

ISLAMIC EMIRATE OF AFGHANISTAN
MINISTRY OF ENERGY AND WATER
DEPUTY OF WATER

TERMS OF REFERENCE (TOR)
FOR
DETAILED DESIGN AND UPGRADING THE FEASIBILITY
STUDY OF SULTAN-IBRAHIM IRRIGATION PROJECT

ANNEX A
MECHANICAL TECHNICAL REQUIREMENTS



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A. HYDRO-MECHANICAL

A.1 BRIEF DESCRIPTION OF THE PROJECT SCOPE

The undertaking covers the design, construction, manufacture, supply, installation, testing and commissioning of the mechanical equipment's for SULTAN IBRAHIM IRRIGATION PROJECT.

A.2 APPLICABLE STANDARDS AND REGULATIONS

A.2.1 GENERAL REQUIREMENTS

The design, Materials, Goods, Plant, manufacture, testing and performances of the Works shall comply with the latest current ISO/IEC Standards / Codes where applicable, and/or other approved Standards or Codes, even if no reference to any standard is made in the Specifications.

When the Contract contains more restrictive requirements than those of the Standards or Codes, the Contract shall prevail.

Any reference in the Contract to standards and codes or to materials and equipment of a particular manufacturer shall be regarded as followed by the words "or equivalent". The Consultant may propose for approval of the Employer alternative recognized Standards or Codes, materials or equipment, provided they are substantially equivalent or better, in every significant respect, to those specified.

If the Consultant proposes deviations from the specified or approved Standards and Codes or desires to use Materials or equipment items not covered by these Standards and Codes, the Consultant shall state the exact nature of the change, the reason for making the change and the proof that these equipment items or Materials are substantially equivalent or better, in every significant respect, to those specified.

For applications where no relevant standard exists, current recognized practice will apply.

Where ISO/IEC Standards / Codes or other Standards are referred to, the edition shall be that current at the base date, together with any amendments issued up to that date.

The Consultant shall keep on site during the period of the electrical and mechanical site works the applicable Standards and Codes of practice concerning the electrical and mechanical site works in general and the field tests of Materials, Plant and equipment in particular. One set of these documents shall be provided by the Consultant to the Employer. The list of these documents established by the Consultant shall be submitted to the Employer prior to starting the electrical and mechanical site works.

Wherever a standard or norm has different annexes applicable in different countries then the annex applicable in Germany shall apply to the Works.

A.2.2 ACCEPTABLE ORGANIZATIONS OF STANDARDIZATION

Standard publications issued by the following organizations of standardization are generally approved standards for the Works:

- AGMA American Gear Manufacturers Association
- AISI American Iron and Steel Institute



- ANSI American National Standards Institute
- ASME American Society of Mechanical Engineers
- ASTM American Society for Testing and Materials
- AWS American Welding Society
- BS British Standards
- CCITT International Telephone & Telegraph Consulting committee
- CECT European Committee for Manufacturing of Boilers & Kindred Steel Structures
- CMAA Crane Manufacturers Association of America
- ČSN Czech National Standards
- DIN Deutsches Institut für Normung
- EN European Standards
- IEC International Electrotechnical Commission
- IEEE Institute of Electrical and Electronic Employers
- IIW International Institute of Welding
- ICEA Insulated Power Cable Employer's Association
- ISO International Standards Organization
- NEMA National Electrical Manufacturers Association
- NFPA National Fire Protection Association
- VDE Verein Deutscher Elektroingenieure
- VDI Verein Deutscher Ingenieure
- SIS Swedish Standards Institute

The applicability and order of preference is explained below.

A.3.3 GENERAL

The standards and regulations listed below are specifically applicable to the Works. For easier overview the standards are grouped into:

- Standards for General Application
- Standards for Mechanical Works
- Standards for Hydro-mechanical Works

Regardless of the above group classification, standards which cover several fields of application shall be considered for all types of Works as appropriate.

Primarily, the latest current IEC, EN, ISO, DIN and FEM standards shall apply. Should various standards cover the same topic, either the standard specifically cited in the Particular Technical Specifications shall apply, or the most stringent standard shall be used.

American, British and other standards shall have lower priority or only be used in case there are no adequate IEC, EN, ISO or DIN standards available.



When the Particular Technical Specifications contain more restrictive requirements than those of the Standards or Codes, the Particular Technical Specifications shall prevail.

A.3.4 STANDARDS FOR GENERAL APPLICATION

Norm	Title
ISO 9000	Quality management systems - Fundamentals and vocabulary
ISO 9001	Quality management systems - Requirements
ISO 9004	Quality management systems - Guidelines for performance improvements
IEC 61882	Hazard and operability studies (HAZOP studies) – Application guide
IEC 61082	Preparation of documents used in electro technology - Part 1: Rules
DIN 40719-2	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 2: Classification of objects and codes for classes
IEC 61346-1	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 1: Basic rules

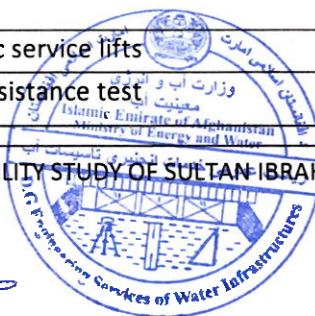
A.3.5 STANDARDS FOR MECHANICAL WORKS

Norm Designation	Title
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
AMCA	Air Movement and Control Association International
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME Boiler and Pressure Vessel Code, Section VIII: Division 1	Rules for Construction of Pressure Vessels - Division 1
ASTM A 516 / A 516M	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 743 / A 743M - C A 6 NM	Standard Specification for Castings, Iron-Chromium, Iron- Chromium-Nickel, Corrosion Resistant, for General Application
ASTM A 770/A 770M	Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications
AWWA C 104 /A21.4	American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
CCH 70.3	Specifications for Inspection of Steel Castings in Hydraulic Machines (Cahier des Charges)
DIN 15018-1	Cranes; steel structures; verification and analyses
DIN 15018-2	Cranes; steel structures; principles of design and construction
DIN 15018-3	Cranes; principles relating to steel structures; design of cranes on vehicles

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DIN 15020-1	Part 1: Lifting Appliances; Principles Relating to Rope Drives; Calculation and Construction
DIN 15020-2	Part 2: Lifting Appliances; Principles Relating to Rope Drives; Supervision during Operation
DIN 1945-1	Displacement compressor; thermodynamic acceptance and performance test
DIN EN 10028-1	Flat products made of steels for pressure purposes - Part 1: General requirements
DIN EN 10028-3	Flat products made of steels for pressure purposes - Part 3: Weldable fine grain steels, normalized
DIN EN 10083-1	Steels for quenching and tempering - Part 1: General technical delivery conditions
DIN EN 10083-2	Steels for quenching and tempering - Part 2: Technical delivery conditions for non-alloy steels
DIN EN 10083-3	Steels for quenching and tempering - Part 3: Technical delivery conditions for alloy steels
DIN EN 10084	Case hardening steels - Technical delivery conditions
DIN EN 10213	Steel castings for pressure purposes
DIN EN 10283	Corrosion resistant steel castings
DIN EN 10293	Steel castings for general engineering uses
DIN EN 12266-1	Industrial valves - Testing of valves - Part 1: Pressure tests, test procedures and acceptance criteria - Mandatory requirements
DIN EN 12266-2	Industrial valves - Testing of valves - Part 2: Tests, test procedures and acceptance criteria; Supplementary Requirements
DIN EN 1418	Welding personnel - Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials
DIN 2413	Design rules for steel pressure pipes
DIN EN 287-1	Qualification test of welders - Fusion welding - Part 1: Steels
DIN EN 60034-7; VDE 0530-7	Rotating electrical machines - Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM code)
EN 81	Safety rules for the construction and installation of lifts
DIN EN 81-1:	Electric lifts
DIN EN 81-2:	Hydraulic lifts
DIN EN 81-3:	Electric and hydraulic service lifts
DIN EN 81-58:	Landing doors fire resistance test



DIN EN ISO 3834-1	Quality requirements for fusion welding of metallic materials - Part 1: Criteria for the selection of the appropriate level of quality requirements
DIN EN ISO 3834-2	Quality requirements for fusion welding of metallic materials - Part 2: comprehensive quality requirements
DIN EN ISO 3834-3	Quality requirements for fusion welding for metallic materials - Part 3: Standard quality requirements
DIN EN ISO 3834-4	Quality requirements for fusion welding of metallic materials - Part 4: Elementary quality requirements
DIN EN ISO 9606-2	Qualification test of welders - Fusion welding - Part 2: Aluminium and Aluminium alloys
DIN EN ISO 9906	Rotodynamic pumps - Hydraulic performance acceptance test - Grades 1 and 2
EN 10028-3	Flat products made of steels for pressure purposes - Part 3: Weldable fine grain steels, normalized
EN 10204	Metallic products - Types of inspection documents
EN 10228-1	Non-destructive testing of steel forgings - Part 1: Magnetic particle inspection
EN 10228-3	Non-destructive testing of steel forgings - Part 3: Ultrasonic testing of ferritic or martensitic steel forgings
EN 10250-1	Open die steel forgings for general engineering purposes – Part 1: General requirements
EN 10250-2	Open die steel forgings for general engineering purposes – Part 2: Non-alloy quality and special steels
EN 10283	Corrosion resistant steel castings
EN 12062:1997	Non-destructive examination of welds — General rules for metallic materials.
EN 12517:1998	Non-destructive examination of welds - Radiographic examination of welded joints — Acceptance
EN 1289:1998	Non-destructive examination of welds — Penetrant testing of welds — Acceptance levels.
EN 1290:1998	Non-destructive examination of welds — Magnetic particle examination of welds.
EN 1291:1998	Non-destructive examination of welds — Magnetic particle testing of welds — Acceptance levels
EN 13445	Unfired pressure vessels



EN 1418:1997	Welding personnel — Approval testing of welding operators for fusion welding and resistance weld
EN 1435:1997	Non-destructive examination of welds — Radiographic examination of welded joints
EN 1713:1998	Non-destructive examination of welds — Ultrasonic examination - Characterization of indications in welds.
EN 1714:1997	Non-destructive examination of welds — Ultrasonic examination of welded joints.
EN 1779:1999	Non-destructive testing — Leak testing — Criteria for method and technique selection
EN 473:2000	Non-destructive testing — Qualification and certification of NDT
EN 571-1:1997	Non-destructive testing — Penetrant testing — Part 1: General
EN 583-4:1999	Non-destructive testing — Ultrasonic examination — Part 4: Examination for discontinuities
EN 970:1997	Non-destructive examination of fusion welds — Visual
EN DIN ISO 12944-1	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 1: General introduction
EN DIN ISO 12944-2	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 2: Classification of
EN DIN ISO 12944-3	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 3: Design considerations
EN DIN ISO 12944-4	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 4: Types of surface and
EN DIN ISO 12944-5	Paints and varnishes - Corrosion protection of steel structures
EN DIN ISO 12944-7	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 7: Execution and supervision
EN 1712:1997	Non-destructive examination of welds — Ultrasonic examination of welded joints — Acceptance levels.
FEM	European manufacturers association of materials handling,
IEC 60041	Field acceptance tests to determine the hydraulic performance
IEC 60193	Hydraulic turbines, storage pumps and pump-turbines - Model acceptance tests
IEC 60308	Hydraulic turbines - Testing of control systems
IEC 60545	Guide for commissioning, operation and maintenance of
IEC 60609-1	Hydraulic turbines, storage pumps and pump-turbines - Cavitation pitting evaluation - Part 1: Evaluation in reaction



IEEE 810	Hydraulic turbine and generator integrally forged shaft couplings
ISO 286-1:1998	ISO system of limits and fits - Part 1 : Bases of tolerances,
ISO 10816-1	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 1: General
ISO 10816-5	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 5: Machine sets in
ISO 1940	Mechanical vibration - Balance quality requirements for rotors in
ISO 1940-1	Specification and verification of balance tolerances
ISO 1940-2	Balance errors
ISO 2394:1986	General principles on reliability for structures
ISO 262:1998	ISO general purpose metric screw threads -- Selected sizes for screws, bolts and nuts
ISO 2768-1: 1998	General tolerances - Part 1: Tolerances for linear and angular dimensions without individual tolerance indications
ISO 4301-5: 1991	Cranes Classification; Part 5: Overhead traveling and portal bridge cranes.
ISO 7752-5: 1985	Controls-Layout and characteristics, Part 5: Overhead traveling and portal bridge cranes.
ISO 4308-1,1986	Cranes and lifting appliances- Selection of wire ropes, Part 5: Overhead traveling and portal bridge cranes.
ISO 4302: 1981	Cranes - Wind load assessment
ISO 8566-5	Cranes - Design principles for loads and load combinations.
ISO 7919-1	Mechanical vibration of non-reciprocating machines - Measurements on rotating shafts and evaluation criteria – Part 1: General guidelines
ISO 7919-5	Mechanical vibration - Evaluation of machine vibration by measurements on rotating shafts - Part 5: Machine sets in hydraulic power generating and pumping plants
ISO 8306: 1985	Overhead traveling and portal bridge cranes, Tolerances for cranes and tracks
ISO 8566-5: 1992	Cranes - Cabins, Part 5: Overhead traveling and portal bridge cranes.
ISO 10245-5:1995	Cranes - Limiting and indicating devices Part 5: Overhead traveling and portal bridge cranes.
NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection



VEÖ-Richtlinien	Verband der Elektrizitätsunternehmen Österreichs
	Richtlinien und Standards der BAST (Bundesanstalt für Straßenbau)
	Richtlinien und Standards der BAW (Bundesanstalt für Wasserbau)

A.3.6 STANDARDS FOR HYDRO-MECHANICAL WORKS

Norm Designation	Title
BS 5950	Structural use of steelwork in building
BS 5950-1	Code of practice for design - Rolled and welded sections
BS 5950-2	Specification for materials, fabrication and erection - Rolled and welded sections
BS 5950-3	Design in composite construction - Code of practice for design of simple and continuous composite beams
BS 5950-4	Code of practice for design of composite slabs with profiled steel
BS 5950-5	Code of practice for design of cold formed thin gauge sections
BS 5950-6	Code of practice for design of light gauge profiled steel sheeting
BS 5950-7	Structural use of steelwork in building - Specification for materials and workmanship: cold formed sections
BS 5950-8	Structural use of steelwork in building - Code of practice for fire resistant design
BS 5950-9	Code of practice for stressed skin design
BS 7668	Weldable structural steels - Hot finished structural hollow sections in weather resistant steels - Specification
CECT	Comité Européen de la Chaudronnerie et de la Tuyauterie
DIN 18800-1	Structural steelwork; design and construction
DIN 18800-2	Structural steelwork; analysis of safety against buckling of linear members and frames
DIN 18800-3	Structural steelwork; analysis of safety against buckling of plates
DIN 18800-4	Structural steelwork; analysis of safety against buckling of shells
DIN 18800-5	Steel structures - Part 5: Composite structures of steel and concrete - Design and construction
DIN 18800-7	Steel structures - Part 7: Execution and constructor's qualification
DIN 19704	Hydraulic steel structures
DIN 19704-1	Criteria for design and calculation
DIN 19704-2	Design and manufacturing
DIN 19704-3	Electrical equipment
DIN EN 10025	Hot rolled products of structural steels
DIN EN 10025-1	Hot rolled products of structural steels - Part 1: General technical delivery conditions
DIN EN 10025-2	Technical delivery conditions for non-alloy structural steels
DIN EN 10025-3	Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels
DIN EN 10025-3	Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels
DIN EN 10025-4	Technical delivery conditions for thermo-mechanical rolled weldable fine grain structural steels
DIN EN 10025-5	Technical delivery conditions for structural steels with improved atmospheric corrosion resistance



DIN EN 10025-6	Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition
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A.4 GENERAL SPECIFICATIONS FOR MECHANICAL WORKS

A.4.1 GENERAL

A.4.1.1 MATERIALS

ISO, EN, DIN (German Industrial Standards), BS (British Standards), ASTM (American Society for Testing Materials), AISI (American Iron and Steel Institute) are pre-approved standards for the supply of materials.

