes in galvanized steel shall be marked to indicate its destination.
6. Pipes Drainage.
   For sprinklers/nozzles system, pipe drainage shall be accomplished by sloping pipe to low point with auxiliary drain as per NFPA13.
7. Special Requirements.
   Full flanges or plugs, according to the diameter shall be installed on the collector’s extremities to flushing rinsing of the pipes.
8. The exposed piping shall be painted with scarlet red enamel paint over two coats of zinic chromate primer; thermal insulation shall be applied to exposed pipes together with Al-cladding.
9. The pipes buried in ground shall be painted with anticorrosive rubber modified bituminous primer or an exterior bituminous coating conforming to the requirements of AWWA C110, two coats of hot enamel paint and 4mm thick pypkote, and the pipes shall be protected using cement mortar lining (15cm thick concrete layer surrounding the pipes).
10. Underground marking tape shall be blue, six inch wide, four mil thick, polyethylene tape with black lettering with the following wording: “Caution: Fire Fighting Waterline Buried Below.” Marking tape shall be installed 12 inches above the top of all water pipe.
11. All water pipe shall be clearly marked with the manufacturer’s name, type, class and/or thickness as applicable. Lettering shall be legible and permanent under normal conditions of handling and storage.
12. The water pipes shall be handled carefully to prevent damage to the pipe, pipe lining, or coating. Water pipe and fittings shall be loaded and unloaded using hoists and slings to avoid shock or damage, and under no circumstances shall they be dropped, skidded, or rolled. If any part of the pipe, pipe's coating or lining is damaged, repair thereof shall be made in a manner satisfactory to the Engineer at the Contractor’s expense.
13. All water pipe and fittings shall be inspected for defects. Damaged pipe will be rejected and the Contractor shall immediately place all damaged pipe apart from the undamaged and shall remove the damaged pipe from the site within 24 hours.
14. Whenever it becomes necessary to cut a length of water pipe, the cut shall be made by abrasive saw or by special pipe cutter.
15. All pipe ends shall be square with the longitudinal axis of the water pipe and shall be reamed and smoothed to assure a good connection.
16. The water pipe shall be laid to the horizontal and vertical alignment shown on the Drawings Submitted by the Contractor and approved by NEPCO. A minimum five foot cover shall be maintained from finish grade to top of water pipe, unless otherwise shown on the approved Drawings. Fittings shall be installed at the location shown on the Drawings.
17. To prevent dirt and other foreign material from entering the pipe and fittings during handling and installation, the open end of the pipe shall be protected by a water-tight plug at all times except when joining the next section of pipe.
18. Under no circumstances shall pipe deflections, either horizontal or vertical, exceed the manufacturer's printed recommendations. Where deflections would exceed the manufacturer’s recommendations, fittings shall be used.
19. Vertical deflections to avoid obstructions that exceed allowable water pipe joint deflections shall be accomplished by the use of fittings and either joint restraints or vertical thrust blocking conforming to the Standard Details. Additional fittings to those indicated on the Drawings will be required to accomplish these vertical deflections.
20. Concrete thrust blocks shall be furnished and installed in accordance with the approved Drawings and Standard Details.
21. Pressurized water pipe ends shall be plugged and thrust blocks installed. Volume and bearing area of thrust blocks for end plugs shall be equal to applicable standards for bends greater than 45^{o}.

34.5.4.1.2 PIPE FITTINGS

1. Fittings for piping 50mm and smaller shall be UL listed and FM approved. The fittings shall be suitable for 300 psi working pressure. Fittings shall be ductile iron or cast iron in black or hot dipped factory galvanized finish.

2. Fittings for piping larger than 50 mm shall be hot dipped factory galvanized mechanical grooved fittings and mechanical joints. Fittings, gaskets and mechanical couplings shall be UL listed and FM approved. The fittings shall be suitable for 300 psi working pressure.
3. Pipes welding shall not be carried out on site as long as possible.
4. The galvanized steel fittings shall be UL Listed and FM approved, and shall be from a well-known brand.
5. Unions and Couplings Screwed unions shall not be used for pipe greater than DN40. For pipes above, flanges will be used.
6. Reducers and male/female reducers
   - One piece reduced fitting must be used for each pipe diameter change.
   - Reduced sleeve for the pipe continuity, and Male/female reducer for a direction change with reduction (T shape + reducer)

34.5.4.1.3. HDPE PIPE & FITTINGS

UNDER GROUND PIPES & FITTINGS (up to 16 BAR) UL/FM approved

a) High density Polyethylene Pipes & fittings (HDPE) PE 100 FM approved manufactured for underground fire protection lines, FM approved and listed to ISO 4427 – SDR 7.4 to be used for fire underground main. Confirm to AWWA C 906 and NFPA 24.

b) Pipes and fittings to be from one Manufacturer to meet above standards.

c) Welding to be butt fusion only, suitable for pipe pressure ratings, and each joint should have separate report showing full details on joint and welding process and result.

D) Mechanical coupling (if required) shall be UL/FM approved.

34.5.4.2. Water piping system

The water pipe system shall comply with specifications in NFPA13, NFPA15, ANSI/AWS B2.1/B2.1M.

34.5.4.2.1. Water pipe

34.5.4.2.2. Water pipes installation

Considering the fixed “deluge” spray system, with dry pipe to nozzles, the water pipes shall basically be installed as follows, maximizing available spaces of the substation.

34.5.4.2.3. Rising pipes to spray nozzles head

The pipes going from the automatic control valve to nozzles in the transformer room, can be any of the following depending on the substation conditions:

a- Underground installation

b- Visible installation above ground, elevated on a support.

c- A combination of the above (a) and (b).

34.5.4.2.4. Piping specification

Pipes and fittings shall be in conformance with the above mentioned in 5.4 and following specifications unless specified otherwise by the Authority having jurisdiction. Obtain approval of local Authorities before proceeding with the work.

Exposed pipes shall be seamless factory galvanized steel to ASTM A 53

34. 5.4.2.4.1. Piping material

Standards for Water pipes of the fixed spray system shall be as indicated in table 8, which specifies the physical and chemical properties and their dimensions. The pipes of the spray system shall be suitable for working pressure not less than 1210 kPa, offering malleability and ductility properties compliant with the service they provide.

Table 8. Pipe materials Table

Materials	Standards
Ferrous pipe (welded and seamless): Specification of steel and galvanized pipe (hot Zinc bathing), welded and seamless, to be used in fire protection systems.	ASTM A795 / A795M – 08
HDPE PIPE	NFPA 24
Specification of welded and seamless steel pipe.	ASTM A453 / A453M–10:
Forged steel pipe	ASME/ANSI B36.10/19
Specification of steel pipe welded by resistance.	A135/A135M– 09
Copper pipe (stretched and seamless): Specification for seamless copper pipe.	ASTM B75 – 02
Specification for seamless copper pipe for water.	ASTM B88–09
Specification general requirements for cast copper pipe without welds, and copper alloy.	ASTM B251-02e1

34.5.4.2.4.2. Connections through walls or foundations

When joining welded and seamless steel pipes defined in table 8 through welding as per 5.4.4.2.4, the minimum pipe thickness for pressures up to 2070 kPa shall be 10 mm for pipes of a diameter up to 127

mm; 3.40 mm thick for pipes with a diameter up to 153 mm; and 4.78 mm thick for pipes with a diameter of 203 and 254 mm.

34.5.4.3. Pipes protection

34.5.4.3.1. Freezing protection

34.5.4.3.1.1. Underground main water pipe

Pipes going from the automatic control valve (pump room) to the transformer premises may be underground.

34.5.4.3.1.2. Visible above ground main water pipe

The water supply pipeline outdoors must be insulated adequately to prevent the water from freezing. The insulating material must be capable of maintaining the temperature above (4ºC) during freezing conditions. All exposed above ground pipes shall be thermally insulated with a thermal insulation (thickness not less than 25 mm) suitable for outdoor application and protected with aluminum cladding of minimum thickness 0.6 mm.

34.5.4.3.1.3. Corrosion protection

34.5.4.3.1.4. Corrosion resistant materials

If the pipes, accessories, hanging supports and structures are exposed to humidity or corrosive atmospheres, corrosion resistant materials shall be used, or a protective coating shall be applied to exposed.

34.5.4.3.1.5. Pipes galvanizing

Above ground Steel pipes shall be galvanized using the hot bathing process.

34.5.4.3.1.6. Protection of buried pipelines

There are four methods commonly used to control corrosion in pipes, and these are coatings, cathodic protection, materials selection and corrosion inhibitors.

a.- Covering and coatings: these are the main tools against corrosion, are often applied in conjunction with cathodic protection systems to optimize the cost of protection of pipelines.

b.- Cathodic protection (CP): is a technique that uses direct electric current to counteract the normal external corrosion of metal pipe. Cathodic protection is used in cases where all or part of the pipe is buried or submerged under water. In new pipelines, cathodic protection helps prevent corrosion from the beginning, in pipelines with a considerable period of operation it helps to stop the existing corrosion and prevents further deterioration.

c.- Materials Selection: Refers to the selection and use of corrosion resistant materials such as stainless steel, special alloys, plastics and extends the life of a structure, e.g. pipe. However, in the selection of materials resistant to corrosion fundamental criterion is, in essence, the protection of a structure, but the protection or preservation of the environment where it exists.

d.- Corrosion inhibitors: are substances applied to a particular environment, reduce environmental attack on the material. either metal or steel reinforcement in concrete. Corrosion inhibitors extend the life of the pipes, preventing faults and avoiding involuntary leakage.

