حديد الإمارات
emirates steel
a SENAAT company إحدى شركات صناعات

Integrated Management System

Engineering Standards

Mechanical Equipment Engineering Standards

PRD-ME-GS-001

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1. PURPOSE

The purpose of the ES Engineering Standards is to provide information and guidelines for the design, erection, installation and commissioning of plant and equipment across ES Sites.

2. SCOPE

The standards referenced in this document are issued to all contractors and form an integral part of the contract documentation.

Compliance is mandatory by all Contractors, ES Departments and personnel, whilst designing, erecting, installing and commissioning plant and equipment within ES sites, and any deviations require the explicit written approval of ES.

3. DEFINITIONS / ABBREVIATIONS

ES - Emirates Steel

MOC - Management of Change

4. RESPONSIBILITIES

VP of Marketing & Strategy - Is responsible for approving the Standards, and delegating members of his department to review them on a periodical basis, and / or write new standards when deemed necessary.

Projects Construction Manager - Is responsible for ensuring that all projects undertaken within ES comply with these standards.

Engineering Manager Projects - Is responsible for revising the Standards as requested by the projects and operations departments.

5. DESCRIPTION

5.1 General Requirements

5.1.1 INTRODUCTION

The mechanical equipment and installations in the United Arab Emirates shall comply with the requirements of this section of “Site Conditions”, Site Regulations and Engineering Standards”.

5.1.2 CLIMATIC AND ENVIRONMENTAL CONDITIONS

The climatic conditions are described in more detail in Section 2 of “Site Conditions”, Site Regulations and Engineering Standards. The design criteria for mechanical equipment shall be based on the following external climatic conditions:

- Max. air temperature in shade: 50° C
- Min. air temperature in shade: 3° C
- Relative humidity between 20% and 100%

Equipment shall be resistant to the saline atmosphere close to the coast

The design and specification of mechanical equipment shall allow for the high ambient temperatures inside the Plant e.g. higher floor levels in the Steel Melt Shop can exceed 80° C and in the Rolling Mill over the cooling beds temperatures can reach 110° C.

Equipment that is installed outside should be provided with suitable sun shelters where necessary.

In areas that are not environmentally controlled equipment shall be protected against the ingress of harmful levels of dust.

All equipment which is not installed in air-conditioned rooms shall be designed and manufactured to suit the harsh environmental conditions of steelworks (e.g. high ambient temperature, fine abrasive and conductive dust, moisture, vibration etc.).

5.1.3 STANDARDS

The individual sections of this document detail the International and National Standards that must be followed and complied with.

5.1.4 DEVIATIONS

Ant deviations from this engineering specification require written approval of Emirates Steel.

5.2 Pumps

5.2.1 CENTRIFUGAL PUMPS

1. General

Each pump unit shall be complete in all respects and shall include prime mover, coupling and guard, bedplate, holding down bolts and all integral piping.

Pumps shall be capable of withstanding accidental reverse rotation without damage. Any residual axial force not hydraulically balanced by the pump impeller/rotor shall be accommodated by the pump bearings.

2. Operating Features

Pump rotation shall be clockwise when viewed from the driving end.

Pump rotation shall be clearly and permanently marked on the casing.

All pump casings shall be provided with valve vents and drains, at optimum positions.

Where pumps are required to operate with pressure and/or flow control valves they shall be designed for "zero flow" conditions (dead head).

Velocity of water in the suction pipe of a centrifugal pump should be in the range of 0.5 to 0.9 m/s if the water is taken from an atmospheric ventilated tank.
Pumps required to operate in parallel shall have characteristics that ensure stable operation over the full design range of output and be capable of starting against closed valve conditions.

The pump characteristic shall be such that the discharge pressure falls continuously with increasing discharge flow. Non-overloading power characteristics shall be provided where possible.

If pumps working in parallel must be automatically or remotely started, being then operationally separated from the manifold or pressure line only by a check valve, the following precautions must be observed: -

- the check valves must be as per ES Engineering Standard: PRD-ES-124 - Selection of Valves (lift check valve, wafer type) of proven first-class quality.
- dual flap swing valves are specifically excluded.
- the pumps must be specially designed as fully protected against reverse rotation, including ad hoc clamping devices if necessary.
- reverse liquid flow through the pumps must be detected, duly signalized and interlocked to avoid their start up in such conditions.

3. Construction

The pumps shall be constructed of materials specifically selected for their duty and to resist deterioration by cavitation, pitting, erosion and corrosion. Specifically, impellers handling scale water must be cast in nodular iron, unless more resistant material is specified.

A corrosion allowance of a minimum of 3 mm must be included on pump casings.

Purpose designed tapped holes should be included for in the casing design for the correct and safe removal. These tapped holes shall be sealed with tapped plugs when not required.

Both the internal and external surfaces of the pumps shall be adequately protected against the pumped media and the environment it is intended for. Consideration shall be given to any special coatings that maybe required to prolong the life of the pump. Painting shall adhere to the ES Painting Standards: PRD-ES-100 - General Requirements & PRD-ES-10 - Colour Codes.

The material selection of the impeller shall be selected on the type of pumped media, pressures, temperatures, and possible contaminants.

4. **Methods of Sealing**

   Pumps shall be suitably sealed to prevent undue loss of liquid and be designed for safe and efficient operation where acids or alkalis are involved.

   Packing and mechanical seals shall be installed in accordance with their manufacturer's recommendations.

   General service water shall be used for gland and seal services, and discharge water shall be routed to site drainage.

5. **Electric Motors**

   Refer to ES Engineering Standard: PRD-ES-059 - Electric Motors

6. **Base Plates**

   All pumps and motors shall be mounted on a common base plate, with provision made for easy removal of the motor and pump rotating element.

   Base plates shall be fabricated steel or cast iron, with top and bottom pad surfaces machined all over.

   Adequate packing for site levelling shall be provided along with all holding down materials.

   Dowelling of pump and motor to be used as much as possible.

7. **Installation**

   Pumps and related pipelines must be installed in such a way that minimal vibrations or forces can be transmitted to each other.

5.2.2 SUMP PUMPS

1. General

This Section covers vertical centrifugal submersible sump pumps for general drainage use. Sump pumps shall be in accordance with Section 1 above, except where modified below.

2. Construction

Sump pumps shall have an integral base and suction strainer.

The motor and pump shall be integrated to form a single compact unit.

Motors shall normally be cooled by the pumped liquid but shall be capable of continuous operation in a dry sump under no load conditions.

Upper and lower level detection shall be fitted to the pump.

The pump design shall take into consideration the pumped media.

3. Installation

Where permanently installed, pumps shall be mounted in accordance with the manufacturer's instructions in sumps of suitable dimensions.

Pipes shall be coupled to pumps to prevent loads being transmitted to the pump casing.

4. Cable Termination

Pumps shall be provided with suitable waterproof cable glands and terminations as necessary.

5.2.3 MARKING

Pumps shall be marked clearly and permanently with an identification plate adequately secured including the following information: -

a) manufacturer
b) model
c) serial number
d) speed
e) horsepower
f) electrical specifications
g) direction of rotation
h) CE Mark.

5.2.4 MANUALS

Operation and Maintenance manuals to be supplied in an electronic format and 1 off hard copy.

The format of the manuals shall be in accordance with ES Engineering Standard: PRD-ES-110 - Engineering Documentation, and project specific agreed with ES prior to final issue.

Actual pump curves shall be included.

5.2.5 DRAWINGS

Drawings to be supplied as per ES Engineering Standard: PRD-ES-110 - Engineering Documentation.

5.2.6 QA DOCUMENTATION

Final Conformity Documentation, which will contain, but not limited to the following: -

- Design Documentation (including permissible flange loadings)
- Actual pump curves.
- Material Test Certificates
- Shaft machining records.
- Impeller balancing records.
- NDT Testing Records
- NDT Inspector Qualifications
- Non-Conformity Reports
- Pressure Test Certificates.
- Any third-party documentation
- Any Check Lists
- Any Audit Sheets
- Any other documentation submitted in a Quality Documentation Package under the applied International or National Standards.
- CE Mark and Conformity documentation.

The documentation shall be fully traceable.

The format of the QA Documentation shall be agreed with ES.

ESI reserve the right to audit or request sample documentation through various stages of the project.

5.3 Pressure Vessels & Vented Tanks

5.3.1 PRESSURE VESSELS

1. General

This Section relates to the requirements for unfired pressure vessels but does not include those where internal pressure is solely due to the static head of the liquid contained therein. The pressurised storage containers, heat exchangers, steam generators, boilers, industrial piping, safety devices and pressure accessories shall meet essential safety requirements and satisfy appropriate conformity assessment procedures.

2. Definitions

For the purposes of this Standard, the terms and definitions given in ASME VIII or EN 7641:2004, EN 764-2:2002 and EN 764-3:2002, shall apply, or other agreed International or National Standards.

The following is typical and shall be used for guidance purposes only:

a. main pressure bearing parts

parts which constitute the envelope under pressure, essential for the integrity of the equipment

b. pressure vessel

housing and its direct attachments up to the coupling point connecting it to other equipment, designed and built to contain fluids under pressure. NOTE A vessel may be composed of more than one chamber.

c. fluid

gas, liquid and vapour in their pure phase as well as mixtures thereof NOTE A fluid may contain a suspension of solids.

d. piping

pipe or system of pipes, tubing, fittings, expansion joints, hoses or other pressure-bearing components, intended for the transport of fluid, connected and integrated into a pressure system

e. assembly

several pieces of pressure equipment assembled by a manufacturer to constitute an integrated and functional whole

f. pipelines

piping or system of piping designed for the conveyance of any fluid or substance to or from an installation (onshore or offshore) starting from and including the first isolation device located within the installation and including all the annexed equipment designed specifically for pipelines

g. **maximum allowable pressure *(PS)***

maximum pressure for which the pressure vessel is designed as specified by the manufacturer

h. **maximum / minimum allowable temperature (*TS*)**

maximum/minimum temperature for which the pressure vessel is designed as specified by the manufacturer

i. **testing group**

one of the four groups designed to specify the extent of non-destructive testing and destructive testing necessary in association with joint coefficient, material grouping, welding process, maximum thickness, service temperature range

j. **joint coefficient**

reduction coefficient related to the testing group and which is applied to the nominal design stress

k. **required thickness**

thickness excluding corrosion or any other allowances specified in EN 13445

l. **hazard category**

category of the pressure vessel considering the potential hazards

m. **testing factor**

a factor considering the amount of NDT testing in castings, applied on the nominal design stress

n. **material manufacturer**

individual or organization that produces material in the basic product form used in the manufacture of pressure equipment

o. **manufacturer**

individual or organization that is responsible for design, fabrication, testing, inspection, installation of pressure equipment and assemblies where relevant

NOTE 1 The manufacturer may subcontract one or more of the above-mentioned tasks under its responsibility.

