Specification

Mechanical Specification for Packaged Equipment

H376521-8000-240-242-0001

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1. General

1.1 Introduction

1.1.1 This document establishes the technical standard for the mechanical equipment design on the Zuuvch-Ovoo Uranium Project.

1.2 Scope

1.2.1 This design criteria describes the minimum engineering standards, practices and requirements that will be taken into consideration during the design, selection, fabrication, testing and commissioning of mechanical equipment.

1.3 Codes, Regulations and Standards

1.3.1 The design, manufacture and installation of all mechanical equipment shall comply with all relevant provincial and national government Acts, By-laws and Regulations of Mongolia.

1.3.2 In the absence of Mongolian Standards, the Standards issued by international organisations mentioned in this Design Criteria shall apply.

1.3.3 The latest editions of standards shall be applied, unless otherwise specified.

1.3.4 Where contradictions arise, the following order of precedence shall take place:

1. Mongolian Codes, standards and legislation.
2. Accepted International Standards.
3. Project specifications or datasheets.
4. Relevant standards from other countries with approval from the Client's representative.

Table 1-1: International Codes, Standards and Specifications

Association	Description
ABMA	American Bearing Manufacturers Association
ACA	American Chain Association
AGMA	American Gear Manufacturers Association
AISC	American Institute of Steel Construction
AIST	Association of Iron and Steel Technology
AISI	American Iron and Steel Institute
AMPP	Association for Materials Protection and Performance
ANSI	American National Standards Institute
API	American Petroleum Institute
AHRI	Air Conditioning, Heating and Refrigeration Institute
ASLE	American Society of Lubrication Engineers
ASME	American Society of Mechanical Engineers
ASNT	American Society for Non-destructive Testing

Association	Description
ASTM	American Society for Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
CAGI	Compressed Air and Gas Institute
CEMA	Conveyor Equipment Manufacturer's Association
CMAA	Crane Manufacturer's Association of America
CSA	Canadian Standards Association
EJMA	Expansion Joint Manufacturers Association
EMA	Engine Manufacturers Association
EPA	U.S. Environmental Protection Agency
FM	Factory Mutual
FSA	Fluid Sealing Association
HEI	Heat Exchange Institute
HI	Hydraulic Institute
HMI	Hoist Manufacturer's Institute
IBC	International Building Code
IFI	Industrial Fasteners Institute
ISO	International Organisation for Standardisation
MHIA	Material Handling Industry of America
MMA	Monorail Manufacturers Association
MPTA	Mechanical Power Transmission Association
MSHA	Mine Safety and Health Administration
MSS	Manufacturer's Standardisation Society
NFPA-13	National Fire Protection Association
NFPA	National Fluid Power Association
NIA	National Insulation Association
NIOSH	National Institute of Occupational Safety and Health
NLGI	National Lubricating Grease Institute
OSHA	Occupational Safety and Health Administration
PFI	Pipe Fabrication Institute
RMA	Rubber Manufacturer's Association
SAE	Society of Automotive Engineers
PLASTICS	Plastics Industry Association
STI/SPFA	Steel Tank Institute/Steel Plate Fabricators Association
TEMA	Tubular Exchanger Manufacturer's Association

1.4 Project Standards and Specifications

1.4.1 In addition to the above codes and standards, this document must be read in conjunction with the following project standards and specifications shall also apply to the equipment design, fabrication/field erection, and inspection and testing, as applicable.

Table 1-2: Project Standards and Specifications

Specification	Description
H376512-8000-240-242-0002	Painting and Protective Coating Specification
H376512-8000-240-242-0003	Mechanical Insulation and Cladding Specification
H376512-8000-250-242-0001	Piping Isolation Specification
H376512-8000-250-242-0002	Piping Insulation and Tracing Specification
H376512-8000-250-242-0003	Manual Valve and Special Piping Items Specification
H376512-8000-250-216-0005	Standard Specification - Piping Material Class Index
H376512-8000-260-242-0001	E&I Requirements for Packaged Plants and Equipment
H376512-8000-260-216-0008	E&I Preferred Suppliers List
H376512-8000-200-242-0001	Site Climatic Conditions Specification
H376512-8000-250-210-0001	Piping Design Criteria
H376512-CG001-250-248-0001	CG001 - Piping Scope of Works
H376512-CG001-200-248-0001	CG001 – General Requirements - Scope of Works

1.4.2 For each equipment package, the relevant package documents such as datasheets and specifications will provide the associated information required to ensure full traceability of all operations.

1.4.3 In the event of significant conflict between the referenced codes/standards and project specifications or manufacturer's preferred procedures, conflicts shall be resolved in consultation with the client or client's representative.

1.5 Abbreviations

Table 1-3: List of Abbreviations

Name	Description
E&I	Electrical and Instrumentation
FEM	Finite Element Method
HAC	Hazardous Area Classification
HVAC	Heating, Ventilation, and Air Conditioning
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
ISO	International Organisation of Standardisation
MSDS	Material Safety Datasheet
OEM	Original Equipment Manufacturers
OSHA	Occupational Safety and Health Administration
RPM	Revolutions per Minute
SI	International System of units

Name	Description
VSD	Variable Speed Drive

2. Language and Documentation

2.1 The primary language for all information, data and documentation during the engineering phase of the project will be in the English language.

2.2 Final design drawings shall be in English.

2.3 All safety signage and labels shall be bilingual, including both Mongolian and English translations.

2.4 Drawing symbols for Single line diagrams will be in accordance with IEC 60617, “Graphical Symbols for Diagrams”. An appropriate legend shall be applied to Single Line Diagrams, Schematic diagrams and Layout drawings describing key symbols used as well as acronyms and abbreviations.

3. General Plant Design Criteria Requirements

3.1 Site and Climatic Conditions

3.1.1 Special attention shall be given to the environmental conditions for the design and operation of equipment. All equipment shall be designed for the temperatures and conditions defined in the relevant equipment datasheet and the Site Climate Conditions Specification listed in Table 1-2.

3.2 Design Life

3.2.1 The equipment should be designed to have a minimum operating life of 25 years. This assumes that, even with the on-set of corrosion, the equipment will remain in a safe and operable condition after 25 years of service.

3.2.2 Designs shall consider a corrosion allowance service-specific and subject to a case-by-case evaluation based on the material of construction of the equipment and the process fluid.

3.3 Operating Conditions

3.3.1 Equipment shall operate 24 hours/day, 7-days/week, and 52 weeks per annum without requiring excessive maintenance, repairs, long work stoppages or direct operator supervision.

3.3.2 Shutdowns for preventative maintenance (frequency and duration) shall be identified in individual equipment specifications.

3.3.3 Equipment shall be designed to operate in an environment and atmospheric conditions as specified in the various equipment datasheets and specifications where it may be exposed to harsh environments, hose-down by process water, direct sunlight, rain and high wind conditions.

3.4 Hazardous Area Classification

3.4.1 Equipment shall also be designed and rated to operate safely within the constraints of the Hazardous Area Classification (HAC), as per the applicable local regulations. The Mechanical discipline shall incorporate the required HAC information in the design deliverables envelopes in the 3D model, HAC attributes in the asset register. For large technology packages composed of multiple equipment, Mechanical package vendors will be required to perform a Hazardous Area Classification study on their scope/equipment as applicable.

3.5 Units of Measure

3.5.1 Except where specifically indicated otherwise, this project will use Metric (SI - International System of Units). Deviation from this requirement shall only be accepted where written approval is received from the Client/Engineer.

3.6 Equipment Selection and Design

3.6.1 Generally, process-equipment selection, capacity and sizing criteria shall be the responsibility of the process group. Detailed sizing/capacity requirements shall be outlined in the individual equipment specifications and data sheets.

3.6.2 Considerations for equipment selection may include:

- Safety
- Compatible spare parts inventory within Clients Stores System and spare rotating assemblies within existing assets
- Proven history of operation in similar applications
- Noise
- High reliability
- Maintainability and maintenance accessibility
- Low operating and maintenance costs
- Cost and availability of spares
- Low capital cost
- Readily available spare parts
- Mechanical vibration
- Equipment sizing
- Mated equipment and connected piping flanges must have the same pressure rating or compatible pressure rating according to the "Piping Material Class Index" listed in the Table 1-2.