34.5.4.4. Drainage

34.5.4.4.1. Slope pipes installation

All water pipes and accessories of the spray system shall be installed with slopes so that the system can be drained after extinguishing or after preventive maintenance.

34.5.4.4.2. Drainage of main pipe

34.5.4.4.3. Drainage connections

Drainage connections of the main pipe and spray system distribution pipes as well as other sections controlled by cut-off valves shall have the following measurements indicated in table 9.

Table 9. Drainage measurements

Drainage connections	Drainage measurements
Up to 51 mm	19 or greater
64, 76 and 89 mm	32 mm or greater
102 mm and greater	51 mm only

34.5.4.4.4. Auxiliary drains

When the change in direction of pipes hinders drainage, auxiliary drainage shall be provided with valves of not less than 19 mm.

34.5.4.5. Joining of pipes and fixtures

34.5.4.5.1. Threaded Pipe and appurtenances

34.5.4.5.1.1. Standard screw Court

All threaded pipes and accessories shall have a thread step as per ANS/ASME.

34.5.4.5.1.2. Thickness of pipe to threaded union

Steel pipes with a thickness less than schedule 30 in pipes 203 mm or greater or thickness of schedule 40 in pipes less than 203 mm shall not be joined through threaded additions, unless the threaded assembly ensures its use is appropriate.

34.5.4.5.2. Welded Pipe

34.5.4.5.2.1. Standards for welded

ANSI/AWS B2.1/B2.1M, Level AR-3 complies with the welding method requirements for pipe joints of the fire protection system.

34.5.4.5.2.2. Specification of Pipe Fittings

Any accessories used for joining pipes through welding, except for butt-weld joints, shall be made in accordance with rules set forth in table 10.

34.5.4.5.2.3. Reduction of pipe

Whenever the pipe or its branches reduce in diameter, reducer accessories designed for such purpose shall be used.

34.5.4.5.2.4. Qualification of the welding

a) Welding preparation. The welding procedure shall be prepared and calibrated, prior to execution, in accordance with requirements indicated in ANSI/AWS B2.1/B2.1M.
b) Responsible for welding. The system supplier shall be responsible for all weldings made, and shall provide Nepco with a written quality control declaration on the welding procedure.
c) Welding qualification records. The supplier shall keep certified records, which shall be available to Nepco, with the date, welding procedure and rating of works performed.

34.5.4.5.3. Pipe joints mechanical accessories

Any mechanical accessories used in pipe unions shall be of compatible dimensions. Steel pipes with a thickness less than schedule 30 in pipes of 203 mm and greater, or schedule 40 in pipes less than 203 mm shall be an exception to the rule and shall not be joined with accessories.

34.5.4.5.4. Brass wielded pipe joint

Copper pipe joints shall be performed with brass welding.

34.5.4.5.5. Certificate of welding procedure

Prior to acceptance testing of water piping system, the contractor must submit a registration of welding procedures, according to AWS 010.9-69.

34.5.4.6. Pipe fittings

34.5.4.6.1. Types of accessories

Accessories used in water spray protection systems shall be made of materials indicated in table 10 or its equivalent in terms of chemical and physical properties and dimensions of other recognized standards. Accessories used in the system shall support the committed work pressure, and in any case shall not be less than 1220 kPa.

Table 10. Materials and dimensions of pipe accessories

Materials and accessories	Standard
Cast iron: Threaded accessories, of cast iron class 125 and 250.	ANSI/ASME B16.4
Flanges and accessories for cast iron pipe.	ASME/ANSI B16.1
Malleable iron: Threaded accessories, of malleable iron class 150 and 300.	ASME B16.3
Steel: Accessories for butt-welding, forged steel, factory manufactured.	ANSI/ASME B16.9
Ends of butt-welds, pipes, valves, flanges and accessories.	ASME B16.5
Specifications for forged carbon steel pipe accessories, and steel alloy for moderate and high temperatures.	ASTM A234/A234
Steel flanges for pipes and flanged accessories.	ASME B1 6.5

34.5.4.6.2. Cupping and pipe unions with Attachments

Generally, the following shall be fulfilled

a) Primary pipe and riser connections. All connections between the primary pipe and riser branches, of diameter between 76 mm or more, shall be executed with flanges.
b) Sections crossing walls. Any connection between sections crossing passes and walls shall be flanged.
c) Connection to equipment: Any connection to equipment and manoeuvre devices, valves, pumps and others, shall be executed with flanges.
d) Threaded connections prohibited. Threaded joiners shall not be used in pipes with a diameter greater than 51 mm.
e) Couplings prohibited. Couplings shall not be used, nor bolt-union accessories between pipes, except for pipes of less than 51 mm and lengths less than 2 m between connections.

34.5.4.6.3. Reducers

Reducing elements of a single piece shall be used in pipe diameter changes.

34.5.4.7. Control Valves

34.5.4.7.1. Types of Valves

34.5.4.7.1.1. Control valves at main and rising pipe (Outside Screw and Yoke, OS & Y).

Any control valves connected to the water supply pipe, main pipe and riser branches to the spray systems shall be valves UL listed and FM approved. These valves shall not close in less than 5 s when operating at maximum speed from the open position.

34.5.4.7.1.2. Testing and draining valve

The draining and testing valves shall be of an approved type, for a 1210 kPa pressure at cold water temperature.

34.5.4.7.1.3. Check valves

Check valves shall be UL listed and FM approved, for vertical and horizontal installation.

34.5.4.7.2 Control valve in water pipe system

34.5.4.7.2.1. Control valve in water supply sources

Each water supply source shall be equipped with at least one control valve, except in connections for the public service fire dept.

34.5.4.7.2.2. Control valves in fire protection system pipes

The firefighting pipe system shall be equipped with control valves suitably located to control any pressurized water supply.

The supplier shall submit the position of control valves in the pipe system for consideration by NEPCO.

34.5.4.7.2.3. Control valves supervision service

Control valves for control and of risers to spray systems, shall be supervised by one of the following methods:

Signaling service at the central control station.

Padlock in open valves.

34.5.4.7.2.4. Check valve in water supply source

Check valve in each water circuit. In the event of more then one source of water supply, a check valve shall be installed in each connection.

Check valve in connections for public service Fire Department. In the case of connections to receive pressurized supply for public service fire dept., a check valve shall be installed in each water supply connection.

34.5.4.7.3. Pressure reducing valve

34.5.4.7.3.1. Operation of pressure reducing valve

Whenever the components of the fire protection system are not a service pressure of 1210 kPa or more under fire operating conditions, pressure reducing valves. UL listed and FM approved, shall be installed, which shall be adjustable to regulate output pressure to a value not exceeding 1140 kPa.

34.5.4.7.3.2. Pressures gauges

Pressure gauges shall be provided, before and after each pressure reducing valve.

34.5.4.7.3.3. Relief valve

A relief valve shall be provided on the exit side of the pressure reducing valve, no less than 13 mm adjusted to operate at a pressure not exceeding 1210 kPa.

34.5.4.7.3.4. Isolating valve

An isolating valve, UL listed and FM approved, shall be installed on the inlet side of the pressure reducing valve.

34.4.7.4 Valve identification

a) Identification of each valve. Each one of the control valves shall be equipped with an identification that indicates the area of the system it protects. The label shall be secured with adhesive or chain, non-corrosive material or other suitable means.

b) Warning. Valves shall have the following warning: “THIS VALVE CONTROLS THE FIRE PROTECTION EQUIPMENT. DO NOT CLOSE IT UNTIL FIRE IS EXTINGUISHED. CAUTION: IF THIS VALVE IS CLOSED AN AUTOMATIC ALARM WILL SOUND”.

34.5.4.7.5. Antifreeze system

An antifreeze solution shall be provided for pipes in cases for which freezing is expected. The antifreeze solutions shall be prepared in accordance with table II, based on the minimum estimated temperature at the site. The use of these products shall be for cases when there is no risk of interconnection or contamination with drinking water.