Material tests according to DIN EN 10204 3.1.C shall be provided for all important parts of the equipment such as: steel plates for parts under hydraulic pressure, all major castings (runner hub, runner blades, wicket gates etc.), large forgings (turbine and generator shaft etc.), high-stressed large bolts etc.

Materials shall be new and of adequate quality, suitable for the purpose, free from defects and imperfections, and with classifications and grades in conformance with the latest issue of the respective ISO, EN, DIN, BS, ASTM or AISI standard. Material specifications, including grade or class data, shall be shown on the appropriate detail drawings submitted to the Employer as part of the Consultant's Documents.

If stock material not specifically prepared for the Works is used, the Consultant shall submit evidence that this material complies with approved standards and that it is adequate for the intended use.

The Consultant shall indicate in the Data Sheets the materials and applicable standards for all major parts.

Materials shall be carefully selected for the intended purpose and under due consideration of site conditions.

A.4.1.2 UNITS OF MEASUREMENTS

SI units shall be used in all documents, calculations, correspondence, drawings, etc. with the exception of pressure, which can be stated in bar.

A.4.1.3 WORKS IDENTIFICATION SYSTEM

The various components of the electrical and mechanical installations, equipment, appliances, conductors, cables, terminals, etc. shall be allocated and indelibly marked with a unique tag number, which shall be used to identify the equipment both on drawings and in the field.

The designation system shall follow the rules of the RDS-PP (Reference Designation System for Power Plants), ISO TS 16 952-10.

The Consultant's Works Identification System shall be submitted for the Employer's approval prior to implementation. The Employer may select one common Identification System for the entire Works and reserves the right to deviate from the Consultant's proposal.



The system shall be based upon area codes allocated to each main area (e.g. control room, relay room, switchyard, turbine room), an equipment code comprising an equipment identifier, and a unique sequence number.

The local designation of all components shall contain descriptive texts in English.

A.4.1.4 CONSTRUCTION PROGRAM

The progress of the work shall comply with the latest revision of the time schedule submitted by the Consultant under Sub-Clause 8.2 of the Conditions of Contract and shall include the following information for individual parts or equipment:

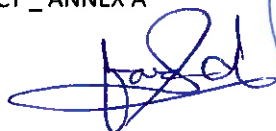
- Design work
- Model testing
- Shop work
- Shop testing
- Transport to the site
- Preparations at the site
- Erection and commissioning
- Pre-commissioning tests
- Commissioning tests
- Trial operation
- Tests on completion
- Taking over by the Employer
- Removal of erection equipment and clearing of the Site.

A.4.2 TECHNICAL DOCUMENTS

A.4.2.1 GENERAL

This sub-section specifies the general scope with a definition of the documents which, together with those listed in the Particular Technical Specifications, shall be delivered by the Consultant to the Employer as part of the Consultant's Documents in compliance with the Conditions of Contract within the periods and in a number and quality as specified in the Conditions of Contract.

The technical documentation shall conform to German standard VGB R 171 "Richtlinien zur Lieferung technischer Dokumentationen für fossile und regenerative Kraftwerke" (Guidelines for Supplying Technical Documentation for Fossil and Regenerative Power Plants).



Technical documents means all drawings, diagrams, specifications, lists and schedules, operation and maintenance manuals, and technical information of a like nature submitted by the Consultant to the Employer as part of the Consultant's Documents.

Technical documents provided by the Consultant shall be folded down to DIN standard size A4 in size. Prints shall be on durable paper, with dark lines on a white background. The technical documents shall show the following particulars either on the title page for A4 size or in the lower right hand corner for A1 or A3 size:

- Name of Employer
- Name of Consultant who prepared the respective document
- Name of Consultant
- Contract number and title
- Title of technical documents (location, item and detail)
- Scale
- Date of technical documents
- Technical document number
- Revision identification
- Serial number in accordance with drawing classification system
- Signature of the Consultant's Representative.

A blank space 90 x 60 mm shall be provided as an extension of the title block for the Employer's review stamp. Provision shall be made for details of revisions to be recorded above the title block.

The design and drawings shall be submitted in such sequence as to facilitate the Employer's review and shall be complete in regard to all computations and data. All technical documents shall be printed on DIN standard size sheets and shall be clearly legible and neat.

Unless specified differently elsewhere a period of twenty eight (28) days after the receipt of design and drawings shall be allowed for review or comments. Another one (1) week shall be allowed for return mail.

Claims or extensions of time will not be granted on account of late submission of drawings to the Employer or for delay caused by drawings requiring re-submission. Should the Employer deem a longer period of time necessary for checking certain drawings, he shall inform the Consultant to that effect in writing, within 21 days of receiving such drawings.

Whenever the Employer notifies the Consultant under Sub-Clause 5.2 of the Conditions of Contract that any of the technical documents do not comply with the Contract, then such documents shall be revised and resubmitted by the Consultant within 14 days. All materials



ordered or work performed prior to review of the relevant designs or drawings by the Employer shall be at the Consultant's risk. When the Consultant prepares or revises his time schedule under Sub-Clause 8.2 of the Conditions of Contract, he shall make allowance for and indicate the dates expected for submission and resubmission of technical documents by the Consultant. He shall also indicate the time for review of the technical documents by the Employer.

All costs for preparation, submittal, modifications and re-submittal of all documents and information required under this Contract shall be borne solely by the Consultant.

The Employer reserves the right to request from the Consultant additional documents as may be required for proper understanding and definition of constructional, operational, coordination or other matters.

The Consultant shall cooperate with other entities in the exchange of drawings, dimensions, data and all other information required to ensure proper coordination of the Works. If the Consultant fails to submit such documents, then the later execution of changes requested by the Employer and the resulting additional cost and/or delays shall be the Consultant's responsibility.

On drawings, catalogue sheets or pamphlets of standard works submitted to the Employer the applicable types, paragraphs, data, etc., shall either be marked distinctively or the non-applicable parts shall be crossed out. Documents not marked in such a manner will not be accepted by the Employer.

If required for proper understanding of the documents, additional descriptions/ explanations shall be given on these documents or on separate sheets. All symbols, marks, abbreviations, etc., appearing on any document shall clearly be explained by a legend on the same document or on an attached sheet (if not used in accordance with the agreed Works Designation System).

Each device appearing on any document (drawing, diagram, list, etc.) shall be clearly designated. The abbreviation mark used for an individual device shall be identical throughout the complete documentation so as to avoid confusion. All documents shall have a uniform title-block agreed by the Employer. Beginning with the very first submittal to the Employer, the Consultant's drawings shall bear a serial number corresponding to a drawing classification plan to be agreed upon by the Consultant and the Employer.

Revised technical documents replacing previously submitted documents shall be marked accordingly. Also, the revised part in the document itself shall be marked clearly with a cloud mark.

A.4.2.2 HAZOP STUDIES

The Consultant shall carry out HAZOP studies conforming with IEC 61882 for different system life cycle phases such as:

- Concept and definition phase
- Design and development phase



- Manufacturing and installation phase
- Operating and maintenance phase

for all safety relevant systems of the Plant such as fire fighting system, alarm system, communication system, control system, HVAC system etc.

For determination of tolerable risk and safety integrity levels, Risk Class II according to IEC 60511 shall be applied.

The results of the study for the "Operating and maintenance phase" shall be incorporated in the form of recommendations and guidelines for safety and operation in the Operation and Maintenance Manuals of the various systems and Plant.

A.4.2.3 DRAWINGS

A.4.2.3.1 LOADING DRAWINGS

For all larger items of Plant which, due to their dimensions and/or weight and transport limitations, will require special means for their transportation, the Consultant shall submit binding loading drawings indicating dimensions, weights, etc., of the respective Works sections and the trailer needed for its transportation to the Site.

A.4.2.3.2 FOUNDATION DRAWINGS

If an item of Plant requires its own foundation or needs a special area for installation, the Consultant shall submit drawings indicating all pertinent dimensions, static and dynamic loads, etc. They shall include all essential details required for proper design and construction of the foundations and/or buildings.

In addition, they shall include openings, sleeves, slopes and the arrangement of any supporting structure, i.e. base-frames or other steel constructions for permanent fixing or erection purposes.

If conduits are to be installed in the foundations, relevant information such as diameter, length, and purpose shall be indicated on the drawings.

A.4.2.3.3 ARRANGEMENT AND LAYOUT DRAWINGS

All layout drawings shall be drawn to scale. The General Arrangement (Layout) Drawings shall show the physical arrangement of Works (constructions, machines, complete switchgears, control panels, instrument cubicles, etc.), civil constructions (buildings, rooms, foundations, ducts, etc.) and reserved areas (for pipes, cables, lines, etc.) in relation to each other and to agreed coordinates and boundaries.

The Arrangement or Layout Drawings of electrical as well as instrumentation and control equipment shall indicate the location of all apparatus wherever used, i.e. in or on machines, control boards, switchboards, cubicles, control desks and panels, etc. The apparatus shall be designated with the same standardized abbreviations and EDS codes as used in all other documents.



These drawings shall take into account the functionality, the requirements for erection, operation, accessibility and maintenance of each item of the Plant.

A.4.2.3.4 OUTLINE DRAWINGS

The Outline Drawing shall show all elements and the main dimensions of individual components, where necessary in plan view, cross-section, side and top views. If reasonably possible, such dimensions may be shown on Arrangement and Layout Drawings.

A.4.2.3.5 DESIGN DRAWINGS

The Design Drawings shall include the shop drawings, assembly drawings, erection drawings, piping diagrams and piping arrangement drawings, etc., showing the dimensions, design and data of all Goods and Plant.

The drawings shall - where applicable - substantially conform to the Tender Drawings and shall show:

- Details of manufacturing and treatment of major single work pieces specially manufactured for this Contract
- Assembly of the Works in plan and elevation with main dimensions
- Sub-assembly of the principal components of the Works with overall dimensions, adjustment and clearance tolerances, numbers of corresponding detail drawings
- Sub-assemblies in which the Consultant proposes to ship the Works
- All necessary details of the parts connecting to the Works supplied by others
- Location and sizes of auxiliary connections for oil, grease, water, air, electrical power etc.
- Location and size of the instruments and accessories provided
- Methods of lubrication and sealing
- Instructions for heat treatment, pressure tests, surface preparation and anti-corrosive protection
- Full details of parts for which adjustment is provided or which are subject to wear
- Method and sequence of installation, field joints, erection and lifting devices, jacks, grout plugs, anchoring details, etc., if not shown on foundation drawings.
- Screw mounting torques and elongations of pre-stressed bolts Materials
- Extent and type of applied corrosion protection.

A.4.2.3.6 INSTALLATION DRAWINGS

The construction, mechanical, electrical and I&C Installation Drawings shall provide detailed information on the disposition of the various items of a system (e.g. transmitters, actuators, connection boxes, cubicles, pipes, valves, pumps, compressors, etc.) and of the piping, wiring (cable trays, conduits, ducts), grounding etc. included in the installation or assembly. They shall be based on dimension drawings of cubicles, rooms, buildings or areas containing the Plant.



A.4.2.3.10 BLOCK DIAGRAMS

Block Diagrams shall be used to show in a simplified manner the main inter-relationships between the elements of a system by means of symbols, block symbols and pictures without necessarily showing all the connections. The symbol used for each component type, e.g. servo-motor, computing module, etc., shall clearly be explained on the diagram or on an attached legend. When appropriate, a Block Text Diagram may be prepared, consisting essentially of explanatory texts enclosed in outlines which are linked by lines showing the functional relationships that exist between the various parts of an installation, works or circuit.

A.4.2.3.11 LOGIC DIAGRAMS

The Logic or Functional Control Diagrams (FCDs) shall be used for representation of logic and sequence controls and interlocking by showing only binary logic elements and their effect on the various process equipment disregarding their electrical realization. Logic function elements (AND, OR, NOR, NAND, STORAGE, etc.) shall be used for processing and combining binary signals.

Step-by-step sequence diagrams for start/stop automatics shall be used.

A.4.2.4 MATERIAL SPECIFICATION

Such specifications shall be prepared for all principal works and installations. They shall describe the performance (design, material, dimensions, corrosion protection, etc.) of the works and include a list of components providing information on the manufacturer, type and technical data to obtain the following:

- Full information on the works, showing that they meet the Specifications, together with data/information of the specific manufacture
- Proof of compliance with Specifications.

For standard proprietary equipment (for example valves, switchgear, control gear, relays, transmitters, indicators, lighting fittings, etc.) catalogues or pamphlets can be submitted.

A.4.2.5 LISTS AND SCHEDULES

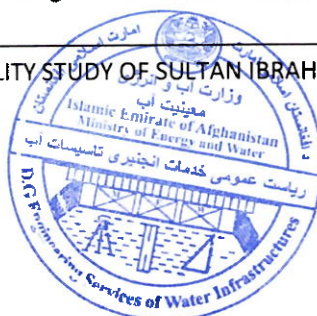
A.4.2.5.1 GENERAL

The Consultant shall, apart from drawings and specifications aforementioned, complete his design documents with various lists and schedules for his design (consumers (AC, DC and Uninterrupted Power), motors, sensors, instruments etc.) and for all items to be supplied by him (governing system, cooling system, I&C system, MCC, excitation, etc.).

A.4.2.5.2 CONSUMER (MOTOR) DATA SCHEDULE (MDS)

Information concerning the electric consumers (motors, heating, etc.) shall be collected and entered in an "MDS".

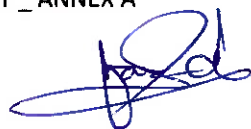
Motor specifications shall include the thermal motor characteristic both for cold and hot condition, the start-up characteristic when running with the driven machine and all data required



for selection of the appropriate motor protection relay (both for cold and hot condition) and for locked rotor protection.

As a minimum, the following information/data are required for electrical consumers (if applicable):

- Works identification number Description
- Manufacturer, type, rated data of driven machine
- Manufacturer and type of electric motor/consumer
- Rated capacity
- Service factor (ratio between motor output and power requirement of the driven machine)
- Rated speed
- Rated voltage
- Rated current
- Ratio of starting current to rated current
- Ratio of pull-out torque to rated torque
- Power factor at rated capacity
- Efficiency at rated capacity
- Power consumption at machine design loading
- Total weight
- Design/enclosure/cooling (according to IEC)
- Duty (continuous/intermittent/start-up)
- Starting method/permmissible starting frequency
- Denomination of feeder
- Motor protection
- Applicable Standard Circuit Diagram
- Maximum number and overall diameter of power cable(s)
- Manufacturer and type of bearing(s)
- Manufacturer, type and quantity of lubricant, service interval
- Manufacturer, type, number, size, spring pressure and service interval of brushes (if applicable).