NOTE 2 In EU member states the manufacturer is responsible for compliance with the Pressure Equipment Directive 97/23/EC. For those manufacturers outside the EU their authorized representative inside the EU assumes this responsibility.

p. weldment

weld metal, heat affected zone and adjacent base material(s)

3. Quantities, symbols and units

Quantities, symbols and units to be used for pressure equipment shall be in accordance with Tables 1 and 2, ASME VIII, EN 764-2:2002

NOTE 1: The choice of the appropriate multiple (decimal multiple or sub-multiple) of a unit is governed by convenience, the multiple chosen for a particular application being one which should lead to numerical values within a practical range, therefore when indicating quantities it is recommended that decimal multiple or sub-multiple quantities be chosen such that the resulting values are easy to handle, e.g. between 0,1 and 1 000. The non-SI units, bar for pressure and L for volume should be used on the nameplate.

Table 1 — Quantities for space and time

Quantity	Symbol	Unit
Time	*t*	s, min, h
Frequency	*f*	Hz
Dimension	any Latin letter a	mm
Length	*l*	mm
Thickness	*e*	mm
Corrosion allowance	*c*	mm
Diameter	*d, D*	mm
Radius	*r, R*	mm
Area	*A, S*	mm^2
Volume, capacity	*V*	$mm^{3\ b\ c}$
Weight	*W*	N, kN
Density	ρ	kg/mm $^{3\ d}$
Second moment of area	I	mm^4
Section modulus	*Z*	mm^3
Acceleration	γ	m/s^2
Plane angle	any Greek letter a	rad, °

a Symbols may use any lower-case letter, except for those defined elsewhere in this table.
b volume may also be given in m3 or L.
c litre "L" is a non-SI unit which may be used with SI units and their multiples.
d Density may also be given in kg/m3.

Table 2 — Mechanical quantities

Quantity [a]	Symbol [b]	Unit
Force	*F*	N
Moment	*M*	N.mm
Pressure	*p, P*	bar c, MPa
Temperature	*T*	°C
Linear expansion coefficient	a	Jtm / m °C
Normal stress	a	MPa
Shear stress	τ	MPa
Nominal design stress	*f*	MPa
Tensile strength	*R*m	MPa
Yield strength	*R*e	MPa
1 % proof strength	*R*p1.0	MPa
Proof strength at temperature *T*	*R*p / T	MPa
Upper yield strength	*R*e H	MPa
0,2 % proof strength	*R*p0,2	MPa
0,2 % proof strength at temperature *T*	*R*p0,2/T	MPa
Ultimate tensile strength at temperature *T*	*R*m/T	MPa
Modulus of elasticity	*E*	MPa
Shear modulus	*G*	MPa
Poisson's ratio	1)	-
Strain	c	%
Elongation after rupture/fracture	*A*	%
Impact energy	*KV*	J
Hardness	*HB, HV*	-
Joint coefficient	*z*	-
Safety factor	*S*	-

a Quantities without a temperature index normally refer to room temperature.
b Some of these symbols, such as R, f, are not part of ISO 31.
C "bar" is a non-SI unit which may be used with SI units and their multiples. The unit bar shall be used on nameplates,
certificates, drawings, pressure gauges and instrumentation and is always used as a gauge pressure. This is in line with the
requirements of the Pressure Equipment Directive 97/23/EC.
Note The use of symbols for temperature may be different from the PED.

4. Prerequisites

Prior to designing and manufacturing a pressure vessel under the standard, the manufacturer must establish a number of prerequisites:

a. The conditions under which the vessel will be operating.
b. Load cases to be considered are enumerated in 5.3.1 to 5.3.2 of EN 13445-3:2009 or its equivalent outside the EU, i.e. ASME VIII
c. The category of the vessel as defined in the Standard applied.

5. Specification

Design shall be in accordance with ASME VIII, or *BS EN 13445:2009,* or agreed International or National Standards. The design conditions shall allow for the most

severe combination of internal and external loads and forces to which the vessel may be subjected to in the cases for testing, normal, abnormal operation, and safe shutdown and inspection.

The design, operating, and test pressures must be clearly stated and communicated to the purchaser.

All International and National Standards to be used for the design, material selection, manufacture, fabrication, installation, testing, and commissioning must be clearly listed and agreed with the purchaser.

6. Construction

All methods of fabrication and construction must conform to ASME VIII, or BS EN 13445:2009, or an agreed International and National Standards.

Consideration shall be given to corrosion and erosion protection (internal and external) where necessary. The design shall incorporate thicker material, as appropriate, and wear allowances and rates shall be clearly stated and communicated to the purchaser.

The uses of expansion loops are preferred to bellows, and by design provide the system with greater integrity. If bellows are deemed to be the only practical option, then a full risk analysis and design justification must be submitted for review by the purchaser.

All vessels shall incorporate adequately designed lifting lugs, and must be correctly NDT tested, load tested by an authorised body prior to use. In cases where testing may not be feasible, design calculations must be submitted to the purchaser prior to use.

All vessels shall be provided with inspection and/or access openings to allow internal visual inspection. Davits shall be provided wherever possible on man access openings. Consideration shall be given to the minimum size of man access openings to allow the use of rescue or BA equipment.

The manufacturer may subcontract work but shall ensure that the subcontractor carries out the work in accordance with the requirements of the International or National Standards.

Where welding operations are subcontracted, the manufacturer shall also either obtain copies of the welding procedure and welding operator qualification records or take other action to ensure that they comply with the applied International or National Standards.

In discharging his responsibility to ensure that the subcontractor carries out the work in accordance with this standard the manufacturer shall ensure that surveillance of the subcontracted work is performed.

Where a manufacturer is producing equipment that requires the intervention of a responsible authority, the manufacturer should inform the responsible authority of his intention to subcontract so that the responsible authority has the opportunity to take part in the subcontractor surveillance.

7. Access

All Plant and Equipment shall be easily accessible for inspection and maintenance.

Where possible Vessels shall be installed in sheltered location. If such a location is not available, then the provision of a protective housing shall be considered in conjunction with the area operations and hazards.

Stairway access shall be provided in preference to cat ladder access. Where cat ladders are necessary, they shall be manufactured with safety hoops and self-closing gate at top of ladder designed to open only onto the platform. Consideration shall be given to the size of the hoops in relation to a person requiring access wearing rescue or BA equipment.

Cat ladder to be securely fixed to ground level allowing concrete plinth on underside. All elevated accessible areas shall be provided with handrails and kick plates.

8. Rating Plates

Nameplates shall be made of material suitable for the intended service and with a thickness sufficient to withstand distortion due to the application of the marking and be compatible with the method of attachment. The minimum thickness shall be not less than 1 mm.

Marking shall be done in characters not less than 5 mm high and shall be produced by casting, etching, embossing, debossing, stamping or engraving, including the identification of the Standard applied.

The marking may be applied before the nameplate is affixed to the equipment providing the vessel manufacturer ensures that the nameplate is applied to the correct equipment.

The nameplate shall be attached in such a way that removal would require the willful destruction of the nameplate or its attachment system.

The nameplate shall remain visible and legible for the lifetime of the vessel.

The units of measurement used in marking or stamping the equipment and accessories shall follow the SI units.

The unit “bar” for pressure shall be used.

The nameplate shall contain the following information. As a minimum the requirements of a) and b) below shall be fully marked. Depending on the type of equipment the requirements of c) shall be marked.

a. Basic Information
    - vessel manufacturer's name or symbol and address
    - reference to the International or National Standard applied and applicable edition
    - year of manufacture
    - type and series or batch identification and serial number identifying the equipment
    - maximum allowable pressure *Ps* in bar
    - maximum allowable temperature *Ts* max in °C
    - minimum allowable temperature *Ts* min in °C
b. Depending on type of equipment, supplementary information
    - identification of fluids, including warning symbols if applicable;
    - design pressure Pd in bar;
    - design temperature Td in °C;
    - test pressure Pt in bar and date

- internal volume in L;
- safety accessories set pressure in bar;
- equipment output in kW;
- voltage supply in V;
- intended use;
- filling ratio in kg/L;
- maximum filling mass in kg;
- tare mass in kg;
- fluid group;
- removable parts made traceable to equipment of which they form a part.

c. where necessary, warnings fixed to the pressure equipment drawing attention to foreseeable misuse which experience has shown may occur.

9. Testing

Pressure Testing shall be in accordance with ASME VIII or BS EN 13445, and applicable edition; or the agreed International or National Standard.

NDT testing must conform to the applied Standard.

The method and risk assessment of any Hydrostatic or Pneumatic tests must be carried out with the consultation of ES.

10. Certification

It shall be the responsibility to submit the necessary Third-Party certification prior to the Plant being put into production.

All necessary information shall be issued to ES in order that a Written Scheme of Examination can be compiled before the Plant is put into production.

The purchaser reserves the right to witness test all or selected items of equipment. All milestone tests should be included in the Project Programme.

11. Documentation

On successful completion of the project the contractor shall issue to the purchaser the following documentation for the safe operation and maintenance of the Plant:

Operation and Maintenance manuals in an electronic format, with a 1 off hard copy. The format shall be in accordance with ES Engineering Standard: PRD-ES-110 - Engineering Documentation, project specific agreed with ES.

Drawings to be supplied as per ES Engineering Standard: PRD-ES-110 – Engineering Documentation.

a. QA Documentation

Final Conformity Documentation, which will contain, but not limited to the following: -

- Material Test Certificates
- Welding Material Certificates
- Welders Qualifications
- Welding Map
- Welding Procedures
- Weld Test Records
- Welders Matrix
- Weld Repair Records.
- NDT Testing Records
- NDT Inspector Qualifications
- Non-Conformity Reports
- Third Party Certification
- Pressure Test Certificates.
- Painting Records – specification/application/thickness checks.
- Consumable Test Certificates
- Design Documentation
- Any third-party documentation
- Any Check Lists
- Any Audit Sheets
- Any other documentation submitted in a Quality Documentation Package under the applied International or National Standards.
- CE Mark.

The format of the QA Documentation shall be agreed with ES.

The documentation shall be fully traceable.

ESI reserve the right to audit or request sample documentation through various stages of the project.

5.3.2 TANKS VENTED TO ATMOSPHERE

1. General

This Section relates to the requirements for above ground liquids storage tanks vented to atmosphere. All tanks shall be designed in accordance with a recognised and agreed international standard.

It does not apply to domestic water cisterns or reinforced concrete storage vessels.