Table II. antifreeze solution

Material	Solution	Specific Gravity	Freezing point (ºC)
Chemically pure glycerine (96.5 %)	50% de water 40 % de water	1,1331 1,151	-26,1 -30,1
Propylene glycol	70 % de water 60 % de water	1,027 1,034	-13,0 -30,1
Diethylene glycol	50 % water	1,078	-25,0

34.5.4.8. Hangers piping

34.5.4.8.1. General

1. Pipe hangers and supports must be in accordance to NFPA13.
2. Pipes supports shall be designed to maintain their integrity in case of fire exposure.
3. All underground piping / valves shall be supported with Concrete Anchor Thrust blocks as recommended by the manufacturer. Provide calculation for the Engineers approval.
4. All Above ground piping / equipment hangers, supports and sway braces shall be fabricated in accordance with ANSI B 31.1. The Hangers, rod supports and supporting devices and accessories shall be capable of supporting at least twice the live loads of the product being supported. All hangers, supports and accessories shall be UL listed and or FM approved.

5. Hangers shall be adjustable clevis type, of yoke and lower U strap design with cross bolt and manufactured from galvanized steel. Cross bolt shall have a double locking nuts.
6. Vertical adjustable supporting rod shall have a load nut below the yoke and a locking nut above the yoke.
7. Concrete anchors shall be factory made cadmium plated alloy steel expansion shield type.
8. Concrete inserts shall be factory made galvanized malleable iron, poured in place type, screwed or toggle style.
9. Riser clamps shall be galvanized steel bands shaped to tightly fit O.D. of the pipe, secured with bolts and nuts.
10. Piercing of load supporting system is not permitted.
11. The supporting structure can be directly attached to equipment if the equipment supplier certifies this supporting feasibility.
12. The welding of pipes on the supports on the pipes is not permitted.
13. Pipes supporting system must be reinforced in order to reduce any movements resulting from nozzles reaction and therefore preserve the system performance and integrity if battering ram is used.
14. The maximum length for a non-supported DN 25 pipe is 0.8 meter.
15. When possible, loop-type clamps will be used
16. If spring hangers are used, they shall be installed and located in accordance with NFPA 13 specifications.
17. The Contractor shall take into account the problem of dilatation (of his systems but also of the buildings) and shall make the coordination with the others Contractors to solve the support problems.
18. The supports system shall be fixed on a reinforced concrete support bases, high quality concrete shall be used and the dimensions of the cement bases shall be as per the approved design drawings anchor bolts for the pipe support system shall be accurately positioned and secured during concrete pouring.

34.5.4.8.1.1. Media Types

Supports shall be UL listed and FM approved, basically the fixed type for primary pipe, risers and branches, hanging type for secondary pipes.

34.5.4.8.1.2. Installation

In general, pipe support and their installation shall comply with the following:

a) Design load. Designed to support 5 times the pipes mass full of water, 114 kg in each pipe support point.
b) Support materials. The materials used for support components shall be made of steel.

Supports shall be manufactured from normalized cold laminated steel profiles, with hot bath galvanization.
Earthing of structures. All steel structures shall be suitably earthed to minimum personnel hazards from passage and contact voltage.
The brackets used to fix the pipes must meet NFPA-13, Chapter 6: Hanging, Bracing, and Restraint of System Piping

34.5.4.8.2. Maximum distance between supports

In the case of steel pipes of 38 mm and greater, the maximum distance between supports shall be 3.0 m. In the case of steel pipes of less than 38 mm, the maximum distance shall be 2.5 mm. In the case of light weight threaded pipes, 76 mm or less, the distance between supports shall not exceed 3.0 m.

34.5.4.9 Water spray system alarm

34.5.4.9.1. Local audible alarm

All spray systems shall be equipped with a local audible alarm activated by water flow, which shall circulate water equal or greater corresponding to the smallest spray nozzle discharge. Paddle type flow alarms shall be avoided.

34.5.4.9.2. Water flow detector device

Alarm devices shall consist of an alarm check valve, or other flow detector device UL listed and FM approved, with their accessories to raise the alarm.

34.5.4.9.3. Fire detection alarm at main control station

The “preaction and deluge” system, in addition to the local water flow alarm, shall be equipped with automatic fire detection devices to raise alarms at the station’s control room.

34.5.4.9.3.1. Audible alarm device

The alarm unit shall include a local mechanical alarm, UL listed and FM approved, which may be a bell, siren or some waterproof electrical device that operates a bell or siren.

34.5.4.9.3.2. Alarm valve Bypass

“Preaction and deluge” alarm valves shall include a by-pass for maintenance test. Lateral passage shall be equipped with a cut-off and drainage valve.

34.5.4.9.3.3. Alarm device control valve

A control valve shall be installed in connection with switch device (pressure type) or alarm equipment moved by a water motor. The control valve shall be of the type that clearly indicates its open or closed position, and shall be built such that a padlock or lock can be placed when in the open position.

34.5.4.9.4. Mechanically operated alarms accessories

34.5.4.9.4.1. Strainer

All spray circuits that use water motor alarms shall include a 19 mm filter, UL listed and FM approved.

34.5.4.9.4.2. Location

Equipment operated with water motor shall be located as close as is practically possible to the alarm valve. The total length of the pipe to hydraulically operated equipment shall not exceed 23m.

34.5.4.9.5. Electrically operated alarm accessories

34.5.4.9.5.1. Installation of electric alarm accessories

Electrically operated alarm accessories, including remote parts corresponding to the wing control plant should be installed according to NFPA-72.

34. 5.4.9.5.2. Tests connection of water flow detector device

Water flow detector equipment, including the associated alarm circuits, shall be tested using water flow through a test circuit. The devices operated with water pumps are the following: drain valve, pressure relief valve, siren works with water, pressure gauge, 3-way valve, nipple, drain tubing, clamps.

34.5.4.9.5.3. Electrical alarm device

Weatherproof electrical alarm equipment shall have a degree of isolation that is not affected by water, especially approved for outdoor use.

34.5.4.9.6. Drainage: Alarm equipment shall include drainages to prevent the risk of freezing.

34.5.5 Connections to public Fire Department Services and Fire Hydrants

34.5.5.1 Connections to public Fire Department Services

The pressure water supply to spray systems through the public service fire dept.'s connection shall be acceptable to cover the limited capacity of the substation's fire protection system. Its usage shall be based on the availability in capacity and pressure of local public service fire dept., and shall employ normalized equipment in NFPA-1901.

34.5.5.1.1. Measures

The measure of the pipe shall not be less than 102mm for connections to fire dept. An exception to the above is when supply to the spray system is calculated hydraulically

34.5.5.1.2. Connections

a) Number of connections. Depending on the distance required by the spray system, one or more public service fire dept. connections shall be made to the water supply, through a check valve in each connection and supply header.
b) Connection header: Fire dept. connection headers shall be connected to the main pipe of the fire protection system between the signal, check and alarm valves of riser branches to the spray systems.

34. 5.5.1.3. Identification of links

Public service fire dept. connection headers shall be identified with a 25 mm sign, which shall read the designated service: (FIXED SPRINKLER SYSTEM "DELUGE VALVE SYSTEM").

34. 5.5.1.4. Valves

34.5.5.1.4.1. Check valves

Each public service fire dept. connection shall include a check valve, UL listed and FM approved. It shall be located as close as possible to the point where it connects to the main pipe.

34.5.5.1.4.2. Prohibition of outer valve

Public service fire dept. connections shall not have close valves.

34.5.5.1.5. Hose connections

34.5.5.1.5.1. Standard hose connections

Public service fire dept. connections shall be made with internal thread turning accessories, which shall have a normalized NH2.5-7.5 thread, as specified in NFPA 1963. An exception to the above is when local public service fire dept. connections do not comply with NFPA 1963, in which case Nepco shall indicate the connection to be used.

34.5.5.1.5.2. Connection caps

Hose connections shall be equipped with a male and female cap, UL listed and FM approved.

34.5.5.1 Fire Hydrants

34.5.5.2.1. DRY BARREL FIRE HYDRANT

Fire hydrants shall be manufactured to comply with AWWA Standard C502. Fire hydrants shall meet all requirements of LPCB/UL listed/FM approved.

1. Fire hydrants shall be rated for a minimum working pressure of 150 Psi (1034kPa).
2. Fire hydrants shall have a main valve which shall provide complete closing of the drains after 4 to 5 turns of the operating nut in the opening direction.
3. The drain ring assembly shall be replaceable without removing the hydrant from the connecting pipe or having to dig.
4. Fire hydrants shall be three-way in design, having one pumper nozzle (size as specified) and two 2-1/2" hose nozzle (side outlet). Nozzle thread type shall be as specified by the end user.
5. The operating nut shall be a one piece design, manufactured of Bronze. It shall be pentagon in shape and the nut dimensions shall be as specified by the end user.
6. An arrow shall be cast on the bonnet flange to indicate the specified opening direction.
7. Hydrants shall bea "traffic-model" having upper and lower barrels joined at the ground line by a separate and breakable "swivel" flange providing 3600 rotation of upper barrel for proper nozzle facing

8. The lower barrel shall be an integrally cast unit. The use of threaded on or mechanically attached flanges is deemed unacceptable.
9. All ferrous part shall be epoxy coated, the lower barrel shall be bitumen coated.
10. Hydrants shall be internally coated by Epoxy to avoid corrosion.
11. A bury line shall be marked on the lower barrel below the break flange to indicate proper installation depth.
12. Hydrant Inlet shall flanged and the size shall be minimum 6".