A.4.2.5.3 MOTOR STARTER LISTS

The motor starter lists shall include all starters and contactors used for motors and contain the following technical information as a minimum:

- Works identification number
- Electrical design data as nominal and actual current rating, voltage rating, coil rating, making and breaking capacity, mode of operation
- Maximum power cable size
- Maximum control cable size
- Current transformer ratio, class and capacity
- Type of protection relaying and catalogue number
- Setting of protection relays and maximum continuous rating of the protected circuit
- Type and current rating of the back-up fuses/MCBs for the main and control circuits.

A.4.2.5.9 WORKSHOP TEST SCHEDULES

Individual Workshop Test Schedules shall be prepared for works/installations (such as turbines, governors, valves, gates, pipes, bifurcation, cranes, hydraulic hoists, machines, generators, transformers, switchgear, control gear, I&C systems, bus ducts, cables etc.) and shall contain at least:

- Works identification number
- Manufacturer
- Place of manufacture
- Place of test
- Date of test
- Objective of test (all individual tests)
- Standards applied
- Certification
- Inspection (by Employer / Independent Test Authority / Consultant/ SubConsultant)
- Release for shipment
- Remarks.



On the above schedule or on separate sheets, the Test Procedure shall be specified giving for each test item (type of test) a description, test method / standards, used instruments, sample/routine test, test judgment.

For complex systems such as control and monitoring systems, governors, etc., Functional Acceptance Tests shall be performed at the Manufacturer's workshops. In addition to the required information above, the Consultant shall provide detailed information about the performance criteria of the system on test.

A.4.2.5.10 SITE TEST SCHEDULES

The scope shall be the same as that for the Workshop Test Schedules above.

A.4.2.5.11 LISTS OF TOOLS AND APPLIANCES

Lists of Tools and Appliances shall detail for all tools and appliances:

- Item and code number
- Description
- Quantity
- Weight where applicable
- Gross storage requirements (separately for open-air, indoor, air- conditioned) for individual components.

A.4.2.5.12 SPARE PART LISTS

Spare part lists shall detail for all parts supplied:

- Item and code number
- Description
- Quantity
- Weight where applicable
- Gross storage requirements (separately for open-air, indoor, air- conditioned) for individual components.

A.4.2.5.13 LIST OF EDS IDENTIFICATION NUMBERS

This list shall contain the used Works identification numbers in alphanumeric order and for each a description (the defined Works denomination, for example as written on the Works label) and the location (short definition of outdoor area and level elevation or building/room with elevation and room number). The form of this list should be suitable for ordering the designation plates and labels.



A.4.2.6 CALCULATIONS

The Consultant shall submit to the Employer as part of the Consultant's Documents the calculations for determining the main sizes, dimensions and operational characteristics, clearly indicating the principles on which the calculations were based. Calculations shall include formulas, standards, test results, basic assumptions, etc. Submission of computer calculations without baseline information such as derivation of the calculation method, applied formulas, definition of variables and constants, explanation of abbreviations etc., will not be accepted.

Hydraulic calculations of main hydraulic components such as runner, spiral case, draft tube, penstock manifold etc. shall be performed using CFD analysis.

Stress and deformation analysis of major mechanical components shall be performed using FEM.

The short-circuit calculations shall be performed in accordance with relevant VDE or IEC standards, using internationally recognized calculation software.

A.4.2.7 INSTALLATION AND COMMISSIONING PROCEDURES

A.4.2.7.1 INSTALLATION PROCEDURES

The installation procedures shall describe in sequential steps Plant erection and shall contain sufficient details regarding equipment preparation on erection bay, handling of large and heavy items, leveling, anchoring, site welding, site painting, erection checks, site pressure tests, site flushing and cleaning of hydraulic systems, alignment and run-out checks.

A.4.2.7.2 PRE-COMMISSIONING PROCEDURES

Pre-commissioning tests and procedures shall be described in sequential steps and in sufficient detail for pre-commissioning of all electrical and mechanical equipment, and shall contain all information required for checking of installations, ratings, cable terminal checking and operational testing of all auxiliary equipment.

A.4.2.7.3 Commissioning procedures

The commissioning procedures shall describe sequentially and in sufficient detail activities for Plant testing.

A.4.2.8 OPERATION AND MAINTENANCE MANUALS

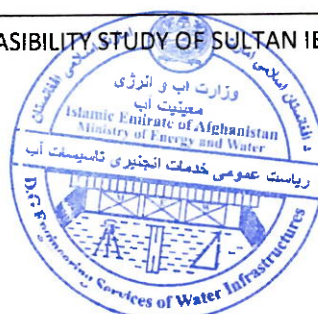
A.4.2.8.1 LANGUAGE

All operation and maintenance manuals shall be provided in English.

A.4.2.8.2 CONTENTS

The Operation and Maintenance (O&M) Manuals shall contain the following information in sufficient detail to enable the Employer to maintain, dismantle, reassemble, adjust and operate the Plant.

a. Table of Contents



b. List of Illustrations

c. Introduction

The Introduction shall contain:

- A brief general description of the work items
- A brief description of the use of the work items
- Definitions of technical terms used in subsequent graphs of the instruction book
- A complete list of all items used in accordance with the Works Identification System.

d. Detailed Description

This shall contain a complete and accurate description of the Works, all components and ancillaries, their assembly and dismantling. An accurate list stating clearances, tolerances, temperatures, fits, etc. shall be included.

e. Operating Principles and Characteristics

A brief summary of the technical operating principles of the Works, including diagrams, circuit diagrams, sequence diagrams, piping, etc.

f. Operating Instructions

The instructions shall be accurate and easy to understand, and shall contain the sequence of individual manipulations required for operation. The information shall be presented in such a manner that the contents of this paragraph can be used for instructing personnel in the operation of the Works. Tables, lists and graphic presentations should be used whenever possible for making the description readily understandable. An appropriate trouble-shooting list shall be included in this chapter.

g. Testing and Adjustment

The entire testing and adjustment procedure required for the Works after overhauls and during operation shall be described.

h. Maintenance Instructions

This section is divided into five paragraphs:

- Preventive maintenance, indicating the inspections required at regular intervals, the inspection procedure, routine cleaning and lubricating operations, regular safety checks and similar steps. The maintenance instructions shall include a tabular (or in other approved form) summary of the required activities, sorted by daily, weekly, monthly, quarterly, yearly, (or other) cycles as applicable.
- This document shall provide the Employer's maintenance staff with brief yet fully comprehensive information, including all references to the applicable, detailed service and maintenance instructions, setting out:



- i. repair and adjustment, describing the inspections, fitting and dismantling of parts, fault tracing as well as repair and adjustment procedures
- ii. spare part lists, containing all data needed for ordering spare parts: These shall include all spare parts; those to be supplied and those not to be supplied under the present Contract. The prices for each spare part (exceeding a unit price of €100 or approximately US\$150) shall be stated in the list.
- iii. tool lists, containing all data needed for identification of tools to be delivered under the present Contract
- iv. list of suppliers and alternative suppliers with addresses.

i. As-built drawings.

A.4.2.8.3 FORMAT AND COMPILATION

For the final O&M Manuals, the text, diagrams, drawings, brochures and all other instruction content shall be reproduced in ink by letterpress or offset printing or in carbon by electrostatic printing. Reproductions obtained by using dyes, chemicals or photo-sensitive or heat-sensitive materials are not acceptable.

All text shall be on size A4 paper except that brochures of smaller sizes will be accepted for minor components of proprietary equipment provided they have adequate binding margins.

The main text shall be on white paper.

The paper used in the final version of the O&M Manuals shall be of the following archival quality material:

- White sheets: 70 g/m² to 106 g/m²;
- Colored sheets: not less than 70 g/m².

Diagrams and drawings provided as part of the O&M manual shall be size

A3 wherever the original is size A3 or larger and size A4 for all others.

The manuals shall be strongly bound in a durable stiff cover of the loose leaf binder type, bearing the title in approved legend. Bound volumes shall not exceed 29 cm by 32 cm in size and be more than 8 cm thick. All volumes shall bear on the spine an approved shortened version of the title.

The Employer will indicate in due time the type of cover to be used.

The Employer may request the Consultant to adapt drawings (construction, single line, wiring, terminal diagrams, etc.) to drawings of another entity in order to facilitate maintenance, surveillance, repair of faults, etc. Catalogue sheets, illustrations, printed specifications, etc., shall be checked and prepared by the Consultant in such a way that the figures, statements and data



valid for the delivered sizes and types of the Works concerned are clearly marked. All figures, statements and data valid for sizes and types not delivered must be crossed out.

A.4.2.8.4 REVISIONS AND SUPPLEMENTS

The completeness of the manuals shall be checked during installation, testing, commissioning and trial operation jointly by the Consultant and Employer.

If it becomes evident during installation, commissioning, trial operation and Defects Liability Period of the Works that the Operation and Maintenance Manuals are inadequate or incorrect, the Consultant shall supply immediately the necessary supplements and corrections. This shall be handled in the following manner:

Deletions

One sheet of errata, printed on pink paper, shall be issued indicating the pages and date of issue of those pages which are to be deleted and are no longer valid.

Corrections, Revisions, Replacements

New sheet or sheets shall be issued to replace the wrong pages. Whenever a new sheet is added to the O&M Manuals, this sheet shall be given the new date of issue and a revision symbol, and an indication "Substituted for ..." with marking of the corrected/revised items.

Insertions, Supplements

Insertions or supplements shall be accompanied by a new respective "Table of Contents" page, where the latter shall be handled as described above under replacements.

The revisions and supplements requested by the Employer shall be made by the Consultant at the Site as far as possible and shall be submitted in each case to the Employer for checking and revision as stated above.

Before issuing the Taking-Over Certificate, the revised copies of the Operation and Maintenance Manuals shall be submitted together with the specified number of complete sets of drawings of the Works as completed. The Works shall not be considered complete for purposes of taking over until the above documents have been supplied by the Consultant.

A.4.2.8.5 TEST REPORTS DURING MANUFACTURING

For all tests carried out in the manufacturing period, comprehensive reports have to be submitted to the Employer containing all relevant information such as description of test, tools and gauges used, data logs of readings, admissible values for readings, evaluation of results, etc. so as to allow full reconstruction of testing and results at a later stage.

A.4.2.8.6 TEST REPORTS DURING INSTALLATION ON SITE

For all tests carried out in the installation period, comprehensive reports shall be issued containing all relevant information such as description of test, tools and gauges used, data logs of



readings, admissible values for readings, evaluation of results, etc. so as to allow full reconstruction of testing and results at a later stage.

A.4.2.8.7 COMMISSIONING REPORT

The commissioning report shall contain all relevant test results, diagrams, settings and characteristic system data.

A.4.3 SPARE PARTS AND TOOLS

A.4.3.1 SPARE PARTS

All spare parts to be supplied shall be interchangeable with the corresponding parts of all the Works and shall be of the same material and workmanship. They shall be replaceable without cutting or destruction of adjacent components.

After the Tests on Completion and before issue of the Taking-Over Certificate, the Consultant shall identify the parts to the Employer. The parts shall be checked and inspected for damage by the Consultant. Functional tests and pre-settings of electrical and electronic parts shall be carried out as far as possible. The Consultant shall re-pack the spare parts for permanent storage and place them in the storage area.

The Consultant shall not depend on the use of the spare parts and consumable products ordered by the Employer for carrying out the Works.

Acceptance of any spare parts will not take place before the Consultant has submitted the complete final detailed list of all spare parts and tools.

All spare parts shall be protected against corrosion and shall be marked with Works Identification System labels. All spare parts, tools and materials shall be delivered in marked boxes of sufficiently sturdy construction to withstand long term storage.

A.4.3.2 SPECIFIED SPARE PARTS

The required specified spare parts are listed separately in the Particular Technical Specifications. The price for each listed special spare part shall be quoted individually in the Tender and the total price shall be included in the Tender Price.

A.4.3.3 RECOMMENDED SPARE PARTS

If any additional spare parts are recommended by the Consultant, these shall be stated in quantity and description in the Tender for each item.

Orders for recommended spare parts shall be optional to the Employer for a period of two years after the date of signature of the Contract Agreement.

A.4.3.4 TOOLS AND APPLIANCES

The tools, wrenches, etc. shall be unused. Customary tools for erection shall be of the forged and polished chrome-vanadium type. Special tools and devices shall be provided as necessary with means for ready identification.

All lifting devices and wire rope slings to be used at site shall be works tested and test certificates shall be supplied to the Employer.

An itemized list and description of all provided tools, auxiliary devices, storage equipment, etc. shall be included in the Tender. Acceptance of any tool or device shall not take place before the Consultant has submitted the complete final detailed List of Tools and Appliances.

Ropes, slings etc. shall be handed over in new condition. The Employer shall be entitled to take over from the Consultant the entire erection tools, appliances and instruments at mutually agreed conditions.

A.4.4 DESIGN AND MANUFACTURE

A.4.4.1 DESIGN AND CONSTRUCTION REQUIREMENTS

The following directions, information and technical requirements for layout, design and erection shall be observed as far as they are applicable to the Plant.

The Plant shall be designed, manufactured, arranged and installed to provide a functional design and neat appearance. All Plant components shall be arranged to facilitate easy surveillance, maintenance and operation. All control sequences shall be simple and rational.

The parts of the Plant shall be designed and arranged so that they can be easily inspected, cleaned, erected and dismantled without involving large scale dismantling of other parts of the Plant. They shall be designed, and manufactured in accordance with the latest recognized rules of workmanship and modern engineering practice.

The regulations, standards and guidelines listed in these Specifications shall be observed in the design, calculation and manufacture of the Plant.

All Plant shall be suitable in every respect for continuous operation at maximum output under the climatic conditions and operating conditions prevailing at the Site.

For individual Plant items, Materials and design are to be selected which are best suited for the operating conditions to which the parts in question will be subjected. Only such design and types of Plant shall be offered that have confirmed their reliability in long-term continuous operation.

All live, moving and rotating parts shall be adequately secured in order to avoid danger to the operating staff. All electrical components shall be safely grounded.

Manufacturers shall take appropriate measure to prevent the ingress of dust into any items of Plant (such as bearings, relays, control and measuring equipment, etc.) which may be endangered thereby.

Suitable lifting eyes and backing-out bolts shall be provided where required or where they will be useful for erection and dismantling.

Pockets and depressions likely to hold water shall be avoided, and if not avoidable they shall be properly drained.



Parts of the Plant principally intended for standby purposes shall be protected from corrosion by careful choice of material and, if necessary, by additional means; these should not reduce their continuous standby readiness.

All design details and layout matters shall be discussed in periodic meetings with the Employer. The first design meeting between the Consultant and the Employer shall take place within 28 days after the Commencement Date. Further design meetings shall take place as agreed between the participants until the design work is completed.

A.4.4.2 ALLOWABLE STRESS

The layout of the Plant shall fundamentally consider the most severe conditions to which components will be subjected during testing and operation.

The dimensions of parts subjected to repetitive and alternating stresses as well as to impacts and vibrations shall take into account safety factors approved in practice.