2. Specification

Tanks shall be in accordance with the relevant specifications taken from the national/international standards. Tanks shall be designed to withstand all loads imposed on them during construction, operation, maintenance, and testing.

3. Construction

Tanks shall be fitted with a tight-fitting lid or roof to prevent the ingress of dust, sand, vermin or other foreign matter. Where necessary a fit for purpose designed sealing arrangement shall be considered.

A freeboard of at least 200 mm shall be maintained during operation, and any devices necessary to prevent surging of the contents shall be fitted.

Any level control devices shall be mounted in still wells and shall be removable without draining the tank. All tanks shall be provided with an externally visible calibrated contents gauge and a dip tape.

Internal and external access ladders and walkways shall be provided.

All tanks shall be provided with inspection and/or access openings to allow internal visual inspection. Size of opening shall be in accordance with section 1.6 of this standard.

Vents shall be 80 mm minimum diameter with swan neck and vermin proof screens.

Visible overflows and valve drain connections shall be fitted. Draw out sumps shall be fitted as appropriate.

Sectional tanks shall be erected with external flanges.

Site welded tanks shall be provided with all necessary construction aids.

4. Access

Stairway access shall be provided in preference to cat ladder access. All elevated accessible areas shall be provided with handrails.

All access shall be in accordance with section 1.7 of this standard.

5. General Requirements

Atmospheric suction tanks for main cooling circuits must be big enough to catch all water which can run during a stoppage of the system by force of gravity from the system towards this tank. This must be ensured when the tank has the maximum water level during normal operation.

The minimum operational water level (min.-max. transmitter water level control) must be at least 30% higher than the required net positive suction head (NPSH) of the system and the pump or pump group whatever is worse under the actual mode of operation.

The required NPSH of the pump or pump group should be taken +15% higher as the design characteristic of the pump or pump group.

6. Internal Protection

Sectional steel tanks shall be hot dip galvanized prior to dispatch and painted internally after erection with an ESI approved non-toxic bitumastic based paint.

Site welded tanks shall be sealed internally after erection and painted internally with the same paint as above.

All painting and protection shall be in accordance with ES Engineering Standards: PRD-ES-100 – General Requirements & PRD-ES-101 – Colour Codes.

7. Rating Plates

Nameplates shall be made of material suitable for the intended service and with a thickness sufficient to withstand distortion due to the application of the marking and be compatible with the method of attachment. The minimum thickness shall be not less than 1 mm.

Marking shall be done in characters not less than 5 mm high and shall be produced by casting, etching, embossing, debossing, stamping or engraving, including the identification of the Standard applied.

The marking may be applied before the nameplate is affixed to the equipment providing the vessel manufacturer ensures that the nameplate is applied to the correct equipment.

The nameplate shall be attached in such a way that removal would require the willful destruction of the nameplate or its attachment system.

The nameplate shall remain visible and legible for the lifetime of the vessel.

The units of measurement used in marking or stamping the equipment and accessories shall follow the SI units.

The unit “bar” for pressure shall be used.

The nameplate shall contain the following information. As a minimum the requirements of a) and b) below shall be fully marked. Depending on the type of equipment the requirements of c) shall be marked.

a. Basic Information
   - vessel manufacturer's name or symbol and address
   - reference to the International or National Standard applied and applicable edition
   - year of manufacture
   - type and series or batch identification and serial number identifying the equipment
   - maximum allowable pressure *Ps* in bar
   - maximum allowable temperature *Ts* max in °C
   - minimum allowable temperature *Ts* min in °C;

b. Depending on type of equipment, supplementary information
   - identification of fluids, including warning symbols if applicable;
   - design pressure Pd in bar;
   - design temperature Td in °C;

- test pressure Pt in bar and date
- internal volume in L;
- safety accessories set pressure in bar;
- equipment output in kW;
- voltage supply in V;
- intended use;
- filling ratio in kg/L;
- maximum filling mass in kg;
- tare mass in kg;
- fluid group;
- removable parts made traceable to equipment of which they form a part.

c. Where necessary, warnings fixed to the pressure equipment drawing attention to foreseeable misuse which experience has shown may occur.

8. Site Testing

Site fabricated and site erected tanks shall be tested in accordance with the relevant design code and local regulations.

The method and risk assessment of any Hydrostatic or Pneumatic tests must be carried out with the consultation of ES.

9. Certification

It shall be the responsibility to submit the necessary Third-Party certification prior to the Plant being put into production.

All necessary information shall be issued to ES in order that a Written Scheme of Examination can be compiled before the Plant is put into production.

10. Documentation

All documentation shall be in accordance with section 11.3.1.11 of this Standard.

5.4 Belt Conveyors

5.4.1 GENERAL

This section relates to the requirements for belt conveyors handling bulk materials having woven fabric carcass construction. It specifies requirements in respect of materials of construction, dimensions, physical properties; including fire and abrasion resistance, and sets out a rationalised range of belts according to their rating, cover thickness and width. This Standard should be read in conjunction with BS EN ISO 14890 :2003.

The belt conveyor systems shall include but will not be limited to:

a. All steel structural elements, channel steel frames, head and tail frames, stringers, transfer towers, platforms, walkways, handrailing, grating, stairs, cat ladders, in-outlet chute, drive guards, decking plates.
b. Drives - pulleys - idlers - belt take-up mechanism as indicated on the conveyor data sheets.
c. Auxiliary items such as:
   - under speed controls - belt slip monitoring.
   - emergency stop trip wires -local stop/start switch with local/off/remote positions and padlocking facilities.
   - belt cleaners together with all accessories to make the conveyor system ready for operation
   - belt tracking detector switches.

   The equipment shall be designed and guaranteed for operation at the service conditions as mentioned in the plant area specifications.

   All troughed belt conveyors shall be suitable for operating 20% in excess over the required capacity.

5.4.2 REFERENCES

British Standards

BS EN ISO 14890:2003

Conveyor Belts - Specification for rubber and plastic conveyor belting of textile construction for general use

BS EN 12882:2002

Conveyor belts for general purpose use - Electrical and flammability safety Requirements

BS EN 12881-1 :2005 Conveyor belts – Fire simulation flammability testing –

Part1: Propane burner tests (Supersedes BS 490 Part 11: Section 2: 1991 Methods of test for safety. Low energy and high energy propane gallery test)

BS EN 1554: 1999

Conveyor belts - Drum friction testing

BS EN ISO 340: 2004 Conveyor belts – Laboratory scale flammability characteristics – Requirements and test method (Supersedes BS EN 20340: 1993 Conveyor belts - Flame retardation - Specifications and test method)

BS 6593: 1985
On-site non-mechanical jointing of plied textile and steel reinforced conveyor Belting

Other Standards

DIN53516: 1987 Testing of Rubber and Elastomers; Determination of Abrasion Resistance.

Unless otherwise stated, the last edition of any Standard or document and amendment thereto current at the date of an order or contract shall apply.

5.4.3 STRUCTURAL STEEL PLATFORMS AND LADDERS

The design of all structural steelworks shall be in accordance with Section 3 of this Standard.

All Plant and Equipment shall have safe and easy access for inspection and maintenance.

Stairway access shall be provided in preference to cat ladder access. Where cat ladders are necessary, they shall be manufactured with safety hoops and self-closing gate at top of ladder designed to open only onto the platform. Consideration shall be given to the size of the hoops in relation to a person requiring access wearing rescue or BA equipment. Cat ladder to be securely fixed to ground level allowing concrete plinth on underside.

All elevated accessible areas shall be provided with handrails and kick plates.

Cat ladder to be manufactured to standard with safety hoops and self-closing gate at top of ladder designed to open only onto the platform.

Cat ladder to be securely fixed to ground level allowing concrete plinth on underside.

Walkways shall be provided along one side of the entire length of all conveyors, which cannot be maintained from grade level or operating platforms. All clearances of walkways along belt conveyors and gantry heights shall be submitted to ES for review.

All bolts and fastenings are to be user friendly and not cause injury to persons using the stairway or handrail.

Adequate access shall be made available to carry out routine lubrication without removing steel parts.

All conveyor head and tail frames shall be constructed from RHS (rectangular hollow section) adequately tied and designed to support the pulley assemblies. The intermediate structure shall be of similar design and construction. Drives shall be supported on frames constructed from RHS suitably tied to the conveyor steelwork.

Head and tail ends of conveyors are to be totally enclosed with minimum 6 mm thick steel plate adequately stiffened and incorporating easily removable covers fixed by means of toggle clamps. The length of these total enclosures shall be kept to the minimum necessary to enclose the head and tail assemblies.

5.4.4 CHUTES

Bulk conveyor transfer points shall be of such design as to avoid product degradation. All chutes shall be constructed of carbon steel plate and shall be rigidly supported from adjacent conveyor structures.

Chutes shall be fabricated from adequate steel quality plates suitably stiffened with RHS and incorporating deflector plates where necessary to reduce free fall of material. The slope of all chute surfaces shall be sufficient to allow for the free flow of the conveyed material.

Where chute sections which will be impacted by the product consideration shall be given to hard facing or fit for purpose material selection and thickness.

All chutes shall be easily removable to allow future replacement of the pulley assemblies. The design of the chutes shall be based on the discharge trajectories of the bulk material. Where called for in the plant area specification, discharge chutes shall be equipped with a device for sensing a plugged chute.

Where material is transferred directly from a discharge pulley to a receiving belt, the trajectory shall be carefully plotted to place the material centrally on the receiving belt. Each feed chute shall be constructed with skirt boards. A continuous rubber seal strip shall be clamped to the lower skirt board by means of level plates.

Easy adjustment shall be possible.

All skirt boards rubbers shall be of a hardness to minimize belt wear.

5.4.5 BELT DRIVES

All motors shall be in accordance with ES Engineering Standard: PRD-ES-059 - Electrical Motors.

All belt drives shall be fitted with a resilient coupling connection between transmission gearbox and conveyor head drum.

5.4.6 CONTROLS

All electrical safety devices shall be included as well as belt slip monitoring and sequential interlocking.

Each belt conveyor shall be furnished with trip wire switches for stopping the conveyors in case of emergency, at any point throughout the conveyor length at walkway side only.

All motors, interlocks and remote controls shall be furnished by the CONTRACTOR together with the brackets required.

The belt conveyor system shall be of such a design that in case of possible emergency stop of the system or a part thereof, and in case of fully loaded belts the motor torque ratings shall be adequate to start up the installation. Furthermore, all electrical and mechanical protection shall be based on such start-up requirements.

5.4.7 IDLERS

All troughed belt conveyor carrying idlers shall be of the three-roll type. Idler design, size and type shall be forwarded to ES for approval.

Troughing angle of the belt shall be the required to meet the conveyed material characteristics.