3.7 Drawings

3.7.1 Drawings shall be on Zuuvch-Ovoo Uranium Project title blocks and follow the Zuuvch-Ovoo Project numbering system.

3.7.2 All drawings shall be cross referenced, including references to other engineering disciplines.

3.7.3 All drawings shall be fully dimensioned and annotated. The dimensional system must include set-out from structural grids, where appropriate.

3.7.4 All drawings shall provide legends and explanatory notes, as applicable.

3.7.5 All drawings shall include references to other engineering discipline drawings or details, as applicable.

3.7.6 All drawings must use 1st angle of view.

3.8 Proven Design

3.8.1 The equipment design shall be based on a proven design and acceptable standard practices in existence in other plants and on similar commercial application.

3.9 Safety

3.9.1 Mechanical Handling

3.9.1.1 Equipment requiring regular maintenance (more than twice a year) and weighing more than 25 kg shall be readily retrievable from its installed position by wheeled trolley, forklift, hoist, or crane (either installed or mobile) onto road transport at ground level or to a designated position where maintenance can be performed.

3.9.1.2 The utilisation of overhead maintenance cranes or hoists will be minimised to operational and maintenance requirements where the plant layout would prevent access of mobile lifting equipment or where the frequency of maintenance or operational activities would demand permanent lifting infrastructure.

3.9.1.3 Where necessary, lifting wells and landing platforms with removable handrails shall be provided to facilitate unimpeded access to ground level.

3.9.2 Noise Level

3.9.2.1 The maximum acceptable compounded sound pressure level for personnel exposure shall be in accordance with the following:

- An 8-hour equivalent continuous A-weighted sound pressure level, $L_{Aeq,8h}$, of 85 dB(A) at 1 meter
- For peak noise, a C-weighted peak sound pressure level, $L_{C,peak}$, of 120 dB(C), at the employee's ear.

3.9.2.2 Equipment and systems shall be designed to limit personnel exposure to these levels. The effect of multiple noise sources and reflective surfaces shall be considered in determining allowable noise levels from individual pieces of equipment.

3.9.2.3 Where it is not practical to meet these limits, noise control plans and hierarchy of control shall be applied to reduce the risk of noise exposure to workers.

3.9.3 Equipment and Installations Required

3.9.3.1 It is essential to ensure that lines are fitted with the following equipment as indicted in the relevant P&IDs:

- Safety valves
- Drains
- Vents.

3.10 Ergonomics

3.10.1 Equipment and machinery shall be designed to take account of the variability in personnel characteristics including body dimensions, posture, body movement and physical strength. All elements of the man-machine systems such as displays, signals, controls and access means shall be taken into account in such a way that clear, easy and unambiguous interaction between operator and machine (in particular for service and maintenance people) is possible.

3.11 Materials

3.11.1 General

3.11.1.1 Materials of construction shall be compatible with the process fluid and operating environment of the equipment and system. All materials shall be verified for compatibility with corrosion and abrasion resistance.

3.11.1.2 All material shall be new and of a suitable quality and grade.

3.11.1.3 Material containing asbestos and/or fibres harmful to health shall not be incorporated into the works. All materials potentially presenting a health hazard must be identified by the Vendor and be accompanied by MSDS. Their use shall be subject to Client's Representative approval.

3.12 Layout and Access

3.12.1 Maintenance Access

3.12.1.1 Walkways, stairs and platforms shall be provided to allow maintenance access to drives, valves, hydraulic cylinders, safety devices and other equipment.

3.12.1.2 Maintenance access shall take into consideration appropriate clearances required for equipment removal and repair.

3.12.2 Manways/Access Doors

3.12.2.1 Manways and circular openings for inspection or access on vessels shall be in compliance with the applicable code and standards for the equipment. All manways shall have a minimum opening of DN 700 (28").

3.12.2.2 Permanently installed davits shall be used for manway and vessel covers weighing more than 25 kg (55 lbs), where frequent access is required. Hinges may be fitted where davits are not practical if approved by the Client/Engineer.

3.12.2.3 Manways and access doors shall not interfere with other mechanical equipment or block access ways when open.

3.12.2.4 Manway cover weights shall be stencilled on each cover.

3.12.2.5 Access doors on equipment handling dusty material shall be dust tight with replaceable gaskets.

3.12.2.6 For equipment other than pressure vessels and tanks, wing nuts shall be provided. The number of fixing points shall be minimised.

3.12.2.7 Conveyor inspection points to have mesh guard which could only be removed by tools.

3.13 Equipment Handling

3.13.1 All equipment, guards and base frames shall be fitted with readily accessible lifting lugs, eyes or sling points as appropriate for installation, erection and maintenance that can readily be achieved.

3.13.2 All items of equipment over 25 kg (55 lbs) shall be furnished with lifting lugs for crane handling. Lifting lugs shall be positioned to minimise the handling hazards. Where lifting attachment points are to be provided, they shall be either standard proprietary lifting eyes or custom designed lifting lugs. The lifting eyes or lifting lugs shall be located at the centroid of the item, such that the item remains horizontal and stable whilst being lifted.

3.13.3 For equipment over 25 kg (55 lbs) that are required to be removed for maintenance, the gross weight shall be stencilled or painted in a conspicuous location.

3.14 Design Loads

3.14.1 General

3.14.1.1 Design loads for mechanical equipment shall be the most adverse combination of loading and shall include, but may not necessarily be limited to the following:

- Dead loads
- Live loads
- Wind loads
- Earthquake loads
- Snow loads
- Seismic loads
- Pressure induced loads
- Loads applied by machine action (e.g., torque)
- Acceleration or deceleration (inertia) loading (e.g., braking forces)
- Impact loads
- Loading produced by thermal expansion or contraction
- Loading produced by material spillage or abnormal operation (e.g. conveyor spillage onto included walkways, blocked chutes)
- Loading produced during the course of plant maintenance (e.g., resting equipment on included platforms)
- Loads due to testing (e.g. hydrostatic test)
- Loads occurring during transport and construction

- Loads applied by piping systems.

3.14.1.2 Equipment shall only be bolted to structural members.

3.14.1.3 Supporting steel between driving and driven machines shall be designed to minimise the coupling misalignment. Possible beam deflection and new building steel orientation will be designed to reduce the deflection.

3.14.1.4 Vendors shall specify the maximum allowable loads on equipment nozzles.

3.14.2 Fatigue Loads

3.14.2.1 Equipment shall be designed for a fatigue life at least equal to the plant design life under normal operating loads, unless otherwise specified or approved by the Client's Representative.

3.14.2.2 Design loads for fatigue failure analysis shall be determined from those loads applied to, or produced by, a machine whilst operating at its maximum rated capacity assuming the machine's prime mover(s) is(are) operating at their maximum continuous rating unless otherwise specified or approved by the Client's Representative.

3.14.2.3 Structural steel connections associated with vibrating machinery shall use bolted connection. Welded connections are prohibited. Design of the bolt shall be based on associated friction forces.

3.14.3 Design for Maximum Static Loads

3.14.3.1 Equipment shall be designed to accommodate the maximum expected static load(s) to which it may be reasonably subjected to during its design life, without the risk of equipment damage or risk of injury to personnel.

3.14.3.2 Where equipment is driven by a prime mover(s), such as an electric motor, it shall be designed to accommodate the maximum torque that the prime mover(s) can produce.

3.14.3.3 Where equipment is driven by a hydraulic or pneumatic prime mover(s), it shall be designed to accommodate the maximum possible torque or force the prime mover(s) can produce at the pressure relief valve setting, provided this setting is considered to be tamper-proof by the Client's Representative.

3.15 Limits and Fits

3.15.1 Limits and fits shall be in accordance with ISO 286 ISO System Limits and Fits

3.15.2 Unless otherwise specified:

- Equipment shall be manufactured to tolerances shown on the drawings or as specified in the documents
- Steelwork tolerances shall be in accordance with the relevant clause of Specification for Structural Steel or Project Specifications, whichever is applicable.