Unless otherwise specified, for custom-designed equipment such as turbines, generators, main inlet valves, etc. the following rules shall apply:

Static loads

The equivalent stress calculated according to the von Mises theory σ_{mises} in relation to the minimum yield point has to be within the following limits:

For uniformly distributed stresses

- Normal operation: $\sigma_{mises} / \text{min yield point} < 50\%$
- Exceptional operating conditions: $\sigma_{mises} / \text{min yield point} < 60\%$
- Extreme load cases $\sigma_{mises} / \text{min yield point} < 75\%$

For maximum local stress peak

For each load case, the limit for maximum local stress peak has to be lower or equal to 1.3 times the value stated above for static loads.

Dynamic loads

The design has to consider dynamic loads and ensure fatigue strength over the expected lifetime of the Plant of at least 50 years with an appropriate safety factor being at least 1.2.

Fatigue strengths of wetted parts

A reduction of the fatigue strength due to exposure to water or humid environment has to be taken into account by appropriate reduction of the endurance limit where applicable.

Definition of operational loading cases

The operational loading cases are defined as follows:



- a) Normal operation means operation under load up to the maximum permissible continuous output under maximum head, taking into account the effects of water hammer and of speed rise after load rejection under the most adverse combination of operating conditions.
- b) Exceptional operating conditions mean the runaway speed, occurrence of short circuits, emergency closure of the main inlet valve under flow, failure of protection device at the wicket gates, operation of servomotor with engaged blocking device etc.
- c) Extreme load case means the pressure test, the blockage of one of two servomotors for operation of the wicket gates or of the main inlet valve etc.

Standard equipment

Standard equipment such as standard type electric motors, standardized armatures, gear boxes, switches, etc. are not subject to the requirements specified above for custom designed equipment. The allowable stress levels shall reflect common industry practice to ensure high quality and durability of the equipment.

Hoisting equipment and steel structures

The allowable stress levels for hoisting equipment and steel structures shall conform to applicable standards as specified in the relevant chapters of the Technical Specifications.

A.4.4.3 DESIGN CRITERIA

The Plant shall be designed for the worst possible combination of the following loading conditions:

- all static and dynamic hydraulic loads
- forces due to short-circuits
- all loads due to dead weight and frictional forces
- seismic or wind loads
- thermal load, and
- other loads.

A.4.4.4 SEISMIC LOADS

Earthquake forces including hydraulic loads that may additionally occur shall be taken into account for the computations. Vertical and horizontal accelerations shall be combined in the most unfavorable way.

Stresses resulting from these loads shall not exceed permissible stresses.

A.4.4.5 WIND LOAD

Except where otherwise stated, the minimum basic wind pressure of $1,250 \text{ N/m}^2$ shall be applied on the vertical projected area, multiplied by the following factors for the different type of structures.

For a cylindrical surface: 0.7

For lattice member, at front side: 1.6



For lattice member, at rear side: 1.2

A.4.4.6 STANDARDIZATION OF PLANT

Every effort shall be made to standardize parts and minimize costs of the Plant to facilitate keeping stocks, maintenance, replacement, interchangeability, etc.

The Employer, therefore, reserves the right to request the Consultant to use uniform types or makes of Plant and Materials. The Consultant shall not be entitled to claim extra payment due to this request. This request shall especially be applicable to small mechanical and electrical works such as:

- piping
- valves
- thermometers
- pressure gauges
- flow meters
- water level gauges
- sight flow indicators
- terminals and terminal racks
- indicating instruments and meters
- auxiliary relays
- LV circuit breakers, contactors, fuses
- motor protection switches
- control devices
- lights, bulbs, plugs, sockets.

A.4.4.7 NOISE

The noise level caused by the Plant shall not exceed the following values unless otherwise stated in the Particular Technical Specifications:

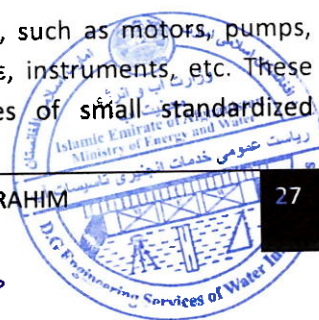
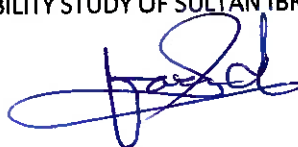
- machine hall, workshops, etc. max. 90 dB (A) at any place 1 m distant from operating equipment.
- offices, control rooms max. 55 dB(A)

The noise level definition and measurement shall be in accordance with ISO and IEC. The values stated shall be adhered to, taking the Consultant's civil construction into account.

A.4.5 IDENTIFICATION PLATES AND LABELS

A.4.5.1 GENERAL

Plates and labels shall be attached to each major equipment item, such as motors, pumps, compressors, accumulators, transformers, cubicles, CTs, VTs, valves, instruments, etc. These shall be inscribed in English (except manufacturer's nameplates of small standardized components).



The plates and labels have to be made of durable non corrosive material, water-proof, oil-proof, and wear-resistant. Writing has to be easy visible, readable, durable and suitably protected against aggressive atmosphere and solar radiation.

Plates and labels have to be allocated in readily visible locations. The plates and labels shall be placed on durable surface (e.g. it is not allowed to put plate or label on the glass of a dial indicator). The material of the plate and the fixation of the plate shall not disturb the reliable operation of the Plant.

All plates and labels shall be protected during erection. Damaged or illegible identification plates shall be replaced by new ones.

All plates should be inscribed bilingual in English. Only SI-units or SI- derived units will be accepted.

A.4.5.2 MANUFACTURER'S NAMEPLATES

The following data shall be shown in accordance with the relevant standards:

- manufacturer's name and address
- Work's serial number and date of manufacture
- main design data.

As a general rule, standardized components, such as small or medium-sized electric motors, transformers, instruments, etc., may be delivered with the manufacturer's standard nameplate which shall be completed or replaced at the request of the Employer.

The design of the manufacturer's nameplates for the main components such as gates, valves, hoists, servo motors, pumps etc., shall be submitted for the Employer's approval sufficiently in advance.

A.4.5.3 IDENTIFICATION PLATES

Each part appearing under a certain Work Identification System, figures or numbers in functional diagrams, piping diagrams, in the Operation and Maintenance Manuals, etc., shall be equipped with a plate showing the same figure or number.

Cubicles and similar units shall also bear this identification number on the rear side if rear access is possible.

A.4.5.4 INSTRUCTION PLATES

All plates showing designations or instructions for operation, safety, lubrication, etc., shall have a uniform design.

A.4.5.5 WARNING PLATES

Warning plates shall be engraved in English and in local language(s) designated by the Employer.

The warning plates shall be subject to approval by the Employer.

A.4.5.6 LABELS FOR CONDUITS, ETC.

Conduits have to be labeled where required.

A.4.5.7 MLABELS FOR CABLES

Each cable when completely installed shall have permanently attached to each end and at intermediate positions as may be considered necessary by the Employer, non-corrosive labels detailing identification number of the cable, voltage, and conductor size.

The cable identification numbers shall comply with those of the cable list. All cables in cable pits and at the entry to buildings shall be labeled utilizing the aforementioned type of label.

A.4.5.8 RATING PLATES

Rating plates shall provide information about the basic design parameters of the equipment, such as pressure, power, voltage, speed etc.

A.4.5.9 SINGLE-LINE DIAGRAMS

Each switchgear room shall be furnished with a copy of the final as-built single-line diagram detailing all electrical data and denominations, separately for each individual switchgear / distribution board / MCC, placed under glass and frame/wall-mounted at an approved location.

The same applies to the Station Single-Line Diagram of which one copy shall be displayed in the control room(s).

A.4.5.10 KEY SYSTEM FOR ELECTRIC BOARDS

Key interlocked switches shall be provided with locks for locking in the neutral position. Similar locks shall be provided for selector switches for locking the switches in any of their positions.

The locks or padlocks shall be coordinated for the different applications and shall be supplied with three keys. A key cabinet at the end of each board (distribution board, MCC, control cubicles, etc.) shall be provided for storing the keys of that board. All keys shall have six master keys to open any lock or padlock supplied. Each key shall have one identification label fixed above the key-hanging hook inside the cabinet.

The cabinet door keys shall be similar and shall be six (6) in number.

A.4.6 CORROSION PROTECTION

A.4.6.1 PAINTING

A.4.6.1.1 SCOPE OF WORK

The Consultant shall procure all materials, and prepare and apply the painting and other protective coats as specified. The Consultant shall provide a complete, reliable coating system.

A.4.6.1.2 PAINTING MATERIALS

Coating materials shall be standard products of a paint manufacturer with proven experience in the field of corrosion protection of the type of Plant to be supplied.

The Consultant shall submit to the Employer as part of the Consultant's Documents full details of the preparation, type of materials, methods and sequences he proposes to use to comply with the requirements for the protection of the Works.

The entire paint material for a particular specified paint system shall be supplied by one manufacturer only, who shall guarantee the compatibility and quality of the paint material. For multicoated painting systems, each coat shall have a different color.

Paint material shall be delivered in unopened original containers bearing the manufacturer's brand name and color designation, storage directions and handling instructions. A complete list of the proposed paint material shall be submitted to the Employer.

With regard to materials, the Consultant shall submit full details including the source of the basic raw materials, volatile matter content, nature of solvent, number of components, type of coat, coverage, time interval between coats and number of coats, compatibility of each coat with the previous coat, toxic properties, physical properties, shelf life, resistance against chemical attack, resistance against ozone and UV-radiation, compatibility with drinking water standards, etc.

The Consultant shall describe in detail the treatment he proposes to apply in order to give adequate protection during transport, site storage, building and concreting, and subsequent erection.

The different coats of primer and subsequent coats shall be each of different shades of color where practicable.

The Consultant shall submit to the Employer for approval an overall color scheme in accordance with the Particular Technical Specifications, for the finished surfaces of all of the Works. All final coats shall be in the colors approved by the Employer. On request of the Employer, painting samples for the different coats and colors shall be provided.

All pigment, paints and primers shall be delivered to Site in sealed containers packed by the manufacturer. The manufacturer's instructions for preparation and application of all painting and protective coats shall be strictly observed.

Paint materials shall be stored and mixed by the Consultant in strict accordance with the manufacturer's instructions. Paint material shall be used before the expiration of the shelf life. All safety regulations shall be observed, especially with regard to fire.

A.4.6.1.3 WORKMANSHIP

1. Consultant's Equipment

The Consultant shall observe all safety and health precautions to protect his workers and others during painting works. The necessary equipment, such as fans, air-conditioning units, safety masks, nets, etc. shall be provided by the Consultant. All equipment shall be in strict accordance with the respective safety codes and regulations assuring efficient work of high quality.

The Consultant shall be responsible for the collection and disposal of empty containers, dirty rags and other wastes. It shall also be the Consultant's

entire responsibility to protect equipment and structures not being painted such as nameplates, instruments, panels, floors, walls, etc. and he shall provide and install all necessary drop cloths and screens.

2. Preparation of Paint Material

Paint shall be delivered ready mixed wherever possible. Adding of diluting agents and mixing of two or multi-component systems shall be done on Site in accordance with the directions of the manufacturer. Mixing and homogenizing of the paint material shall be done by a mechanically driven paddle or agitator in the original container. After mixing, the paint shall be poured into a clean container to ensure that no settled pigments are at the bottom.

The Consultant's equipment shall be of perfect quality, and servicing and maintenance must be guaranteed. Cleaning of equipment shall be consistently carried out at each working interval.

3. Surface preparation

The term "preparation", as used below, includes any cleaning, smoothing or similar operations that shall be required to ensure that the material to be painted attains a suitable condition.

To be ready for painting, a surface should be clean, dry and sound. The surface to be coated shall be free from any deleterious material liable to impair good paint adhesion or attack the coat.

For removing rust and mill scale on structural steel, piping and other steel surfaces, those parts suitable for sandblasting shall be sandblasted to a grade specified or required in accordance with relevant standards. This applies particularly to parts which will be in contact with water, exposed to heavy condensation and humidity or subjected to high temperature.

For health reasons, sandblasting with quartz sand shall be avoided.

Sand blasting shall be such as to obtain a smooth surface free of foreign matters with a roughness of min. 0.04 mm. Corundum or an equivalent mineral shall be used and the grain size of the blasting medium shall not exceed 1.2 mm.

All parts of the Works shall be sandblasted at the shop unless otherwise specified or approved by the Employer.

The Consultant shall proceed with blast cleaning only when the following time and relative humidity schedule for application of the first coat can be achieved and maintained:



Relative Humidity	Time
85% or above	Do Not Blast
80 - 84%	2 hours
70 - 79%	4 hours
60 - 69%	10 hours
50 - 59%	12 hours
30 - 49%	24 hours under 30%
1 week	

Parts which cannot be sandblasted shall be cleaned of rust by power tool cleaning to the highest degree possible.

Hand or power tool cleaned parts of minor importance and not exposed to water or humidity may be coated with a quick-drying rust-proof primer formulated on a combination of synthetic resins (ready-mixed paint).

Hot-dip galvanized surfaces which are to be painted shall be lightly sandblasted prior to through cleaning.

4. Application

The most commonly used methods of application are painting by brush, roller, pressure and airless spraying equipment. Selection of the application method depends on the surface to be painted. The quality of the paint shall in no way be negatively influenced. The manufacturer's directions shall govern the choice of application method. Inaccessible surfaces shall be painted prior to erection with prime and finish coats according the specification. Areas inaccessible to spraying equipment shall be painted by brush. Corners and edges shall be pre-coated. Bolts, screws, studs, rivets etc. shall be painted as a whole with the complete paint system after erection.

The primer shall be applied to an absolutely clean and dry surface only. Temperature and dry-out time shall be in accordance with the manufacturer's directions. Whenever possible, the prime coat as well as one intermediate coat shall be applied indoors at the Consultant's shop.

During painting, the air temperature shall be at least +5°C and the temperature of the items being painted must be at least 3°C above the dew point. During drying of the paint, the temperature shall not be below 0°C. For all paints, the surface temperature of the metal shall not be higher than +50°C during painting. Concerning special paints, the requirements set by the paint manufacturer shall be followed.

Cleaning and painting work shall be interrupted outdoors and in non- conditioned rooms under the following conditions: rain, fog, dew, polluting winds, sand and other dusts. Surface

preparation and application of the first paint layer are parallel operations to be carried out within a maximum delay of 4 hours.

All painting shall be free of cracks and blisters and all runs shall be brushed out immediately. After application of the last coat the paint system shall be free of pores. After erection of the equipment, all damage to painted surfaces shall be repaired. Welds, rusty spots, beads, flux deposits etc. shall be repaired and repainted. For touching up, the same materials shall be used as for the main painting work. Repaired finish coats shall be of the same appearance as the original coating.

Electrical plates, surface hardware, fittings and fastenings shall be removed before starting painting operations. They shall be carefully stored, cleaned, and reinstalled after completion of work.

Equipment requiring special knowledge, skills and tools shall be prepared to receive field coating and painting to meet requirements of the painting schedule.

Parts which are embedded in concrete need not be protected against corrosion. However, transition zones of large steel pipes and of steel linings shall be painted over a length of 1 m within the concrete, and all other steel surfaces embedded in concrete over a length of 200 mm within the concrete.

In linings surrounded by concrete, surface preparation and painting works shall be carried out after all works such as concreting, welding, grouting and cleaning have been completed. The Consultant shall take into account the local climatic conditions and use adequate installations for sandblasting, dust control and sand extraction.