There shall be sufficient clearance between the roller edges and the belt edge. All idlers shall be designed with free turning concentric rolls.

Rolls shall have round edges to avoid belt wear.

All idlers shall have the following qualities: -

- Design in strict accordance with environmental conditions.
- Idler supports suitable for accurate alignment, with slotted holes both sides.
- Adequate bearings to provide the life specified.

5.4.8 BELTING

All belting shall be obtained from a competent belt manufacturer.

All belting shall be of synthetic carcass construction with abrasion resistant covers.

All belting shall be fire resistant. Please refer to Appendix 1for Guideline for Risk Assessment on Conveyor Belts

The non-mechanical jointing of all conveyor belts shall unless otherwise specified by the manufacturer comply with BS 6593: 1985

Unless otherwise specified, belt splices shall be field vulcanised and the belt shall be of sufficient length to make the splice.

5.4.9 HEAT, FIRE, AND WEAR RESISTANCE

a. Heat Resistance

The covers shall be suitable for continuous operation with lumps at 150 degrees C and fines at 130 degrees C.

b. Fire Resistance

The conveyor belt shall be capable of passing the Low Energy Propane Gallery Test as specified in BS EN 12881–1 :2005 Method A Single Burner Test

The conveyor belt shall be capable of passing the Drum Friction Test, BS EN 1554: 1999: Method A1 (constant load)

c. Abrasion Resistance

The belt shall be capable of sustaining the abrasion test specified in DIN53516, with a volume of material lost not greater than 90mm3, however belts with a material loss of 150 mm3 may be considered on commercial grounds.

5.4.10 PULLEYS

Gravity take-up pulley bearings shall be mounted on a fabricated RHS sliding frame, designed to carry the counterweight and operate in rolled steel guides. The whole unit shall be provided with steel mesh guards.

5.4.11 MECHANICAL CONVEYOR DESIGN

All belt conveyors to be designed in accordance with related standards, and to satisfy ES requirements.

All holding down bolts shall be furnished by the CONTRACTOR.

All bolting required for mounting mechanical components or conveyor framing and/or chutes shall be provided by the CONTRACTOR.

Safety guarding shall be provided for all accessible operating parts of conveyors and conform to the relevant International and National Standards. All couplings and nip points shall be provided with steel sheet guards. Tail pulley tensioning gear and convex bends shall be provided with wire mesh guards.

Each bulk conveyor shall be equipped with a plough type scraper near the return pulley on the return part of the belt and a belt cleaner at the head.

The minimum radius on vertical belt conveyor curves shall be sufficient to ensure that the belt will always remain in contact with the troughing idlers.

Except as specifically noted in plant area specifications, all bearings shall be calculated for a lifetime of 50,000 hours of operation under local environment service conditions.

5.4.12 FABRICATION

All materials shall be new and in accordance with the national/international codes nominated for the plant area concerned.
Cold rolled or pressed metal structural shapes shall only be used with the prior approval of ES.

Special material requirements are identified in the plant area specification.

Welding shall be in accordance with ES Engineering Standard – PRD-ES-036: Welding.

Field connections shall be high tensile (HT) bolted and/or pinned with a minimum of site welding.

5.4.13 TESTING

Testing of conformance to all aspects of this Standard shall be carried out, by the manufacturer to the frequency dictated in BS EN ISO 14890: 2003

The manufacturer will provide evidence that these tests have been carried out and will provide a copy of all documents. These documents are to be issued to ES.

Test Certificates

Each belt produced shall have a test certificate which shall indicate conformance with this Engineering Standard and the results of any tests performed upon it. The supplier shall retain test certificates for at least five years from the date of order and copies supplied to the purchaser.

Site Testing

For existing installations where the fire resistance properties need to be site checked, this can be done in accordance with BS EN ISO 340: 2004 with the covers intact. Note compliance with this standard does not mean compliance with the standard outlined in this document.

The conveyor head and driver unit's components shall be shop tested under zero load conditions.

5.4.14 PAINTING AND PROTECTION

This shall be in accordance with ES Engineering Standards: PRD-ES-100 - General Requirements & PRD-ES-101 - Colour Codes.

5.4.15 ENVIROMENTAL CONSIDERATIONS

The raw material handling system transfer towers (junction houses) on the conveyor systems shall be equipped with dust extraction equipment in compliance with local environmental standards. The dust extraction points shall be connected into a bag filter plant system. The contractor shall carryout a survey of the existing filtration system to confirm sufficient capacity is available for the additional equipment covered under the contract.

5.4.16 DOCUMENTATION

The supplier shall provide the following information, with every consignment of belting:

1. Purchaser's Order Number.

2. Supplier's Order Number.
3. Weight of individual rolls dispatched.
4. Belt Description: Width; rating; plies; cover thickness; belt length.
5. Certificate of Compliance to this Standard.
6. Branding of Conveyor Belts - All Conveyor Belts to be branded with the following identification markings: -
   a) Manufacture identification
   b) Unique belt number (Traceable)
   c) Manufacturing Standard. All markings to be clearly visible every 10 to 15 meters on the top cover.
7. CE Documentation.

The documentation shall be fully traceable.

The format of the QA Documentation shall be agreed with ES.

ESI reserve the right to audit or request sample documentation through various stages of the project.

Operation and Maintenance manuals to be supplied in an electronic format and 1 off hard copy, the layout to be agreed with the purchaser.

Drawings and manuals shall be supplied as per ES Engineering Standard: PRD-ES-110 - Engineering Documentation.

5.4.17 GLOSSARY

Carcass: The woven fabric material forming the tension member of the conveyor belt, together with the skim coats.

Skim: The material between the fabric plies, which provides adhesion between the plies.

EP: An abbreviation identifying the fibbers used in the woven fabric part of the conveyor belt carcass, indicating a polyester (E) yarn for the warp and a nylon (P) (polyamide) material for the weft.

Warp and Weft: The Warp is the longitudinal weave member of the fabric; the Weft is the weave member at right angles to the Warp.

5.5 Lubrication Systems

5.5.1 SCOPE

This Standard deals with oil, oil mist, air/oil, grease and bulk lubrication systems. If classifies the various systems available and details the practices that shall be adopted in the design of plant and components, layout and installation, commissioning and acceptance of lubrication systems. It also gives requirements concerning the documentation that is required with every installation.

5.5.2 DEFINITIONS

For the purposes of this Standard the following definitions shall apply.

1. **LUBRICATION SYSTEM**

   A lubrication system is one in which two or more application points on a machine, a group of machines or a process line are served with the same lubricant from a common source.

2. **WET SYSTEM**

   A wet system is a circulating oil system which is subject to the ingress of water.

3. **DWELL TIME**

   The dwell time is the time in which a quantity of lubricant will remain in the reservoir under normal running conditions. That is: -

   Dwell time (mins) = Volume of fluid in reservoir (litres) rate of circulation (litres/min)

4. **TOTAL EQUIVALENT LENGTH OF PIPE**

   For the purposes of calculating pressure drop this equals the total lengths of straight pipe plus the sum of the pipe length equivalent of associated fittings in the relevant part of the system.

5. **PRESSURE DROP**

   The difference in pressure of a medium before and after an event, e.g. having flowed through a length of pipe.

6. **LAMINAR FLOW** (Also known as streamline, viscous or straight-line flow.)

   A type of flow in which there is a continuous steady motion of the particles, the motion at a fixed point varying in a definite manner.

7. **TURBULENT FLOW**

   A type of flow in which there is unsteady motion of the particles, the motion at a fixed point varying in no definite manner.

8. **FILTER**

A device for removing particles from a lubricant in order to obtain the required degree of cleanliness in the system.

9. UNIT OF PRESSURE

The unit of pressure adopted in this Standard is the bar.

5.5.3 GENERAL PRINCIPLES

1. DESIGN

Detailed discussions at the initial design stage shall take place between the development, design, plant and lubrication engineers of ES, the machinery or plant suppliers and the suppliers of the lubrication system and equipment to determine the most effective, efficient and economic lubrication system together with a suitable service lubricant. The choice of the lubricant shall consider any rationalised list for the ES Group or Works concerned.

Detailed information shall be provided by the contractor so that schedules can be prepared concerning re-lubrication periods, repacking of bearings, oil changes and capacities of systems, reservoirs and pumps.

Where existing plant is to be modified similar considerations and discussions shall take place as appropriate.

2. ENVIRONMENTAL CONDITIONS

The environmental conditions to which a lubrication system may be subjected shall be carefully considered during the design stage, particularly in connection with filtration for the lubricant and the reservoir venting air.

3. MONITORING & CONTROL

The operation of all lubrication systems shall be adequately monitored. The results from the monitoring instrumentation shall be transmitted to a control centre specified and located, as agreed, with the purchaser.

The transmitted results may be actual values or alarm signals, as specified by the purchaser. The manual control of a system shall be limited to starting, stopping and level control. The monitoring of all controls shall be undertaken, and such controls should be interlocked with the Plant and Equipment served by the system.

4. PROVISION OF A LUBRICATION SYSTEM

Machine elements that require the application of lubricants continuously or at regular intervals shorter than once per month should be serviced by a lubrication system, unless otherwise agreed by the purchaser.

Any one production line or complete machine e.g. crane, or conveyor system shall be served by as few lubrication systems as possible. Generally, lubrication systems should operate automatically, any exceptions shall be as agreed by the purchaser. Lubrication systems shall be provided with suitable and adequate safety devices.

5. USE OF GREASE NIPPLES

The use of grease nipples should be avoided in the interests of economy of manpower and shall be restricted to application points which are isolated and require attention at intervals longer than once per month. Wherever possible such points shall be piped to an easily accessible central position and connected to a battery plate, piston type metering valve or divider as specified by the purchaser.

6. MINIMISING FRICTION

Machine elements shall be designed to incorporate materials and bearings which will provide low wear rates with minimum lubrication attention. Optimum use shall be made of rolling element bearings, proved self-lubricating materials, anti-scuffing materials and treatments and efficient sealing elements for the exclusion of contaminants and retention of lubricants. Wearing surfaces should be capable of being replaced e.g. by replaceable liners or welded deposits.

7. RATIONALISATION OF COMPONENTS

The rationalisation of lubrication components and equipment for both new and existing plant shall be considered in order to minimise the volume and variety of spares.

8. BULK STORAGE

Consideration shall be given to the stocking of lubricants in bulk and the connection of the storage vessel to the system reservoir.

9. SAFETY

All dangerous parts of a lubrication system shall be securely guarded and comply with the relevant statutory requirements.

Attention is drawn to the information concerning the guarding of machinery contained in BS PD 5304:2005 Guidance on safe use of machinery.