3.15.3 Where tolerances are not specified, the following general tolerances shall apply:

Table 3-1: General Tolerances

Component	Tolerance
Machined Components	± 0.25 mm
Small fabricated or cast components	± 1.5 mm
Large fabricated or cast components	± 3.0 mm
Fabricated Platework – Flatness	± 2.5 mm per metre

3.15.4 Machined surface finish designations shall be clearly noted on all drawings as per ISO 21920-1:2021. The arithmetic mean deviation (Ra) method shall be used with surface roughness expressed in micrometres.

3.15.5 Where the surface finish of a machined component is not defined, it shall be rough machined to a surface roughness of Ra 3.2 micrometres or better.

3.15.6 The surface finish of machined flange faces shall be in accordance with the requirements of the applicable flange standard.

3.15.7 Allowable deviation from axis shown on the vendor's drawing shall be one degree for all nozzles and coupling.

3.15.8 Fits between proprietary mechanical components and custom designed components supplied by the Vendor (e.g., bearings mounted on shafting) shall be in accordance with the proprietary component manufacturer's recommendations.

3.15.9 Machinery that rotates at less than 1,800 rpm, and only in one direction, shall be preferentially designed on size, or with clearance fits.

3.15.10 Shaft design shall consider the ease of assembly and maintenance of the bearings. For long shafts, press fit tolerances shall be defined at the location of the bearings and a clearance fit shall be defined for the extended shaft.

3.15.11 Fitted parts shall be match marked for assembly.

3.15.12 Fitted parts shall have pusher and puller holes.

3.15.13 Critical spare part assemblies shall be shop fitted and assembled to associated machines.

3.15.14 Machines and assemblies shall be shop assembled prior to shipment.

3.15.15 Large, fabricated flanges, over 1,830 mm (6 ft), should have four finding holes and four alignment holes.

3.16 Vibration Control and Balancing

3.16.1 Dynamic and vibration loadings from machinery shall be isolated from the supporting structure. Care shall be taken to isolate equipment vibrations from piping, air ducting, structural members, electrical raceways, conduit, sensitive equipment or other resonating items by use of isolation mounts, pulsation dampers and/or flexible joints.

3.16.2 The equipment shall operate without excessive vibration under normal conditions of operation. Minimum vibration level requirements for rotating equipment shall be to ISO 7919 standard – Mechanical vibration of non-reciprocating machines.

3.16.3 The vendor shall supply shop static and dynamic balancing of all rotating equipment/assemblies in accordance with ISO 1940-1:2003- Mechanical Vibration – Balance Quality Requirements for rotors in a constant (rigid) state – Part 1: Specification and Verification of Balance Tolerances. The balance grade shall generally be G2.5 unless the specific application or type of equipment dictates otherwise.

3.16.4 Other applicable standards include:

- ISO 2017, Mechanical vibration and shock – Isolation of machines.

3.16.5 Machines that use vibration isolation devices shall have a rigging, jacking or lifting points for repair and/or replacement.

3.16.6 Vibration monitoring sensors and instrumentation shall be considered as per clients Predictive Maintenance (PDM) program for rotating equipment. For further information, refer to the E&I Requirements for Packaged Plants and Equipment as listed in Table 1-2.

3.16.7 Bolts subject to shock and/or vibration shall be provided with a positive locking device to prevent loosening. Further information is provided in Section 4.4 Fasteners.

3.16.8 Shaft critical speeds or any equipment resonance shall be checked to ensure they are not within the range of 75% to 150% of the machine operating Frequency. The equipment components shall not have any resonance modes which are excited by any vibration operating frequency during normal operation of the equipment.

3.16.9 The lateral critical speeds of rotating equipment/assemblies shall avoid the operating speeds by at least 30%, and for the torsional mode, shall avoid the operating speeds by a least 10%. There shall be no critical speed close to the 0.5 times the running speed or the impeller blade pass frequencies.

3.16.10 The overall vibration velocity levels (unfiltered) recorded at site on the bearing housings of rotating equipment/assemblies, in two orthogonal radial directions with one being that of least stiffness, and in the axial direction, shall not exceed 2.6 mm/s (0.512 ft/min) RMS, unless the specific application or equipment type dictates otherwise. The limit is applicable to all operating conditions and operating speeds.

3.16.11 None of the vibration components, including those for unbalance, misalignment or any mechanical or electrical problem shall exceed 50% of the overall vibration amplitude.

3.16.12 In general, the vibration amplitude in the axial direction shall not exceed 50% of any vibration in the radial direction.

3.16.13 Where structural steel is part of the equipment supply, the natural frequencies of the structure shall avoid the equipment operating speed by at least 30%.

3.16.14 Structural steel shall be designed to no closer than 0.5 or 2-times the component running speed harmonic, or near any blade pass or vane pass frequency. Preferentially the design will be such that the natural frequencies of the steel support is tuned to a higher frequency than machine's operating frequency. The evaluation and selection of vibration damping, where required, shall be in accordance with ISO 10816 standard, Mechanical Vibration – Evaluation of Machine Vibration by Measurements on Non-Rotating Parts or equivalent.

3.17 Welding

3.17.1 Welding shall not be permitted after stress relief.

3.17.2 Welding shall comply with AWS D1.1 and D1.6 standards, as a minimum. Welding procedures shall be submitted to the Client's Representative for review of all joints prior to the start of fabrication.

3.17.3 Welding shall be executed in accordance with the welding procedures. Welds shall be full penetration, full fusion, free of undercut, craters and surface cracks and porosity.

3.17.4 All weld joints shall be thoroughly de-scaled after welding.

3.17.5 Weld will be tested in accordance with AWS B1.10 :2016 – Guide for the Non-destructive Examination of Welds.

3.18 Surface Treatment

3.18.1 Surface preparation and material selection shall be in accordance with plant specific requirements and the latest version of the Standard Painting and Protective Coatings Specification as listed in Table 1-2.

3.18.2 Proprietary equipment may be supplied with the manufacturer's standard surface treatment, if approved by the Client's Representative and provided it is suitable for the specified service conditions and the coating life will be a minimum of 5-years.

3.18.3 Machined surfaces, which receive no further surface treatments, shall be cleaned and fully protected until the equipment is put into service with one coat of a strippable membrane or one coat of an approved protector that can be readily removed by solvents.

3.18.4 Surface preparation and painting shall be as defined in the project Painting and Protective Coatings Specification as listed in Table 1-2.

3.18.5 For stainless steel surfaces passivation is required.

3.19 Skid Mounted Equipment

3.19.1 Where it proves economical and practical, consideration should be given to pre-assembling the largest practical units for shipment and erection. This must be considered during design and agreed to by all relevant parties.

3.19.2 All self-contained, skid mounted equipment and ancillary equipment shall be:

- Supplied complete with all wiring and electrical/instrumentation devices complete and installed. Wiring and conduit shall be properly identified and terminated at appropriate junction boxes, per E&I Requirements for Packaged Plants and Equipment listed in Table 1-2
- Supplied complete with piping installed with minimum field connection and easy access for maintenance.

4. Equipment Components Design Requirements

4.1 General

4.1.1 Labelling and Nameplates

4.1.1.1 Equipment shall be clearly identified with a securely attached 6 mm thick stainless-steel nameplate. Lettering will be etched or stamped with all information to be provided by the vendor, required by the Client's Representative and/or required by the applicable code.

4.1.1.2 As a minimum, the nameplate shall include, where applicable, the following information:

- Client's tag number/equipment number
- Equipment serial number
- Model and size
- Motor kW (HP) and RPM
- Unit operating RPM
- Working temperature range
- Working pressure range.

4.1.1.3 Where components are to be separated for shipment, each separable component shall be provided with a clearly stamped stainless steel temporary label to clearly identify the component and will be matched marked for assembly at site. The temporary label shall be securely attached to each separate item by suitable stainless-steel tie to allow clear identification of the component.

4.1.2 Lubrication

4.1.2.1 All mechanical operating parts, unless noted otherwise, shall be provided with means of lubrication suited for the operating conditions. In general, the recommended lubrication procedures by the equipment manufacturer shall be followed.