34.5.5.2.2. WET BARREL FIRE HYDRANT

GENERAL

Fire hydrants shall be manufactured to comply with AWWA Standard C503. Fire hydrants shall meet all requirements UL/FM. Coupling must be quick coupling as per Civil Defense requirements where coupling must be Listed & Certified.

1- Fire hydrants shall be rated for a working pressure of 200 Psig. Technical Specification for Fire Protection System SPEC/1.0.13 35.
2- Hydrant Body shall be Ductile Iron, Stainless Steel, or Bronze as specified.
3- All ferrous part shall be Internally & Externally Epoxy coated.

34.5.5.2.3. UNDER GROUND HYDRANTS

Underground fire hydrant valves shall be of screw down type and are suitable for a maximum working pressure of 16 bar. The Inlet shall be flange type and the Outlet of this hydrant shall be round threaded 2 ½" size to BS 336 Standard. Underground fire hydrants are manufactured to comply BS 750:2006 & EN14339:2005 and shall be BSI Kitemark Approved.

MATERIALS

- Body material shall be made of grey cast iron or Ductile Iron as per BS standard.
- Material of spindle shall be made of Stainless steel to BS EN 10088-1.
- Material for the screwed outlet is made of High tensile brass to BS 12163.
- Spindle sealing (two seals) is of the toroidal sealing ring ('O' ring) type.
- Design of the spindle cap in accordance with BS 5163.
- A Wiper ring is positioned above the spindle sealing to prevent the ingress of foreign matter.

DESIGN FEATURES

- The Hydrant shall be compactable against resistance to disinfection products.

RESISTANCE TO OPERATING LOADS

- Maximum operating torque value (MOT) 105 N-m.
- Minimum strength torque value (mST) 210 N-m.

CORROSION PROTECTION

- All Ferrous components liable to corrosion shall be shot blasted (inside & outside) to SA 2-1/2 standard.
- Each hydrant should be painted from inside a 3 Coat epoxy paint system including primer, intermediate & Top coat.

DRAINING

- Hydrant draining system is by self-operating frost valve.
- Volume of retained water 80 ml.
- Time of draining~3 min. 20 Sec.

34.5.6 Water spray system

The water spray system, which includes spray nozzles themselves, must meet specified in NFPA-15.

34.5.6.1 General

34.5.6.1.1 Water spraying for transformer protection

34.5.6.1 .1.1. Transformer protection by water spraying

Each transformer must be protected by an independent sprinkler system which shall incorporate an open nozzle to spray water, and sprinklers installed around and above transformer (pilot pipe) to detect the fire. The system should include a water spray system by discharge or flooding, which must achieve the maximum effectiveness in the following effects: cooling, suffocation and emulsification on all surfaces of the transformer, including lower parts and ground level.

Transformer distant radiators protection. In cases where groups of radiators, are distant by more than 8 m from the transformer tank or, a wall is interposed between radiators and transformer tank; radiators group should be considered as a different fire area, and should be protected by an independent system of fire detectors and water spray.

34.5.6.1.2. Water screens

Water screens that are installed to cover absence of protection fire walls, should be an independent spray system from automatic control valve, and its operation must meet the same fire detection signal of protected transformer protected.

The use of water screens shall be optional.

34.5.6.1.3. Cables protection

Power and control cables must be protected from exposure to fire heat and burning oil runoff and spills.

34.5.6.1.4. Pressurized water supply to spray systems

34.5.6.1.4.1. Water pressure and volume

Water flow and pressure, must be able to keep design spraying conditions by 1 hour minimum time in addition to the water demand by one hydrant point (for one hydrant connection the minimum hose stream flow rate shall be 250 gpm (946 L/min and shall last for a minimum of one hour), and subjected to the approval of the AHJ.

34.5.6.1.4.2. Maximum water demand

Water maximum demand should consider a tolerance over established flow for protection against fire, and must comply with the terms specified in these specifications

34.5.6.1.5. Alarms and supervisory signals

In general, it must comply with the terms specified in these specifications.

34.5.6.1.5.1. Transformer bays alarms

Each protected transformer must have an audible alarm, activated by a hydraulic or electric motor.

34.5.6.1.5.2. Control Central Unit Alarms

Central control station must be equipped with audible and visible alarms service, indicating the affected equipment.

34.5.6.2. Spraying system design

34.5.6.2.1. Transformer firefighting system

5.6.2.1.1. Water spray scope

The sprinkler system must have ability to reach and penetrate the water to all parts and corners of the transformer to achieve effective control of fire by the effects of: 1-cooling, 2- suffocation, 3-emulsification.

Spraying density to each part of transformer must be based on calculations, test data and / or knowledge relating to similar conditions to the installation in study.

34.5.6.2.1.2. Fire extinction

Spraying for fire extinguishing should be designed so that within a reasonably short time, fire extinguishing has been achieved and all surfaces and oil content must be cooled below oil ignition temperature, by this procedure it should be avoided the fire resignation after it has been extinguished.

Spraying at transformer top half. Water spray application to structurally weak parts of transformer (considering them as upper half of tank), should consider a minimum expenditure of 20.4 (l/min) m^2. Spraying at transformer bottom half. For parts at lower half of tank (considered structurally strong part of transformer and as a fire area in vertical drainage), there should be a density of no less than 10.2(l/min) m^2. Spraying at ground level (transformer foundation). Soil level protection, which includes the concrete basement with rails and wheels, there should be a water discharge not less than 6.1 (l /min) m2. Spray at high speed. Water spray should be at high-speed application and direct impact on protected areas.

34.5.6.2.1.3. Fire intensity control

Spraying system design must include protection by "Fire intensity control", which should minimize damage and avoid fire extension to other areas. The spraying should last until fire extinction, considering a minimum time of 60 minutes and as required by AHJ. Water density on surfaces likely to oil spill should not be less than 20.4 (l / min) / m2.

34.5.6.2.1.4. Exposed surfaces protection

Spraying density for protection of exposed surfaces should be limited to heat absorption, in order to achieve safety of equipment surfaces or installations to protect:

Protection of vertical surfaces. A vertical or sloped parts of the tank, water must be discharged not less than 10,2 (l/min)/m^2. Protection of transformer tank bottom. The bottom surface of the tank should be covered with directed water spray at a density not less than 10.2 (l/min)/m2, taking into account water slip at these areas. Protection of joints. Special attention should be given to spray application of boards around the transformer. Bushings and surge arresters protection. Bushings and surge arresters shall be included as exposed surfaces protection Water spray application to bushings must be authorized by their manufacturers and / or by NEPCO.

34.5.6.2.1.5. Electric cables protection

Water spray density. Protection of insulated electric cables, from fire exposure risks and/or burning oil runoff, should provide a water spray reference density of 12.2 (l/min)/m2, projected over cables laying plane.

Fire protection screen. When a fire protection screen (a steel plate with a thickness of 1.6 mm or equivalent deflector screen), is installed below the cables laying, minimum water density to apply over these cables can be reduced to 6.1 (l/min)/m2. The deflector steel plate (or equivalent screen) against flames, must be wide enough to extend at least 152 mm from the edges of trays or cable racks.

Initiation of water spraying. All power and control cables to be protected are those installed within transformer spray area; thus, spraying should start with the same opening of the automatic control valve.

34.5.6.2.1.6. Structures and other equipment

Structural supports involving water spray system and other systems relative to transformer must be protected according to the following:

- Protection of steel structures. Structural steel members subjected to efforts should be protected as "exposed areas", by spray nozzles spaced at least 3 m, so that water discharge has a density of not less than 4.1 (l /min)/m2 in case of horizontal structures, and not less than 10.2 (l/min)m^2 for vertical structures.

- Protection of metallic pipes. The protection of metallic pipes and cable ducts laid on supporting structures must be through spraying directed towards the surface of the projected plane through pipes or cables.
- Spraying nozzles must be spaced not more than 3 m, and should not be placed more than 0.8 m below the level of the pipes to be protected.

34.5.6.2.1.7. Wind design

Water spray systems, both to protect transformer and other areas or equipment, must be designed for an effective spray resisting turbulences caused by fire and wind speed of 10 m/s.

34.5.6.2.1.8. Head pipes and nozzle's location

The nozzles should be distributed strategically around the transformer in two or more levels and should not be installed above the transformer, unless water spraying -due to energized electrical equipment- cannot be otherwise carried out. The contractor shall include manufacturer technical features of nozzles.

34.5.6.2.1.9. Electrical clearances

All system components must be located at a separation not less than "spraying safety distance" respect to un-insulated energized parts. Anyway, these distances should be greater than " dielectric distance" for transformer Basic Impulse Level (BIL).

Dielectric Distance. All dielectric safety distances must be based on Transformer Basic Impulse Level (BIL), having obtained these values, up to 161 kV nominal voltage from NFPA-70, and from 230 kV nominal voltage and higher, from ANSI-C2, Table 124.

