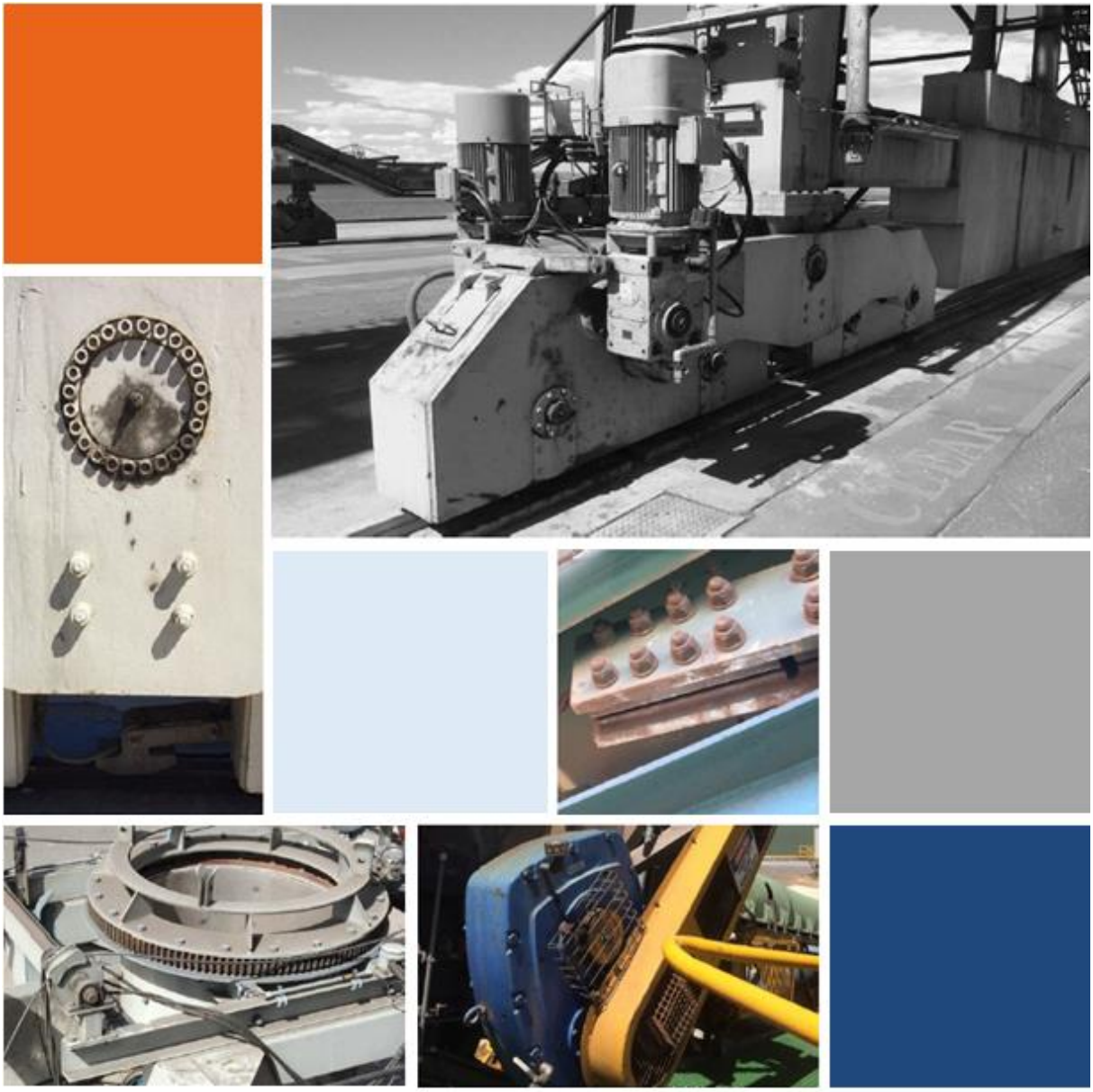
MID WEST PORTS

TECHNICAL GUIDELINE

MWPA300 – MECHANICAL ENGINEERING GUIDELINES – GENERAL



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1. PREFACE

This guideline applies to mechanical equipment to be used within the Geraldton Port facilities operated and administered by Mid West Ports Authority (MWPA).

It specifies the general requirements for the selection, design, manufacture, supply, modification, inspection and testing of mechanical works and shall be read in conjunction with all related MWPA Guidelines and specifications.

Deviation from this specification shall be approved in advance by the responsible MWPA Engineer.

2. GENERAL REQUIREMENTS

2.1. GENERAL INFORMATION

General information related to the Geraldton Port facility may be found on the MWPA website, general technical information regarding Geraldton Port may be found in the **MWPA100 – General Guidelines** document.

2.2. CONTRACT DOCUMENTS

Unless otherwise specified, all mechanical work shall be in accordance with the General Conditions of Contract, the Contract Specifications, Contract Drawings, this Specification and the documents listed in **Section 4** below.

This document is not intended to replace bespoke project basis of design, design criteria or specifications but is intended to provide developers, designers and contractors with a benchmark for which their equipment and designs must meet on a technical basis.

2.3. PREFERRED EQUIPMENT

The MWPA places very high importance on equipment selection and commonality. Judicious selection of equipment can result in reducing the stock of emergency spares carried on site and assists in efficiency of maintenance due to a good understanding by the maintenance staff of the installed equipment.

When selecting mechanical equipment for new projects, preference shall be given to items that are interchangeable or common with equipment currently in use at MWPA and performing satisfactorily.

Table 1: MWPA Preferred Equipment

Equipment	Preferred Manufacturer
Gearboxes	Rossi Bevel Helical
Brake Motors	SEW
Electric Motors	Toshiba High Efficiency Motors
Steel wire ropes	Nobles
Winches and sheaves	Nobles
Bearings and Housings	NSK, FAG
Locking elements	Ringfeder
Hydraulic motors	Rexroth/Hagglunds
Gearbox Oil	Synthetic unless specifically noted
Lifting Eyes & Lashing	RUD

3. APPLICABLE DOCUMENTS

3.1. DOCUMENT PRECEDENCE

As a general guide, where particular aspects are not covered in the MWPA Technical Guidelines or where conflict between documents exists, the following precedence for standards applies:

1. Statutory Regulations;
2. Design Codes and Standards;
3. Project Specific Specification;
4. MWPA Technical Guidelines; and
5. Other References (e.g. Recognised Industry Best Practice, novel technology).

Notwithstanding the general order of precedence, if there is a conflict between documents the clause presenting the more conservative and pragmatic guidance shall govern. If in doubt, or in cases where non-compliance is anticipated, clarification shall be sought from MWPA.

3.2. GOVERNMENT ACTS AND REGULATIONS

All work shall be carried out to comply with the requirements of the Statutory Authorities having jurisdiction over the site. These requirements shall include, but not be limited to, the following, as applicable:

- Western Australian Occupational Safety and Health Act (1984) and Regulations (1996)
- Safe Work Australia Act (2008)
- Western Australia Health Act (1911)
- Western Australian Mines Safety and Inspection Act (1994) and Regulations (1995)
- Radiation Protection and Control Act (1982)
- Electricity Act (1945)
- Electricity Regulations (1947)
- Environmental Protection Act (1986) and Regulations (1987)
- Poisons Act (1964)
- Clean Air Act (1964)
- Pollution of Waters by Oil and Noxious Substances Act (1987)
- WA Mining Act and Regulations (1995) - Amended 2009
- Dangerous Goods Safety Act (2004) and Regulations (2007)
- Site specific Statutory Requirements and Environmental Guidelines
- All associated standards referenced within the above.

In each case, the latest edition or issue and amendments thereto of the relevant Standard, Act, Regulation, Code or Guideline at the start of the project shall apply.

3.3. MWPA STANDARD SPECIFICATIONS AND GUIDELINES

This guideline should be read in conjunction with all other parts of the MWPA Technical Guideline series, where relevant, as listed below:

- MWPA 000 Series – Port Development Guidelines;
- MWPA 100 Series – General Guidelines;
- MWPA 200 Series – Drafting and Surveying Guidelines;
- MWPA 300 Series – Mechanical Guidelines;
- MWPA 400 Series – Guidelines for Maritime Structures;
- MWPA 500 Series – Civil Engineering Guidelines;
- MWPA 600 Series – Buildings and Structures Guidelines;
- MWPA 700 Series – Electrical and Instrumentation Guidelines;
- MWPA 800 Series – Guidelines for Rail; and
- MWPA 900 Series – Additional Guidelines.

Where the referenced MWPA guidelines do not yet exist, the relevant Australian Standards and industry best practice shall apply.