10. NOISE

Lubrication systems as installed shall not cause personnel to be exposed to sound levels in excess of those recommended in International standards. In assessing sound

levels emanating from lubrication systems equipment, the sound levels of other plant, equipment and the effect of structures in the immediate vicinity shall be considered. Sound level measurements shall be made in accordance with best international codes practice, before and after the new installation.

5.5.4 CLASSIFICATION OF LUBRICATION SYSTEMS BY PRINCIPLE OF OPERATION

Lubrication systems are divided into two main categories: -

a. total loss systems
b. circulating systems.
c. Aerosol.
d. Oil/air.
e. Bulk oil storage.
f. Bulk grease storage.

1. TOTAL LOSS SYSTEMS

Total loss systems are those in which none of the lubricant, oil or grease, fed to the application points is returned to the system.

Total loss system types are as follows: -

a. Two Line System

Two supply lines are connected to a pumping unit which through a manually or automatically operated reversing valve pressurizes and relieves each line in turn. Piston type metering valves connected across the supply lines are actuated by the differential pressure in the two lines.

b. Single Line System

The lubricant is supplied under intermittent or continuous pressure through a single line pipe work to injectors, piston type dividers or restrictors which feed the lubricant to the application point.

c. Direct Feed System

This consists of a pumping unit having one or more pumping elements from which a separate line is run to individual application points. This type can provide a sequential or semi-continuous feed.

d. Mist Systems

A mist system is one in which particles of lubricating oil, suspended in compressed air, are piped to the application points.

2. CIRCULATING SYSTEMS

Circulating systems are those in which the lubricant fed to the application point is after use, collected and returned to the system reservoir.

The capacity of a circulating system shall be defined as Small, Medium and Large as determined by the rate of flow of the pump as follows: -

Small: up to and including 45 litres/min.

Medium: above 45 litres/min and up to and including 280 litres/min.

Large: above 280 litres/min.

3. AEROSOL SYSTEMS

Aerosol systems are ones in which minute particles of lubricating oil, suspended in an air stream, are generated at a central point and piped to the application points where the oil mist is converted back to useful oil through specially designed devices. Aerosol lubrication systems are generally divided into two categories:

a. For air line lubrication.

b. For bearings, slides, gears, etc., lubrication.

The difference between the two categories is the size of the oil particles, together with the distance over which they can be transported.

4. OIL / AIR SYSTEMS

Oil/air systems consist of a pump delivering oil via manifolds to injection units where fixed quantities of oil are intermittently fed into an air stream feeding each application point. The air can also act as a cooling medium. The oil is not atomised but is propelled through the small-bore pipework by the flow of air. Oil/air systems are divided into two categories:

a. Small systems having a reservoir capacity up to 22 litres.

b. Large systems having a reservoir capacity over 22 litres.

5. BULK OIL STORAGE SYSTEM

Where it is considered practical the provision of bulk oil storage should be investigated. This method not only ensures immediate availability of the system application oil but also allows the purchase of the oil to be obtained at an advantageous price. Distribution from a bulk oil storage system may be by pipeline or road tanker.

6. BULK GREASE STORAGE SYSTEM

Where it is considered practical, the provision of bulk grease storage should be investigated. This method not only ensures immediate availability of the system grease, but also allows the purchase of the grease to be obtained at an advantageous price. Distribution from a bulk grease storage system shall be by pipeline. Where automatic fill facilities are fitted to grease application system reservoirs, the grease storage system is maintained under pressure.

5.5.5 OIL SYSTEMS

1. GENERAL PRACTICE

a. MACHINES SUBJECT TO WATER WASHING

Parts of machines subject to water washing shall be served by a separate lubrication system. Such systems e.g. a system feeding a bottom driven edger or vertical roll drives or a system serving roller table geared drives subjected to high pressure descaling jets shall be designed specifically to minimise the ingress of water.

b. PLAIN BEARINGS

Oil lubricated plain bearings shall be served by a lubrication system which should be exclusive to the bearings.

c. MACHINES WITH EXTENDED RUN-DOWN TIME

Lubrication systems serving machines with an extended run down time or machines connected with a process which cannot be conveniently stopped within a given time of a system failure, shall be provided with a header tank/gravity feed system or a suitable alternative system of sufficient capacity to maintain lubrication for the run down period.

d. SYSTEM LAYOUT AND ACCESSIBILITY

Pumping stations i.e. pumps, and adjacent system equipment shall be mounted next to the main reservoir. They shall be in a clean area or adequately housed and provided with adequate lifting facilities. The system equipment should be located adjacent to the main reservoir; the remainder should be on or near the machine served by the system.

Main reservoirs shall be located to ensure adequate drainage by gravity from all return points in the system.

The position of electrical control panels and system monitoring panels shall be as agreed with the purchaser.

Indicating instruments, including sight glasses shall be clearly marked and sited so that they are legible from the working floor or a convenient walkway.

System equipment which will or may require adjustment and maintenance shall be easily and safety accessible. Sprays and nozzles shall be accessible for cleaning.

e. PIPEWORK

Pipe work other than that submerged in the lubricant shall be easily accessible for inspection and maintenance. Where pipe work is required below floor level it shall be contained within trenches or ducts. Pipe work shall not be buried. Where pipe work passes through walls or floors it shall be flanged immediately on either side of the obstruction. Fire stopping shall be used to seal any gaps between the pipe and wall. Flange bolts shall be accessible for maintenance. Pipe work in unavoidably hostile environments e.g. exposed to cooling water, descaling water or other corrosive conditions shall be of non-ferrous or stainless-steel pipes. Pipe work which may be subject to mechanical damage shall be adequately protected. Pipe work shall not be attached to or obstruct parts of machinery subject to regular removal. Potential leakage points, particularly hoses and swivel joints shall not be mounted directly above ignition sources. See also Clause 5.9.

f. FLUID CONDITION TEST POINTS

Test points shall be provided to allow representative samples of fluid to be taken for fluid condition tests. The location of these test points shall be as agreed with the purchaser. See also clause 5.2.16.

2. RESERVOIRS

a. NUMBER

Normally one reservoir is required for each system. Where in the opinion of the purchaser or contractor there is the possibility of significant lubricant contamination, particularly the ingress of water, two fully sized reservoirs shall be installed.

b. ACCESSIBILITY

Reservoirs shall be easily accessible for inspection and maintenance.

Where possible the reservoir shall be installed in an oil cellar, basement or other sheltered location. If such a location is not available, then the provision of a

protective housing shall be considered in conjunction with the area operations and hazards.

The floor of the area shall be sloped towards a separate sump complete with pumping facilities.

c. CAPACITY

The capacity of the reservoir shall be based on the sum of the following: -

1. running capacity, that is the product of the rate of circulation and the dwell time. The dwell time for various levels of contamination shall be as specified in Table 1;
2. system capacity, that is the maximum volume of oil that can be drained back to the reservoir;
3. volume of internal fittings and components where significant; free space allowance, which should be between 10% and 20% of the total volume of the reservoir.

TABLE 1

Minimum Dwell Time min	Level of Contamination
40	Potentially high level of water contamination e.g. fluid film bearings for supply rolls in wet mills. Dwell time shall apply to each tank.
30	Considerable risk of contamination by water and or mill scale e.g. gear drives of roller tables adjacent to mill stands. Dwell time shall apply to each tank.
20	Limited contamination e.g. mills gear and steel plant gear systems.
10	Dry conditions e.g. electrical motor bearing systems.

d. DESIGN AND CONSTRUCTION

Reservoirs shall be constructed from rolled mild steel plate in accordance with BS EN 10025-1:2004 and be not less than 4 mm thick.

All internal welds shall be continuous to prevent the lodgment of foreign matter, e.g. grit.

Bottoms of reservoirs shall be sloped towards the drain and away from the pump suction. For systems where the dwell time is 30 mins and above the slope shall be at least 1 in 10. For systems where the dwell time is less than 30 mins the slope shall be at least 1 in 20.

Reservoirs over 1.6 m in height shall be fitted with external steps and an internal access ladder which should have open mesh steel or suitable non slip type treads.

Provision shall be made on the top surface of the reservoir for breathers, threaded or flanged filling point connections and manholes or man equipment access holes. Access holes shall be large enough to allow the passage of complete heating coils, floating suctions and other equipment normally installed within a reservoir. At least one access hole is required in reservoirs for small and medium systems and at least two access holes in reservoirs for large systems. Entrances in the top of reservoirs shall be raised to prevent the ingress of water.

Well protected and accessible means shall be provided to drain off water, sludge and other contaminants and to empty the reservoir.

e. TESTING

Reservoirs shall, before painting, be subjected to a hydrostatic test by filling with water to the total volume an allowed to stand for at least 24 hours. Any leakage or permanent distortion shall be rectified.

The purchaser reserves the right to witness test all or selected items of equipment.

The manufacturer/contractor shall provide documentary evidence of all testing carried out and issue certificates etc. with the QA Documentation.

f. PROTECTION – INTERNAL SURFACES

The main internal surfaces of reservoirs shall be shot, or grit blasted or pickled before the application of any protective coating. The internal surfaces shall be protected by paint compatible with the fluid to be contained in the reservoir.

The paint specification and application method must be included in the QA documentation package.

g. PROTECTION – EXTERNAL SURFACES

External surfaces of reservoirs shall be finish painted as specified by the purchaser before delivery to site. Openings shall be plugged or suitably closed to prevent the entry of contaminants during transport and storage.

The paint specification and application method must be included in the QA documentation package and conform to ES Engineering Standards – PRD-ES-100: General Requirements & PRD-ES-101: Colour Codes.

h. SAMPLE POINTS

Sample points shall be provided in all reservoirs, being situated at the midpoint of the fluid working level.

i. TEMPERATURE CONTROL

To maintain or raise the operating temperature of the oil, heaters shall be fitted to the reservoir. (See - Heat Exchangers.). The application of insulation to the reservoir shall also be considered.

j. MARKING

Reservoirs shall be marked clearly and permanently with an identification plate adequately secured including the following information: -

1. plant register number;
2. main plant items served by the system;
3. fluid grade in accordance with the ESI classification or coding system;
4. reservoir capacity in litres;
5. capacity in litres per 10 mm of dip.
6. CE Mark

k. MOUNTING

Reservoirs shall be mounted either: -

1. over a pit of equal capacity to the reservoir or;
2. on a plinth or support not less than 100 mm high. A layer of bituminized felt shall be provided between the plinth or support and the underside of the reservoir.

l. BREATHERS

All systems shall have breathers to provide an overall ratio of at least 1 to 1000 of breather area to reservoir top surface area.