Spraying Distance. The determination of "spraying safety distance", must be based on field test results in function of water purity (electrical resistivity), and the size of water spray particles.

34.5.6.2.2. Water screens (Optional)

Water screens for protection of neighboring areas should be optional

34.5.6.2.2.1. Basic arrangement for water screens

I- Independent system: Each water screen should be an independent system associated to water spray system of the transformer.

II- Water screens usage: Water screens should be formed depending on the needs of the surrounding areas to be protected:

a) Lack of protective screens. In case there are no protective screens between transformers and/or between transformers and close to buildings, with the consequent risk of damage to adjacent areas, water screens must be above from soil level.

b) Inadequate protective screens. In case of having protective screens and these do not have minimum required dimensions, water screens must be lifted over existing protective screens to complete the protection.

c) Other areas to be protected. Other areas requiring protection, shall be indicated by NEPCO.

34.5.6.2.2.2. Water screens height and length

Height of screens (No wind conditions). In the absence of wind, or very light breeze, the height of water screens should be at least as transformer top height.

Height of screens (Wind conditions). In the presence of wind, the height of water screens should reach at least, the same level reached by flames pushed and bent by wind. Design must be based on a speed of 10 m/s.

Length of screens. To determine the length of water screens, it must be used the criteria that amongst flames from fire, and equipment or adjacent spaces to be protected, it must be interposed a water shield screen to prevent the transmission of heat radiation.

34.5.6.2.2.3. Water consumption

Water consumption for water screens formation, must be at least 10.2 (l / min) / per linear meter and per height meter. Water distribution in space must be uniform for its full protective effect.

34.5.6.2.2.4. Water screens starting and control

Automatic control. Water screens should start with the same starting automatic signal of transformer water spray system. Manual control station. Water screen system must have a remote station "start" and "stop", manually and electrically operated at central control station. Manual control should be allowed to add or suspend, at operator criteria, water screens according to fire development.

34.5.6.2.3. Automatic control valves for water spray systems

Each water spray system, either to transformer protection or water screens application, must be provided with an automatic control valve, with a water supply shut off control valve installed before it.

34.5.6.2.3.1. Shut off control valve

Shut off control valve to be installed before automatic control valve, should be installed vertically, gate type, with indicator, and should have lock mechanisms to ensure its open position.

34.5.6.2.3.2. Automatic control valve (Deluge Valve)

I- Automatic valve requirements (Deluge valve)

Operation of automatic control valve, together with quick release device must meet the following:
Simple and instantaneous driving at its opening
Opening control, through automatic remote signal
Construction with corrosion resistant material
Operation signal: electrical signal and hydraulic signal, to act together in order to instantaneous operation of the deluge valve

II-Valve types

Automatic valves " deluge valves" should have a special design (double knock "interlock type") made of cast steel, UL listed and FM approved type, evaluated for special purpose by testing laboratories. They can be operated by hydraulic, pneumatic, solenoid or spring power, with control signal. Hydraulic, electrical, pneumatic or mechanical, on fast opening device.

III- Auxiliary devices and accessories

As auxiliaries and accessories of automatic control valves shall have the following:

a) Special tools for manual operation. Device or tool to manually open or close the valve for testing and maintenance purposes, and eventually as a means of emergency actuator.
b) Instruments of measurement and control. Gauges must be fitted with indicators, pressure switches, limit switches, solenoid valves and related to remote signaling and automatic operation.
c) Drainage valves. Drain valve to evacuate water from the body of the valve and piping attached.
d) Device for restoring the normal position. Device or mechanism to reset the valve automatically and manually to local normal closed position.
e) All necessary trimming components as per the manufacturer's recommendations to ensure proper operation and reliable performance of the deluge valve.

IV- Automatic deluge valve location

Automatic deluge valve must be located as close as practical, to each equipment or protected area.

V- Fire Wall for Automatic control valve (Deluge Valve)

The Automatic control valve (Deluge Valve) shall be protected by a proper fire wall, the design, shape and height of the fire wall shall be submitted to NEPCO for approval

34.5.6.2.4. Draining valve

For the drainage pipes rise and nozzles heads, must be provided with drain valves at low points of the pipes.

34.5.6.2.5. Spray nozzles

34.5.6.2.5.1. Nozzles types

The spray nozzles must be of open type, full cone cup and high-speed projection for direct application to fire surfaces. For flood or sprinkler, the total flooding nozzles can be used the same type with different spray characteristics.

34.5.6.2.5.2. Spraying pattern

For calculating the spray pattern should be considered the following:

a) Use of different nozzles of type to operate at the pressure of 800-700 kPa and get water particles of 0.15 to 1.0 mm.
b) Minimum density of required spray for each part of transformer, as specified in Chapter 5.6.2.1.
c) Environmental Conditions: The force shall be greater than the wind environment of 10 m /s.
d) Dielectric distance to no insulated live parts.
e) Safety spraying distance. Possibility of spray reaching to live parts.

If the design of the supplier concerning paragraphs (a) and (b) differs from indicated in the respective mentioned sections, the supplier must provide complete information to NEPCO to their agreement and approval.

Must meet NFPA-15 Standard for Water Spray Fixed Systems for Fire Protection.

34.5.6.2.5.3. Spray nozzles material

The quality of the materials of the spray nozzles must be such that they do not suffer alterations in their spray characteristics due to corrosion and deformation that can suffer from heat of fire. In the usual conditions of quick response sprinkler .system should be employed brass nozzles.

34.5.6.2.5.4. Spray nozzle's locations

Spray nozzles may be placed in any position in order to obtain suitable cover for fire extinguishing and/or control, taking into account the limiting effect of wind and draw caused by fire fine water particles. Spray nozzles shall have threaded connections and with extensions that allow obtaining maximum ease of adjustment in directing the nozzles.

34.5.6.2.6. Head pipes for nozzles

5.6.2.6.1. Pipes dimensions

Each system shall individually consider the measurements of suitable pipes based on the calculation.

34.5.6.2.6.2. Head nozzles

34.5.6.2.6.3. Pipes slopes

Welded pipe union. Welded pipe unions and accessories shall comply with provisions set forth in 5.4.5.2.

Pipe union with mechanical accessories. Pipe unions with mechanical accessories shall comply with indications made in section 5.4.5.3 of these specifications.

34.5.6.2.6.4. Test pressure gauge connections

Intake header pipes shall be provided resources to connect pressure gauges to measure pressure at the nozzles farthest away and/or highest in each section of the system.

34.5.6.2.7. Support structures

The pipes of spray headers of the system shall be firmly secured to independent structures, self supported, in order to maintain their integrity under violent fire conditions or other forces that may alter the position of nozzles. All supports in the area of the fire shall be protected by the spray nozzles.

34.5.6.2.8. Filter

34.5.6.2.8.1. Filter for spray head pipes

Size of filter: A common filter be provided in the of water supply for all spray systems that use nozzles with water passage of less than 9.5 mm, or for any system where water may carry obstruction materials.

Type of filter: the spray header filter shall be of the basket type, corrosion resistant metal, self cleaning with purge valve, removable and accessible for cleaning during emergencies.

34.5.6.2.8.2. Individual Filter for nozzles

a) Nozzles with individual filters: Spray nozzles with diameter less than 3.2 mm shall include an individual filter.
b) Losses caused by obstruction. In terms of nozzle filters, special attention shall be paid to water diameters less than 6.5 mm, so that obstructions do not cause excessive losses.

34.5.7 Fire automatic detection system

The automatic fire detection system must meet NFPA-72 Standard. National Fire Alarm Code.

34.5.7.1. Requirements for automatic fire detection system

The fire detection system shall be designed so that by signals from the detectors, the fire fighting system starts automatically. Detector devices must meet the following:

a) High reliability in fire detection.
b) Outdoor operation resistant with minimal maintenance (weather proof detectors and terminal boxes).
c) No alteration at operating characteristics across the years.

34.5.7.2. Response features and fire detectors type

34.5.7.2.1. Response features

Fire detectors of outdoor transformers, shall be heat sensing elements and shall have accurate detection ability including incipient fires. The detectors shall not operate falsely or prematurely due to normal conditions of temperature fluctuation of environment.

The detectors shall have the following characteristics in order of preference:

a) Dynamic response of “Thermal delay compensation”
b) Static response of "fixed temperature"

The detectors of paragraphs (a) and (b) should be adjusted at factory so that they operate with an appropriate advance factor or reduced thermal delay factor, respectively, so that they response to any temperature rising condition. The supplier must show to NEPCO, by temperature versus time graph, the performance of heat detectors with the curves of environment air temperature, chosen security level and detector element temperature.

34.5.7.2.2. Heat detectors type

Heat sensor type detectors must be:

a) Fixed temperature (or maximum temperature) and rate of rise temperature detector (Temperature speed detector).
b) Spot type.
c) Explosion proof.
d) Weather proof.
e) The spots must be two zones each zone cover the transformer surface area.