3.4. AUSTRALIAN STANDARDS

Table 2: Applicable Australian Standards

No.	Title
AS/ISO 1000	The international system of units (SI) and its application
AS 1100	Technical Drawing
AS 1101.3	Graphical symbols for general engineering – Welding and non-destructive examination
AS 1110	ISO metric hexagon bolts and screws – Product grades A and B
AS 1111	ISO metric hexagon bolts and screws – Product grade C
AS 1112	ISO metric hexagon nuts
AS 1138	Thimbles for wire rope
AS 1163	Cold-formed structural steel hollow sections
AS 1170.0	Structural design actions – General principles
AS 1170.1	Structural design actions - Permanent, imposed and other actions
AS 1170.2	Structural design actions - Wind actions
AS 1170.4	Structural design actions - Earthquake actions in Australia
AS 1171	Non-destructive testing – Magnetic particle testing of ferromagnetic products, components and structures
AS 1210	Pressure vessels
AS 1214	Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)
AS 1237	Plain washers for metric bolts, screws and nuts for general purposes
AS/NZS 1252	High strength steel bolts with associated nuts and washers for structural engineering

No.	Title
AS/NZS 1269	Occupational noise management
AS 1275	Metric screw threads for fasteners
AS 1318	Use of colour for the marking of physical hazards and the identification of certain equipment in industry (known as the SAA Industrial Safety Colour Code)
AS 1319	Safety signs for the occupational environment
AS 1403	Design of rotating steel shafts
AS 1418	Cranes, hoists and winches
AS 1442	Carbon steels and carbon-manganese steels – Hot rolled bars and semi-finished products
AS 1443	Carbon and carbon-manganese steel – Cold finished bars
AS 1444	Wrought alloy steels – Standard, hardenability (H) series and hardened and tempered to designated mechanical properties
AS/NZS 1554	Structural steel welding Set
AS 1627	Metal finishing – Preparation and pre-treatment of surfaces
AS 1654.1	ISO system of limits and fits – Bases of tolerances, deviations and fits
AS 1654.2	ISO System of limits and fits – Tables of standard tolerances grades and limit deviations for holes and shafts
AS 1657	Fixed platforms, walkways, stairways and ladders - Design, construction and installation
AS/NZS 1664.1	Aluminium structures – Limit state design
AS/NZS 1664.2	Aluminium Structures – Allowable stress design
AS/NZS 1665	Welding of aluminium structures
AS 1666.1	Wire-rope slings - Product specification
AS 1666.2	Wire-rope slings – Care and use
AS/NZS 4024	Safety of machinery - Conveyors
AS 1796	Certification of welders and welding supervisors
AS 1866	Aluminium and aluminium alloys – Extruded rod, bar, solid and hollow shapes
AS 2177	Non-destructive testing – Radiography of welded butt joints in metal
AS 2207	Non-destructive testing – Ultrasonic testing of fusion welded joints in carbon and low alloy steel
AS 2317	Collared eyebolts
AS 2321	Short-link chain for lifting purposes
AS 2382	Surface roughness comparison specimens
AS 2625.1	Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts - General guidelines
AS 2671	Hydraulic fluid power - General requirements for systems (ISO 4413:1998, MOD)

No.	Title
AS 2700	Colour standards for general purposes
AS 2729	Rolling bearings - Dynamic load ratings and rating life
AS 2740	Wedge-type sockets
AS 2741	Shackles
AS 2759	Steel wire rope – Use, operation and maintenance
AS 2784	Endless wedge belt and V-belt drives
AS 2788	Pneumatic fluid power – General requirements for systems
AS 3569	Steel wire ropes - Product specification
AS/NZS 3678	Structural steel – Hot rolled plates, floor plates and slabs
AS/NZS 3679	Structural steel – Hot rolled bars and sections
AS 3709	Vibration and shock – Balance quality of rotating rigid bodies
AS 3782.1	Acoustics – Statistical methods for determining and verifying stated noise emission values of machinery and equipment
AS/NZS 3931	Risk Analysis of Technological Systems – Application Guide
AS 3990	Mechanical equipment - Steelwork
AS 4002.1	Hydraulic fluid power - Particulate contamination of systems - Method of coding the level of contamination
AS 4024.1	Safety of machinery
AS 4037	Pressure equipment - Examination and testing
AS 4100	Steel structure
AS 4343	Pressure equipment – Hazard levels
AS 4458	Pressure equipment - Manufacture
AS 4497.1	Roundslings -Synthetic fibre - Product specification
AS 4497.2	Roundslings -Synthetic fibre - Care and use
AS 4738.1	Metal castings - Ferrous sand moulded
AS 4775	Emergency eyewash and shower equipment
AS 4991	Lifting devices

3.5. INTERNATIONAL STANDARDS

Table 3: Applicable International Standards

International Standard	Standard Title
ISO 1999	Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment
ISO 7061	Shipbuilding - Aluminium shore gangways for seagoing vessels
ISO 10823	Guidelines for the selection of roller chain drives
ISO 9001	Quality Management Systems – Requirements
BS 4235	Specification for Metric Keys and Keyways

4. HEALTH, SAFETY AND ENVIRONMENTAL REQUIREMENTS

For general HSEQ requirements refer to **MWPA100 – General Guidelines**, the MWPA Contractor Handbook and service drawings, as well as the documents available on the Mid West Port's website.

4.1. PROHIBITED AND HAZARDOUS SUBSTANCES

The following materials and related compounds are prohibited and shall not be used:

- Asbestos
- Polychlorinated biphenyls (PCBs)
- Ceramic fibres
- Chloro-fluoro-hydrocarbons (CFCs)
- Paint containing lead
- Radioactive materials

Material Safety Data Sheets (MSDS) will need to be provided by suppliers for all materials that are hazardous.

4.2. NOISE

Mechanical equipment noise levels shall comply, where practical, with the National Standard for Occupational Noise [NOHSC: 1007(2000)]. In accordance with the National Standard for Occupational Noise [NOHSC: 1007(2000)], noise levels of mechanical equipment under normal operation shall not exceed an eight-hour equivalent A-weighted sound pressure level $L_{Aeq,8h}$ of 85 dB(A) at one metre in all directions.

However, as the plant shall be operating over a twelve hour shift this level is reduced in accordance with ISO 1999:1990 Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment.

The noise levels of mechanical equipment shall therefore not exceed a 12-hour equivalent A-weighted sound pressure level $L_{Aeq,12h}$ of 83 dB(A) at one metre in all directions.

For peak noise, the limit shall not exceed a C-weighted peak sound pressure level, $L_{C,peak}$ of 140 dB(C).

Clients will be advised of specific mechanical equipment where the supplier cannot guarantee conformance to the above noise limits. Technical purchase recommendations will document such cases.

AS 3782 shall be utilised and referred to when determining noise emission values for equipment.

4.3. SAFETY

All mechanical equipment shall be in accordance with the current safety requirements of the Mines Safety and Inspection Act and Regulations and all other applicable Statutory Authorities, the Australian Standards, the MWPA Safety Standards and this Specification.

4.4. ENVIRONMENTAL

All mechanical equipment shall be in accordance with the environmental requirements set out by MWPA or the applicable Statutory Authority.

4.5. ENERGY EFFICIENCY

All mechanical equipment to be installed shall be designed and specified to minimise the overall energy consumption (diesel and electrical) for the equipment.

5. PROJECT DELIVERY REQUIREMENTS FOR MECHANICAL EQUIPMENT

All new or modified existing mechanical equipment to be installed shall follow a project delivery process which ensures that all aspects and implications of the proposed equipment have been considered prior to implementation.

5.1. PLANT LAYOUT AND ACCESS CONSIDERATIONS

All new equipment shall be designed with plant maintenance requirements considered and incorporated in the design.

The layout of plant shall consider the clearance requirements for at least the following:

- Installation
- Operability
- Firefighting
- Maintainability
- Access and head clearance
- Piping and electrical cable routes
- Crane and vehicle access
- Emergency evacuation routes
- Lay-down areas and housekeeping facilities
- Plant and area specific needs

5.2. PROJECT DELIVERY PROCESS FOR MECHANICAL EQUIPMENT

New mechanical equipment or alterations to existing mechanical equipment being considered for installation within the Geraldton Port facility is required to undergo a structured assessment and delivery process, as below:

1. Problem/Opportunity identification.
2. Option/Concept Study: Initial investigation of problem, identification of Options and Concept development for Options (including budget estimates).
3. Presentation of Option study to stakeholders and selection of preferred Option.
4. Decision by MWPA ports to proceed/revise proposal and funding application.
5. Detailed engineering development for preferred Option.
6. Design reviews for engineering development, including Safety in Design (SiD) reviews, HAZOP, HAZID.
7. Operational readiness planning: Planning and implementing any operational changes or training requirements needed when new equipment is installed (manuals, changes to SCADA system, inspection requirements, spare parts and maintenance documentation for new equipment).
8. Implementation/installation of new equipment.
9. Commissioning and testing of new equipment, monitoring run-in period.
10. Hand-over of equipment to Operations.
11. As-builts for any drawings or modifications made to equipment during implementation.
12. Close-out project.