4.1.2.2 Lubrication systems shall be designed to permit lubrication with equipment running. All grease fittings shall be readily accessible for greasing without removing guards. For equipment requiring multiple lubrication points, the lubrication fitting within reasonably close proximity to one another shall be piped to one side with the grease nipples mounted on a common bulkhead to allow easy access. Lubrication tubing and piping shall be stainless steel or hydraulic hose.

4.1.2.3 Oil lubrication with cooling system may be required on selected equipment as per plant standards. Lubrication heating and or cooling, where applicable, shall be used to maintain lubricant within the range of allowable operating temperatures. All equipment fitted with lubrication systems shall be constructed with containment trays and drains to collect lubricant spillage during operation and servicing.

4.1.3 Insulation and Cladding

4.1.3.1 Insulation and Cladding shall be as defined in the Standard Insulation and Cladding Specification listed in Table 1-2.

4.2 Base Plates

4.2.1 Motors and gear drives shall be mounted on a common steel base plate and secured with through bolts. Integral side mounts shall only be used for special applications. The base frames shall be of rigid construction and may be of either fabricated or cast steel construction. In corrosive areas, alternate base frame materials or composites shall be considered.

4.2.2 Through bolting is permitted. Blind tapped holes are prohibited.

4.2.3 Bases shall be designed to prevent the retention of water, dust and spilled process fluids or materials.

4.2.4 Mounting surfaces on the base frame shall be machined to appropriate tolerances to permit machine alignment and levelling according to the tolerances specified by the equipment manufacturer. Shim allowancing of 6 mm shall be included in design dimensioning at the motor feet. Allowance for grouting and grout holes shall be included in design.

4.2.5 Base plates shall be provided with corrosion resistant or protected jacking screws for longitudinal and transverse alignment of motors and gearboxes.

4.2.6 Levelling screws shall be furnished on the base plates of all major equipment, to be mounted by means of anchor bolts and grout. Anchor bolts shall have 6 mm diameter clearance for ease of field alignment.

4.2.7 Machinery base plates that have milled surfaces for motor and gear drive feet shall be stress relieved prior to machining.

4.3 Steelwork Support

4.3.1 All steel fabrication associated with mechanical equipment (e.g., steel fabrication that appears on mechanical drawings) such as machine and drive base fabrications, pump bases, equipment support framing, etc., shall be designed for all load cases including installation, testing and dynamic loads.

4.3.2 Dynamic and static loads need to be clearly illustrated on the drawings.

4.3.3 Support steel work will be the vendors standard and proven design.

4.4 Bolting, Fastening and Fixing

4.4.1 All bolting for pipe flange connections shall be according to ASME B16.5 Table 1C. All other screw threads, bolts, and nuts must be Grade 8.8 or higher for carbon steel applications and A4 or higher for stainless steel applications. Structural bolts and nuts shall be according to ASME B18.1.1.

4.4.2 Bolted connections shall consist of a minimum of two M20 bolts. Unless otherwise approved, load-bearing joints shall be made with Grade 8.8/S bolts.

4.4.3 Fasteners for critical service applications shall be accompanied with material test certificates identifying type, grade, origin and heat number.

4.4.4 All bolts used in the assembly of mechanical equipment, plate work and machine framing which may require disassembly for maintenance shall be coated with “Loctite” Nickel 771 anti-seize or approved equivalent.

4.4.5 On vibrating equipment, jam nuts shall be provided with weld angles to secure the nut and prevent it from loosening.

4.5 Drives

4.5.1 General

4.5.1.1 All drives shall be rated for service factor specified for the individual equipment based on the intended service. At a minimum, a service factor of not less than 1.5 times the maximum rated motor power shall be used.

4.5.1.2 Mechanical equipment shall be designed to prevent thrust loads from being transmitted to motors.

4.5.1.3 Operating speed ranges shall not exceed the drive manufacturer’s recommendations.

4.5.1.4 In explosion-proof areas, all equipment shall be direct coupled. Gear reducers or variable speed drive (VSD) shall be used for speed reduction.

4.5.1.5 ISO standard specifications are preferred, with alternate specifications to be submitted for review by Client’s Representative.

4.5.1.6 Drive and driven sheaves and sprockets shall be installed with a minimum of overhang on the shaft.

4.5.1.7 Consideration shall be given to the use of variable speed drives (VSDs), fluid couplings, or hydraulic motors where the application involves high and/or shock loading.

4.5.2 Gear Reducers

4.5.2.1 Gear reducers shall be designed for continuous duty with capacity to stop and start under full load conditions.

4.5.2.2 Gear drives shall be rated in accordance with ISO 14179 in relation to thermal transmittable power.

4.5.2.3 Gear reducers shall be capable of transmitting torque of not less than the greater of:

- The maximum stalled torque produced by the drive motor, unless specified otherwise, this shall be taken as 3.0 times the motor full load torque
- Where a brake is installed, 1.5 times the maximum braking torque.

4.5.2.4 Gear ratings shall be calculated in accordance with ANSI/AGMA 2001-D04 for helical gearing and ANSI/AGMA 2003-C10 for bevel gearing. The calculated gear rating shall not be less than the greater of:

- The specified service factor multiplied by the demand power
- The drive motor nameplate power multiplied by a service factor of 2.0.

4.5.2.5 Gear reducer thermal ratings shall be calculated for oil bulk temperatures not exceeding 85°C while operating under full load conditions at the highest recorded temperature specified in the Site Climatic Conditions Specification as listed in Table 1-2. Solar radiation shall be considered where sunshades are not fitted.

4.5.2.6 The thermal rating of the gear reducer shall not be less than the drive motor nameplate power for continuous duty. Where possible, the thermal rating of the gear reducer shall be able to withstand the process temperature without the need for a cooling system. Auxiliary cooling systems, if required, require the approval of the Company.

4.5.2.7 An air oil cooling system is preferred over a water-cooled system.

4.5.2.8 Gears that are case hardened shall be finish machined after case hardening.

4.5.2.9 All gears in speed reducers shall be helical type except for low-speed reductions where spur gearing is acceptable.

4.5.2.10 Gear service life shall be 100,000 hours at motor full load unless otherwise specified.

4.5.2.11 Gear reducers shall be supplied complete with inspection covers, labyrinth seals with double lip seals incorporated, oil drains, oil sight glasses giving indication when running and oil dip sticks with oil operating range clearly marked. Magnetic drain plugs shall be provided to remove any metallic particles in the lubricant.

4.5.2.12 Gear reducers should be provided with the necessary fittings to allow ‘kidney loop’ filtration systems to be fitted. Where necessary, isolation valves and additional piping shall be provided to enable gearboxes to be filled and drained easily from local platforms.

4.5.2.13 Gear reducers shall be fitted with desiccant air breathers complete with filter element (e.g. Hydac BDE, Stauff SDB or equivalent). Low volume applications may be fitted with bladders to prevent air ingress.

4.5.2.14 Gear unit casings shall be designed and constructed to maintain shaft alignment under extreme load and thermal conditions. The housing mounting shall be designed so that casing distortion is avoided when it is bolted to the base plate. The internal surface of the casing shall be protected against corrosion damage.

4.5.2.15 Gearbox casings manufactured from cast or fabricated steel are preferred. Where the duty is shock-free, cast-iron casings may be offered subject to the approval of the Company.

4.5.3 Couplings

4.5.3.1 Flexible couplings shall be supplied with taper-lock bushings, unless otherwise specified by the specific plant.

4.5.3.2 Straight bore coupling shall be complete with keyways and double set screws at 120 degrees apart.

4.5.3.3 Coupling running at more than 970 rpm shall be statically balanced with half keys in place.

4.5.3.4 Couplings shall have two or four puller holes min M12 x 30 dp.

4.5.3.5 Bore coupling fits shall have a clearance according to ANSI LC1 or LC2 locational clearance.

4.5.3.6 Couplings fitted with flexible elements shall have these removable without disassembly of other drive components.

4.5.3.7 Couplings shall be selected in accordance with the manufacturer's recommendations based on the nature of the driving and driven torques, with a minimum service factor of 1.5 applied to the rated motor torque or braking torque, whichever is larger. The service factor for couplings shall not be less that 1.5 (2.0 for shock loaded equipment), based on the driver nameplate power.