A properly equipped paint shop shall be set up at the Site with a crew of specialists experienced and skilled in the preparation and application of protective coatings, to deal with all site-protective treatment.

5. Quality Control

The minimum dry-film thickness prescribed in these Specifications shall be observed. No measured thickness shall be less than the specified thickness. Where the minimum thickness is not achieved, the coat shall be repaired to attain the specified minimum dry-film thickness.

The dry-film thickness shall be measured by approved gauges.

For checks on porosity, the Consultant shall furnish a DC variable high tension test instrument with built-in pore counter. The test voltage shall not exceed 2,000 V. The porosity check shall cover 100% of the area treated with corrosion protection.

Upon completion of each coat, the painter shall make a detailed inspection of the painting finish and shall remove from adjoining work all spattering of paint material. He shall make good all damage that can be caused by such cleaning operations.

A detailed inspection of all painting work shall likewise be made, and all abraded, stained, or otherwise disfigured portions shall be touched up satisfactorily or refinished as required to produce a first-class job throughout and to leave the entire work in a clean and acceptable condition.

Adherence tests shall be performed and the acceptance criteria shall be in accordance with relevant standards.

6. Guarantee

The guarantee period for all painting shall be 5 years, starting from the issue of the Taking-Over Certificate. This painting guarantee period shall be effective regardless of any other guarantee periods for the Works or parts of the Works.

A.4.6.1.4 PAINTING SYSTEMS

The Consultant shall state in his Tender the manufacturer and identification of the product which he proposes as an equivalent.

The manufacturer's painting system shall be generally used to the maximum possible extent, final coats (of boards and panels) shall match adjacent installations (e.g. when combined together in one continuous row).

A.4.6.1.5 COLOR CODE

For color of equipment the Consultant shall refer to the Particular Technical Specifications. If the equipment color code is not listed in the Particular Technical Specifications, it shall be agreed upon after award of the Contract.

The coloring of piping, moving parts, etc., shall be according to internationally recognized standards.

A.4.6.1.6 REPAIR OF PRIMER AND FINISH COATS

1. General

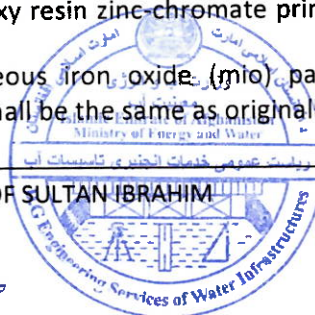
For touching up, the same paint shall be used as for the original painting work. Repaired finish coats shall be of identical appearance with the original with no different in the color. The Employer may require paint on areas which are severely damaged to be removed and repainted.

2. Galvanized and Painted Structures

Repairs to galvanized and painted structures shall be carried out as follows:

Damages to painting and galvanization:

- surface preparation: scraping, wire-brushing or grinding
- repair of coatings: one coat of 2-component epoxy resin zinc-chromate primer; dry film thickness minimum 0.050 mm
- two coats of 2-component epoxy-resin micaceous iron oxide (mio) paint. total film thickness min. 0.160 mm; the color of the paint shall be the same as originally applied.



Damage to painting only:

- surface preparation: thorough cleaning of the damaged surface, i.e. removal of oil, grease, dust, etc.
- repair of coatings: two coats of 2-component epoxy-resin micaceous iron oxide (mio) paint; total film thickness min. 0.160 mm
- the color of the paint shall be the same as originally applied.

3. Painted Structures

Repairs to painted structures shall be carried out as follows:

- surface preparation: scraping, wire-brushing or grinding
- prime coat: one coat of 2-component epoxy resin zinc-chromate primer; dry film thickness minimum 0.050 mm.

A.4.6.2 GALVANIZING

Unless otherwise specified, all structural steel including ladders, platforms, hand rails and the like and all exterior and interior steel surfaces of outdoor works as well as bolts and nuts associated with galvanized parts shall be hot-dip galvanized, electrolytically galvanized or sheradized, as may be appropriate to the particular case.

1. Material

For galvanizing, only original blast-furnace raw zinc shall be applied, which shall have a purity of 98.5%.

The thickness of the zinc coat shall be:

- for bolts and nuts, approx. 60 micrometers
- for all other parts, except for hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 70 micrometers
- for hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 140 micrometers, in accordance with "VDEW, Druckrohrleitungen - Association of German Electricity Utility Companies, Steel Penstocks".

The approval of zinc coatings requires a test of the acid/base capacity of the contact medium.

2. Cleaning

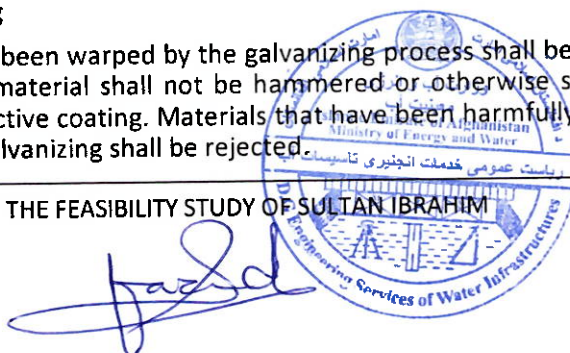
All material to be galvanized shall be cleaned carefully of rust, loose scale, dirt, oil, grease, and other foreign matter. Particular care shall be taken to clean slag from welded areas.

3. Galvanizing of Hardware

Bolts, nuts, washers, locknuts and similar hardware shall be galvanized in accordance with the relevant standards. Excess speller shall be removed by centrifugal spinning.

4. Straightening after Galvanizing

All plates and shapes which have been warped by the galvanizing process shall be straightened by being re-rolled or pressed. The material shall not be hammered or otherwise straightened in a manner that will injure the protective coating. Materials that have been harmfully bent or warped in the process of fabrication or galvanizing shall be rejected.



5. Repair of Galvanizing

Material on which galvanizing has been damaged shall be re-dipped unless the damage is local and can be repaired by soldering or by applying a galvanizing repair compound; in this case, the compound shall be applied in accordance with the manufacturer's instructions.

A.4.6.3 FINISHED SURFACES

Where the finish is not indicated or specified, the type of finish shall be that type which is most suitable for the surface to which it applies and shall be consistent with the class of fit required.

Surfaces to be machine-finished shall be indicated on the shop drawings by symbols. Compliance with the specified surface shall be determined by the sense of feel and by visual inspection of the work compared to applicable "Standard Roughness Specimens", or with roughness feeler gauge instruments. Both "Standard Roughness Specimens" and feeler gauge instrument shall be procured by the Consultant at the request of the Employer.

A.4.6.4 UNFINISHED SURFACES

As far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined to secure proper alignment.

Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts shall be filled in an appropriate manner.

A.4.6.5 PROTECTION OF MACHINED SURFACES

Machine-finished surfaces shall be thoroughly cleaned of foreign matter. Finished surfaces of large parts and other surfaces shall be protected with wooden pads or other suitable means. Unassembled pins or bolts shall be oiled or greased and wrapped with moisture-resistant paper or protected by other appropriate means.

A.4.6.6 ROUNDING, CHAMFERS, EDGES

The edges of surfaces to be painted shall be rounded (minimum radius 2 mm) or chamfered accordingly. This requirement must be stated in all shop drawings for the relevant parts

A.4.7 WELDING AND HEAT TREATMENT

A.4.7.1 GENERAL

All welds shall be as shown in the detailed drawings and shall be made in such a manner that residual shrinkage stresses will be reduced to a minimum.

The Consultant shall submit with his Tender adequate information concerning the proposed:

- extent to which automatic welding techniques will be applied
- extent to which manual welding techniques will be applied



- extent to which it is the Consultant's intention to use pre-weld heat treatment, post-weld stress relieving, full anneal stress relieving or normalizing consistent with the thicknesses and types of material proposed
- weld electrodes, welding wire and flux which will be used with the selected plate material or materials
- standard tolerances for the deviations of mating weld profiles.

A.4.7.2 WELDING

Pieces to be joined by welding shall be cut accurately to size including the required allowances. According to the proposed welding method, the welding edges shall be sheared, flame-cut or machined to allow thorough penetration and fusion of the weld with the base material.

The cut surfaces shall be free of all visible defects, such as laminations, surface defects caused by shearing or flame cutting operations. The edges and surfaces to be welded shall be free of rust, mill scale, grease, oil, paint or any other foreign matter. Welding over zinc primers shall be permitted subject to submission of a certificate of a recognized institution stating the pertinent limiting parameters for this welding procedure. In all other cases, welding over paint shall be prohibited; all painting materials next to the joint to be welded shall be removed well beyond the heat-affected zone.

Unless otherwise allowed by the Employer, all steel parts to be welded shall be manufactured of steel produced by the open hearth or electric, with a carbon content not higher than 0.20% and a phosphorous content of not more than 0.05%.

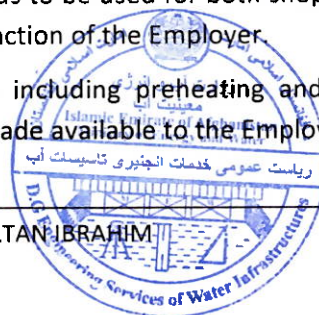
Wherever welding is specified or permitted, a welding process conforming to DIN or other approved standards shall be used. Approval of the welding process shall not relieve the Consultant of his responsibility for correct welding, the use of correct electrodes and for minimizing distortion in the finished structure.

The Consultant shall produce a record drawing as part of the Consultant's Documents to show the process to be used. The drawing shall include details such as the form of edges to be welded, electrodes and other welding materials, welding sequence, etc. Changes in the welding process after the welding method has been reviewed shall require the consent of the Employer.

Where possible, welding shall be carried out in the workshop. Welding which has to be performed in the field shall be clearly so indicated on drawings.

The Consultant shall follow the steel manufacturer's recommendations concerning electrodes, welding and material pre- and post heat treatment. Notwithstanding the above, the suitability of the electrodes to be used for welding and the welding methods to be used for both shop and field welding shall be demonstrated by trials and tests to the satisfaction of the Employer.

Additional copies of all records of all welding procedures, including preheating and stress relieving, chemical analysis and physical properties, shall be made available to the Employer.

	STRESS		
	Compression	Bending, tension > 0.9 allowable stress	Alternating, dynamic
<u>Small risk</u> Stairs, rails, doors	0	0	1
<u>Medium risk</u> Cranes, roof trusses, bridges	2	2	5
<u>High risk</u> Penstocks, steel linings, spiral casing, guide vane, runner, draft tube, gates, stoplogs	3, 4, 5, 6	3, 4, 5, 6	3, 4, 5, 6

Design, preparation, performance and testing of welded construction

actions shall suit the kind of stresses and the grade of risk, considering a supposed failure of the welded member.

The following table shows a general classification by means of numbers with the signification of each number explained thereafter.

Any structure not especially mentioned shall be classified by the Consultant and shall be subject to approval by the Employer.

Signification

0 = Without special prescriptions: Only skilled welders shall be employed who follow proven rules of workmanship.

1 = Full penetration welds: The weld preparation shall allow the filling of the weld profile without defects. The root of double welded butt joints shall be ground before welding the second side. If the second side is inaccessible for welding, such single welded butt joints shall be built up against a backing strip.

2 = Welder qualification test: All welders and welding operators shall have passed qualification test in accordance with the respective National Standard or rules of AWS-American Welding Society, or the DIN EN 287. Weld ground flush. The weld shall be ground on both sides of the steel plate. The weld surface shall be finished so as not to reduce the plate thickness by more than 3%. Butt welds with a smooth surface and a chamfer of less than 8% of the width of the top layer need not be ground. Connections rounded. Where stresses are to be deviated, already the design shall care for a reduced notch effect. Welds shall be smoothly ground and rounded.

3 = Welding procedure test: The Consultant shall describe the proposed welding procedure. Further he shall prove with tests, that the properties of the weld and transition zone are at least equal to those specified for the base material. The welding procedure test may be combined with the welder's qualification test.



4 = Welding performance test, executed during fabrication and site welding: Run-off plates shall be tack-welded to one end of the plate under work. The weld shall continue on that run-off plate (test plate), welded in the same manner and under normal working conditions.

- One test plate is required every 20 m of weld seam, but at least one of each weld type.
- The laboratory tests shall cover the same range as the welding procedure tests.
- On request by the Employer, test plates shall be welded in his presence.

5 = Ultrasonic and/or radiographic test: Depending on the location of the weld seams and the plate thickness, ultrasonic and/or radiographic tests shall be performed. The Consultant shall submit a proposal to the Employer as part of the Consultant's Documents. If not stated differently in the Particular Technical Specifications, 20% of the weld length shall be radiographed, but at least one film per weld type. The Consultant shall record the results of the ultrasonic and/or radiographic testing in these reports and drawings.

6 = Marked with welder's stamp: The welder shall mark every seam welded by him with his number, so it can be recognized until the end of the fabrication period.

.4.7.3 WELDING QUALIFICATIONS

For welding of principal stress carrying parts (Medium and High Risk Welds, see above table), the standard of welding procedures, welders and welding operators shall conform to standards equivalent to the requirements of the EN 287 and EN 729.

For welding of less important parts, the standards and qualifications shall conform either to the AWS Standard Qualification Procedure or equivalent standards.

All welders and welding operators assigned to the work shall have passed a performance qualification test. If more than one year has elapsed since the welder or welding operator passed his last test, then he shall again be tested.

Welders' and welding operators' test certificates shall be submitted to the Employer before the welding work is started.

A.4.7.4 WELDING WORK

All welding (except welding of thin plates or piping of small sizes) shall be performed by the electric-arc method and where practical, with process controlled automatic machines.

The strength of welding of all equipment subject to high and /or alternating stresses, vibrations etc. shall be at least equal to the strength of the parts being weld-jointed.

Between plates and other sections where such stresses are to be transmitted only butt welds shall be permitted. All main butt welds shall have 100% penetration and where possible, shall be welded from both sides. The backside of the first run shall be suitably gauged out to clear metal before the sealing runs are deposited.



Butt welds on site which can be welded from one side only shall be provided with backstrips on the whole length of the seam to be welded. The backstrips shall be fixed to the downstream side of the upper element, to prevent accumulation of water and dirt.

For any welding work, only the appropriate welding rod, either arc or gas, shall be used. The properties shall conform to the material to be welded as specified in the respective standards.

The electrodes for arc-welding shall be classified on the basis of mechanical properties of the as-welded deposited weld-metal, type of covering, hydrogen absorption, welding position of the electrodes and type of current.

Electrodes shall be used only in the positions and under the conditions of intended use in accordance with instructions with each container. Electrodes for manual welding shall preferably be of the heavily coated-type and shall be suitable for welding in any position.

Tacks shall be removed before welding.

Electrodes shall be dried in electric ovens before use.

After being deposited, welds shall be cleaned of slag and shall show uniform sections, smoothness of weld metal, feather-edges without overlap, and no porosity and clinker. Visual inspection of the ends of welds shall indicate good fusion with the base metal.

Where weld metal is deposited in successive layers, each layer shall be thoroughly cleaned before the next layer is applied.

The difference in thickness of adjacent butt welded plates shall not exceed 3 mm. Where plates of greater thickness are to be welded, a transition with a gradient of 1:5 shall be formed.

Welds shall be balanced as far as possible to minimize distortion and residual stress. Box type girders shall be welded in such a way as to be completely airtight.