Depending on the nature of equipment under consideration, the above process may be modified to suit the individual project requirements, with the underlying requirement that a structured and documented delivery process shall be followed.

5.3. SAFETY IN DESIGN

Safety in Design is based on the understanding that the most significant opportunity to deliver a safe working environment exists during the design phase of a project. At this point designers and engineers have the greatest chance to make changes to a proposed design to arrive at a safe solution.

Safe design is a process defined as:

> *"The integration of hazard identification and risk assessment methods early in the design process to eliminate or minimise the risks of injury throughout the life of the product being designed. It encompasses all design including facilities, hardware, systems, equipment, products, tooling, materials, energy controls, layout, and configuration".*

Reference: *Australian Safety and Compensation Council Guidance of the principles of safe design for work, 2006.*

Any new or modified mechanical equipment to be installed in the Geraldton Port facility shall include a formalised and documented SiD process. Generally, this shall take the form of formalised and documented design reviews at project specific milestones as well as the generation and updating of a live risk register document.

To obtain maximum benefit from the SiD process it is important that the full spectrum of stakeholders is represented at these design reviews, including Port Engineers, Designers, Operators, Maintenance personnel and any other parties who may have valuable experience to contribute. The process should consider all possible phases of the new equipment delivery, including:

- Construction
- Normal operations
- Emergencies
- Maintenance
- Future works on or around the asset
- Decommissioning

5.4. DESIGN INTENT AND BASIS OF DESIGN

The design intent for the assessment and supply of mechanical equipment is to ensure that fit for purpose equipment that provides for safe and reliable operation over the duration of the required design life is designed, manufactured and supplied.

5.5. DESIGN OF STEEL STRUCTURES FOR MECHANICAL EQUIPMENT

The design of general purpose mechanical steelwork shall be in accordance with AS 3990: Mechanical equipment – Steelwork. Specialised equipment governed by specific standards (e.g. cranes to AS 1418) shall be designed in accordance with these standards.

Fatigue loading and life shall be assessed according to the methods specified in AS 3990 Appendix C.

The design of mechanical steel structures shall thoroughly consider the environment into which the equipment is being placed. Steel structures shall be designed to avoid any upturned members or pockets where water or bulk solids spillage may be trapped.

Full length welding is preferred over stitch welding to avoid corrosion. Where full length welding is not possible, silicon sealing of any gaps is required.

5.6. DESIGN OF ALUMINIUM STRUCTURES FOR MECHANICAL EQUIPMENT

The design of general purpose mechanical aluminium structures shall be in accordance with:

- AS/NZS 1664.1 Aluminium Structures – Limit state design

or:

- AS/NZS 1664.2 Aluminium Structures – Allowable stress design

Design for fatigue shall be as per the applicable clauses in the respective design standard chosen above.

The design of aluminium structures shall include, but not be limited to:

- Assessment of the aluminium alloys and section types to be used;
- The welding and fabrication processes to be used;
- The marine environment within Geraldton port; and
- The nature of the load, including whether loading is cyclic, reversing or shock and the potential for overload conditions.

5.7. STATIC LOAD AND DYNAMIC LOADING

Loading and load cases shall be developed as per the dead load, live load, wind load and special loads methods in the standards listed in Sections 5.5 and 5.6.

The design of mechanical equipment shall include assessment of loading that may occur due to transient or abnormal conditions, such as:

- Load spikes due to relief valve overshoot etc.
- Load elasticity and dynamic effects
- Allowance for out of plane loads as per relevant design standards
- Poor load sharing between members (load diagonaling, etc.)
- Loads occurring during construction and erection
- Loads due to inertial effects of acceleration and deceleration
- Loads due to thermal expansion or contraction

Loading determined from electric motors shall include for a factor of 3 X Full Load Torque (FLT) for start-up conditions. This load factor may be reduced where variable speed drives or fluid couplings are used.

6. EQUIPMENT TECHNICAL REQUIREMENTS

6.1. GENERAL

The design, installation and operation of equipment and associated systems shall meet the requirements of all project documentation and the following minimum requirements:

- Safe operation
- Meet the duty cycle and design life as specified in the basis of design
- Provide for a cost effective, fit for purpose solution
- Meet the required reliability and availability requirements as specified in the Equipment Datasheets
- In accordance with process and plant operational data and conditions as specified in the Equipment Datasheets and specifications
- Be designed for operation under the defined site conditions as specified in the basis of design
- Suitable for operation in a marine, highly abrasive, dust laden atmosphere
- Suitable for high pressure wash down with water/detergents
- Conform to MWPA HSEQ requirements, policies and procedures
- The preferred unit of measure for equipment shall be Metric as per AS/ISO 1000

6.2. MODULARISATION

Where practical, systems of components of mechanical, structural and piping equipment shall be modularised to minimise the extent of site assembly. Modules shall be skid mounted and packed for transport as a complete module ready for site installation.

6.3. EQUIPMENT IDENTIFICATION, MARKING AND LABELLING

Equipment shall be supplied complete with markings and/or labels as a means of equipment identification.

All mechanical and ancillary equipment shall be individually marked/labelled irrespective of whether it is part of an overall package or plant.

6.4. EQUIPMENT NAMEPLATES

Equipment shall be permanently identified with stainless steel 316 nameplates with minimum dimensions 25mm x 75mm x 1.5mm thick. Nameplates shall be engraved or etched with minimum 6mm high letters and shall include, at a minimum, relevant manufacturing and performance details as follows:

- MWPA Asset No.
- Equipment Description (Heat exchanger, fan, etc.)
- Equipment technical details (Power, RPM, voltage)
- Manufacturer name and model number

Figure 1: Example of Equipment Nameplate (Sample Only)

6.5. MATERIALS

6.5.1. GENERAL

When requested, the contractor shall obtain from the steel manufacturer or supplier the certified mill test reports or test certificates as evidence that the material complies with the applicable Australian Standards.

All materials shall be new and in good condition.

Unless otherwise specified on the drawings, the contractor shall use only materials that comply with the requirements of this specification.

6.5.2. STEEL

Steel plate and sections shall:

- Be in accordance with the Australian Standards
- Have a minimum yield strength of 250MPa
- Hot rolled plate, flat, strip – AS 3678 with minimum 250 Grade unless shown otherwise on the drawings
- Structural open sections and bar shall be 300 Grade steel to AS 3679, unless shown otherwise on the drawings
- Rectangular and square hollow sections shall comply with AS 1163 and shall be Grade C350 steel, unless shown otherwise on the drawings
- Circular hollow sections shall comply with AS 1163 and shall be Grade C350 steel, unless shown otherwise on the drawings
- Crane rails shall comply with AS 1085
- Cold formed thin-gauge sections, including purlins and girts, shall be Grade 450 steel to AS 1397
- Floor plate shall be the raised angular pattern type from Grade 250 steel to AS 3678 or AS 1594, unless shown otherwise on the drawings
- Steel used for critical mechanical componentry (e.g. shafts, hoists, brakes) shall be supplied with additional test certificates as called for in the specific equipment quality documentation

Before and during fabrication all steel materials shall be covered from the weather or kept in a protected environment.

Unless otherwise noted, the following key sizes apply to general mechanical steel work:

- All plate work: 8mm thick plate
- All gussets, cleats, brackets, etc.: 10mm thick plate
- All flanges and stiffeners: 75mmx10mm thick flat
- Where no gasket is nominated, flange connections shall be assembled with full flange face coverage of adequate thickness of silicone sealant

6.5.3. WELDING ELECTRODES

Welding electrodes shall conform to AS 1553, AS 1858, AS 2203 and AS 2717 or other codes as applicable to the welding process being used. The nominal tensile strength of the weld metal shall be greater than or equal to the tensile strength of the steel parts being joined.

6.6. TOLERANCES

6.6.1. GENERAL

All mechanical equipment shall be manufactured to the tolerances indicated on the relevant MWPA drawing(s) or as specified in the contract documents.

Limits and fits shall be in accordance with AS 1654.

Precision mechanical equipment shall use geometric tolerancing methods to ISO 1101 on the design drawings.

6.6.2. STEELWORK

Unless otherwise noted, steelwork tolerances shall be in accordance with the AS 3990 or AS 4100.

6.6.3. PLATEWORK

The maximum out of plane dimension measured from a 2.0 metre straight edge in any position on the platework surface shall not exceed 5mm.

6.6.4. NON-TOLERANCED STEELWORK AND PLATEWORK

Non-toleranced steelwork and platework tolerances shall be in accordance with the relevant sections in this specification.