For systems having a dwell time of 30 minutes and above (see Table 1) breathers of the inverted 'U' type shall be fitted. All other systems shall be fitted with a suitable proprietary make of breather having a protective filter.

m. OIL RETURN

Except where basket type return line strainers are fitted, the oil return pipe shall terminate below the minimum level of the oil and shall be located as far as possible from the suction take off to maximize the settlement of any sediment.

A baffle shall be fitted to the return pipe, to minimise the disturbance of any sediment.

n. MEANS OF SUCTION

On small systems a suction pipe shall be provided to draw oil at 150 mm above the reservoir bottom.

On medium and large systems, a floating type suction shall be provided where the dwell time is 30 minutes and above. Where the dwell time is below 30 minutes a suction pipe shall be provided to draw oil at 250 mm above the reservoir bottom. Medium and large systems shall be provided with a low-level suction. Suction lines shall be as short and direct as possible. The use of elbow and tee fittings should be avoided.

o. LEVEL INDICATION

On small systems oil level indication shall be provided by means of a protected sight glass assembly with a ball check valve and a backing calibrated in litres with white figures on a black background.

On medium and large systems, a dial type float operated contents gauge calibrated in litres shall be provided.

On all systems the system capacity, that is the maximum volume of oil that can be drained back to the reservoir, shall be indicated as appropriate to the type of level indication provided.

Reservoirs equipped to remote filling shall have fitted level indicating and/or controlling devices to prevent overfilling.

p. FLUID CONDITIONING POINTS

To facilitate oil reconditioning the provision of filtration and centrifuge suction and return connections shall be considered and such provision agreed with the purchaser.

q. FILLING AND EMPTYING

For medium and large systems, the fill pipe shall extend to a point accessible to road bulk delivery tanker at which point is shall terminate in a suitably sized connection, compatible with the delivery tanker discharge, protected by a horned closure cap secured to the pipe by a chain. Alternatively, the fill pipe shall be connected directly to the bulk storage tank. The fill pipe shall incorporate a filter of adequate size to permit free filling consistent with the viscosity of the oil. Precautions shall be taken to ensure that the filter always remains in use. Filter elements shall be removable for cleaning. These provisions shall also be considered for small systems; otherwise a gravity drain system shall be incorporated. Emptying the reservoir should be by the fill pipework, using one of the system pumps with the necessary valves and associated pipework.

3. PUMPS

1. TYPE

Pumps shall be of positive displacement, of the single or multi piston type, gear, screw, or vane type as specified by the purchaser and should be driven by independent motors.

2. COUPLING

The coupling shall be of the flexible type and shall have adequate capacity to transmit the power required. If the pump design is such that reverse rotation will automatically cause damage, the coupling between the pump and motor should be of the ‘one way’ type.

3. CAPACITY

The rated capacity shall exceed the rate of circulation by at least 25%. Pumping sets shall be of sufficient power to start circulating at least two thirds of their rated output of oil at the lowest temperature at which the system is expected to start operating.

4. PROTECTION

On medium and large systems pumps shall be protected by a non-return valve and a pressure relief valve piped directly to the reservoir. On small systems pumps may be fitted with integral relief valves.

5. STANDBY PUMPS

Automatically controlled standby pumps shall be provided for Medium and Large Systems. See also clause 5.7.1.

6. MOUNTING

Pumps shall be mounted at least 100 mm above the maintenance working surface. They shall be securely mounted to ensure alignment under operating conditions.

7. GUARDING

All moving parts shall be fully enclosed by suitable guarding in accordance with appropriate International and National Standards.

8. MARKING

Pumps shall be marked clearly and permanently with an identification plate adequately secured including the following information: -

1. manufacturer
2. type number
3. serial number
4. direction of rotation.
5. CE Mark

4. PRESSURE VESSELS

Pressure vessels shall comply with the relevant statutory requirements.

Means shall be provided for venting residual pressure from the system prior to opening the inspection cover.

Normal oil capacity should be equivalent to 4 minutes normal supply unless otherwise agreed e.g. where plain bearings are not involved.

Level indicators shall be provided

Marked clearly and permanently with an identification plate adequately secure including the following information:

a) CE Mark
b) Pressure Rating of vessel.
c) Manufacturer
d) Type Number
e) Serial Number

5. HEAT EXCHANGERS

a. HEATERS

It is desirable to supply lubricant to a plant or machine within a specified viscosity range and to ensure that this is maintained it is necessary to:

a) Heat the oil in the reservoir to a minimum start up temperature or higher to effect air or water release.

b) Cool the circulating oil to remove heat introduced during the operation of the system.

c) Insulate the reservoir and/or pipework to reduce unwanted heat loss or gain.

Heaters shall be fitted to reservoirs unless otherwise specified. The normal operating bulk oil temperature shall be 38°C but the heating system shall be rated for continuous operation at 50°C and be capable of heating static oil in the reservoir to 85°C. Finned tube heaters shall not be used in systems containing leaded EP oils or subject to possible appreciable ingress of solid contaminants.

The heating system shall be capable of raising the lubricant from 9°C to the operating temperature in not more than 8 hours. Heater ratings shall not exceed those specified in Table 2. Heaters shall either be steam or electric as specified by or agreed with the purchaser.

b. ELECTRIC HEATERS

Electric heaters shall be of the immersion type with an individual maximum rating of 3 kW. The element shall be enclosed in an oil tight sheath and shall be renewable without loss of oil. Electric heaters shall be controlled by: -

a) a minimum/maximum thermostat and

b) a present maximum temperature cut out.

c) low level switch

Table 2

Heater Type	**Conditions**		
Electric	**Viscosity**	**Max Rating kW/m^2**	
	cSt @ 37.8°C	**Non-leaded Oils**	**Leaded Oils**
	68 68 to 220 220 to 460	16 11 8	11 8 5

c. COOLERS

Coolers shall be provided where necessary to maintain the operating oil temperature using water as the cooling medium. Tubular coolers or we could give plate type as an alternative?) shall be installed in the vertical plane with adequate space allowed to enable the tube stack to be removed for maintenance. The lubricant bypass arrangement shall be fitted to facilitate ease of maintenance and the valve arrangement such that it will not be necessary to isolate the main system when the bypass is being worked on. Automatic thermal controls shall be fitted unless otherwise agreed with the purchaser.

The water pressure shall always be lower than the oil pressure and the water coolant flow shall be isolated when the oil system is shut down.

The water cooler shall be marked clearly and permanently with an identification plate adequately secured including the following information:

a) Manufacturer.
b) Model or type.
c) Serial number.
d) CE Mark

6. FILTRATION AND SEPARATION

a. DESIGN

Filter systems shall be designed for the continuous removal of foreign matter from the oil in circulation. The degree of filtration shall be consistent with the application requirement of the circulation oil system. Filters shall be sized so that they will filter the maximum pump displacement within acceptable limits for pressure drop.

The system shall include fill line strainers and may include suction and return line strainers.

For wet systems, water traps shall be provided which shall drain into an open tundish.

b. PRESSURE LINE FILTERS

On small systems a manually operated self-cleaning filter is a minimum requirement.

Medium and Large systems shall be fitted with duplex filters or automatic self-cleaning filters.

c. MAGNETIC FILTERS

Magnetic filters, when specified by the purchaser, shall be fitted in the return line.

d. CENTRIFUGAL SEPARATION

Wet systems shall be provided with centrifugal separation.

For other systems necessitating the removal of finer solids and immiscible fluids, centrifugal separation shall be considered.

e. INSTALLATION

Filters shall be constructed and installed so that their elements can be maintained without removing pipe work, incurring fluid loss or the necessity to stop the system. Filters which are fitted with a drain shall be mounted so that the drain is not less than 450 mm above the maintenance floor level.

f. MARKING

Filters shall be marked clearly and permanently with an identification plate adequately secured including the following information: -

1. manufacturers name and brief address
2. type designation
3. element code of reference
4. direction of flow
5. degree of filtration in µm.
6. CE Mark

g. CONTROL

Indication of filter condition shall be provided using pressure gauges before and after the filter.

Where required by the purchaser, this indication shall be linked to the electrical alarm circuit using a differential pressure switch.

7. PRESSURE AND FLOW CONTROL

a. PRESSURE LIMITS

Unless otherwise stated, a lubricant supply pressure of 1.0 bar (gauge) shall be maintained at the application points. Pumps shall therefore be rated so that the end of line pressure shall be 2.1 bar g. Pressure switches shall be provided to control the operation of standby pumps (see also clause 5.3.5).

b. REGULATION

Orifices and jets shall be designed to control the lubricant flow requirements at the application points. Individual orifices and jets shall have a minimum restriction 1.6 mm diameter. Manually controlled valves or cocks shall not be used to regulate flow.

8. INSTRUMENTATION & MONITORING

a. RESERVOIR INSTRUMENTATION

A device shall be provided to indicate the oil level within the reservoir (see clause 5.2.15). Medium and Large Systems shall be provided with high and low oil level sensors which shall initiate either visual or audible alarms.

Medium and large systems shall be provided with high and low oil level sensors which shall initiate either visual or audible alarms. The limits shall be readily adjustable and indicated on the display panel. A temperature indicating device shall be fitted.

b. FILTER INSTRUMENTATION

On all systems the differential pressure across the filer shall be indicated.

On Medium and Large systems where a full flow filter is fitted pressure gauges and pressure differential switches shall be provided.

c. CONDITION MONITORING

System operation shall be monitored by visual and or audible alarms, the initiation of which may be by various devices e.g. flow switches, level switches, pressure switches and timers. The results from the monitoring instruments shall be transmitted to a control centre. Where indicator lights are used, they shall be grouped on a common display panel and shall be in accordance with BS 4099 (IEC 73). Typical monitoring conditions are: -

1. line systems; failure to complete a cycle
2. lubricant levels in reservoirs
3. high and low system pressures
4. high and low flow rates
5. high and low temperatures
6. special warning requirements, e.g. pressure drop across an automatic filter
7. pump selection
8. reservoir selection of twin reservoir systems.

Where display panels are installed, all the above typical monitoring conditions should be incorporated.

A specific requirement may be to stop the plant in the event of a system failure.

9. PIPEWORK

a. SUCTION AND RETURN PIPEWORK

To ensure pressure losses remain low, suction pipe runs shall be kept as short and direct as possible. Elbow and Tee pieces shall be kept to a minimum and the use of Tee pieces directly before the pump inlet shall be avoided. Return pipework shall be sized to run not more than half full. The pipework shall be sloped back to the reservoir at a slope of preferably not less than 1 in 20, with a minimum of 1 in 40.

Pipe up to and including 150 mm nominal size shall be in accordance with EN 10255 or equivalent Medium or Heavy tube.