All welds transverse to the direction of flow and the longitudinal welds of distributors, shut-off valves and manifolds shall be ground flush with the plates on the inside. Welds shall be ground flush on both the inside and the outside wherever dynamic stress occurs.

Particular care shall be taken in aligning and separating the edges of the members to be joined by butt welding so that complete penetration and fusion at the bottom of the joint will be ensured.

All pinholes, cracks and other defects shall be repaired by chipping or grinding the defects to sound metal and re-welding. Where fillet welds are used, the members shall fit closely and shall be held together during welding.

The ignition of weld electrodes shall not be started at the plate beside the weld, but at the seam flanks to prevent detrimental increments of local hardness. Where ignition points of electrodes are discovered, they shall be ground appropriately.



Where auxiliary structural members are welded to components for the purpose of assembly or installation, these connecting welds shall be given particular care.

These auxiliary structural members shall be removed not by knocking them off, but by burning, followed by grinding the affected areas flush with the plate, without producing additional thermal stresses.

A.4.7.5 HEAT TREATMENT

The cost of any heat treatment prescribed by the manufacturer of the materials and the Consultant respectively for the welded parts to be supplied shall be included in the Contract Price.

Heat treatment of field erection welding seams shall be performed according to the specifications for the welding procedure for the corresponding parts, which shall be submitted to the Employer as part of the Consultant's Documents.

A.4.7.6 QUALITY AND PROCEDURE CONTROL

Quality control methods, e.g., radiography, ultrasonic crack detection, etc., shall be done in accordance with the appropriate manufacturing code. However, the Consultant shall indicate clearly in his Tender the extent to which these methods shall be used.

All welded joints which have to be tight shall be inspected or tested by dye penetration tests.

All major welds carried out on parts under hydraulic pressure shall be subject to at least 20% radiographic and 100% ultrasonic examination. All welds on the skin plates shall be additional dye penetration tested as directed by the Employer.

The Consultant shall indicate in the corresponding drawings the type of non-destructive testing to be carried out during manufacture and at Site.

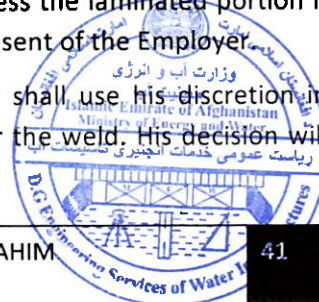
All radiographic films and data shall become the property of the Employer. Additional non-destructive controls can be required when it is desired to examine the acceptability of any welds when, in the opinion of the Employer, serious doubt exists as to their quality; in this case, the expense of this examination shall be borne by the Consultant.

When required in the Particular Technical Specifications, the detailed description of welding procedure (including type of welding electrodes, sequence of welding seams, etc.) for certain parts of the delivery shall be submitted to the Employer before commencement of manufacture.

A.4.7.7 DEFECTS AND REPAIRS

Plates with laminations discovered after cutting shall be rejected unless the laminated portion is only local and can easily be repaired; such repairs shall require the consent of the Employer.

Defects in welds will be reported to the Employer. The Consultant shall use his discretion in determining whether or not it is advantageous to remove and repair the weld. His decision will require approval by the Employer.



Defects in welds which are to be repaired shall be chipped out to sound metal and the areas magnifluxed or ultrasonically tested to ensure that the defective material has been completely removed before repair of welding is carried out. The Employer shall be informed and given the opportunity of making an examination after the defect has been removed and before repair welding commences. Repairs shall be carried out in accordance with the relevant Standards and to the approval of the Employer. The Consultant shall be fully responsible for the in-service performance of all welding work.

The Work shall be 100% inspected again by the method used first to determine such faulty work.

A.4.8 MECHANICAL WORKS, METAL AND STEEL STRUCTURES

A.4.8.1 GENERAL

All mechanical parts of the Works and steel structures of any mechanical or electrical installation shall comply with this General Technical Specifications and the requirements of the Particular Technical Specifications. Such Works shall be of a reliable design providing the highest possible degree of uniformity and interchangeability. The design and arrangement of Works and installations shall facilitate easy erection, test, operation and maintenance.

All mechanical works shall be pre-assembled in the manufacturer's premises to an utmost extent.

Revolving parts shall be statically or, if required in the Particular Technical Specifications, dynamically balanced so that when running at normal speed and at any speed up to the maximum, there will be no vibration due to lack of balance.

A.4.8.2 BOLTS, SCREWS, NUTS, ETC.

All bolts, studs, screws, nuts, and washers shall be to the ISO metric system except other standards will be considered for specific applications. The extent to which other standards are proposed shall be indicated by the Consultant in his Tender. Bolts and nuts shall be hexagonal or socket headed. Sizes smaller than 4 mm shall be used only for instrument and relay internal connections.

Steel nuts and bolts shall be zinc or cadmium plated. Stainless steel bolts, nuts washers and screws shall be used in water or when exposed to high humidity, for holding renewable parts and parts made of stainless steel.

Where mild steel bolts and nuts are used, they shall be of the precision cold forged washer faced type if commercially available in the size required. All parts, other than structural steel work, bolted together, shall be spot faced on the back to ensure that nuts and bolt heads bed down satisfactorily. Bolts machined from bar stock shall not be used without approval of the Employer.



All bolts or studs which will be subject to high stress and/or temperature shall be of approved high tensile material with nuts of approved material. All bolts and studs larger than 60 mm in diameter which are not accessible for tightening and releasing by commercially available pneumatic impact wrenches shall be drilled for heaters or shall have an extension for pre-tensioning by hydraulic tools.

Washers shall be provided under bolt heads and nuts unless otherwise approved by the Employer. All ferrous nuts and bolts on Works items where dismantling may be required during the life of the Works shall have their threads coated with an approved anti-seize compound. When in position, all bolts or studs shall project through the corresponding nuts by at least one thread, but this projection shall not exceed three threads, unless more length is required for adjustment. All nuts and set screws shall be securely fastened, to prevent loosening due to vibrations, using spring washers, lock nuts, split pins, self-locking inserts or 'Loctite' as appropriate for the purpose and material used.

Screws under water that have to be painted should only be of hexagonal type to ease demounting (no socket heads).

The Consultant shall supply the net quantities plus 10% of all standard size bolts, screws and other similar items and materials required for installation at the Site. Any such rivets, bolts, screws, etc., which are surplus after the installation of the Works has been completed shall become spare parts and shall be wrapped, marked and handed over to the Employer.

A.4.8.3 SEALS

The material for large seals (such as for gate seals) shall be of non-ageing rubber material, which shall be unaffected by wetting and drying or temperature changes. In case the Consultant intends to supply synthetic rubber material, with or without fluoro-carbon cladding, he shall furnish the name of the manufacturer and technical data of the material for the Employer's approval.

The seals shall be mounted in a manner suitable for their purpose (dust or water tight) and shall be designed and mounted in such a manner that they are adjustable and can be readily removed and replaced. All adjusting screws and bolts for securing the seals and seal assembly in place shall be of stainless steel.

PTFE seals shall not be used in presence of abrasives.

A.4.8.4 PROTECTION GUARDS

All moving parts of machinery including shafts, couplings, collars, projecting key heads, gear wheels, and rope/belt-drives shall be completely guarded to provide full protection. The guards shall be of approved design and shall be fitted, where necessary, with inspection doors/openings. All guards shall be arranged so that they can be removed without disturbing the parts of the gears and works which they protect.



A.4.8.5 DRIVES AND GEARS

Gears shall be designed so that all stresses are within allowable limits when the maximum loads are being handled. All gears shall be designed and calculated in accordance with DIN, or equivalent international standards.

Where worm gears are used as a direct drive, they shall have the same load and time rating as the motors driving them. The gears shall work in oil and the temperature rise of the oil bath shall not exceed 40-50°C under normal working conditions at Site. The materials of the mating faces of worm wheel and worm shall be of a bronze/steel alloy.

Where practicable gear wheels shall be forced fit on the shaft and in addition, shall be keyed adequately to prevent any relative motion between the wheel and shaft. Where gears and couplings are secured in position by means of keys, they shall be easily accessible for tightening or removal. All keyways shall be machine cut. Couplings and collars shall be the shrouded or protected-type, free from projections of any kind.

A.4.8.6 LUBRICATION, LUBRICANTS, FUEL

Efficient means of lubrication, suitable for use under Site conditions, shall be provided for all moving parts.

Self-lubricating types of bearings shall be given preference, unless otherwise specified or practicable.

The contamination of the air, water and soil by lubricants and fuel shall by all means be avoided by applying an appropriate design and layout of the Works in conformity with the latest recognized standards for modern engineering practice.

The number of different lubricants, transformer oils, oils for pressure systems, etc., throughout the Works shall be limited to a minimum to facilitate stock keeping and maintenance.

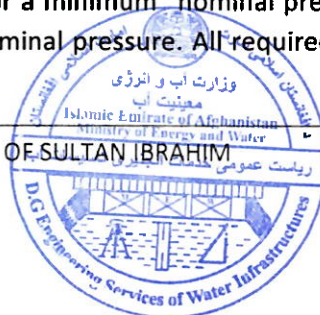
The Employer reserves the right to request the Consultant to use certain types of lubricants, oils, etc. which are available in the country. The Consultant shall not be entitled to claim extra payment for this request. All different types of oils, lubricants, etc., shall be stated in the Tender and are subject to the written approval of the Employer.

Unless otherwise stated in the Particular Technical Specifications, the first oil or grease filling for bearings, pressure oil systems, transformers, etc., including the necessary quantity for flushing and for the first oil change, shall be included in the Contract Price.

A.4.8.7 PIPING, FITTINGS, VALVES AND GATES

A.4.8.7.1 GENERAL

Unless otherwise stated, all piping shall be designed for a minimum "nominal pressure" of PN 10. All piping shall be tested with 1.5 times the design/nominal pressure. All required piping shall be



furnished complete with flanges, joints, expansion joints, gaskets, packing, valves, drains, vents, pipe suspensions, supports, etc.

Metric (DIN) flanges shall be used throughout. Welded flanges shall be weld-neck or slip-on flanges.

Welding as well as application of corrosion protection coats shall be done in the manufacturer's shop to the greatest extent possible.

Flanged connections or joints shall be provided only as required for transport, installation or for reasons of dismantling for repair.

Joints between stainless and normal steel flanges shall be of the insulated type.

If the piping crosses over joints of civil structures of different settlement, the piping shall be provided with flexible joints to allow for vertical, horizontal, and angular deviations.

Piping installation shall be sloped to prevent trapping of air bubbles. Where required suitable venting system shall be provided.

Adequate clearance shall be given to parallel pipes to allow for easy maintenance without disturbing other lines. All overhead piping shall have a minimum clearance of 2.00 m from operating floors and platforms.

Where required water piping shall be provided with anti-condensation insulation.

A.4.8.7.2 WATER PIPING AND FITTINGS

Pipe connections embedded in concrete shall be welded. Other pipe connections shall be flanged. The flange material shall be in conformance with the pipe material. The Consultant shall select the location of the welds as to ensure sufficient access for adequate touch-up treatment for corrosion protection.

All steel pipes shall be of stainless steel.

Stress calculations of steel pipes shall be in accordance with DIN 2413, "Steel Pipes under Internal Pressure" or with "AD-Merkblätter; German Association of Manufacturers of Pressure Vessels, Memos". The superimposed stress of bending, tension, compression, etc. shall not exceed the admissible stresses (stated in the above mentioned standards) at maximum applied load at any point of the piping.

The maximum applied load shall take into account test pressure, water hammer pressure waves, thermal forces, dead weight, etc. On request of the Employer, a calculation on pipe stresses shall be submitted by the Consultant.

The minimum steel pipe wall thickness shall be the "normal" or "standard" wall thickness as stated in the applicable standards.

Bends shall preferably be of the forged type. Mitered bends shall be allowed for larger sizes subject to the Employer's approval. For smaller fittings ductile iron is also permitted.



A.4.8.7.3 VALVES, GATES

Small valves and gates shall conform to DIN 3230, "Conditions and Terms for Delivery of Valves." Generally, valves shall be leak-proof in either flow direction (except for non-return valves) when the nominal pressure is applied.

All valves with design pressures higher than PN 10 and diameters larger than DN 100 shall be workshop-tested to DIN 3230 for tightness and soundness of materials.

Valves shall close clockwise and be provided with position indicators. The drive units of motor-driven valves shall also be provided with handwheels for manual operation. The handwheel shall be operable under all conditions and shall be independent of the motor drive. Further, it shall not be rigidly coupled to the motor drive and shall not compulsory turn when the motor is energised.

To facilitate operation, large valves and gates shall be provided with by-pass lines for pressure balancing, if required.

All valves shall be readily accessible for both operation and maintenance, and where necessary for ease of operation the spindles shall be extended and an approved form of pedestal hand-wheel provided at convenient operating floor level.

Valves spindles and pins shall be of stainless steel, spindle nuts and bushes of bronze, the body at least of improved C.I. (nodular cast iron).

A.4.8.7.4 OIL PIPING

Piping of a diameter < 50 mm shall be of non-corrosive material. Pipes larger than 50 mm in diameter shall be made of seamless steel. Only socket welded fittings and flanges shall be used (compression fittings and flare fittings are not acceptable).

Pipe connections larger than 50 mm in diameter shall be provided with steel-flanged connections.

All piping shall be subject to hydrostatic test at a pressure 100% greater than the maximum working pressure. The entire pipe arrangement shall be subjected to the pressure test after complete assembly on the Site.

Oil pipes shall not be embedded in concrete. Oil pipes crossing civil structures shall be routed through sleeves embedded in the concrete.

All oil piping shall be acid-treated to guarantee clean surfaces, completely free from welding residues.

This treatment shall be applied to workshop and site manufactured piping respectively.

The piping can either be treated in an acid-bath or by being completely filled with acid. The duration of the treatment shall be approx. 6 hours. The piping shall then be neutralized, flushed and corrosion protected for final installation.

A.4.8.7.5 PIPE SUPPORTS AND HANGERS

All pipework and accessories shall be mounted and supported in a safe and neat manner.

All brackets, stays, frames, hangers and supports for carrying and staying the pipes, including their fasteners shall be included in the supply and completed by the Consultant on the Site. Pipes and fittings shall be supported at or near flanges wherever possible.

Supports and hangers shall be designed and arranged so that any pipe can be withdrawn without disturbing the others.

All heavy valves and other mountings shall be supported independently of the pipes to which they connect, to the satisfaction of the Employer.

The Consultant shall supply drawings showing the location of each major anchor and support and the weight to be carried by that support.

A.4.8.7.6 MECHANICAL INSTRUMENTS

All mechanical parts of instruments shall be suitably protected against shocks and vibrations, heat, humidity and splash water, etc.

Pressures gauges shall be provided with a damping liquid, e.g., glycerine, to suppress vibrations.

A.4.8.7.7 PRESSURE OIL SYSTEMS

Pressure tanks shall be designed, fabricated and tested in accordance with specified standards. The appropriate inspection certificates shall be furnished. If the pressure is held by compressed air, then the requirements outlined in "Compressed Air Systems" of these General Technical Specifications shall also be applicable.

Oil sump tanks shall be provided with:

- suitable access openings
- fine mesh strainer combined with a magnetic filter through which all oil returning from the servomotors shall pass. The strainer shall be readily removable for cleaning.
- dehumidifying air filter
- flush-mounted oil-level indicator
- filling connection with a suitable strainer
- drain connection with hand operated shut-off valve.