Table 4: Manufacturing Tolerances for Non-toleranced Dimensions

Normal sizes (mm)		Machining	Cutting/Bending/Welding
Over	Up to		
	6	±0.1	N/A
6	18	±0.2	±1
18	50	±0.2	±2
50	250	±0.2	±2
250	1000	±0.3	±3
1000	2000	±0.5	±4
2000	4000	±0.5	±5
4000	8000	±0.6	±6

6.7. SURFACE FINISH

Machine surface finish designations shall be clearly indicated on all workshop drawings, in accordance with AS 1100 – Part 201.

The centre line average method shall be used in accordance with AS 2536. Surface roughness shall be expressed in micrometres (µm).

Machining to a specific R_a roughness value (Arithmetic Average of Absolute Values) shall be verified against a roughness comparator, in accordance with AS 2382.

Where the surface finish of machined surfaces is not specified, the surface finish shall be machined to Ra roughness of 3.2µm.

6.8. FASTENERS

Only new corrosion resistant and commercial grade fasteners complying with all applicable standards, including AS 1111, AS 1112, AS 1237 and AS 1275, shall be used.

The minimum diameter bolt or screw thread shall be 12mm. All bolts and stud bolts shall project a minimum of two threads and a maximum of six threads.

Masonry anchor bolts shall be Hilti Chemical anchor or accepted equivalent, having a minimum thread diameter of 16mm unless specified otherwise.

High strength bolts with nuts and washers shall conform to AS 1252.

High strength bolts and nuts shall be tightened in accordance with AS 4100. Where a torque control method of tightening is used, the tightening device shall be kept calibrated in accordance with AS 4100.

Taper washers shall be provided on bolted sections whenever required by the shape of the sections being connected.

All bolt holes shall be drilled or punched. Gas burning of holes is not permitted.

For normal applications, a lock washer shall be provided under each nut. Where bolted connections are subject to heavy vibration, self-locking metal nuts shall be used. Bolts or screws assembled into blind holes shall have threads treated with an accepted thread locking compound, Loctite or equivalent, before assembly.

Non-structural fastening of mechanical equipment shall have the fasteners coated with an anti-seize compound at final assembly.

6.9. SHAFTING

Rotating steel shafts shall be designed in accordance with AS 1403.

Shafts for general light to medium duty use shall be manufactured from normalised steel to AS 1442 Grade K1045. The use of an equivalent or alternative steel shall be subject to the MWPA Engineer's approval.

The following material property values of K1045 steel shall be used:

Endurance limit (f_e) = 255 MPa

Yield Strength (f_y) = 300 MPa

Materials for specialised and heavy duty shafts may be selected and proposed by the supplier to suit the specific application needs, but require sign off by the MWPA Engineer prior to design approval.

6.10. BALANCING

All appropriate rotating equipment shall be dynamically balanced by the manufacturer.

Quality shall be in accordance with the minimum specified in either the relevant MWPA Standard or as specified in AS 3709 (ISO 1940).

Pump impellors and fans shall be dynamically balanced by the manufacturer. The minimum balance quality shall be G2.5.

6.11. KEYS AND LOCKING ELEMENTS

Keys and keyways shall be in accordance with BS 4235. The grade of key material shall be as specified in BS 4235.

Locking elements using tapers shall be selected using the manufacturer's selection methodology with shaft and hub tolerances and surface finishes matched to the locking element requirements. The shaft design shall include consideration of the maximum angular deflection allowable for the locking element under consideration.

6.12. BEARINGS, HOUSINGS AND SEALS

6.12.1. DESIGN REQUIREMENTS

Unless otherwise specified in the particular equipment specification, bearing seals and minimum bearing life shall as in the tables below.

Table 5: Bearing Lives for Equipment

Equipment	L10 Life (Hours)	Seals
General	>60,000	Lip + taconite
General Gearboxes	>60,000	Lip + taconite
Slurry pumps	>60,000	Labyrinth
Water Solution, Chemical pumps	>60,000	Lip

Table 6: Bearing Housing Requirements

Bearing Housing Type	Mounting Requirements
Bearing housing type SN 500 series	<40mm diameter shaft, two bolt mounting
Bearing housing type FSSN 500 series	40 to 140mm shafts, four bolt mounting
Bearing housing type SD 3100 series	>150mm shafts, four bolt mounting
Hydraulic demounting	>150mm shafts

Bearing seals shall be designed to protect bearings against loss of lubricant and entrance of corrosive matter.

Where labyrinth seals are referred to, overlapping fingers shall be fastened alternately to the shaft and bearing housing to form labyrinth shaped cavities. The direction of the labyrinth shall be either perpendicular or parallel to the shaft centreline. The cavities shall be purged with lubricant from the direction of the rolling elements.

Plummer blocks shall be mounted so that direct static tension loads on the holding down bolts and cap bolts are avoided. In addition to seals, a thrower shall be provided above upper bearings on vertical shafts or where wet and extremely dirty conditions prevail.

Thrust and guide bearings shall be provided on vertical shafts. Pairs of plummer blocks shall be fully self-aligned with one “fixed” and one “free” type for each shaft. Plummer blocks shall be supplied with covers when mounted at shaft ends.

6.12.2. INSTALLATION REQUIREMENTS

Each pair of bearings supporting a shaft shall have one fixed and one floating bearing. The fixed end shall be clearly marked on the bearing housing by punching the word "fixed" into the housing base.

All adjusting screws shall be galvanised and wherever exposed to wash-down water are to be wrapped in protective waterproof tape.

Bearing housings shall be set square to the shaft such that the radial gap measured between the labyrinth seals at any two diametrically opposite points does not vary by more than 0.1 to 0.15mm.

When bearings are fitted to the non-drive end of a shaft, a steel blanking plate shall be provided in the housing to seal off the open end.

For conveyor pulleys and similar uses, plummer blocks shall be mounted as shown on MWPA drawings.

Plummer block bearing cap bolts shall be tightened to the torque recommended by the manufacturer.

Spring washers shall be fitted under the mounting bolt nuts and plain washer under the bolt heads. Nuts shall be installed so that they are readily accessible. If, for clearance reasons, the nuts are located above the mounting foot then a plain washer and a locknut shall be used.

Grease points for bearing housings shall be mounted in a common manifold outside the guard for ease of access for re-greasing. The connection between the manifold and bearings shall use stainless steel tubing.

Bearing radial clearance shall be set in accordance with the manufacturers recommendations.

6.13. HEAT TREATMENT AND STRESS RELIEVING

Where heat treatment or stress relieving is specified, the procedure shall be fully described on the relevant drawings or in the applicable specifications.

A certificate from an approved NATA testing laboratory shall be provided for all components for which heat treating or stress relieving has been specified.

6.14. CASTINGS

Castings shall be produced in accordance with AS 4738.1 Metal Castings Part 1: Ferrous sand moulded.

Castings shall be free from blow holes, gas pockets and sand inclusions. They shall be dressed and be cleaned of gates and rises or other projections used in the production of the casting. As a minimum, castings shall be clearly identified by raised lettering indicating the following:

- Part number/drawing number
- Material

The engineering drawing for the casting shall denote the position and details of the casting identification markings.

6.15. PACKS AND SHIMS

Packers and shims material shall be Grade 316 stainless steel. All packing and shims shall be new, flat and free from corrosion, burrs or kinks.

Where specified, machined packing pieces shall be provided. Packers shall have a minimum thickness of 5mm.

The minimum number of packing pieces and/or shims shall be used at each packing point. Where a number of assorted packers and shims are installed, these will be regarded as temporary and, prior to final inspection and bolting down, shall be replaced with not more than two packing pieces and a minimum number of shims.

Tapered shims and shims less than 0.05mm thick shall not be used. More than six shims shall not be used at one location.

In wet and corrosive areas, silastic material shall be used to seal around the shims to prevent ingress of water.

6.16. CHAIN DRIVES

Chains drives shall be designed to ISO 10823: Guidance on the Selection of Roller Chain Drives. Adequate facility shall be available for chain tensioning. Where sprocket centres are fixed, an adjustable chain wheel idler shall be used. Generally, chain drives shall run in enclosed chain cases, be adequately lubricated and be protected from dust and moisture. Sprockets shall have at least 17 teeth and utilise an odd number of teeth.

6.17. BELT DRIVES

6.17.1. DESIGN AND SUPPLY REQUIREMENTS

Belt drives shall be designed in accordance with AS 2784. Belts shall be standard wedge type and provided in matched sets. The following configurations shall apply:

Table 7: Belt Drive Requirements (DIN7753/1)

Equipment	Drive Belts
SPA less than 2.2 kW	Minimum two and maximum three belts
SPB less than or equal to 75 kW	Minimum two and maximum five belts
SPC greater than 75 kW	Minimum two and maximum 10 belts

Belt drive pulleys from 25 to 127mm bore shall incorporate taper lock hubs. Smaller pulleys may be bored and keyed.