34.5.7.3. Fire detector’s location

34.5.7.3.1. Generals

The contractor should consider detectors location and spacing, in accordance with particular conditions of each installation, with data from experience, testing, engineering studies, codes and standards (like the NFPA and Jordanian national codes), factory recommendations, and certification of recognized laboratories.

Location and spacing of fire detectors shall comply with the following requirements:

a) Fast response of fire detectors.
b) Response to incipient fire, small and slow.
c) Accommodation of detectors to available space geometry.
d) Wind considerations, usual temperature fluctuations of environment, and spaces for transformer maintenance.

NEPCO will provide to the supplier, drawings and general information concerning installation conditions of the transformer to be protected, including proximal heat sources that could affect detector operation.

34.5.7.3.2. Location and spacing of fire detectors

34.5.7.3.2.1. Fire initiation areas

In general, location of transformer fire detectors shall be considered in two parts:

a) Upper half including cover and top of the transformer tank. This part is considered as critical due to the ease of fire initiation through tank rupture and thus leaks and spills of overheated oil.
b) Lower half, structurally strong, as another possible fire initiation area due to the overheated oil spill.

34.5.7.3.2.2. Detectors above transformer

Location and spacing of detectors shall avoid locations directly above transformer and exposed to fire destruction, except for those replaceable type elements.

34.5.7.3.2.3. Detectors for electric cables

The protection of power and control cables in trenches or ducts, located in transformer fire area, shall not have its own detectors, and the water sprinkling to this part, must begin with the same automatic control valve used for transformer protection.

34.5.7.3.2.4. Detector spacing for transformer maintenance

To facilitate transformer inspection and maintenance works, detectors must be installed separately with an appropriate safety distance from transformer, in accordance with the relevant protection level.

34.5.7.3.3. Fire detector's location for more than two spray systems

In cases where two or more spray systems were in an area protected by a separate detection system, each system must operate independently.

34.5.7.3.4. Protection of fire detector elements

34.5.7.3.4.1. Corrosion protection

The fire detectors should be protected with the use of stainless material, or else the manufacturer should apply an appropriate protective coating.

34.5.7.3.4.2. Protective covers

The detector elements that require protection from weather conditions should be provided with a protective cover or other appropriate means.

34.5.7.3.4.3. Protection against mechanical damage

The detector elements must be installed so that they are protected from harm.

34.5.7.4. Supervisory service of detection system.

34.5.7.4.1. Electric Detection System

34.5.7.4.1.1. Fire detection system supervision

Fire detection systems that depend on electrical type detector action, such as circuits of relays and other similar devices, must be permanently monitored such that their activation will be a positive notification of a fire event.

34.5.7.4.2. Pneumatic signaling detectors system

34.5.7.4.2.1. Fire detection system supervision

Fire detection system operated with pneumatic signal or hydraulic signal must be supervised with continuous air or water pressure, so that the pressure detectors (switches) activation will be a positive notification of fire event.

34.5.7.4.2.2. Air pressure supply to detector heads (liquid expansion type)

Head detector, liquid expansion type, must have a constant reliable air pressure supply.

34.5.7.4.2.3. Pipes for air filling

Air supply pipe to detector heads, coming from an air compressor and a reliable source, should not be less than 13 mm, and must have a check valve and a shutoff control valve.

34.5.7.4.2.4. Relief Valve

A pressure relief valve of approved type shall be installed between air compressor and fire detector heads, adjusted to relieve at a pressure of 30 kPa above the maximum air pressure at which the system shall operate normally.

34. 5.7.4.2.5. Detectors head pressure

Air pressure to be sustained in the detector head, shall be in accordance with quick release device requirements of the automatic control valve, or it must be above 140 kPa of set pressure, calculated from the highest pressure within the normal range of air supply. Allowed air leakage should be 10 kPa in 24 h in a system of 280 kPa,

34.5.7.4.2.6. Local test valve and remote starting electric valve

a) Local test valve: Detector heads pressurized by water or air shall have a manually operated valve to allow for the local testing of spray system by sudden pressure drop, which must operate the fast operation device of automatic control valve once receive another signal from one of the spot heat

detectors. The valve must be an approved type fit for that purpose, and it shall be maintain its closed position by proper locking.

b) Remote manual starting solenoid valve: In the detector head, pressurized by water or air, a solenoid valve shall be installed, which can be operated from central control station and under the same principle of sudden pressure drop, can manually start the spray system.

34.5.8 Control system

The control system, supervised service and alarm shall comply with specifications set out in NFPA-72.

34.5.8.1.Spray system automatic starting

Operation of the SCADA system, shall be based on the fact that the substation is unmanned, and the best form of supervision to fight fires in a transformer is a person. Therefore, the control system shall be designed to achieve the following.

28.5.8.1.1 Automatic startup of spray system

The normal startup of the systems that integrate the transformer's fire protection shall be automatic, where circuits, complying with a series of conditions imposed and in successive sequence shall indicate the start up based on the fire detector signal as a signal indicator device.

34.5.8.1.2. Personnel intervention

At the fire alarm, personnel of the central control station, in coordination with personnel located in the transformer bay, shall intervene actively but not automatically, to control the fire fighting activities.

34. 5.8.1.3. Spray system non-automatic Start-up

Non automatic start-up of systems or individual equipment integrating the fire protection system, must be located in the following zones, as described on below paragraphs.

34.5.8.3.1 Central control unit

a) Remote manual start up station. Manual start up of all individual systems and equipment of the items that integrate fire protection.

b) No manual stop. The central control station shall not have the capability to stop, except for water screens.

c) Local communication resources. Voice communication resources between personnel in transformer bays and the central control station shall be installed by NEPCO.

34.5.8.1.3.1 Pumps house

Local control shall be possible for all equipment and individual equipment from start and stop stations for testing and eventually putting into service.

Manual start up of the spray system shall be performed from the control room; this way, operators shall not run any risks.

34.5.8.1.3.2 Transformer Bay

It shall not be possible to manually start the spray system from transformer bays for testing and/or in emergency situations.

34.5.8.1.4. Spray system stop

Any stop action of the fire protection system shall be performed through voluntary and manual intervention of the personnel at the substation.

34.5.8.2 Control, supervision system and general alarms circuits

34.5.8.2.1. Central control station unit and remote communications centre

34.5.8.2.1.1. Central control station

Control of the fire protection system shall be centralized, including supervised services and alarms in the central control station, which shall be located in the control room of the power substation. The system shall advertise and raise local alarms on the conditions of equipment installed in the pump room.

34.5.8.2.1.2. Remote communications centre

In the event that the substation does not have personnel in permanent service, the alarm and supervision signals of problems shall be transmitted to a remote communications centre with a person in service at all times.

34.5.8.2.2. Control, supervision system and alarms circuits

Service control, supervision and alarm circuits shall have response characteristics that are effective to initiation, transmission and processing resource signals that accurately identify transformer fires based on complete programming of the functional principles of automatic detection.

34.5.8.2.3. Basic circuits

Basic circuits involved in the control, supervised service and alarms are:

a) Fire detection circuits using sensor elements.

b) Automatic and manual start up control circuits of the transformer fire extinguishing system.

c) Automatic and manual start up control circuits of the water screen system.

d) Control circuits of main and emergency firefighting pumps.

e) Supervised and alarm circuits of circuits indicated in a), b), c) and d).

34.5.8.2.4. Circuits design

34.5.8.2.4.1. Circuits types

Control, supervision and alarm circuits can be electronic, electromechanical or a combination of both, and they must feature:
Easy maintenance
Grouped into functional units and individual programming.
Minimum energy consumption.

34.5.8.2.4.2. Design

All circuits shall be isolated, earth free.
Wiring and equipment shall be installed compliance with provisions set forth in NFPA-70.
Circuit faults shall not affect operation of any other alarm indicator circuit.

34.5.8.2.5. Operating conditions for control devices, supervision system and alarms

34.5.8.2.6. Supply source to control units

All equipment, devices and components of the control system, monitored service and alarm, installed, shall be UL listed and FM approved, approved for the specific use, and shall operate satisfactorily under the following conditions:

a) At 85 and 100 % of rated voltage.
b) At room temperatures 0º C ± 2º C and 49º C ± 2º C, for a minimum duration of 3H.
c) At relative room humidity of 85 ± 5 % under room temperature conditions of 32 ºC ± 2ºC for duration of at least 24 hours.

34.5.8.2.6.1. Energy supply to control units

Control stations shall have three sources of electricity; these shall consist in a secondary backup supply and a supply for problem circuits.

34.5.8.2.6.2. Primary supply (principal)

The mains supply shall consist of an extremely reliable supply for the light and power services, of 2 or 3 wires with neutral conductor no fuse, so that the lack of a phase does not prevent operation by another phase; one phase may be used for primary power and another for signaling problems. The circuit of the normal power supply shall clearly indicate “FIRE ALARM CONTROL CIRCUITS”.