Sump tanks shall be installed so that the bottom of the tank and the drain connection are at least 40 cm above the floor. The bottom of the tank shall be inclined in the direction of the drainage. The pumps shall be removable without the necessity of emptying the tank.

Servomotors shall be provided with suitable connections for pressure gauges on the pressure and suction sides of the piston. Servomotor piston rods shall be of stainless steel provided with a hard chromium layer of approximately 0.05 mm thickness.



A.4.8.7.8 HYDRAULIC PRESSURE UNITS

Hydraulic pressure units for hydro-mechanical equipments shall be designed, fabricated and tested in accordance with standard DIN 19704-98 taking into account the special requirements described hereunder.

A.4.8.7.9 MANUFACTURING AND TESTS

Welds on pipes shall be of the homogeneous type; i.e. welding material shall be similar to pipe material.

Oil tank tightness shall be tested.

Before commissioning a power unit, the pipes shall be insed until a grade of cleaning compatible with the power unit components is achieved.

A.4.8.7.10 MAINTENANCE

It shall be possible to isolate any pressure generating device (pump, pressure vessel, cylinder, etc.) from the pipe-work by means of lockable valves.

Large oil tanks shall include a manhole.

A.4.8.7.11 SAFETY

The orifice controlling the minimum permissible opening/closing time shall be attached directly to the cylinder.

A.4.8.7.12 OILS

Oil of an approved grade and quality shall be used for all purposes, like bearings, hydraulic systems, etc.

The number of different lubricants, oils for pressure systems, etc., used in the equipment throughout the plant shall be limited to a minimum in order to facilitate keeping stocks and maintenance.

The Consultant shall submit the following information to the Employer as part of the Consultant's Documents:

- oil trade name and classification according to ISO Standard 6743/0
- kinematic viscosity at 50 C, in cSt
- Engler viscosity, in °E
- total acid index, in mg KOH/g
- solid impurities content, in %
- water content, in %
- flash point, in C
- solidifying temperature, in C.



The following table establishes the general quality requirements:

Oil Application	Total Acid Index in mg KOHg		Water Content % in Vol.		Kinematic Viscosity at 40 C in cSt		Solid Contamination
	Danger Threshold	Limit Condition	Danger Threshold	Limit Condition	Danger Threshold	Limit Condition	Danger Threshold / Limit Condition
Initial Index +0.7	Initial Index +0.9	Initial Index +0.7	0.1	0.2	+/- 15% of ref. value	+/- 20% of ref. value	By particle counting +1 Initial grade By the gravimetric method 60 mg/l P < 80 bar 90 mg/l 30 mg/l 80 bar < P < 150 bar < 50 mg/l



Foaming : In all cases to be visually monitored

The Consultant is responsible for ensuring that the properties of the delivered oil do not exceed the threshold value.

If the threshold value is exceeded, the Employer shall have the right to request either complete refill with the corresponding oil, or treatment of the oil and cleaning of the affected system, at the Consultant's expense.

A.4.8.7.13 OIL TESTS

Upon request from the Employer, the Consultant shall test the oil characteristics at his own expense.

A.4.8.8 COMPRESSED AIR SYSTEMS

The provisions for safety of the entire compressed air system shall conform to internationally accepted standards.

Vessels shall be of the cylindrical type and shall be mounted on a structural steel base. The inner surfaces of the vessels shall be protected with an appropriate paint coating or the vessels shall be hot dip galvanized. Each vessel shall be equipped with the following devices:

- 2 inlet sockets with valves
- 2 outlet sockets with valves
- 2 pressure safety valves
- 2 dial pressure gauges, one of the gauges with 4 electrical contacts
- 1 manhole or inspection hole
- 1 drain valve.

In case the pressure vessel is used for pressurized oil or water systems, the vessel shall further be equipped with:

- 1 transparent level gauge with shut-off valves at both ends
- level indicators with electrical contacts in a number as required or specified.

Compressors shall be provided with:

- automatic lubrication
- air-intake filter and silencer
- thermometer for measuring temperature of the compressed air
- automatic shut-down if the discharge air temperature exceeds a predetermined, adjustable value
- discharging valves
- water drain valves
- water/oil separator



- pressure safety valve
- compressed air cooler
- non-return valve
- inlet pressure valve
- outlet pressure valve
- automatic moisture trap

The water / oil separator shall be equipped with an automatic solenoid- operated drain valve to achieve automatic draining during standstill. The compressor stages shall be equipped with discharge valves, which shall close time delayed after start to avoid compressor start against full pressure.

The compressors shall be delivered as package units on common frame with the appropriately sized AC squirrel cage motor and the respective motor starter panels, ready for operation.

Each vessel shall pass a pressure test at 1.5 x maximum working pressure for 8 hours in the manufacturer's workshop before coating is applied.

If requested by the Employer, each compressor shall pass a performance test in the manufacturer's workshop to a standard mutually agreed upon, e.g., DIN 1945, VDMA 4362, without extra cost. The readily assembled compressors, controls, and switch-gear shall be subjected to functional tests.

Each vessel shall be furnished with a test certificate of an independent, reputable underwriters' society.

A.4.8.9 PUMPS

Non-submersible pumps and motors shall be mounted on common frames and shall be of protection class IP 54.

Materials of the pumps shall be as follows:

Casing:	cast iron (C.I.)
Impeller:	bronze / stainless steel
Shaft:	stainless steel
Sleeves:	stainless steel
wear rings:	bronze
keys	stainless steel

The impeller diameters shall be neither maximum nor minimum impeller size for the selected pump size.

The pumps shall withstand corrosion and wear by abrasive matters within reasonable limits.



Shafts sealed by packing glands shall be fitted with sleeves. Seals shall be exchangeable without extensive disassembly of the pump. Leakage water shall be directed to suitable drainage facilities.

Each pump shall be fitted with:

- check valve at the discharge side
- air and drain valve
- pressure gauge.

The size of the pump motor shall be 15% higher than the maximum power required by the pump at any operation point.

For submersible pumps, pump and motor shall be contained in the same casing and designed as a package unit with incorporated suction strainer and check-valve. Protection class for submersible motor and pumps shall be IP 68.

The motors of submersible pumps operating in potable water shall not be filled with oil or other media detrimental to potable water. Motors of submersible pumps operating in dirty water may be filled with oil.

Dirty water submersible sump pumps with the motors mounted on top of the pump shall be suitable for running dry continuously, without damage to seals, bearings, or motors.

For all other items, the requirements described for non-submersible pumps shall apply.

For any pump, the overall pump-motor efficiency for the specified rated head and discharge shall not be less than 60%.

If requested by the Employer for pumps of a capacity higher than 30 kW, one in three pumps shall pass a performance test, with measurements taken at 0%, 50%, 80%, 100%, and 120% of specified discharge at rated speed. The results have to be certified in a workshop certificate.

Prior to the test, the manufacturer shall provide certified motor performance curves.

A.4.8.10 LIFTING EQUIPMENT

A.4.8.A.1 DESIGN AND CALCULATION STANDARDS

Generally, for design, stress calculation, manufacture and installation, the following standards and codes, besides other relevant standards and regulations, shall be applicable:

Design FEM rules for design of hoisting appliances 1998 (Fédération Européenne de la manutention):

- ISO 4301-5: 1991, Cranes Classification; Part 5: Overhead traveling and portal bridge cranes.
- ISO 7752-5: 1985, Controls-Layout and characteristics, Part 5: Overhead traveling and portal bridge cranes.



- ISO 8566-5: 1992, Cranes - Cabins, Part 5: Overhead traveling and portal bridge cranes.
- ISO 10245-5:1995, Cranes - Limiting and indicating devices Part 5: Overhead traveling and portal bridge cranes.
- ISO 4308-1,1986, Cranes and lifting appliances- Selection of wire ropes, Part 5: Overhead traveling and portal bridge cranes.
- ISO 4302: 1981, Cranes - Wind load assessment
- ISO 8566-5, Cranes - Design principles for loads and load combinations.
- DIN 15018, Cranes, Steel Structures, Calculation and Design

Manufacturing and installation

- ISO 8306: 1985, Overhead traveling and portal bridge cranes, Tolerances for cranes and tracks
- ISO 4310: 1981, Cranes - Test code and procedures
- DIN 15020, Rope Drives Safety devices for the operating personnel




Safety devices for the operating personnel shall be provided wherever it is necessary.

The safety rules outlined in VBG 8 of the German "Verband der Berufsgenossenschaft" or similar internationally recognized codes shall be observed.

Unless otherwise specified, the lifting equipment shall be classified to DIN 15020 as follows:

- for lifting capacity up to 100 kN (10 tons) "class 2 m", representing an average daily working time of 2 to 4 hours and an equal share of small, medium, and heavy loads (normal duty)
- for lifting capacity above 100 kN (10 tons) "class 1 Am", representing an average daily working time of 2 to 4 hours and a small share of heavy load lifts (light duty).

The Consultant shall state the various load combinations and factors of safety taken as a basis for calculation of the different components of the crane. In addition, the various factors of safety for the different load combinations shall be stated.

Each item of lifting equipment such as cranes or elevators shall be subject to a test operation with an overload = $1.25 \times$ nominal load.

The crane girders and rails shall be calculated for a deflection not exceeding $1/1,000$ of the span at maximum nominal load.

Steel structures of lifting equipment shall be of welded construction, which can be assembled on Site. All field connections and joints shall be bolted.

For maintenance, inspection and lubrication, appropriate ladders, platforms and steps shall be provided, fitted with anti-slip checkered plates, tabular handrails and skirting. Walkways, stairs and platforms for lifting equipment shall generally be designed for a service load of $3,000 \text{ N/m}^2$.

A.4.8.A.2 MATERIAL STANDARDS

The material to be used for manufacturing lifting equipment steel structures shall conform to DIN EN 10025. However, the Consultant shall restrict the structural steel to FE 360 B, FE 430 C and FE 510 C. For these structural steels, connecting bolts and welds, the allowable stresses given in DIN 15018 shall apply.

If the Consultant intends to supply material other than that mentioned above, he can do so, provided that their equivalence to the specified material standards is verified by the Consultant and approved by the Employer.

A.4.8.A.3 ADMISSIBLE STRESSES

The stresses between the track rails, their fixing elements and the concrete shall not exceed the following values:

DETAIL DESIGN AND UPGRADING OF THE FEASIBILITY STUDY OF SULTAN IBRAHIM
IRRIGATION PROJECT _ ANNEX A



mean allowable compressive stresses: 6 MPa

allowable compressive stresses on edges: 10 MPa

allowable bond stresses: 0.6 MPa

A.4.8.A.4 GENERAL DESIGN MATTERS

Nameplates stating the nominal capacity in tons shall be attached to both sides of the lifting equipment structure and to both sides of the tackle. The printing shall be clearly legible from the floor.

Hoists, ropes, drums, sheaves and related works shall be calculated to DIN 15020 or equivalent standards.

Flexible couplings shall be installed to relieve the bearings and shafts from any stresses due to misalignment and to facilitate the removal of motors, wheels and gears. The motor couplings also shall be of the flexible type.

All couplings, drive wheels and gears shall be press fit and keyed to the shaft.

All wheels shall have a hardened tread with a minimum Brinell hardness number of 400, and shall be made of carbon steel or low-alloy steel forgings. They shall have double flanges, shall be machined to a uniform diameter concentric with the hub bore.

All bearings shall preferably be anti-friction bearings designed to permit easy shaft disassembly and easy replacement. The minimum average lifetime under design load conditions shall be 5,000 hours.

All sleeve bearings except those for the hooks and rope sheaves shall be lubricated by central lubrication systems. An independent system for the trolley and one or two independent systems for the bridge will be acceptable. This central lubrication system shall satisfy the following requirements:

- the lubricant quantity for each bearing shall be variable
- lubricant filters shall be installed in every lubricating pipe
- the lubrication piping shall be arranged to be easily accessible for maintenance.

For all high-speed gears and pinions, oil bath lubrication shall be provided. Low-speed gears may be lubricated with soft grease. Suitable oil and grease drip pans shall be installed and be readily accessible for draining and cleaning.

Bridge and trolley drives shall be equipped with a spring-set, electrically (solenoid or electro-hydraulic) released shoe or disc brake, with capacities of at least 1.5 times the full operating torque of the drive.



The brake shall be applied when the motor control switch or the main switch is in the "off" position and/or in case of power failure in any phase. The braking action shall be gradual and the brake shall become fully effective after a certain time lag.

A.4.8.11 STEEL STRUCTURES

Generally, design and stress calculation shall conform to DIN 18800, Steel Structures, Calculation and Construction

For standards applicable to steel structures of lifting equipment, refer to "Lifting Equipment".

The permissible design stresses for materials, bolts, rivets, etc. are given in DIN 18800.

Adequate clearance of at least 2 m shall be provided at overhead steel structures to allow unobstructed passage.

Stairs and ladders shall have an inclination of approximately 30° and 75° respectively. Stairs shall be complete with handrails, min. 90 cm high, and kickboards of 8 cm height.

Vertical ladders shall be installed alternating left hand/right hand side to horizontal platforms placed approx. every 10 m of vertical height. Vertical ladders of more than 2.5 m height shall be guarded. Load assumptions for ordinary platforms shall be:

- for platforms used by personnel and for support of light equipment with single weights of less than 500 N: 2,500 N/m²
- for all other platforms 5,000 N/m²

Unless otherwise specified or stipulated in the applicable standards. Platforms and stairs shall be provided with anti-slip checker plates.

A.4.9 HYDRO-MECHANICAL EQUIPEMENT- DESIGN AND MANUFACTURE

A.4.9.1 SELECTION OF EQUIPMENT

The type of gate, stoplog or valve shall be determined after considering the operating parameters, frequency of operation, importance and convenience of operation and maintenance and cost.

The following types are normally applied:

Regulating and sluiceway gate	Radial gate, flap gate, fixed wheel gate
Intake and culvert gate	Fixed wheel gate or slide gate
Navigation lock gate	Miter gate
Navigation lock gate for passage of flood	Sector gate



Stoplogs, bulkheads	Slide gate
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A.4.9.2 DESIGN LOADS

The equipment will be designed to withstand the worst possible combination of loads considering the operating condition and the frequency of operation, etc.

Loads to be considered are as follows:

- hydrostatic load: Hydrostatic load shall be the water head difference between the upstream and downstream sides of the gate, trash rack or stoplogs.
- dead weight
- wave height due to wind
- sediment load
- wind load
- operating load
- water pressure variation and vibration force induced by flowing water: Water pressure variation and vibration force induced by flowing water will be considered. The gate shall be capable of operating satisfactorily without vibration under any gate opening and conditions of water flow.
- wave height due to earthquake
- dynamic water pressure during earthquake
- inertia force during earthquake: the inertia force during an earthquake shall be the multiplication of the dead weight by the seismic intensity.
- temperature loads: The effect of solar heating shall be taken into consideration.

A.4.9.3 ALLOWABLE STRESSES

The allowable stresses in the design shall be according to DIN 19704, DIN 18800 (EC 3) and the relevant standards.

A.4.9.4 CORROSION ALLOWANCE

A corrosion allowance is not required.