Driving motors and intermediate speed reducers shall be mounted on pivoted bases or slide rails to allow adequate adjustment for belt tensioning. Bases shall incorporate jacking screws with lock nuts. Bases shall also be suitable for next size up motor.

6.17.2. BELT DRIVE INSTALLATION

Alignment and tensioning of belt drives, whether supplied pre-assembled or not, shall be checked on site, corrected if necessary and witnessed by the MWPA Engineer.

Motors shall be assembled, with pulley fitted, on motor slide rails and driving and driven pulleys shall be aligned to tolerances recommended by the equipment manufacturer.

Pulley grooves shall be thoroughly cleaned to remove all oil, grease, rust and burrs. Centre distances between the pulleys shall be reduced before V (or wedge) belts are placed by hand into their respective grooves. No implements shall be used to force belts into pulley grooves.

Before tensioning multi-belt drives, belts shall be adjusted within the grooves by hand so that the slack of all belts is on the same side, i.e. either top or bottom.

Belts shall be tensioned using the method recommended in Appendix B of AS 2784.

6.17.3. BELT DRIVE ALIGNMENT

The allowable misalignment tolerances on V belt pulleys shall be 1/4 degree.

This applies to:

- Using a straight edge to bridge the outside of both pulleys across the centre line of the shaft, this represents a maximum gap of 2mm for a 500 diameter pulley, or 4mm for a 1,000mm pulley between the edge of either pulley and the face of the straight edge. Other diameters can be calculated by proportion. Tilting of the pulleys relative to each other as checked using a spirit level.

6.18. FLEXIBLE COUPLINGS

6.18.1. DESIGN REQUIREMENTS

Flexible couplings shall be the elastomeric type for higher torque duties. Coupling selection shall be as per the manufacturer's approved methodology, with due consideration of the drive and driven machinery characteristics and any overloads that may occur.

Flexible couplings shall be configured for uncoupling and flexible element replacement without disturbing the drive alignment.

6.18.2. INSTALLATION AND ALIGNMENT REQUIREMENTS

Coupling halves shall be aligned using a dial indicator or other accepted equipment to measure peripheral and angular differences between the coupling flanges as the shafts are rotated through 360°.

The dial indicator shall be set up to take peripheral and angular alignment readings at 0°, 90°, 180° and 270°.

Driving and driven halves shall be adjusted horizontally or vertically using adjusting screws and/or packers and shims until the coupling flanges are aligned within the tolerances specified by the manufacturer.

All readings shall be demonstrated to be repeatable. Misalignment shall be corrected with the use of levelling shims. Where possible, electric motors shall be moved rather than driven equipment.

Allowance shall be made for potential movements such as thermal expansion or contraction, hydraulic loading, gears with rising pinions, motor rotors seeking a magnetic centre and the like during alignment of drive and driven equipment.

Where pipe, duct or chute flanges are connected to equipment which is driven via a drive coupling, a full set of alignment measurements shall be made on the coupling with the pipe or chute flange connecting bolts loosened, and another with the bolts tightened, to ensure that the coupling alignment is not altered by tightening the flange connections.

When the electrical and direction check and no-load run of the motor is complete and coupling alignment field test records have been checked and accepted by the MWPA Engineer, coupling bolts shall be installed and tightened in accordance with the manufacturer's instructions.

Where specified, after couplings have been bolted up dowel holes shall be drilled, reamed and dowels fitted to fix the location of motors and coupled units on base plates.

6.19. BRAKES

Where hoisting is involved or where the brake is holding back a continuously applied load, hydraulic thruster, spring-applied hydraulic released or electro-magnet release brakes shall be used with the mechanism failing to safety. Band type brakes are non-preferred.

Brakes shall include independent proximity sensing equipment indicating whether the brake has been released or applied.

6.20. BASE FRAMES

Base frames shall incorporate the following features:

- Non cast iron construction
- Mounting pads and feet (if bedplates are required) shall be machined true and parallel (after stress relieving)
- A single machined packing piece shall be provided under each motor foot
- Shall not obstruct access to oil drain plugs
- Stainless steel shims shall be provided. All packing pieces and shims shall have an effective loading area approximately equal to that of the feet. Location of shims shall not obstruct free flow of grout
- Where locating dowels are fitted, packing pieces and shims shall have a clearance hole for the free passage of the dowels. Holes in the shims for holding down bolts shall be slotted to allow withdrawal of the shims
- Motor alignment jacking bolts shall be provided for motors 7.5kW and above with jacking bolt heads to face the motor or reducer mounting feet with two nuts on either side for adjustment. For motors and drives up to 100kW these shall be M20, for 100kW and above M24 bolts shall be used
- Drainage facility to enable draining of rain and wash down water where base frames are grouted

- Drive bases shall be provided with certified lifting lugs, suitably dimensioned and positioned to allow slinging of the complete drive assembly without damage to drive equipment, including motor terminal boxes. Lugs shall be stamped with their respective safe working loads (SWL).

6.21. GEARBOXES AND GEARING

Gearbox thermal ratings shall be calculated on full sun exposure and no wind if outdoors, or no sun exposure and no wind if indoors. The thermal rating shall not be less than one times the connected motor power and shall be agreed on with recommendations from the gearbox supplier.

Drive sizes shall be rationalised where possible with existing MWPA drives.

The inside of the gearbox shall be painted with oil resistant primer. The primer and all sealing shall also be suitable for use with synthetic oil. No pinion shall have less than 19 teeth. The face width of all pinions shall be greater than that of the mating wheel. Gears that are case hardened shall be finish machined after case hardening.

All gearboxes shall be supplied complete with inspection covers, oil drains with valves, breathers with filtration and oil sight glasses or oil dip sticks. Gearboxes with ratings exceeding 7.5kW shall be provided with means of alignment (e.g. base frame mounted jacking bolts). Isolation valves and piping shall be provided to enable gearboxes to be readily drained and re-filled.

Gear power transmission capacity shall be determined according to AS 2938, or an appropriate specification nominated by the supplier (DIN, ISO) and approved by the MWPA Engineer.

The gear service factor shall be selected with a service factor as recommended by the manufacturer (except that the service factor shall not be less than 1.5) applied to continuous rated motor power.

The mechanical rating shall permit overloads of 300% of the connected motor torque rating during momentary peak loads not exceeding five (5) peaks per hour.

6.22. WELDING

All welding materials, workmanship, inspection and testing shall conform to AS 1554, AS 4100 and this Specification. Unless otherwise accepted, the welding procedures shall be pre-qualified. Welding plant and equipment shall be adequately sized for the work. Contractors shall ensure that power supplies (GPO, welding plug or diesel generator/welder) are adequately sized to achieve the required welding output currents and voltages.

Automatic welding may be used where appropriate. Submerged arc welding may be used for welding fabricated beams or columns.

Steelwork shall be workshop-fitted and workshop-assembled as far as practicable, to minimise on-site work.

All welds shall be category SP to AS 1554 except for minor welds to such items as brackets carrying light fittings, electrical cable trays and location attachment welds, which shall be GP to AS 1554.

The preparation of steel edges for welding shall be carried out in accordance with AS 1554.

Plates or sections to be welded shall be held in the correct position by tack welds, bolts, clamps, shims and wedges, guys, struts, or other suitable devices until the welding is complete. Jigs and fixtures shall be used where practicable.

All unqualified tack welds shall be completely removed prior to welding. Where qualified tack welds are to be incorporated into a final weld made by a different process to that used for the tack weld, consumables of equivalent strength must be used for both processes and the welders installing the tack welds shall be qualified.

Weld symbols on drawings shall be to AS 1101.3 Graphical symbols for general engineering Part 3: Welding and non-destructive examination.

Welding of aluminium shall be to AS 1665.

6.22.1. POST WELD HEAT TREATMENT

Depending of the individual case, Post weld heat treatment may be required on welded components. No welding is allowed on components after they have been heat treated.

Post weld heat treatment is generally only required on:

- Pressure vessels and shall be carried out to AS 4458
- Highly stressed weldments using thick sections and/or highly alloyed steels
- Weldments subject to high fatigue or vibration loading

Refer to the technical documents produced by the Welding Technology Institute of Australia (WTIA) for useful guidelines regarding Post weld heat treatment requirements.

6.22.2. NON-DESTRUCTIVE TESTING (NDT) REQUIREMENTS FOR WELDING

Refer Sections 9 and 10 of this Specification.

6.23. LIFTING EQUIPMENT

6.23.1. GENERAL

All heavy components shall be supplied with removable lifting facilities (e.g. lifting eyes, lug, etc.) for crane handling.

The lifting methods and procedures for equipment shall be included and considered as part of the equipment design process.

6.23.2. SHACKLES

Lifting facilities shall be designed for handling and installation using “Grade S” shackles, in accordance with AS 2741, and shall be depicted on drawings together with slinging details.