4.5.3.8 Fluid couplings shall be of the extended delay type when specified on the data sheet. Fluid couplings shall be capable of 5 equally spaced start-ups per hour at maximum design load.

4.5.3.9 Overheat safety lead plugs are to be provided with the design meltdown temperature hard marked on the plug.

4.5.3.10 Controlled torque couplings and sheer pins shall not be used, unless otherwise specified or approved by the Client's Representative. The over torque protection shall be accomplished with electronic control or hydraulic system.

4.5.4 V-belt Drives

4.5.4.1 Whenever belt drives are proposed, they shall be sized to transmit the driver nameplate power rating with a service factor of not less than 1.5. Under no circumstances shall there be less than two matched standard belts for each drive, regardless of the service factor.

4.5.4.2 Belt drives shall be designed to transmit the maximum motor starting torque or two times the running torque, whichever greater, without slip.

4.5.4.3 V-belt drives shall be complete with standard stock sheaves. All sheaves will be cast iron, be complete with keyways, and tapered hubs with split compression type bushings. Sheaves shall be statically and dynamically balanced. Selection and installation of the bushing shall be specific as per plant requirements.

4.5.4.4 All V-belts will be of standard 5 V or 8 V sections. 3 V profile shall only be used if approved by the Client's Representative.

4.5.4.5 Drive ratios shall be selected such that standard pulley sizes are used.

4.5.4.6 The speed ratio shall be selected such that standard pulley sizes are used and shall not exceed the following, without being approved in writing by the Client's Representative:

- For general application 3:1
- For pump drives 2:1.

4.5.4.7 Minimum arc of contact on smaller sheave shall be 120 degrees. Drive and driven sheaves and sprockets shall be installed with a minimum of overhang on the shaft.

4.5.4.8 Independent belt tension adjustment shall be provided.

4.5.4.9 Refer to project electric motor list for frames series with heavy duty bearing ends designed for direct sheave mounting.

4.5.5 Chain Drives

4.5.5.1 Chain drives shall be in accordance with specific plant requirements:

- Chains shall be standard ANSI (or approved equivalent) roller type with minimum 1.5 service factor.

4.5.5.2 Drives shall be designed to transmit the maximum motor starting torque. Standard roller chain and sprockets shall be rated for steady loads with a minimum service factor of 1.5 based on driver nameplate power rating.

4.5.5.3 The chains shall have a minimum of six cottered links plus one spare offset link.

4.5.5.4 Sprockets shall be flame cut with hardened teeth and tapered hubs having split compression type bushings keyed to shaft. Multiple width sprockets shall be fabricated from stock plates. Large cast sprockets and miniature hubs shall be avoided and may only be used with the Client's Representative's written approval.

4.5.5.5 The minimum safety factor equals to the average tensile strength of the chain divided by the applied chain tension produced at the drive sprocket at full motor torque shall be 12.

4.5.5.6 All chain drives shall be enclosed in a dust free, oil-tight casing with seals, oil filler cap, dipstick and drain plug. The casing shall be split along the centreline of the main sprockets and fitted with inspection ports for all sprockets.

4.5.5.7 Chain drives shall be arranged such that the tension side of the chain is easily accessible.

4.5.5.8 Drive ratios shall be selected so that standard sprocket sizes are used. Maximum sprocket ratios shall not exceed 3:1. Minimum wrap angle shall not be less than 120 degrees.

4.5.5.9 All drive and driven sprockets shall be reversible.

4.5.5.10 Sprocket Hubs shall be drilled and tapped for puller holes.

4.5.5.11 Sprockets larger than 305 mm pitch diameter shall be plate type mounted to rabbeted flanged hub with a 406 mm bolt circle diameter.

4.5.5.12 Gates Poly Chain GT Carbon drive belts may be used only by Client's Representative's approval.

4.6 Hydraulic Power Systems and Equipment

4.6.1 All Vendor supplied hydraulic systems shall be shop assembled and tested. All hydraulic lines shall be pickled, neutralised and sealed before shipment and shall require a minimum of field fit.

4.6.2 Hydraulic reservoirs shall be painted internally with zinc rich self-curing inorganic coating. Hydraulic fluid reservoirs shall have sufficient capacity to contain all the fluid that will drain from the system into the reservoir by gravity flow plus the fluid from any accumulators.

4.6.3 Reservoirs bottom plate shall be sloped for drainage.

4.6.4 Hydraulic power units, including piping/tubing, flanges and hose assemblies shall, as a minimum, conform to the requirements as specified by NFPA and the applicable sections of SAE, ASTM and ASME (or equivalent).

4.6.5 Hydraulic systems shall be permanently supported to eliminate static deflection and vibration during operation in addition to meeting all code requirements. Valves, instruments and other components shall be independently supported.

4.6.6 The circuits shall be designed to prevent uncontrolled movement of hydraulic actuators at any time. This includes movements in the event where hydraulic pressure is lost due to failure of electrical power, control power, control components, etc. (fail-safe design).

4.6.7 Design and manufacturing of hydraulic circuits shall minimise leakage and surge pressure.

4.6.8 An attempt shall be made to standardise hydraulic fluid across the project. Where flammability is a risk, fire safe fluid shall be used. No hydraulic system shall be used that runs hot enough or in a location severe enough to warrant use of fire-retardant oils.

4.6.9 Drip trays shall be installed under pumps, motors, valve trains, reservoirs and relief valves, where applicable, to minimise risk of pollution.

4.6.10 Provide all hydraulic systems with adequate cooling and/or heating to ensure proper operation under continuous duty at specified operating conditions.

4.7 Guards

4.7.1 All exposed rotating or moving parts shall be provided with totally enclosed safety guards made to comply with OSHA and MSHA requirements.

4.7.2 In general, guards shall have a custom design different from original equipment manufacturers (OEM). Drawings and design details will be provided as required. If client's custom design is not specified, the guards shall be OEM. Guards are excluded only if explicitly stated in the scope of work.

4.7.3 Pinch or nip point guarding or fencing shall be considered at loading points on conveyor belts.

4.7.4 Conveyor bend and tail pulleys shall have a 1,000 mm clearance from fencing to pinch points.

4.7.5 Where manual grease lubrication is required, all lubrication points must be readily accessible from outside the guards to allow lubrication while the unit is operating. Grease nipples must be mounted at convenient accessible locations around the equipment and must be connected to grease points by hose and stainless steel tube as required. Stainless steel tubing must be connected via Swagelok compression fittings or equivalent and secured with Stauff pipe clamps or equivalent for ease of removal and replacement. All hose and tubing must be protected from mechanical damage.

4.7.6 Guards shall be designed for easy removal, replacement, and access for maintenance where appropriate. Safety guards shall be designed for lubrication of enclosed moving parts and tachometer readings on shafts without dismantling guards. Guards shall allow

belt tension to be checked without removal of the guard. Where operators' observations of the process are required while the equipment is operating, e.g. wash sprays, material movement, etc., guards shall be designed such that observations can be done without having to remove the guard or part of the guard.

4.7.7 Fabricated guards shall be made to plant standard material.

4.7.8 Guards shall be equipped with handles of proper design and lifting lugs where the weight exceeds 25 kg. All guards weighing 15 kg or greater shall have the weight of each removable section permanently marked on it.

4.7.9 Guards shall have slotted x/y brackets for mounting.

4.7.10 Larger fabricated guards shall have guide pins for location relationship of parts.

4.7.11 Guards for driver and driven sheaves and sprockets shall be of sufficient size to accommodate an increase of three standard sheave sizes without modification.

4.7.12 All guards shall be painted as per the Painting and Protective Coatings Specification as listed in Table 1-2.

4.7.13 Guards protecting fluid couplings or any other potentially dangerous hot liquids, will be splash-proof.

4.7.14 Where expanded metal guarding is being used, flat rolled mesh should be used, with the long lengths of the openings positioned vertically.