34.5.8.2.6.3. Source and capacity of secondary supply (back-up)

I- Secondary supply (back-up): Secondary or backup power shall automatically provide the power to control circuits, supervised service and alarms within 30 seconds every time the main feed is not capable of providing the required minimum voltage, which is considered as 85 % of the rated value. The secondary power source shall consist of an accumulator battery exclusive for this service, with operating capacity as indicated in section 5.8.2.6.4.1

II- Failure circuits supply: Regardless of the main supply, power shall be provided to fault signal circuits when main power fails. For this purpose, secondary (backup) power can be used as defined in 5.8.2.6.3.1 or from the other phase of the 3 wire supply indicated in section 5.8.2.6.2.b)

34.5.8.2.6.4. Storage batteries

a- Control batteries capacity: Accumulator batteries shall be capable of operating the supervised service control and alarms system under normal signal traffic conditions for a duration of 60 hours.

b- Automatic batteries charger: Accumulator batteries shall automatically be kept in a fully loaded state at all times. Recharge current shall be such that the battery, after being subjected to a simple discharge cycle as indicated in section 5.8.2.6.4.1, shall reach full load within 48 hours.

c- Batteries installation: Accumulator batteries shall be installed, in compliance with provisions set out in NFPA 70, in a closed steel cabinet on the ground and ventilated so that its gases do not adversely affect the signaling system, including overcurrent protection devices. Terminals shall be provided for connecting portable meters to determine voltage and current.

34.5.8.3. SCADA SYSTEM

Control circuits shall include the supervisory signaling service specifying at any time the essential conditions for the proper operation of the fire protection system.

34.5.8.3.1. Coded signals

34.5.8.3.1.1. Alarm coded signal

The coded alarm signal shall consist of no less than 3 complete wheels of transmitted numbers, and each returned wheel shall consist of no less than 3 impulses.

34.5.8.3.1.2.Supervisory coded signal

A supervisory coded signal can consist of two roulettes of numbers transmitted to indicate a condition, and a roulette of numbers transmitted to indicate the re-establishing of the supervised condition back to normal.

34.5.8.3.2. Automatic fire detection and alarms service

34.5.8.3.2.1. Automatic fire detector

The fire detection system shall comply with the provisions set out in section 5.7 Automatic fire detection system herein, and shall transmit the fire signal to the central control station for subsequent alarm and automatic start up of the fire fighting system.

34.5.8.3.2.2. Verification characteristics

The automatic fire detection and alarms system shall include verification characteristics. False operation must be avoided. The fire alarm shall be initiated within 5 s from the moment fire is detected.The pumping system of a power transformer unit triggers when it detects either the fire alarm due to temperature change or a fixed temperature threshold or when it receives a pneumatic alarm from the protected zone.

34.5.8.3.3. Water flow alarm and spray system supervisory signals

34.5.8.3.3.1. General

The water spray system shall be equipped with a water flow signal device, which shall also indicate any abnormal conditions of its components that may hinder system performance, as indicated in 5.4.8. The circuits shall be designed and installed so that these cannot be interfered with or removed without causing an alarm.

34.5.8.3.3.2. Water flow alarm service

The water flow signal indicator device that raises the alarm shall operate within 90 s from starting water flow at a rate equal or greater than that produced by the spray nozzle.

34.5.8.3.3.3. Spray system malfunction signal

Signals shall indicate the reason for the malfunction of the spray system specifically; the cause may be valve position, temperature, pressure, levels, and others.

34.5.8.3.3.4. Control valve

Supervised control valves shall produce a fault signal after the first turns of the wheel, or when the valve rod has moved 1/5 of its run from its normal position.

When signal indicator devices of 2 or more valves use one common circuit, the fault signal shall remain until all valves in the group reach their normal position.

The fault signal shall not extinguish if any position of the valve is not its normal position.

34.5.8.3.3.5. Pressure sources

Pressure sources shall be supervised to obtain a distinctive signal that indicates the required pressure is in abnormal state:

a) The pressure signal indicator device connected to the pressure tank shall detect low- and high-pressure conditions. It shall raise a signal in accordance with the pressure increase or drop by 69 kPa.
b) The pressure signal initiator device at the detector header in dry pipe shall detect high- and low-pressure conditions.

34.5.8.3.3.6. Water tank level

a) A signal initiator device shall supervise the pressure tank level and shall detect abnormally high or low water level conditions. Signals shall be obtained when the water level increases or drops. Signals shall be obtained when the water level increases or drops 76 cm from its required level.
b) A signal initiator device shall supervise the level for other tanks other than the pressure tank, detecting low level conditions. Low level signal shall be obtained when water level has dropped 300 cm.

34.5.8.3.3.7. Water temperature

In low temperature regions, tanks or water containers shall be supervised to obtain another signal indicating if water temperature has dropped to 4 ºC.

34.5.8.3.3.8. Pump

Firefighting pumps, including impulse motors and controllers, shall be supervised in accordance with requirements set out in 5.3.Herein.

34.5.8.3.4. Operation under fault conditions

34.5.8.3.4.1 Arrangement of alarm signals circuits

a) Self-adjusting and self-resetting alarm circuits. Alarm signal circuits connected between the fire alarm unit, or between the transmitter element located in protected areas and the central control station shall be arranged so that a simple earth fault of the conductor shall not prevent transmitting the alarm signal. Circuits shall be self-adjustable in the event of a simple fault or a simple earth fault, and shall automatically reset as soon as the fault or earth fault is corrected.
b) Detection of earth fault. Alarm signal circuits shall be fixed so that conductors are normally isolated from earth, and shall include a reference circuit to earth to detect and automatically indicate the existence of a simple earth fault.

Noninterference of alarm and supervised signals. Alarm signals and supervision signals not received at the central control station shall be fixed so that they do not interfere with each other; alarm signals shall have priority over supervised signals.

34.5.8.3.4.2. False fire alarm

Presence of a simple fault or simple earthing fault in any of the circuits shall not necessarily raise a signal interpreted as a fire alarm.

34.5.8.3.5. Audible signal devices

34.5.8.3.5.1. General

The sound devices to be used in alarm, supervised and fault systems, shall be:

a) Electromechanical: Bells, buzzers, comets and sirens.
b) Integral electronic tone generator

c) Speaker powered by a remote amplifier.

34.5.8.3.5.2. Characteristics of sound devices

a) Devices: Audible signal devices shall be UL listed and FM approved, weather proof, approved for the service, protected against the effects of temperature, corrosion, humidity and other physical effects.

b) Special audible signal. Audible signal devices for the alarm system shall produce signals that are distinctive from other similar ones used for other purposes in the same area.

34.5.8.3.5.3. Distinctive audible signals

Distinction between signals shall be:

a) Audible fire alarm signal: With flashing and distinctive from other signals, and shall not be used for other devices.

b) Common audible signal for supervised service and faults. Different from the fire alarm. The same audible supervised and faults signal shall be distinguished through visible indication. The visible indicator shall persist until the faults have been corrected. The switch or silencing valve shall be placed in the silent position if no faults exist, and be audible in the event of faults.

34.5.8.3.5.4. Failure signals silencing switch

The fault audible signal circuit shall allow for the use of a silencer switch, if the signals are transferred to a visible lamp indicator, placed next to the silencer switch. The visible indicator shall persist until the faults have been corrected. The silencer switch of valve shall be placed in silence position if no fault exists, and raise the audible signal from other areas.

34.5.8.3.5.5. Alarm signal silencing switch

The use of the audible alarm signal silencer switch shall be allowed only if it involves using a key or located inside a panel with a lock. Subsequent alarms from other signal initiator devices shall cause the alarm to sound again. The switch shall be placed in the silent position when no alarms exist, and operate the fault signal until the switch is re-established to its normal position.

34.5.8.3.6. Conductors integrity monitoring

All interconnection resources between equipment, alarm devices and other devices shall be supervised to verify the integrity of conductors, so that in the event of a simple fault or earthing of conductors, these will be automatically signaled at the central control station, within 200 seconds. They shall not cause an alarm signal.

34.5.8.3.7. Energy supply monitoring

Any primary source of energy to equipment, including battery chargers, shall be supervised at their connection point to verify their integrity.

34. 5.8.3.8. Signals transmission

34.5.8.3.8.1. Transmission methods

Signal transmission to the permanently staffed remote communications centre (NCC) shall be provided by NEPCO with the resources available, which may be any of the following:

a) An exclusive and independent line from any other manoeuvre network.

b) Telephone using a commercial telephone network.

c) Private radio system, using exclusive frequencies.

d) Transmission line carrier wave systems.

e) Other communication methods approved by NEPCO.

NEPCO shall indicate in its Particular Specifications the method to be used for transmitting alarm and fault signals.

34.5.8.3.8.2. Audible signals to be transmitted

The audible fault signal transmitted to the remote communications centre can be used by other signals. The act of silencing the audible signal shall not prevent another signal line occurring immediately after.