6.23.3. WIRE ROPE AND WIRE ROPE SLINGS

Mechanical equipment using wire ropes for the lifting or moving of loads shall be designed and utilised in accordance with AS 759.

Wire rope slings for lifting shall be manufactured and supplied to AS 1666.1 and utilised in accordance with AS 1666.2

6.23.4. SYNTHETIC FIBRE SLINGS

Synthetic fabric slings shall be manufactured and supplied to AS 4497.1 and utilised in accordance with AS 4497.2.

6.23.5. LIFTING LUGS AND PADEYES

Each eye or lug shall be designed to a recognised standard such AS 4100, approved by the MWPA Engineer and sized to carry a minimum of twice the lifting load.

Lifting points shall be positioned to give optimal balance with an even weight distribution and minimise handling hazards.

Lifting points shall be clearly marked with the words "LIFT HERE". Additionally, the gross weight of the lift shall be stencilled or painted in a conspicuous location, such that they can be read from both sides of the component, and identified as the gross lifting weight.

Removable lifting facilities shall be bolted to each component in the workshop prior to shipment and remain attached until erection work is completed.

Each lifting lug shall be stamped with its Working Load Limit (WLL).

Lifting lugs used for lifting equipment from floating equipment such as barges or ships shall use a recognised maritime design standard such as:

- DNV Standard for Certification 2.7-1 Appendix A and D
- API RP2A Recommended Practice for Planning, Designing, Fabricating and Installing Fixed Offshore Platforms

6.23.6. CRANES AND HOISTS

The design of cranes and hoists shall be in accordance with AS 1418. Refer to Mines Safety and Inspection Regulations 1995 (WA) Regulation 6.34 and Schedule 3 for categories of cranes and hoists which fall under Classified Plant and require registration before use. Refer to ***http://www.dmp.wa.gov.au/6702.aspx*** for definitions and registration information.

Cranes to be supplied shall be assessed to AS 1418.1 to determine the crane group, structure and mechanism classifications to be applied.

As a minimum requirement, OHT cranes to be supplied shall include:

- AS 1418 M5/C5 hoist/crane classification
- Two-speed long travel and hoisting
- Pendant control
- Catenary power supply
- Hoist and long travel limit switches

6.23.7. LIFTING BEAMS, C-HOOKS AND BULK MATERIAL GRABS

Lifting beams, C-hooks and bulk material handling grabs shall be designed to AS 4991. Test, certification and marking requirements shall be as per AS 4991 requirements.

AS 4991 requires:

For duty specific application:

- Design in accordance with the duty classifications of AS 1418.1

For duty – general application:

- A minimum design load of 1.5 times the capacity
- A proof load of (2 x WLL) up to 10t WLL, (1.04 x working load limit + 9.6t) for WLL from 10 to 160t

- Design for a minimum of 20,000 load cycles with the WLL load applied
- Induced horizontal or out of plane forces included

All lifting devices shall be clearly marked with the following information:

- Identification of manufacturer
- Model, where applicable
- Identification number
- Tare mass of equipment
- Working load limit/rated capacity
- Group classification as defined in AS 1418.1 where greater than class C3.

6.24. LUBRICATION

Lubricants shall be specified by the equipment manufacturer and preferably matched to a lubricant from the MWPA list of lubricants already in use.

Each lubricating system shall be filled with a lubricant recommended by the manufacturer and accepted by the MWPA Engineer. The accepted lubricant shall be suitable for the particular duty and ambient temperature conditions. Two or more brands or types of lubricants shall not be mixed.

The amount of oil used shall be adjusted in accordance with manufacturer's instructions before and during start up to ensure correct performance.

Lubrication systems shall be flushed through with flushing oil under pressure as directed by the MWPA Engineer. Once cleaned, the system shall be closed off with plugs, either conspicuously located or suitably tagged.

Where specified, grease lubrication systems shall be provided. Grease points for manual lubrication shall be piped to a Common Block mounted in a readily accessible location. Manifold blocks shall be covered to prevent contamination.

Grease lines shall be 316 stainless steel, of adequate size and strength and permanently marked for identification. Distribution lines to individual grease points shall be 6mm tubing and 6mm braided rubber, high pressure, corrosion resistant, flexible hose where flexibility is required.

All greased bearings shall be packed on assembly with the manufacturer’s recommended lubricants and quantity of lubricant.

Nipple plates shall be located in accessible positions. Grease Nipples shall be Tecalemit 4785/13.

Equipment or machinery shall not be deemed ready to run until the MWPA Engineer has been advised in writing of the lubrication details and status of each mechanical component.

6.25. GENERAL VENTILATION DUCTING AND LIGHT SHEET METAL WORK

Ducting shall be leak proof. Supports shall be designed and spaced such that visible sagging of the duct does not normally occur, however supports shall be structurally adequate to withstand a duct plugged with any transported solids.

Expansion joints shall be used to accommodate thermal movement and isolate vibration. Ducts shall be provided with clean out inspection hatches.

Sharp edges shall be turned in and any bend radius shall not be less than twice the material thickness. Duct sections shall be designed no longer than 8m and with sleeve or flange joints.

6.26. SAFETY EQUIPMENT AND PRACTICES

6.26.1. EYE WASH AND EMERGENCY SHOWERS

Portable eye wash stations and emergency shower stations shall be provided by the operator, when required, in locations where dust, process slurries and reagents constitute a hazard. The stations shall be located away from areas subject to flooding and preferably close to perimeter kerbing. Consideration shall be given to the use of plunge baths where fluid exposure could cause significant harm to personnel (e.g. ASME B31.3 Category M fluids).

In accordance with AS 4775, the water delivered by the emergency shower or eye wash unit should be tepid (i.e. between 15.6°C and 37.8°C).

Potable water lines feeding the emergency showers and eye wash stations shall be insulated and equipped with thermostatic valves to discharge water to prevent the water temperature from exceeding 35°C. Depending on ambient conditions, further consideration shall be given for external cooling or heating of the water.

6.26.2. SAFETY GUARDS

Safety guards for mechanical equipment shall be in accordance with AS 4024.1 and AS 1755.

Guards shall be:

- Suitably designed and manufactured to prevent injury to personnel, and shall meet mining and other regulations pertinent to the site.
- Fitted with lockable doors or opening covers where access is required for routine inspection and maintenance. Inspection includes checking drive belt tensions and shaft speeds. Maintenance includes applying lubrication.
- Sufficiently ventilated to prevent heat build-up.
- Designed to avoid trapping spillage and water.
- Easily removable without disturbing other parts of the equipment and limited to nominally 25 kg. Larger guards shall have lifting provisions or be hinged to enable access to equipment.

6.26.3. PERSONNEL HEAT PROTECTION

Insulation or guards shall be provided on equipment with surface temperatures greater than 60°C in areas that can be readily accessed and touched.

6.26.4. WARNING NOTICES

Warning notices not to weld or cut shall be provided externally on all lined equipment as applicable and be in accordance with AS 1319.

7. GENERAL MECHANICAL EQUIPMENT INSTALLATION PROCEDURES

7.1. PREPARATION OF CONCRETE FOUNDATION BASES

All laitance shall be removed from the top of the concrete base and all loose material shall be removed by wet scabbling before mechanical equipment is placed on the concrete.

A flat area shall be prepared on each side of each holding down bolt by grinding or other accepted means to receive packers and/or shims.

7.2. PREPARATION OF STEELWORK SUPPORTING MECHANICAL EQUIPMENT

Where equipment is mounted on steelwork, the bearing areas shall be cleaned of all rust and scale prior to placing packers. Bearing areas shall be painted to the same finish as the surrounding steelwork prior to placing of packers. Paint shall only be removed to bare clean metal if the equipment has a special requirement for a machined fit-up.

7.3. POSITION AND LEVELLING

Equipment, equipment base plates or motor slide rails shall be accurately set on steel packing pieces on prepared concrete bases or structural steel members.

The centrelines and levels of equipment or base plates shall comply with those specified or in the manufacturer's installation instructions.

Equipment shall be levelled within 0.5mm/metre, unless otherwise required by the equipment manufacturer. In the case of pumps and other flanged equipment for connection to piping, it shall be the flanges that are levelled and plumbed.

7.4. ADJUSTMENT OF HOLDING DOWN OR ANCHOR BOLTS

The position of holding down or anchor bolts shall be adjusted by moving them within the limits of the concrete pockets or structural steel bolt holes.

If the movement available is not adequate, this shall be reported to the MWPA Engineer for a decision on the modifications to be made either to the foundation or the equipment base.

Holding down bolts or anchor bolts shall not be altered by cutting and welding or heating and bending unless directed to do so by the MWPA Engineer.

7.5. GROUTING AND PERMANENT FIXING

Grouting or permanent fixing shall not be commenced until the setting and alignment has been accepted by the MWPA Engineer.