Pipe over 150 mm nominal size shall be hot finished seamless or electric resistance welded in accordance with BS EN 10216-1:2002, BS EN 10217-1:2002 or equivalent.

b. PRESSURE PIPEWORK

For pressures up to and including 16 bar pipes shall be as for suction and return pipe work in accordance with clause 5.9.1. For pressures above 16 bar pipes shall be in accordance with one of the following: -

1. cold drawn seamless or electric resistance welded steel pipe in accordance with BS EN 10216-1:2002 or equivalent.
2. stainless steel pipe in accordance with BS EN 10217-7:2005 or equivalent.

c. PROTECTION OF PIPEWORK

Pipe work whether fabricated or in straight runs shall be delivered to site with the bores free from scale and corrosion and the ends securely capped. The bores shall be protected against corrosion by a coating of an anti-corrosive fluid which has water displacing properties, and which is compatible with the system lubricant.

d. FLANGES

For pressures up to and including 16 bar flanges shall be in accordance with BS EN 1092-1:2007 or equivalent.

10. PIPE AND TUBE FITTINGS

Pipe and tube fittings shall be suitable for the duty.

11. HOSES

Hoses shall be of two wire braid construction and shall be fire resistant. Hose assemblies should have machine swaged end fittings with female running nuts at each end.

Consideration shall be given, where appropriate, for the use of nonconductive hose e.g. on automatic welders, large motors.

12. INSTALLATION

a. PIPEWORK FABRICATION

Joints in long runs of steel pipe work shall, wherever possible be welded to form continuous lengths.

Socket welding fittings shall be in accordance with BS 3799 or equivalent.

Butt welding fittings shall be in accordance with BS EN 10253-1:1999 and BS EN 10253-2:2007 as appropriate.

For design pressures up to and including 16 bar welding shall be to Class II quality, in accordance with BS 2971 or equivalent. For design pressures above 16 bar welding shall be to Class I quality in accordance with BS 2633 or equivalent.

Bends and offsets shall be cold formed in a standard pipe bending machine wherever possible. Bends shall be used in preference to elbow fittings. Elbow fittings shall only be used where space restricts the use of bends.

b. PRESSURE PIPEWORK

Pressure pipe work shall be installed so that the oil will drain back either to the reservoir or to an item of plant. Rises and down loops etc. should be avoided. Where these are unavoidable, suitable vents and drains shall be provided.

For medium and large systems, a means of draining the pressure pipe through a valved bypass back to the reservoir shall be provided.

c. RETURN PIPEWORK

Return pipe work shall be sized to run not more than half full. The pipe work shall be sloped back to the reservoir at a slope of preferably not less than 1 in 20 and with a minimum of 1 in 40. Advantage shall be taken of the maximum slope that can be obtained.

d. PIPE SUPPORTS

Pipe work shall be adequately supported and securely fixed at regular intervals as specified in Table 3. Pipe work shall be adequately supported and securely fixed immediately before and after a bend or offset.

Pipe and tube clips shall be used solely on the outside diameter of the pipe or tube for which they are designed.

Brackets for multi-line pipe work running in parallel shall be installed so that the spacing between adjacent pipes is not less than a dimension equal to the largest diameter or the pipes installed.

Table 3

Nominal Size	6 to 10	15 & 20	25 & 32	40 and above
Outside Diameter (mm)	6 to 16	18 to 25	28 to 50	
Maximum Pitch of Pipe Supports (m)	0.5	1.0	2.0	3.0

e. FLANGE JOINTS

Flanges and flange joints shall have full face contact. Flange bolts shall be complete with nut and washer. Bolts shall engage the full nut and extend no more than two full threads past the outer face of the nut when fully tightened.

Tightening of bolts shall be to the prescribed torque setting.

f. HOSES

Hose assemblies shall be installed so that: -

1. each hose is of the correct length
2. motion is in one plane and torsion stresses are avoided
3. short radii and ‘S’ bends are avoided. Wherever possible the minimum bend radius should be 50% greater than that specified in BS EN 853:1997. Swept elbow fittings shall be used where sharp changes in direction are necessary
4. they are securely supported and are not allowed to become twisted or compressed.

5. they do not rub against other hoses, machinery or structures
6. they are protected against damage and are restrained if their failure would constitute a hazard.
7. they are easily and safely accessible for inspection and maintenance.

g. GUARDING

All moving parts of the lubrication system shall be fully enclosed by suitable guarding in accordance with appropriate International or National Standards and statutory requirements.

13. COMMISSIONING

a. CLEANING OF PIPEWORK

The completed system shall be purged clean of any foreign and harmful substance. The cleaning method which shall be agreed with the purchaser should be one or a combination of any of the following processes: -

1. removal and light hammering with physical cleaning prior to the flushing procedure require in clause 5.13.2.
2. removal and subsequent immersion pickling.
3. in situ circulating pickling.

Where and after processes (b) and (c) have been used, the acid solutions shall be effectively neutralised and pipe bores temporarily protected with an anti-corrosive fluid with water displacing properties and which is compatible with the system lubricant. Pipe work and fittings shall not be left for any length of time without the application of the anticorrosive fluid.

Where process (c) is used as the sole means of cleaning, effective precautions shall be taken to ensure that there is no entrapment of the pickling acid, flushing fluids or any sediment. All such entrapment areas shall be fitted with suitable plugged outlets.

b. FLUSHING OF THE SYSTEM

Lubrication systems shall be final flushed using a suitable flushing oil initially at a temperature of 80°C reducing to 20°C and raising again to 80°C. Pipe work, particularly in the area of welded joints, shall be hammered during the flushing period to assist in loosening any scale or foreign matter in the system. During flushing the permanent filter, pressure vessel, cooler and final application points shall be bypassed using hoses, pipe or tube as cross connections. For Medium and

Large systems flushing shall be affected on a continuous basis through a temporary return line filter for a period of not less than 24 hours and thereafter until the system is clean, following which the pipe work and all entrapment points shall be drained. For Small systems the conditions and duration of the flushing operation shall be agreed between the contractor's commissioning agent and the purchaser. The flushing oil shall be removed from the reservoirs and the reservoirs shall be thoroughly cleaned prior to the introduction of the system lubricant.

14. ACCEPTANCE REQUIREMENTS

a. TESTING

A pressure and operating test shall be applied to the complete assembled system.

The system shall be filled with the lubricant specified and pressurised to the maximum working pressure using the system pumps including the standby pumps.

All air shall be released from the system.

The test pressure shall be maintained at maximum system working pressure for at least 6 hours during which time continual checks for external leaks shall be made.

All leaks shall be rectified, and all connections proved fully leak proof before the system is considered acceptable.

Leaking connections in high pressure lines shall be tightened only after the pressure in the line has been reduced below 3.2 bar or to return line pressure.

The purchaser reserves the right to witness all or selected tests.

b. RECORDS

On completion of all testing and when the system is acceptable by the user the following information shall be recorded by the contractor's commissioning engineer:

1. operating pressure settings of the system in bar
2. pressure at which the standby pump is energised in bar
3. pressure at which the low-pressure switch operates in bar
4. pressure at which the warning devices operate in bar
5. differential pressure switch settings
6. heating element setting

7. cooling element settings
8. high/low level switch settings
9. safety device settings
10. end of system pressure in bar
11. flow rate at each point of application in litres/min
12. sound levels in dB(A) (see clause 3.10).

Such records shall be used as the purchaser's fingerprint document for the system.

5.5.6 GREASE SYSTEMS

1. GENERAL PRACTICE

Direct feed systems may if the application conditions warrant, include primary and secondary dividers in the supply lines. Bursting discs shall be provided in the supply pipes to the primary dividers to protect the pump. The use of secondary dividers, however, should be avoided. Only primary dividers should be considered for two-line systems.

Single line systems shall not be used unless specified by or agreed with the purchaser.

The system shall be sized to operate with a grease of No. 2 NLGI rating and a maximum flow of 70 kg/h.

Where pipe work or metering elements are unavoidably located in hostile environments they shall be adequately protected as agreed with the purchaser. Pipe work shall not be attached to or obstruct parts of machinery which is subject to regular removal.

The provision of tee-in grease nipples in critical areas shall be considered and discussed with the purchaser.

Indicating instruments and devices shall be clearly marked and be legible from the working floor or convenient walkway.

System equipment which will or may require adjustment and maintenance shall be easily and safely accessible.

The system pressure shall be agreed with the purchaser.

All isolation valves shall have an individual and unique identification number and adequately secured to an agreed position adjacent to the valve location.

2. RESERVOIRS

a. CAPACITY

Reservoir contents which are not automatically replenished shall have a supply capacity of at least one week.

b. DESIGN AND CONSTRUCTION

Reservoirs shall: -

1. be of a metal construction with a positive means of attachment to the pump base which shall not involve the use of an adhesive.
2. have a screwed, toggle clipped or bolted top which will remain sealed during level checks and replenishment.
3. prevent the ingress of liquid or solid contaminants
4. ensure positive pump prime
5. provide an effective means of level indication
6. have a bottom fill connection to enable the reservoir to be filled through a sealed circuit. The fill connection shall be equipped with a strainer.
7. have means of eliminating pressure build up during filling.
8. have adequate facilities for emptying and cleaning with adequate and safe means of access.

c. FILLING FROM BULK SUPPLY

Consideration shall be given to the replenishment of reservoirs by bulk supply or by remote filling. Such reservoirs shall have supply and pressure relief connections of adequate size. Consideration shall also be given to the provision of level indication and controlling devices which prevent over filling. Provision shall be made so that when filling points to the reservoir are disconnected, they can be immediately sealed or capped to prevent the ingress of contaminants.

3. PUMPS

a. CAPACITY

The rated capacity shall exceed the basic system capacity by at least 25%.

b. MOUNTING

Pumps should be driven by independent motors and shall be mounted in a sufficiently rigid and suitable manner to ensure alignment under normal operating conditions, e.g. workload, temperature variations.

Pumps and their drives shall be mounted where they are adequately protected from damage and are easily and safely accessible for maintenance purposes.

c. DRIVE COUPLINGS

Solid or flexible drive couplings shall have adequate capacity to transmit the power required. Where the pump is designed to rotate in one direction only a one-way type coupling shall be fitted between the motor and pump.

d. PUMPS OPERATED THROUGH LINKAGES

Pumps that are mechanically operated through linkages shall be so mounted that neither the actuator nor pump is subjected to deflection load. When the linkage is dismantled, the pump driving arm shall be capable of being rotated through 360° for pump and system testing.

e. MARKING

Pumps shall be marked clearly and permanently with an identification plate adequately secured including the following information: -

1. manufacturer
2. type number
3. serial number
4. direction of rotation
5. CE Mark.