4.8 Access

4.8.1 Access requirements

4.8.1.1 Walkways are to be 750 mm minimum.

4.8.1.2 Spatial access around equipment is to be 900 mm or greater if specified by the vendor.

4.8.1.3 Minimum headroom of 2,100 mm is required.

4.8.2 Access Ladders

4.8.2.1 Any ladder servicing equipment over 3,000 mm in height shall be equipped with a personnel safety cage, starting at 2,100 mm above the base of the ladder, as per ISO 14122-4.

4.8.2.2 Ladders shall be used only where stairs are impractical, access is infrequent or for emergency egress such as a platform with stair access but ladder on opposite side.

4.8.2.3 Where ladders must extend more than 9,144 mm multiple ladder sections shall be used.

4.8.2.4 Safety cages and ladders shall be in conformance with the applicable details of the Structural Engineering Practice, Ladder and Cage - Typical Details, and Equipment Engineering Practice (Vessels).

4.8.2.5 Ladder safety devices such as fall arrest harnesses, may be used on boiler, water tank, and chimney ladders with an unbroken length over 6,100 mm in lieu of cage protection and landing platforms.

4.9 Bearings

4.9.1 General

4.9.1.1 Bearings shall comply with the following requirements:

- The equipment manufacturer shall select bearings for each specific application. The selection procedures and ratings shall be in accordance with the latest copy of applicable standards. ABMA standards are preferred. Where practical, bearings shall be of standard types and size
- Operating temperatures for oil or grease in bearings shall not exceed the bearing manufacturer's recommendations for the particular application and specified lubricant
- All bearings shall be heavy duty, dust-tight, self-aligning, anti-friction roller bearings of the multi-cylinder, spherical or tapered roller type. Grease lubricated bearings shall be re-greaseable
- Bearings shall be selected to provide a minimum L10 life specified in Table 4-1. The L10 life shall be calculated in accordance with methods of ISO 281, at the maximum speed and radial and axial loads resulting from rated motor power
- Rolling element bearings with non-metallic cages are not permitted
- Each pair of bearings supporting a shaft shall consist of one fixed and one floating unit
- Unless otherwise specified, externally mounted bearings shall be housed in cast, split type housings for shafts up to and including DN 300 diameter
- Bearings less than 25 mm internal diameter may be of the sealed for life type
- Bearings, bearing housings and other moving parts shall be provided with seals, which exclude dirt, foreign matter, water including high pressure hosing, and prevent loss in lubricant. Labyrinth type seals are preferred
- Use of lip seals shall be subject to Approval and, where used, replaceable sleeves shall be provided to prevent seals from rubbing directly on shafting
- Bearing housing mounting surface flatness and finish shall be in accordance with the housing manufacturer requirements
- Refer to Section 4.1.2 for additional requirements regarding lubrication.

Table 4-1: Minimum Bearing Life

Type of Equipment	Minimum L10 Life (hours)
Cranes, trolley and hoists (maintenance)	12,500
Gear drives, combination drives	60,000
Pumps	60,000
Agitators	80,000
Screens	80,000
Compressors, blowers, process fans and turbines	100,000

Type of Equipment	Minimum L10 Life (hours)
Cranes, trolley and hoists (process/operations)	100,000
Equipment not specified above – up to 12 hrs/day operation	45,000
Equipment not specified above – continuous 24 hr/day operation	60,000

4.9.2 Bearing Lubrication

4.9.2.1 Grease lubrication is preferred for low-speed rolling element bearings where the risk of foreign matter ingress is high and there may be long periods between required attention.

4.9.2.2 Oil lubrication is preferred on high-speed equipment or equipment with operating temperatures above 90ºC.

4.9.3 Bearing Ingress Protection

4.9.3.1 All bearings shall be fitted with bearing isolators or other sealing devices to prevent lubricant contamination. A summary of recommended bearing protection devices is listed in Table 4-2.

4.9.3.2 For applications likely to be subject to direct exposure to high-pressure washdown, bearing isolators with suitable IP ratings (e.g. IP66 or better) should be selected.

4.9.3.3 It should be noted that elastomeric lip seals provide limited protection in process plant environments. The effective lifespan of lip seals in a typical process pump application may be as low as 2,000 hrs[1].

Table 4-2: Bearing Protection Guidelines

Lubrication Type	Environment/Application	Recommended Bearing Seal Type
Grease	Abrasive Dust	Grease-Purged Taconite Seal
	Slurry Pumps	Grease-Purged Labyrinth + V-Ring (i.e. Warman -10 Bearing Seal)
	Process Plant	Labyrinth Type Bearing Isolator
	Protected Environments	Elastomeric Lip Seal (Subject to Approval)
Oil	Critical Equipment	Dual Face Magnetic Bearing Protector (AESSEAL® MagTecta™ or equivalent)
	General Process Plant	Single Face Magnetic Bearing Protector
		Dynamic Labyrinth Bearing Isolator (LabTecta™, Inpro/Seal or equivalent)
	Protected Environments	Elastomeric Lip Seal (Subject to Approval)

4.10 Lifting Equipment

4.10.1.1 All design capacity shall be clearly identified on the lifting equipment.

[1] Bloch, Heinz P. Budris, Allan R. (2014). *Pump User's Handbook - Life Extension (4th Edition) - 6.6 Bearing Housing Seals in the Lubrication Environment.* Fairmont Press, Inc

4.10.1.2 All equipment used for lifting systems shall be designed and manufactured in accordance with the applicable standards and shall be design registered with the authorities having jurisdiction prior to use.

4.10.1.3 Monorail hoists and cranes of more than two tonne capacity shall have motorised lift and travel motions. Jib cranes over five tonne capacity shall have powered rotation, lift and trolley, if the crane duty warrants this level of assistance.

4.10.2 Hoists and Overhead Travelling Cranes

4.10.2.1 Hoists shall conform to the applicable standards referenced by the Hoist Manufacturers Institute.

4.10.2.2 Overhead cranes and other lifting facilities shall comply with the design and manufacturing requirements as stipulated in FEM codes. Electric overhead traveling cranes shall conform to ANSI B30.2 and CMAA spec 70 or similar standard as applicable.

4.10.2.3 Bridge cranes shall be manufactured in accordance with CMAA spec 70.

4.10.2.4 Equipment shall be subject to static and dynamic load testing prior to certification by an approved Third-Party in accordance with OSHA regulations and the relevant acts.

4.10.2.5 Access platforms or catwalks for the purpose of crane or hoist maintenance shall be provided with cable safety lines for access to components.

4.10.2.6 Overhead cranes or other lifting devices shall be provided at all locations where access with a mobile crane is not possible and lifting of equipment or system components for maintenance purposes is required.

4.11 Pressure Vessels

4.11.1 Pressure vessels shall be designed, fabricated, inspected and tested in accordance with EN 13445. Refer to the specific equipment datasheet for certification requirements.

4.11.2 Except for pressure vessels that are exempt from registration under the classification, capacity, pressure limits, and intended use specified in Clause 6.2.2 of the “Regulation for the Installation and Safe Operation of Pressure Vessels”, all other pressure vessels shall be registered and certified in accordance with the Mongolian Regulation for the Installation and Safe Operation of Pressure Vessels.

4.11.3 Nozzles DN 600 and below shall comply with ASME B16.5.

4.11.4 All process pressure vessels shall be designed to withstand the loads exerted by internal and external pressure, vessel mass, wind, snow, earthquake, reaction of supports, impact, shock, temperature, maximum allowable nozzle loads, and any other loads that may be present. If vacuum condition is specified in the datasheet, the vessel shall be designed to specified vacuum pressure. The design of vessels, supports, structure, and foundations shall meet, but not be limited to, the following load combinations:

- Normal operating load cases, including provision for the dynamic loads associated with flashing, high velocity blast tube/choke feed and impingement block/slurry pool impact in flash vessels and disrupted slurry feed and continued vapor feed in heater vessels

- Empty vessel with superimposed transport and offloading loads which may include loads associated with rotating the vessel axis from horizontal to vertical
- Corroded, empty erected vessel load combined with the greater of the design wind, snow or earthquake loads
- Operations under design pressure with operating dead load, the vessel full of slurry at design density with no air space, attached equipment and piping loads and combined with or without the greater of the design wind, snow or earthquake loads. The most conservative combination of these loads shall be taken
- When vessel field hydrostatic test is specified in the datasheet, the hydrostatic test pressure, weight of the vessel and test water contents, attached equipment loads and 75% of the design wind loads
- Design wind, snow and earthquake loads shall not be assumed to occur simultaneously.