After thoroughly cleaning all load surfaces and tolerance tube pockets, the equipment shall be grouted with an accepted non-shrink, non-rust or epoxy grout mix with a minimum 28-day crushing strength of 45MPa (unless specified otherwise) and struck off square with the sole, bed or base-plate periphery. A nominal thickness of 30mm is to be allowed for grouting, but may depend on the size and type of equipment.

The concrete surface to which grout is placed shall be free of laitance, grease, oil, dust, liquid, foreign substances or loosened aggregate immediately prior to grouting.

Metal surfaces in contact with grout shall be clean and free of oil, grease and other foreign substances. The presence of tightly bonded paint is acceptable.

Grouting under equipment with open top bases or sub-frames shall have at least two openings 100mm x 30mm deep, diametrically opposed to allow for stormwater and/or wash down drainage.

Secondary grouting and edging shall be with an accepted non shrink, non-rust grout mix.

All anchor bolts shall be re-torqued after final set of grout.

7.6. ASSEMBLY

Where it is necessary to assemble equipment and/or machinery outdoors, it shall not be carried out in wet or dusty conditions unless the work area is suitably protected.

Prior to commencement of assembly, moving parts and bearing surfaces shall have their protective coatings stripped with suitable solvents and cleaners and shall be lubricated in accordance with the equipment manufacturer's instructions.

Any error in fabrication which prevents the proper assembling and fitting of parts shall be immediately reported to the MWPA Engineer, together with a proposed method of correction for acceptance.

7.7. ALIGNMENT

All drive and driven equipment, whether pre-assembled or not, shall be aligned on site and witnessed by the MWPA Engineer.

All drive and driven equipment, whether pre-assembled or not, shall be aligned by the contractor once installed and witnessed by the MWPA Engineer.

Field alignment test records shall be completed by the contractor and submitted to the MWPA Engineer for acceptance, detailing:

- Equipment/machine number and description.
- Equipment/machine shaft speed in RPM.
- Final offset alignment measured in the horizontal and vertical plane.
- Final angular alignment measured in the horizontal and vertical plane.
- Number and thickness of shims used at each position.

Where possible, electric motors shall be moved rather than driven equipment.

All alignment adjustments shall be made using adjusting screws and shims. No loads shall be applied to shafts and other rotating elements to alter the alignment.

The doweling of equipment, where required, shall be carried out as soon as possible after approval of alignment has been given by the MWPA Engineer.

All adjusting screws shall be wrapped with “Denso” tape after final alignment.

7.8. EXTERNAL FACTORS AFFECTING ALIGNMENT

Allowance shall be made for potential movements such as thermal expansion or contraction, hydraulic loading, gears with rising pinions, motor rotors seeking a magnetic centre and the like during alignment of drive and driven equipment.

Where pipe or chute flanges are connected to equipment which is driven via a drive coupling, a full set of alignment measurements shall be made on the coupling with the pipe or chute flange connecting bolts loosened, and another with the bolts tightened, to ensure that the coupling alignment is not altered by tightening the flange connections.

If alignment is found to be affected, the contractor shall notify the MWPA Engineer of the extent to which alignment is affected and shall submit a proposal for rectifying the problem.

7.9. MEASUREMENT AND TOLERANCES

The preferred method is to measure offset and angular alignment differences between the driving shaft and the driven shaft centrelines using laser alignment equipment. Offset and angular alignment readings at 0°, 90°, 180° and 270° shall be taken to calculate the required machine foot adjustments required.

An acceptable alternative is alignment using dial indicators to measure coupling flange offset and angular misalignment as the shafts are rotated through 360°. Dial indicators shall be set up to take offset and angular alignment readings at 0°, 90°, 180° and 270° so appropriate machine foot adjustments can be applied.

Regardless of the alignment measurement method used, the contractor shall abide by the decision of the MWPA Engineer whether to accept or reject an alignment.

The following default alignment tolerances shall apply to all equipment, unless a lower tolerance is specified by the equipment manufacturer:

Table 8: Alignment Guidelines

Shaft Speed (rpm)	Maximum Allowable Offset at Centre (mm)	Maximum Allowable Angularity	
		(milliradians)[1]	(gap at Coupling Edge/ 100mmØ)[2]
Up to 200	0.10	1.0	0.10
200 to 1500	0.05	0.5	0.05
1500 to 3000	0.03	0.3	0.03
Above 3000	0.02	0.2	0.02

[1] One milliradian is equal to a gradient of 1 thou per inch, or 1mm per metre

[2] Gap difference at coupling edge per 100mm diameter, as used by Pruftechnik laser equipment

Any alignment rejected by the MWPA Engineer shall be realigned until the measurements are within the required tolerances.

8. QUALITY CONTROL

The contractor shall be responsible for ensuring that the quality control requirements of the contract are met.

These Quality Control requirements shall be in accordance with the General Conditions, the contract drawings, this Specification and the documents listed in Section 3.

The contractor's drawings or scope of work shall clearly describe all materials, manufacturing procedures, treatments and testing of all components.

The MWPA Engineer reserves the right to witness all the operations of the contractor and subcontractors and to inspect all equipment at any time during and after manufacture.

9. INSPECTION AND TESTING

9.1. INSPECTION AND TEST PLAN

All inspection and testing required by this specification and the relevant Australian Standards shall be performed.

An Inspection and Test Plan (ITP) shall describe the inspections, tests and verifications for the works required, identify the mandatory hold and witness points and describe the sequence of work activities. The ITP shall be submitted to the MWPA Engineer prior to fabrication commencing.

Inspection and testing shall comply with AS/NZS ISO 9002.

The minimum acceptance requirements in the ITP shall be:

- 100% visual check on materials and copies of certificates (if applicable)
- 100% check on dimensions
- 100% visual check on all welds
- 100% visual check on surface treatment
- Survey monitoring of erected steelwork
- Signed off inspection check for each item by contractor's inspector
- NDT as required by this specification.

Any subsequent amendments to the ITP shall be submitted for review and accepted by the MWPA Engineer prior to being implemented. The ITP shall include all of the non-destructive weld testing required, as shown on the drawings or in the detailed specification.

The ITP shall be adhered to. All ITP inspection activities shall be performed by appropriately qualified personnel. The name of the person who has the responsibility of upholding the ITP shall be submitted to the MWPA Engineer.

9.2. NDT EVIDENCE

The contractor shall be responsible for ensuring that the NDT is performed by Companies registered with NATA for the relevant class(es) of test. Supporting documentary evidence shall be made available on request.

9.3. WORKSHOP ACCESS

Access to the applicable fabrication premises, documentation, records and working area shall be provided to the MWPA Engineer. Access is required for the purpose of quality surveillance and audits to verify conformance to this specification, the NDT results and the ITP.

9.4. TEST RESULTS

A copy of the test results shall be provided on request.

9.5. WELD INSPECTION AND TESTING REQUIREMENTS

The minimum requirements for inspection and testing shall be outlined in the ITP. These shall comply with the requirements of AS 1554.

In addition to testing specified in AS 1554, the following NDT is required for this specification:

- Visual inspection at random of the weld preparations prior to welding
- All welds shall be 100% visually inspected by the contractor's welding supervisor

The testing procedures to be used are:

i. Radiographic testing to AS 2177
ii. Ultrasonic testing to AS 2207
iii. Magnetic particle testing to AS 1171
iv. Both ultrasonic and magnetic particle testing to AS 2207 and AS 1171

The extent of testing shall be as follows:

- All full strength butt weld splices for beams or columns using procedure (i) or (iv)
- All other butt welds, test 10% of the length of all welds longer than 1,000mm or one in 20 of all other joints where welds are less than 1,000mm long using procedure (i) or (iv)
- All critical welds, as specified on the design drawings using procedure (i) or (iv)
- All fillet welds, test 10% of the length of all welds longer than 1,000mm or one in 20 of all other joints using procedure (iii)
- All welds greater than 32mm, test the root pass using procedure (iii)
- All plates or sections thicker than 32mm restrained at a T-junction by welding (e.g. Web stiffeners welded to flanges) to be tested for lamination using procedure (ii).

All welds failing to meet the permissible levels of imperfections allowed in AS 1554 Part 1 shall be removed or repaired and then re-tested, along with two extra samples of either 10% or one in 20, as applicable, of the original welded section.

10. PAINTING

Painting of mechanical equipment shall be in accordance with the contract documents or, if not specified in the contract documents, in accordance with **MWPA401 - Guideline for Protective Coatings MWPA 401**.

11. PACKAGING AND PROTECTION

11.1. GENERAL EQUIPMENT PACKAGING

Goods shall be properly and carefully packed and protected, in accordance with industry best practices, having regard to the method of carriage and handling and to the climatic conditions through which the goods will pass whilst being transported to their final destination.