34.6 Testing, commissioning and Training

34.6.1 Testing

Prior to the final test carried in the present of NEPCO, the system shall be test in the present of the civil defense department, and NEPCO Engineer and the system shall be accepted by the civil defense department. The execution and procedure of each test shall be agreed between the contractor and Nepco, and their execution shall be performed in compliance with current regulations. A test protocol shall be produced, signed by the contractor and Nepco. Tests shall be witnessed by the representatives of Nepco and the supplier, unless the first explicitly relinquishes in writing to being present; this condition shall not exempt the supplier from its responsibility of fully complying with this specification.

The supplier shall warn Nepco in writing, four (4) weeks before the start date of tests.

Nepco may define to the manufacturer, at any time, certain test aspects as complementary to those specified in the Standards, such as: test execution method, their sequence, parts of equipment on which to perform tests, characteristics of tests and execution conditions.

All tests shall be documented through the corresponding reports.

Tests shall be made to all bolts, in the Fire Extinguishing System lines, which are under pressure, inside the pump room. These tests shall be considered, obligatory and prior, to any functional hydraulic and overpressure test of the Extinguishing System.

Tests shall consider the activation of all detectors and deluge valve, bells, manual call poits, panels, and the execution of all actions, including an actual activation of the extinguishing process, in a controlled form and for a period of time to be agreed. Tubes and all items of equipment shall be delivered, stored and maintained in closed storage with their open ends effectively plugged, capped or sealed. All fittings, valves and sundry items shall be stored in clean bins or bagged and stowed in suitable racks.
All such stored items shall be maintained under weatherproofed cover to be supplied by the contractor until they are ready for incorporation in the works.
Particular care shall be taken to ensure that electrical equipment and components are kept clean and dry.
Before installations are handed over or subjected to the inspection and tests, the entire installation shall be thoroughly cleaned, both internally and externally.
All fire protection installations shall be flushed out with clean water. During the flushing out, provision shall be made to exclude any items of plant, which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Engineer.
The fire protection system shall be tested in accordance with the NFPA codes and the relevant standards, with particular reference the requirements set forth in this section.
All testing shall be performed under the work of this section. All services required for testing shall be a responsibility of the work of this section. The Contractor shall notify the Engineer of all tests, 48 hours prior to testing. The fire protection piping System shall be tested hydrostatically for not less than 24 hours and at one and half time of the system pressure without any leaks or as directed by the local fire department.
If the systems are tested in sections, the connection to the previously tested section shall be included.
All tests that may be required by the local fire authorities shall be performed under the work of this section, in the presence of their representative, if so required.
All leaks shall be corrected and the system re-tested until no leaks are found, at no cost to the client.
Functional tests of all water flow alarms are a responsibility of the works of this Section.
When the various systems are completed, operation tests shall be run on all equipment to demonstrate proper operating conditions. These tests shall be run under the observation of the inspector and the client's operating engineer. The client's operators shall be instructed during this period. Operation tests shall be performed under the work of this section. Should any piece of equipment or apparatus of any material or work fail in any of these tests, it shall be immediately removed and replaced by a perfect material, and the portion of the work replaces shall again be tested under the work of this Section. Cost to repair any damages to the building construction occasioned by pipe leaks or defective materials shall be become under the works of this section, at no cost to the client. All corrective work shall commence immediately after damage occurs.

34.6.2 HYDROSTATIC TESTING

A. Prior to acceptance , the CONTRACTOR shall "open-bore" flush the water pipe then perform hydrostatic tests Open bore flushing is required of all installed water pipes to remove any foreign matter.The CONTRACTOR shall furnish, install and remove all pumps, fittings and pipes necessary to perform the flushing; shall provide all additional excavation and backfill; and shall dispose of all water and debris flushed from the water pipe

B. Hydrostatic testing will be conducted in the presence of the ENGINEER on newly installed water pipes after "Open-Bore" flushing, in accordance with the requirements of AWWA C600 and as stated hereafter. The CONTRACTOR shall furnish all assistance, equipment, labor, materials, and supplies necessary to complete the test to the satisfaction of the ENGINEER. The CONTRACTOR shall suitably valve-off or plug the outlet to existing or previously-tested water pipe prior to performing the required hydrostatic test.

C. Prior to testing, all air shall be expelled from the water pipe. If permanent air vents are not available to accommodate testing, the CONTRACTOR shall install corporation stops and blow-off lines so the air can be expelled as the line is filled with water.

D. The hydrostatic pressure shall be a minimum of 12 bar or 1½ times the operating pressure of the water pipe (measured at the highest elevation of the newly-installed water pipe), whichever is greater, unless otherwise directed by the ENGINEER. Acceptance pressure testing shall be done with all service lines installed, corporation stops open, and pressure against the closed curbs stops. The duration of each hydrostatic pressure test shall be 24 hours. Pumping will cease after the required test pressure has been reached. If the pressure remains constant for testing period without additional pumping, or pressure drop is less than five psi, that section of water pipe is acceptable.

E. If the pressure drops five (5) psi or more during the initial one hour hydrostatic pressure test, the CONTRACTOR shall conduct a leakage test. Leakage shall be determined by measuring "make-up" water necessary to restore the specified test pressure. The quantity of water lost from the water pipe shall not exceed the number of gallons per hour as determined by the following formula:

F. L = ND(P) 0.5 7400
   L = Allowable leakage in gallons per hour
   N = Summation of mechanical and push-on joints in length of water pipe tested
   D = Diameter of water pipe in inches
   P = Test pressure in pounds per square inch

G. Should the tested section fail to meet the pressure test as specified, the CONTRACTOR shall locate and repair the defects and then retest the water pipe as specified above. Any specific leakage point detected shall be corrected by the CONTRACTOR to the satisfaction of the ENGINEER regardless of the allowable leakage specified above.

H. All tests shall be made with the auxiliary gate valves open and pressure against the hydrant. After the hydrostatic test has been successfully completed, each valve shall be tested by closing in turn and relieving the pressure beyond. This test of the valves will be acceptable if there is no immediate loss of pressure on the gauge when the pressure comes against the valve being checked. The CONTRACTOR shall verify that the pressure differential across the valve does not exceed the rated working pressure of the valve.

I. Defective materials or poor quality of WORK, discovered as a result of the hydrostatic tests, shall be replaced by the CONTRACTOR. Whenever it is necessary to replace defective material or correct the workmanship, the hydrostatic test shall be repeated until a satisfactory test is obtained.

J. The ENGINEER shall be present for all hydrostatic and leakage tests. The CONTRACTOR shall notify the ENGINEER at least 24 hours prior to any test and shall notify the ENGINEER at least two hours in advance of the scheduled time if the test is to be cancelled or ostponed.

K. After completion of testing, all test and air vent pipe shall be removed and the corporation stop closed at the water pipe, in the presence of the ENGINEER.

34.6.3 TRAINING REQUIREMENTS:

Prior to final acceptance, the installing contractor shall provide operational training to each shift of the owners personnel. Each training session shall include system operation, manual and automatic functions, trouble procedures, supervisory procedures, auxiliary functions and emergency procedures.

34.6.4 OPERATION and MAINTENANCE:

Prior to final acceptance, the installing contractor shall provide complete operation and maintenance instruction manuals, four (4) copies for each system, to the owner. All aspects of system operation and maintenance shall be detailed, including piping isometrics, wiring diagrams of all circuits, a written description of the system design, sequence of operation and drawing(s) illustrating control logic and equipment used in the system. Checklists and procedures for emergency situations, troubleshooting techniques, maintenance operations and procedures shall be included in the manual.

34.6.5 AS-BUILT DRAWINGS:

Upon completion of each system, the installing contractor shall provide four (4) copies of system "As-Built" drawings to the owner. The drawings shall show actual installation details including all equipment locations as well as piping and conduit routing details. Show all modifications, One (1) copy of reproducible engineering drawings (transperance copy) and one soft copy (CD) shall be provided reflecting all actual installation details

34.6.6 ACCEPTANCE TESTS:

1) At the time "As-Built" drawings and maintenance/operations manuals are submitted, the installing contractor shall submit a "Test Plan" describing procedures to be used to test the fire fighting system(s). The Test Plan shall include a step-by-step description of all tests to be performed and shall indicate the type and location of test apparatus to be employed.
   The tests shall demonstrate that the operational and installation requirements of this specification have been met. All tests shall be conducted in the presence of the owner and shall not be conducted until the Test Plan has been approved.
2) The tests shall demonstrate that the entire system functions as designed and intended. All circuits shall be tested.
3) Upon acceptance by the owner, the completed system(s) shall be placed into service.

34.6.7 SYSTEM INSPECTIONS:

1) The installing contractor shall provide two (2) inspections of each system, installed under this contract, during each year of the warranty period. The first inspection shall be at the six month interval, and the second inspection at the 12 month interval, after system acceptance. Inspections shall be conducted in accordance with the manufacturer's guidelines and the recommendations of NFPA .
2) Documents certifying satisfactory system(s) operation shall be submitted to the owner upon completion of each inspection.

34.6.8 WARRANTY:

All fire fighting system components furnished, and installed under this contract, shall be guaranteed against defects in design, materials and workmanship for the full warranty period which is standard with the manufacturer, but in no case less than (5) year from the date of system acceptance.