4.11.5 Design of pressure vessels shall consider all loads from appurtenances such as platforms, ladders, etc., and nozzle loading. Assessment shall be to WRC 107 and WRC 297.

4.11.6 A vessel with a horizontal axis designed to support full weight load of water shall be tested while resting on its support saddles, without additional supports or cribbing.

4.11.7 Insulation supports and any fireproofing attachments welded to the vessels shall be supplied and fitted to the vessels in the workshop.

4.11.8 Where certification is required, the Contractor shall be required to arrange third party verification of pressure vessel design for compliance with EN 13445, or equivalent international code subject to approval, as part of its submission for approval to authorities using an accredited and certified Professional Engineer.

4.11.9 Vessel Details

4.11.9.1 Threaded pipe connections shall not be utilised on pressure vessels. All connections shall be flanged.

4.11.9.2 Vessels shall be provided with a minimum of one access way or two inspection openings in each pressure compartment. Exceptions are:

- Vessels of less than 900 mm diameter containing internals, a minimum of one end flange and one 150 mm diameter handhole or inspection openings shall be provided
- Vessels of less than 900 mm diameter without internals, a minimum of two 150 mm diameter handhole or inspection openings shall be provided.

4.11.9.3 Each manway shall incorporate a davit arm support unless an overhead crane or monorail is provided. Manway minimum size shall be DN 500 for a vessel less than 1,200 mm diameter, and DN 700 for a vessel 1,200 mm diameter and over.

4.11.9.4 Vessel internal baffles, partitions and supports shall be fabricated in removable sections to enable removal through the largest manhole without cutting or welding.

4.11.9.5 Vessel dip pipes and blank flanges shall be provided with jacking studs and lifting lugs to enable removal and installation.

4.11.9.6 Insulated vessels shall be provided with sealed insulation block outs at nominated locations to enable thickness test inspections in service.

4.11.9.7 Where practical, nozzles in vessels shall be in the vapour space and the number minimised.

4.11.10 Vessel Internals

4.11.10.1 Vessel internals which require regular maintenance shall be accessible via the inspection port or other.

4.12 Pumps

4.12.1 General

4.12.1.1 Centrifugal process solution pumps shall comply with either ASME B73.1, API 610 or ISO 5199. Contractor's standards shall apply for centrifugal slurry pumps. Centrifugal water pumps shall comply with ISO 2858. Pumps servicing flammable fluid shall comply with applicable API standards. Positive Displacement pumps shall be to API 675, API 674 or to manufacturers standards for piston diaphragm types, as appropriate.

4.12.1.2 Each pump set shall be complete with driver, coupling, coupling guard, shaft seals, auxiliary piping, and mounted on a common base plate. Pump sizes shall be rationalised where practical.

4.12.1.3 Pumps shall be suitable for outdoor installation.

4.12.1.4 Chemical process pumps shall feature back pull-out design and spacer couplings.

4.12.1.5 Bearing isolation shall be labyrinth type positive static seal or magnetic type bearing isolation seal.

4.12.1.6 Metering pumps shall be of the positive displacement type.

4.12.1.7 In general, pump drives shall have the following characteristics:

- Belt drives: service factor of 1.25 nominal motor power plus one belt
- Gear boxes: ISO service factor of 2 at nominal nameplate motor power.

4.12.2 Pump Shaft Seal Selection

4.12.2.1 Generally unflushed mechanical seals are preferred unless otherwise recommended by the Contractor.

4.12.2.2 Sealing requirements for pumps handling hazardous fluids shall be determined on a case-by-case basis.

4.12.3 Pump Layout

4.12.3.1 The preferred drive arrangement for slurry pumps is V belt drive with an in-line reverse overhead motor mounting arrangement (ZV type).

4.12.3.2 When applicable, slurry pumps shall use centrifugal vertically split pumps. For high heads or large particle sizes to 25 mm, centrifugal all-metal vertically split slurry pumps shall be

utilised. For high pressure, high percentage of solids, piston diaphragm type pumps shall be used.

4.12.3.3 Sump pump impellers shall be of dual entry type.

4.12.3.4 The sump pump operating speed vs. shaft length (sump depth) shall be selected such the pumps speed is outside the shaft resonance speed (see the shaft speed allowable range for the given pump size).

4.12.3.5 The minimum gap between bottom of the sump pump suction and sump floor shall be between 50 mm and 150 mm.

4.12.3.6 Vertical process pumps may be considered for use in pump boxes or applications where these types of pump configuration, are considered to be more effective for a particular service. The impact on operation and maintenance of the systems needs to be evaluated on a case-by-case method with approval from the Company's Engineer.

4.12.4 Impeller Diameters

4.12.4.1 To facilitate future increases in fixed speed direct drive liquor pump performance, the maximum impeller diameter initially selected shall be less than or equal to 90% of the maximum possible impeller diameter based on maximum design flow rate.

4.12.5 Pump Speeds

4.12.5.1 Generally variable speed drive control of pumps is preferred for flow control. Slurry pumps shall be belt driven if not using a variable speed drive. Pumps using variable speed drives shall have a maximum motor turn down from 1.2 to 0.4 of synchronous speed and synchronous speed should correspond to the maximum flow scenario.

4.12.5.2 Where slurry pumps are utilised, and reduced impeller diameters cannot be selected to facilitate future increases in pump duty, pumps shall be selected to operate at less than or equal to 90% of the maximum permitted speed for the pump, so that a future increase in duty can be accommodated by changing drive pulleys to increase pump speed.

4.12.5.3 Impeller tip speeds shall not exceed the safe speed for the specified material/linings. Pump impeller tip speed shall not exceed the value specified in ANSI/HI 12.1-12.6 for pump service class, or as recommended by the pump Contractor.

4.12.5.4 Four pole electric motors are preferred, except for low-speed pumps that are direct coupled or where V belt ratio limitations require lower speed motors of more poles.

4.12.5.5 Two pole motors shall generally be avoided, except for high head water pump duties.

4.12.6 Pump Drive Power

4.12.6.1 Where friction losses exceed nominally 75% of pump TDH, fixed speed pump motors shall be non-overloading. Motors driven by variable speed drives shall overloading with following overload capacities:

- Centrifugal pumps with coarse fluids, 60s at 150% of rated VSD current output
- Centrifugal pumps with clean fluids, 60s at 120% of rated VSD current output
- Positive displacement pumps, 60 s at 150% of rated VSD current output.

4.12.6.2 For VSD driven pumps the motor shall be sized to allow for any performance derating due to VSD, or reduction of available power due to operation away from synchronous speed, plus margins as given below.

4.12.6.3 Pump motor size selection shall be individually assessed and nominally based on:

- For calculated maximum hydraulic power size <75 kW:
  - 1.2 Times the calculated maximum hydraulic power size then next standard motor size up; or
  - Two standard motor sizes above calculated maximum hydraulic power, wherever is greater.

4.12.6.4 For example, 46 kW calculated hydraulic power x1.2 = 55.2 kW, next standard motor size is 75 kW. Two standard motor sizes above calculated maximum hydraulic power is also 75 kW which is larger size, hence 75 kW motor is selected:

- For calculated maximum hydraulic power >75 kW
  - 1.1 Times the calculated maximum hydraulic power size then next standard motor size up; or
  - One standard motor size above calculated maximum hydraulic power, wherever is greater.

4.12.6.5 For example, 145 kW calculated hydraulic power x1.1 = 159 kW, next standard motor size is 185 kW. One standard motor size above calculated maximum hydraulic power is 150 kW; hence 185 kW motor is selected.

4.12.6.6 Where particularly viscous slurries are being pumped, drive sizing requires individual assessment and shall consider expected variations in slurry rheology.

4.12.6.7 Where abrasive slurries are being pumped, consideration shall be given to potential reduction in pump efficiency due to component wear when sizing electric motor power.