The contractor of the goods shall take all additional measures, beyond those specified herein, considered necessary in his experience to safeguard his particular equipment and shall also advise and obtain the approval of the MWPA Engineer of any variation to this Specification which he may consider necessary to suit his particular equipment.

The mating surface of components permanently assembled prior to painting shall be uniformly coated with an approved rust-preventative before assembly. Surfaces that will be packed or shimmed shall be coated with an approved rust-preventative.

All exposed bright surfaces shall be treated with a suitable rust inhibitor such as Shell Ennis SDC or Balm Blue Parts Coater or approved equivalent, paying particular attention to any items which are being forwarded by sea.

Fragile Items must be wrapped in crepe-cellulose wadding or some equally efficient cushioning material and floated in excelsior. Delicate instrumentation should be packed in plastic cocoons.

All pieces which protrude in such a manner as to be subject to physical damage during shipment and handling shall be dismantled, match-marked and crated.

Information regarding specialised handling and storage requirements/techniques shall be provided with the goods.

Immediately upon completion of inspections and tests, equipment shall be thoroughly cleaned of scale, dirt and other foreign material.

Items shall be drained of liquids such as lubricating oil, cooling fluid and insulating oil only if required by shipper.

Liquids used for cleaning or hydrostatic testing must be completely drained before shipment. Items must be thoroughly dry when packed for shipment.

If water has been used for cleaning or hydrostatic testing, such water must have contained a non-fouling rust preventing fluid, or tested items must be thoroughly flushed with a non-fouling rust preventing fluid.

Items that can be damaged by exposure to a high humidity environment shall be individually packaged so that no component surface is unprotected. Each piece of equipment or part of an item shall be vacuum sealed in plastic film prior to being crated. A moisture absorbing medium must be placed inside the vacuum sealed plastic covering.

Small parts that are easily damaged or lost shall be removed from major equipment components, tagged to facilitate reassembly and adequately protected from damage during shipping and storage.

Connections for such purposes as instrumentation and lubricating oil must be identified with securely attached metal tags. Such tags shall identify the purpose of each connection and the instrument of line of connecting piping.

Exposed bolted connections and flanges must be protected by cover plates and must be adequately secured and sealed.

Threaded connections must be greased and protected by plugs or caps.

Tapped openings disconnected during shipping and storage must be dry-filled with solid, long-shank plugs.

Tapped openings that are normally plugged under service conditions must be plugged for shipping and storage.

Components of skid-mounted packages to be shipped disassembled must have couplings and instrumentation terminals adequately protected and supported to prevent damage and to exclude dirt and moisture during shipping and storage.

Large or heavy items must be securely bolted to substantial skids for shipment.

Temporary supports must be provided for parts or components that may become damaged during shipping. Supports must be tagged as temporary. If they are to be removed by cutting, the location to be cut must be clearly marked.

All temporary members must be painted a distinctive colour to identify members to be removed.

Packaging must be suitable for withstanding aircraft, ship, small boat and truck movement, crane handling and lifting. Items to be shipped by sea must be completely enclosed in waterproof wooden crates.

Unless otherwise approved by the MWPA Engineer, all packing shall be in cases or crates which shall be of strong export quality and of suitable construction to allow for stacking on top of each other. The base of all cases or crates shall be constructed for ready lifting by fork-lift truck and should be clearly marked with slinging positions.

The contents of each case or crate shall be made weatherproof and dustproof by the use of a non-permeable film of suitable strength such as plastic sheet, shrink-wrap plastic or tar paper or approved equivalent.

Contents shall be a snug fit inside the case or crate and shall be restrained from movement by being properly bolted to the base and braced by suitably padded battens fixed firmly to the case or crate. Where metal or prepared paintwork may come into contact with the case or crate timbers it shall be protected from abrasion by felt pads, foam rubber, plastic or cardboard.

All cantilevered or similarly attached portions of equipment shall be supported to resist additional loads imposed during transport.

11.2. PACKAGING FOR PRECISION ROTATING EQUIPMENT

Special care shall be taken to prevent brinelling of bearings and to protect all machined surfaces. Shafts shall be blocked on centring brackets or false bearings used to relieve bearings of load during transportation. All items of equipment having roller bearings shall be fitted with approved shaft locks to restrain all rotor movement during transport.

Shaft locks shall prevent the longitudinal, radial movements and the rotational movement of the rotor and must be capable of removal and replacements when the motor is connected by a fixed coupling to drive equipment e.g. pump. All items fitted with shaft locks must have adequate warning notices displayed in a prominent position on the equipment frame.

Keys shall be supplied and securely taped into keyways on shafts.

Vertically mounted motors in equipment shall be specially supported for transport to prevent damage to the rotor and stator end plates.

Where gearboxes are transported to site without normal oil fill, vapour phase inhibitors or approved equivalent shall be used to protect internal surfaces. This shall be noted on dispatch documents and on a metal tag attached to the gearbox detailing type of inhibitors etc.

12. TESTING AND COMMISSIONING

12.1. GENERAL

As part of the contract the contractor shall, at its own cost, supply a suitably qualified person to supervise testing at the site and the entire commissioning and putting into service of all equipment, machinery and services installed under the contract, and shall demonstrate to the satisfaction of the MWPA Engineer that all such plant is in accordance with the contract and is commercially usable.

The contractor shall submit for approval the intended testing and commissioning procedure four weeks prior to the commencement of testing. The MWPA Engineer or his representative's approval of the procedure is required prior to any testing or commissioning.

12.2. PRE-COMMISSIONING

The contractor shall test, adjust and set, where necessary, all limit switches, clutches, couplings, safety valves, pressure switches and other protective devices so that they effectively and accurately protect the various portions of the plant from damage from causes within or outside the plant. This shall include testing by operation of all limit switches, safety clutches and other protective devices by movement of the various portions of the plant to the points of operation of the protective devices and under the loads and speeds at which they are designed to operate.

When the mechanical work as herein specified has been completed and made ready to function as designed, and the checking and testing of electrical equipment after installation, as specified herein, has been completed, it shall be run and tested under no-load conditions. The contractor shall ensure that all safety devices, limit switches and isolators are operative and correctly set and all parts requiring lubrication are properly lubricated before and during the run.

The contractor shall take all action necessary to ensure that there are no loose parts, tools, timber or any other foreign material on or in the equipment being tested, or in any position that could cause damage.

The following items of plant shall be run and adjusted during no-load testing of the installation:

- The operation and alignment of all bearings, idlers and pulleys shall be checked and adjusted as necessary for correct operation, and all holding down bolts and adjusting screws securely fixed after all adjustments have been completed.
- All equipment shall be run for at least six hours, including four hours' continuous operation, and the drive units, bearings and other mechanical components fitted to these items of equipment checked for correct operation.

The contractor shall replace any parts of its supply that the above test reveal as faulty, and carry out any adjustments to the plant and equipment which the tests indicate are necessary, prior to carrying out full load testing of the installations specified herein.

12.3. COMMISSIONING

When pre-commissioning and dry run tests have been completed and the MWPA Engineer or his representative is satisfied that the plant is in running order and adjustment, the contractor shall carry out full load commissioning of the plant.

All product (ore, concentrate, water, etc.) and up and downstream stream logistics (ships, trains, etc.) required for commissioning shall be provided by the MWPA and must be requested and pre-arranged as part of commissioning planning activities.

The contractor shall commission the equipment under load conditions and the equipment will not be accepted until all performance criteria specified have been met.

Takeover of the works will be certified only when load tests and commissioning have been completed as specified and the performance criteria met.

The commissioning of all equipment shall be carried out in two complete and uninterrupted 12 hour periods, with throughput varying up to the design maximum. During such commissioning the contractor shall demonstrate the efficient, stable, spillage free operation of the plant, and that the design maximum continuous throughput is achieved.

All equipment shall be checked to ensure safe and satisfactory operation on completion of assembly and installation.

Each piece of equipment supplied under the contract shall be operated individually for not less than six hours of uninterrupted duration without working load, and shall be started and stopped from the local controls. Such operation of each piece shall be carried out in the presence, and to the satisfaction of, the MWPA Engineer or his representative.

All tests shall be witnessed and results recorded. A copy of test results shall be submitted within seven days of the test.

Ambient, bearing and gearbox temperatures shall be measured at 30 minute intervals during the running tests for all drives with motors larger than 0.5kW.

When specified, power consumption measurements shall be taken at hourly intervals during running tests using an ammeter.

All defects indicated by the test results shall be rectified and the test repeated. The method of rectification shall be to the approval of the Superintendent.

12.4. TESTING AND COMMISSIONING RECORDS

The contractor shall make up a record sheet to enable the logical recording of all testing and commissioning data. The format of this record sheet shall be agreed between the MWPA Engineer or his representative and the contractor.

Two copies of the record sheets, duly signed, shall be handed to the MWPA Engineer or his representative within seven (7) days of the testing or commissioning being carried out.