A.4.9.5 SKIN PLATES

The minimum thickness of skin plates for gates and stoplogs shall be calculated using DIN 19704:

- for lock gates, barrage gates and safety gates 12 mm,
- for other gates and inspection gates 10 mm,



A.4.9.6 GATE HOISTS

A.4.9.6.1 OPERATING LOAD

The operating load of the hoist is the sum of the self-weight of the gate leaf, the self-weight of ballast if any, the friction loads due to the rolling, bearing and sealing parts, and other loads, all summarized as follows:

- dead weight of the gate leaf and/or ballast weight
- friction force due to rotating and/or sliding parts
- friction force due to seal rubbers
- buoyancy
- uplift force and down pull force
- all loads resulting from the maximum torque of hoist motor under gate jammed conditions
- loads due to the action of earthquake.

The closing force of all gates shall have an allowance of more than 25% against the sum of all upward forces such as buoyancy, uplift, etc. at any gate opening under any reservoir water level.

A.4.9.6.2 ALLOWABLE STRESSES

The allowable stresses in the design will be according to DIN 19704 and the standards referred to herein.

The factor of safety for wire ropes of gate hoists should not be less than 8.

A.4.9.6.3 OPERATING SPEED

For general use: 0.25 - 1.0 m/min

For emergency closure gates, like power-intake: 2 - 3 m/min

A.4.9.6.4 MOTOR OUTPUT

The capacity of all electric motors is to be more than that calculated from the following equation.

$$\text{Output} = \frac{Wv}{6.12 n}$$

where, W operating load (tonnes)



H total efficiency obtained by multiplying respective efficiencies of the mechanical parts as given below.

Table: Efficiencies of Mechanical Parts

Item	Mechanical parts	Efficiency
1	Drum	0.95
2	Sheave (plain bearing)	0.95
3	Straight & helical gear	0.95
4	Bevel gear reducer	0.80 - 0.85 with
5	Worm gear reducer	0.50
6	Oil-hydraulic hoists	0.85

* Friction coefficient

- Spindle screw 0.2
- Worm gear screw 0.06 - 0.1

A.4.9.6.5 DIAMETER OF WIRE DRUMS AND SHEAVES

The minimum diameters of drums and sheaves for gate hoists shall be as follows:

- 25 - 32 times diameter of wire rope for drum
- 14 - 16 times diameter of wire rope for sheaves.

Drums to have 2 spare turns on the anchor end and one spare turn on the other end.

A.4.9.6.6 OIL HYDRAULICS

The oil hydraulic hoists and servomotors will be designed according to the guidelines of DIN 19704. The piston rod of servomotors shall be ceramic coated.

Hydraulic cylinder rods are to be sized to withstand earthquake vibration in the fully extended position without permanent distortion or damage.

A.4.9.6.7 LEAKAGE OF GATES

Water leakage under any head and without the use of any additional sealing materials per m length of gasket:

for gates: 0.1 l/s per m length of seal

for stoplogs: 0.2 l/s per m length of seal

A.4.9.7 CRANES AND LIFTING EQUIPMENT FOR GATES

A.4.9.7.1 DESIGN LOADS

Design loads for cranes shall be according to DIN 15018 or FEM, but will be include at least the following:

In service or operating condition:

- dead loads due to dead weight
- live loads including the hook load multiplied by an impact factor of 1.3
- horizontal loads due to inertia and skew loads due to traveling
- wind loads during operation: For outdoor cranes, the in-service design wind loads shall be applied.
- loads due to collision with buffers
- loads due to the action of earthquake.

Cranes for lifting gates, stoplogs and the like shall be designed after taking into account the operating load.

- Out of service condition:
 - o dead loads due to dead weight
 - o storm wind load: For outdoor cranes, the storm wind pressure will be 1,250 N/m².

Fixed and moving crane structures and mechanisms are to be designed to withstand earthquake loading when in service or out of service without permanent deformation or failure.

A.4.9.7.2 ALLOWABLE STRESSES

The allowable stresses in the design shall be according to DIN 15018, DIN 15020 or FEM and the relevant standards given herein.

A.4.9.7.3 OPERATING CLASSIFICATION

The group classification of all cranes is to be A3/M2 with a minimum life of 5×10^5 cycles in accordance to the FEM and DIN Standards.



A.4.9.7.4 WIRE ROPES

The factor of safety of wire ropes is to be 6 based upon the minimum ultimate strength of the wire ropes.

A.4.9.7.5 QUALITY OF MATERIALS AND EQUIPMENT

No welding, burning, filling or plugging of defective castings or any other defective components shall be permitted without the Employer's prior agreement in writing.

After the final heat treatment, any steel casting which has been repaired by welding shall be tested for cracks by radiographic and/or gamma ray examination or any other tests which the Employer may require. The cost of these and other additional tests shall be borne by the Consultant.

Where stainless steel cladding consists of plates welded to mild steel sections, the welds shall be adequate to ensure that the stainless steel is securely fixed for all conditions of load and wear. Generally, all stainless steel parts shall be welded with stainless electrodes. The thickness of the stainless steel cladding shall not be less than 6 mm.

A.4.9.8 MATERIAL PREPARATION

A.4.9.8.1 MATERIAL IDENTIFICATION

All components shall be clearly marked in accordance with the approved scheme for the identification of members, welds and welders according to ISO 9001.

The Consultant shall maintain full identification of primary structural steel throughout fabrication and the Consultant's reference number shall be die-stamped, using round nosed dies or by paint marking, on cut sections of plate and sections, in a manner to be approved by the Employer.

A.4.9.8.2 CUTTING AND EDGE PREPARATION

The plate shall be cut to size by thermal cutting or machining in accordance with specified procedures. Cold shearing is not permitted.

The hardness of flame cut edges shall be limited to 325 HV10 maximum either by controlled speed flame cutting, by preheat, or by grinding back or machining after cutting.

The cut edges shall be 100% visually examined for laminations, cracks, and other defects. If such defects are detected, the extent shall be established. A repair procedure shall be agreed with the Employer.



Any beveled edge that has been damaged shall be restored to the minimum tolerances. Where such restoration involves welding, only welding procedures approved by the Employer shall be used.

A.4.9.8.3 FORMING OF CURVED PLATES

Curved plates and section shall be formed to the correct curvature by cold rolling without reducing the yield strength of the material. The limit on the amount of strain induced by the cold process shall be 3%. The finish product shall meet the requirements of the Committee Européen de la Chaudrainerie et de la Tôlerie (CECT) or BS 7668.

A.4.9.8.4 STRAIGHTENING

All rolled plates, bars and sections shall be flattened and straightened and made free from twist, without damage, before marking and cutting. The limit on the amount of strain induced by cold working shall be 3%.

A.4.9.9 SPACING OF SEAMS AND SPLICES

A.4.9.9.1 STIFFENERS

Where required, transverse splices shall be located not closer than 120 mm intervals. The pitch of stiffeners for circular steel liners or penstocks shall be not less than 60 t (where t is the thinnest liner thickness).

A.4.9.9.2 SPLICES

Splices shall be kept to a minimum by making individual sections as large as possible consistent with the size of the plate supplied and the Consultant's approved assembly sequence.

Splices shall be arranged to minimize overhead welding. Spliced materials of different widths and thickness shall have smooth transitions.

Lapped joints are not permitted.

When two or more members intersect or overlap at a joint, the order in which each member comes into the joint will be determined by wall thickness and/or diameter. The member with the thickest wall will be the continuous or through member, and the sequence for framing the remaining members shall be based on the order of decreasing wall thickness.

A.4.9.9.3 BEAMS

Segments of beam with the same cross-section may be spliced. The use of the beam shall determine the location and frequency of splicing. In cantilever beams there shall be no splice located closer to the point of support than one-half the cantilevered length. For beams



employed in any span between supports, there shall be no splice in the middle one-fourth of the span. Splices shall not be located closer together than twice the depth of the beams, or 900 mm, whichever is larger. The web splice shall be offset from the flange splice by a minimum of 100 mm.

A.4.9.10 LAYING-OUT, ALIGNMENT AND FIT-UP

A.4.9.A.1 LAYING-OUT

At all stages during fabrication, the Consultant shall ensure correct positioning, alignment and levels in accordance with the required data.

Overloading, damage or any permanent deformation of any of the structural components at any stage of the erection shall be rectified in accordance with a procedure approved by the Employer.

No structural welding shall commence until members to be joined have been properly aligned and braced to prevent distortion.

A minimum of toe-to-toe clearance of 75 mm shall be maintained between parallel welds.

A.4.9.A.2 ALIGNMENT AND FIT-UP FOR WELDING AND TACK WELDING

Whenever practicable, clamps, holding devices or other setting up fixtures shall be used in assembling parts of the structure to avoid temporary welded attachments or tack welding. In fit-up where clamps cannot be used, temporary spacer strips shall be used to ensure the correct root gap prior to tack welding.

Ring stiffeners, stiffeners and diaphragms shall be close fitted to the shape of the surface to which they are attached either by machining or by flame cutting and grinding.

At intersections, the utmost attention shall be paid to good alignment of the structural parts where members meet on opposite sides of a through member. As-built dimensions shall be used to align such plates and not theoretical dimensions.

A.4.9.A.3 TEMPORARY ATTACHMENT WELDS

Temporary attachment welds are not permitted at steel liners and steels exceeding 500 MPa yield strength. All other temporary weld attachments and their removal shall meet the requirements of the Specifications.

A.4.9.A.4 COPE HOLES

Cope holes for ring stiffeners, stiffeners and diaphragms shall be permitted to a maximum radius of 25 mm. The cut edges of the cope holes shall be ground smooth to remove all notches, prior to fit-up of the member(s). The fillet portions of all welds are to be returned through the cope hole.



A.4.9.11 TEMPORARY AND NON-STRUCTURAL ATTACHMENTS AND CUT-OUTS

A.4.9.11.1 WELDING

Temporary and non-structural attachments shall be fitted to the shape of the surface to which they are attached, and welding shall be to a proven procedure by qualified welders. Temporary or non-structural attachments shall not be welded within 75 mm of any other structural weld measured from weld toe to weld toe.

Temporary attachments and cutouts are not permitted at steel liners and steels exceeding 500 MPa yield strength.

A.4.9.11.2 REMOVAL

The removal of temporary attachments shall be either by thermal cutting or by grinding. If thermal cutting is employed, the attachments shall be cut off at a minimum distance of 5 mm from the surface of the material and then ground flush. Following removal, the area of the attachment weld shall be subjected to 100% magnetic particle inspection.

Temporary attachments shall not be removed by hammering, or by any other technique, which may cause mechanical damage to the surface of the steel forming the main structure.

Following removal, any damage area shall be ground to merge smoothly with the original surface, and the surface is to be magnetic particle inspected. Where gouges up to 20% of the steel member thickness have been made, then after grinding and testing they shall be repair welded to an approved procedure. Where gouges of 20% or more of the material thickness, the repair procedure or alternative solution shall be proposed by the Consultant and be subject to the approval of the Employer.

A.4.9.11.3 TEMPORARY CUT-OUTS

When temporary cut-outs are necessary, they shall be prepared with the same degree of care as for permanent cut-outs and shall be cut out prior to erection of the member(s).

Special care shall be taken to ensure that the weld preparation applied to the cut-outs is appropriate to the final erected orientation of cut-out at the time of re-welding. The cutout shall be trial fitted prior to erection of the member. A welding sequence developed such that welding will be minimized shall be followed. All cut-outs shall be prepared with rounded corners not less than 50 mm.

A.4.9.11.4 FINISHING OF SURFACES

Prior to completion, the Consultant shall remove all burrs, tack welds and other marks made by welding, scaffolding or temporary bracing used in the fabrication procedures.



Any plate defects resultant from handling or fabrication works shall be repaired mechanically or to an approved welding procedure in accordance with the requirements of these Specifications. The method applied for plate repairs shall be subject to the approval of the Employer and shall comply with limits of BS 7668.

A.4.9.12 REPAIR AND REMEDIAL PROCEDURES

A.4.9.12.1 REPAIR WELDING

Welding repairs shall be carried out in accordance with these General Technical Specifications.

In the case of repairing a crack, the cause of cracking shall first be established satisfactorily before repair is allowed.

A.4.9.12.2 STRAIGHTENING OF DISTORTED MEMBERS

Prior to straightening of a distorted plate or rolled section, calculations of the strains involved shall be submitted to the Employer for review.

Members may be straightened cold prior to welding if the deformation does not exceed 3% strain.

When carried out hot, the temperature of heated areas shall not exceed 600° C. The part to be heated shall be substantially free of stress and from external forces except those stresses imposed resulting from the mechanical straightening used in conjunction with the application of heat.

Flame heating rectification shall be carried out only in accordance with approved procedures and with the agreement of the Employer in each specific instance.

Straightening procedures, which will include full details of methods of monitoring temperatures and times, are to be submitted to the Employer for approval prior to straightening. Methods of assessing the extent of any damage to the parent material by straightening are to be included in the proposals.

Hammering shall not be permitted.

A.4.9.12.3 TEMPORARY FABRICATION AIDS

Where possible, slings shall be wrapped around primary structural members for the purpose of lifting or rearing sections of the structure. Timber packers or other suitable devices shall be used to prevent distortion and damage, particularly where slings pass over protrusion such as stubs, flange outstands, etc.



Additional precautions shall be taken to ensure that miscellaneous projections such as pipes, pipe supports, nozzles, etc. are fully protected from interference with lifting slings during installation.

Adequate safety factors shall be used to cater for the effects of variation in self-weight, impact, dynamic effects and unequal sling lengths when determining lifting requirements.

Proper account shall be taken of the effects of differential deformation of support points during lifting. Structural calculations to investigate local member adequacy shall be carried out by the Consultant to prove the integrity of any lifting operation and shall be submitted to the Employer prior to execution of the operation.

A.4.9.12.4 TEMPORARY BRACING AND SUPPORTS

Scaffolding supports and facilities for supervision and inspection of the work shall be provided as necessary. They shall be sufficiently solid to prevent deformation. Any anticipated deformation shall require an immediate stiffening of the structure.

Adequate temporary bracing shall be provided and shall be left in position until such as the structure is sufficiently far advanced for the bracing to be no longer required.

A.4.9.12.5 RECTIFICATION OF SURFACE DEFECTS AND EDGE LAMINATIONS

Surface defects revealed during fabrication or blast cleaning shall be treated in accordance with the requirements of DIN 18800 or BS 7668. Repair by welding of any surface defect or exposed edge lamination shall only be carried out with the approval of the Employer and using a procedure complying with EN 1011 or equivalent Standard.

A.4.9.13 ERECTION LOADS AND STABILITY

During site assembly, the Consultant shall take account of all temporary erection loads imposed on the structure from supports, and slinging at each stage of the structure assembly.

At each stage of the structure assembly, the Consultant shall take account of the local or overall stability from self-weight and environmental loads; inclusive of scaffolding, staging, welding shelters and temporary works. The Consultant shall ensure that all stresses induced in the structure during fabrication and load out are within acceptable limits.

The Consultant shall take due consideration of the effect of wind on the structure or parts of the structure during construction.

The Consultant shall demonstrate to the satisfaction of the Employer that he has considered all relevant erection and temporary loads.

The Consultant shall produce a procedure for each erection or transport activity where the item under consideration exceeds 50 tons in weight, and at other times when requested by



the Employer. The procedure shall cover all aspects and shall satisfy the requirements of the relevant standards.