4.13 Fans

4.13.1 The type of fan and materials of construction shall be selected based on the service and application.

4.13.2 Fans shall be capable of providing the required flow rates and pressures over the full range of operating conditions. Operating points of the fans shall be below 80% of the maximum static pressure of the performance curve.

4.13.3 Fan drives shall be selected to adequately cover all load conditions including cold start. Fans with the lowest practical operating speed (preferably less than 1,500 rpm) shall be selected. Fans shall not be fitted with 2-pole motors, unless approved. Drive type to be direct or belt drive.

4.13.4 Fans and drives shall be delivered as a complete assembly with motor either pedestal mounted or on a common base frame.

4.13.5 Fan bearings shall be pedestal mounted and not be mounted directly to the casings. The use of flingers between the bearing and the casing seal shall be considered if liquid leakage from the seal is expected.

4.13.6 Belt guards shall allow clearances for speed adjustment by pulley change and allow for adequate cooling. Individual shaft guards shall be fitted and allow safe access to bearings for lubrication and monitoring.

4.13.7 Impellor type shall be backward inclined laminar or radial blade and be of solid construction. Aerofoil blades shall not be used.

4.13.8 Fans shall be located within systems to handle “clean air”. Where this is not practical the fan construction shall be robust and shall be capable of handling occasional out of balance conditions due to fouling. Use of sprays and radial blades shall be considered to assist in cleaning of the impeller.

4.13.9 Impellor assembly and impellor shall be dynamically balanced to ISO 21940, Balance Quality Grade G6,3.

4.13.10 Fan casing shall include an inspection door for cleaning, maintenance and inspection, and a drain complete with plug at low point. Fan casing shall incorporate an effective shaft seal.

4.13.11 Split casings are preferred to allow for impellor removal without removal of connection ductwork.

4.13.12 Silencers shall be supplied if required to meet the noise limits in Section 3.9.2.

4.13.13 Fans shall be selected to right of performance curve to avoid possible operation in unstable area (surge region).

4.13.14 Fans in clean gas operation may be supplied with inlet guide vanes for flow control and start-up. Inlet guide vanes in dusty gas systems shall be avoided where possible and subject to Approval.

4.13.15 The requirements of this section are not intended to apply to specialist, high-speed applications such as Mechanical Vapour Recompression (MVR) Turbofans and Compressors.

4.14 Tanks

4.14.1 Steel tanks shall be designed and fabricated to meet the requirements of API 650 “Welded Steel Tanks for Oil Storage”.

4.14.2 The minimum bottom plate thickness for tanks shall be 6 mm unless specified otherwise.

4.14.3 Engineers shall carry out calculations to confirm the required minimum thickness for the specific application.

4.14.4 Tanks containing hazardous fluids (i.e. acids, fuels, mixed acid or fuel slurries caustics etc.) shall have a minimum separation distance derived by projecting a line from the mid-level of the liquid level of the tank to the top inside face of the wall at an angle of 26.5° from horizontal.

4.14.5 Where possible, tank drains, and tank overflows shall be piped to the bottom edge of the tank and directed toward the sump.

4.14.6 Platforms for fibre reinforced polymer tanks shall be supported from grade or adjacent building steel.

4.14.7 Open tanks shall be provided with access to view the level of solution in the tank.

4.14.8 Tanks shall be able to be completely drained to assess condition of floor for preventative maintenance during scheduled inspections and routine clean out.

4.14.9 Tank hold down bolting shall not interfere with nozzle bolt up.

4.15 Fire Protection

4.15.1 Various fire detection and protection systems will be employed that is outlined in the Fire Protection Design Basis (H376512-8000-248-210-0002) in accordance with NFPA-13.

4.15.2 The types of fire protection and detection systems are as follows:

- Automatic detection system
- Manual detection system
- Fire extinguishers
- Fire hydrants inside and outside buildings
- Standpipe system
- Sprinkler system
- Automatic gas suppression system.

4.16 Air Compressors

4.16.1 The Equipment must be supplied as complete units and include all auxiliary Equipment necessary for complete operation.

4.16.2 The Equipment must incorporate standard, heavy-duty and proven designs and the Supplier must not deviate from this philosophy where practicable. The Supplier must highlight any specific sections within this document that require the Supplier to use non-standard or unproven designs. The Supplier must select Equipment components for which it carries a service strategy and reasonable supply of spare parts.

4.16.3 The Supplier is to ensure sufficient cooling air to facilitate the removal of waste heat that must be discharged from the top of the Air Compressors. The Compressors must be self-regulating to maintain optimal usable temperature. The after cooler must remove the majority of any moisture carry-over from the compressor systems. The Supplier is to advise with the requirement of aftercoolers depending on required air consumptions specified on the data sheet.

4.16.4 Regenerative air dryers must be designed to automatically switch between regeneration and drying cycle, with provision for manual over-ride.

4.16.5 Air receivers must be supplied as complete units with all the require controls including instrumentation e.g. pressure relief valves, pressure indicators, automated condensate drain traps.

4.16.6 Air Filters must be designed to ensure removal of oil aerosol, oil vapor and solid particles that may result in the contamination of the Compressed Air System.

4.16.7 Piping and valves within terminal limits must be in accordance with the Supplier's standard design.

4.17 Cyclones

4.17.1 The cyclone, launders and any supporting structure and drilled support feet or lugs shall be designed for a maximum load of the cyclones full of slurry at a design wet bulk density.

4.17.2 The cyclone vessel shall also be designed for the maximum operating pressure and internal dynamic forces to which it can be subjected to in its application.

4.17.3 The cyclones and any supporting structure shall also be fitted with lifting lugs with adequate safety factors to lift the cyclone assembly in empty fully assembled condition.

4.17.4 Where the individual cyclone can be removed separately to any support structure, then the cyclone shall have suitable individual lifting provisions also to suit its mass.

4.17.5 Carbon steel cyclone shells shall not be less than 4.5 mm thick. All elastomer lined steel shall have a 6mm radius on all lined corners and edges. Cyclones in Treatment Processing Plant it shall be stainless steel due to the high corrosive environment.

4.17.6 Cyclone clusters shall be supplied complete with individually mounted cyclones (including cyclone body, frustum, vortex finder and spigot) and shall include feed distribution system, overflow and underflow collection launders. Pneumatically actuated knife-gate valves to control flow to each cyclone or cyclone cluster.

4.17.7 All cyclones shall be capable of automatically handling feed flows stopping and restarting under full load conditions, during normal operation.

4.18 Agitators

4.18.1 All Agitators shall be designed. fabricated. assembled and tested according to an internationally accepted standard.

4.18.2 Agitators shall be capable of starting under full load. Vendor to assume maximum load is 70% concentration by mass in a tank silted condition.

4.18.3 The drives shall be by means of a directly coupled motor via a gear reducer.

4.18.4 Motors shall be sized to be non-overloading.

4.18.5 Couplings shall be readily accessible and easy to disconnect.

4.18.6 Blade type configuration and lining shall be selected to suit the specified duty, and to minimise hydraulic imbalance.

4.18.7 As far as possible impeller assemblies shall be designed to operate without the need for steady bearings at tank bases.

4.18.8 Impellers shall be designed with keyed hubs for fitting to shafts and shall be fitted with bolted blades for easy removal and replacement.

4.18.9 Impellers shall be dynamically balanced, and the blades match marked to ensure correct balance upon assembly.

4.18.10 Where blades and shafts are lined, the liner shall be applied evenly and smoothly so as not to impact on the hydraulic balance and shall be of adequate thickness to provide an extended life.

4.18.11 The equipment shall be designed for operation with the impeller running in the specified liquid, in water, in air, and during filling and emptying of the tank.

4.18.12 Operational speed of the equipment shall not be within 30% of the first lateral or torsional natural frequency of the shaft / impeller.

4.18.13 Torsional natural frequencies shall not be within 20% of any existing frequencies (i.e., rotational speed, gear tooth meshing frequency, blade passing frequency, vortex shedding frequency).

4.18.14 Operational speed of the equipment shall not exceed 80% of the first critical speed. Operation in the range of 25% to 50% of first critical speed shall be avoided.