4. METERING DEVICES

Two-line metering elements should be of a design which requires that the internal valve or piston be lapped into their respective bores. They shall be fitted with an adequately protected indicating device and means to adjust lubricant delivery. Suitable identification shall be stamped on each manifold.

Each element of a progressive divider shall be stamped with a suitable indication of grease delivery and whether the divider is cross ported. Indication of operation shall be provided if required.

5. GREASE NIPPLES

Where it is agreed by the purchaser that grease nipple batteries should be used, the grease nipples shall be spaced to give not less than the minimum clearance specified in BS 1486 or equivalent.

For normal applications grease nipples should be G$^1/_4$ ($^1/_4$ BSP) steel hook on type in accordance with BS 1486: Part 2 or the brass hook-on type in accordance with BS

1486: Part 1. In recessed locations which limit the use of hook-on nipples, a straight hydraulic nipple in accordance with BS 1486: Part 1 or equivalent shall be used.

6. INSTRUMENTATION AND MONITORING

a. CONTROL

Automatic intermittent system cycle time may be controlled by electrical or mechanical timers or by impulse counters. Direct feed systems may also have the cycle time controlled in the same manner but may require a separate process timer for the pump operation period.

b. MONITORING AND WARNING

Methods of warning of system failure include audible alarms, indicator lights etc. Where coloured indicator lights are used they shall comply with BSEN 60073:2002 or equivalent.

Initiation of warning may be by various devices e.g. flow switches, level switches, pressure switches and timers.

Typical uses of alarms are:

1. line systems; failure to complete a cycle
2. lubricant levels in reservoirs and tanks
3. high and low system pressures.
4. failure of line metering elements.

7. PIPEWORK

a. MAIN LINES

Steel pipes shall be in accordance with EN 10255:2004, heavy tube and shall be selected from the size range and up to the pressures specified in Table 4.

Table 4

Nominal Size	Maximum Working Pressure bar
20	400
25	300
40	100
50	70

Pressures state in Table 4 may be exceeded in certain circumstances dependent on the conditions of use, e.g. straight runs.

b. BRANCH AND DISCHARGE LINES

Unless exceptionally vulnerable to damage, small branch and discharge lines shall be either 6 mm, 10 mm or 12 mm outside diameter pipe and shall be in accordance with one of the following as specified by or agreed with the purchaser: -

1. Cold drawn seamless steel tube.
2. Cold finished seamless stainless-steel tube.
3. Brass tube.
4. Copper tube deoxidized non-arsenical copper grade.
5. Nylon or other suitable plastic material.

c. PROTECTION OF PIPEWORK

Pipe work whether fabricated or in straight runs shall be delivered to site with the bores free from scale and corrosion, the ends securely capped, and the bores protected as for oil systems in accordance with Clause 5.9.3.

The bores shall be protected against corrosion by a coating of an anti-corrosive fluid containing water displacing properties, and which is compatible with the system fluid.

8. HOSES

Hoses shall be selected as for oil systems in accordance with Clause 5.11.

Consideration shall be given in high temperature applications for the use of all metal flexible hoses or polymer/metal high tensile hose having an inner core of PTFE with a stainless-steel braid outer covering.

Consideration shall be given, where appropriate, for the use of non-conductive hose, e.g. on automatic welders, large motors.

Suitable alternative hose shall only be used with the purchaser's consent.

9. PIPE AND TUBE FITTINGS

a. FITTINGS FOR MAIN LINES

Fittings shall be either: -

1. wrought steel fittings in accordance with BSEN 10241:2000 or equivalent
2. compression couplings in accordance with BS 4368 Part 1 or equal.
3. Welded fittings in accordance with BS 3799.

b. FITTINGS FOR BRANCH AND DISCHARGE LINES

Fittings shall be of the cap nut male type in accordance with BS 2051 Part 1 or equivalent.

Olives for fittings shall be suitable for metric size tube. The dimensions of the hexagons across the flats shall correspond with ISO bolt and nut sizes.

Where, because of space limitations, the use of standard fittings is not possible suitable alternative fittings may be used as agreed by the purchaser.

10. INSTALLATION

a. PIPEWORK FABRICATION

Fabrication and welding shall be as for oil systems in accordance with Clause 5.12.1.

The use of elbows shall be kept to a minimum. Bends and offsets shall be cold formed in a standard pipe bending machine wherever possible. Bends and offsets shall not be formed using oxy-acetylene or other heat generating appliance. Pipe connections shall be used to facilitate the replacement of a section of pipe work. In multi-line pipe work pipe connections shall be staggered to provide access for maintenance.

Welded branch connections should be used in preference to screwed tees. Suitable sockets or couplers shall be welded to the main pipe and after welding a hole shall be drilled in the pipe equal in size to the internal diameter of the socket or coupler.

During installation every precaution shall be taken to prevent future contamination of the lubricant. Steel pipe and tube ends shall be cleaned and de burred prior to assembly. Tube in the 6, 10, and 12 mm range shall be cut with wheeled cutters after which the edges shall be reamed to restore the bore to its correct dimensions.

b. PUMPS

Motor driven pumps, where appropriate, shall be mounted on a preformed concrete plinth or steel fabricated base of at least 450 mm high. The concrete plinth or steel base shall be securely fixed to the floor, platform or area upon which it stands.

c. PIPE SUPPORTS

Pipe work shall be adequately supported and securely fixed as for oil systems in accordance with Clause 5.12.4.

d. HOSES

Hose assemblies shall be installed as for oil lubrication systems in accordance with Clause 5.12.6.

11. COMMISSIONING

a. CLEANING

The completed pipe system shall be blown out by compressed air before the introduction of the lubricant. Where compressed air is not available the pipe system shall be purged clean by a method approved by the purchaser.

Before the commencement of cleaning and in order to prevent the retention of any contaminants, plugs shall be removed from all main pipe bleed points and all feed connections removed from all metering devices and application points to ensure that there is no entrapment of foreign substances.

Documentary evidence shall be provided to show the final level of contaminant in the system after cleaning and prior to use in production.

b. CHARGING THE SYSTEM WITH LUBRICANT

Pipes and tubes shall be charged with the system lubricant using either a mechanical or air operated pump. Extreme care shall be taken to prevent and eliminate air pockets. When air free lubricant flows evenly from each bleed point and feed connections, these shall be progressively refitted commencing nearest the pump.

12. ACCEPTANCE REQUIREMENTS

a. PRESSURE TESTING

All connections shall be proved to be fully leak proof before the system is accepted.

Systems that require alternate high and low pressures in the main line to complete a cycle of operation shall be pressurised to 125% of the system working pressure and shall be held for 30 minutes without the further operation of the pump.

Pressure Testing shall be in accordance with the agreed International or National Standard.

NDT testing must conform to the applied International or National Standard

The purchaser reserves the right to witness test all or selected items of equipment. All tests should be included in the Project Programme.

b. RECORDS

On completion of all testing and when the system is acceptable by the user the following information shall be recorded by the contractor's commissioning engineer and submitted to the purchaser: -

1. pump operating pressure in bar
2. end of system or return pressure in bar
3. timer interval
4. system pumping time
5. safeguard timer setting
6. metering elements operating satisfactorily.

Such records shall be used as the purchaser's fingerprint document for the system.

c. DOCUMENTATION

On successful completion of the project the contractor shall issue to the purchaser the following documentation for the safe operation and maintenance of the Plant:

1. Manuals - Operation and Maintenance manuals to be supplied in an electronic format and 1 off hard copy, the format shall be in accordance with ES Engineering Standard: PRD-ES-110 – Engineering Documentation, project specific to be agreed with ES.
2. Drawings

   Drawings supplied to be in accordance with ES Engineering Standard: PRD-ES-110 – Engineering Documentation.
3. QA Documentation

   Final Conformity Documentation, which will contain the following: -

   - Material Test Certificates
   - Welding Material Certificates
   - Welders Qualifications
   - Welding Map
   - Welding Procedures
   - Weld Test Records
   - Welders Matrix
   - Weld Repair Records.
   - NDT Testing Records

- NDT Inspector Qualifications
- Pressure Test Certificates.
- Non-Conformity Reports
- Third Party Certification
- Painting Records – specification/application/thickness checks.
- Consumable Test Certificates
- Design Documentation
- Any third-party documentation
- Any Check Lists
- Any Audit Sheets
- Any other documentation submitted in a Quality Documentation Package under the applied International or National Standards.

The documentation shall be fully traceable.

ESI reserve the right to audit or request sample documentation through various stages of the project.

5.6 Compressed Air Systems

5.6.1 GENERAL

Systems should be designed to use only proven manufacturer's parts and be identical to those used in existing ES equipment where practicable e.g. Atlas Copco GA200 / GA250.

The design, fabrication, installation, commissioning, testing, and certification of the compressed air systems shall conform to ASME VIII. Deviation from this Standard shall only be done with the agreement of the ES representative.

Heavy duty cylinders should be used with internal cushioning.

A dedicated instrument compressed air system should be provided, and air piped to all plant areas.

In addition to main system reservoirs, additional reservoir capacity should be installed as required in areas of high-volume consumption in order to maintain the cycle times required by the equipment.

Installed capacity should be not less than that necessary to fulfil both equipment requirements and general-purpose requirements and provisions should be made for future additional compressors.

The compressor house should be remote to the plant, enclosed and designed with ease of maintenance and cleanliness in mind. The compressor house should have an integral EOT crane and good mobile plant access e.g. forklift. The compressor house shall have adequate ventilation to allow for heat generated from the compressor equipment.

Consideration should be given to vibrations of the compressors and pipe distribution system and appropriate measures incorporated.

A ring main distribution system is the preferred option for the factory compressed air system.

Adequate cleaning treatment (pickling, flushing, mechanical dirt removal, passivation or any other required procedure) must be performed by the Contractor to ES's satisfaction prior to any kind of cold test of the system.

The system shall provide air quality to a minimum of ISO 8573.1 2.4.3. In warm climates the dew point requirement may be relaxed if agreement is obtained from ES.

Where lubricated air is required appropriate lubricators shall be provided locally.

For further information on instrument quality compressed air refer to ES Engineering Standard: PRD-ES-08 - Instrument Compressed Air Supplies.

Consideration shall be given to designing the equipment such that noise levels are kept to a minimum without affecting the efficiency of the Plant.

Where a manufacturer is producing equipment that requires the intervention of a responsible authority, the manufacturer should inform the responsible authority of his intention to subcontract so that the responsible authority can take part in the subcontractor surveillance.

5.6.2 DEFINITIONS

1. **accumulator**

   Vessel, normally cylindrical, which is used to store fluid or gas for future release of energy in the compressed air fluid and gas. Normally contains a diaphragm or piston between the fluid (liquid or air) and gas chambers. Fluid is normally introduced at one end and the gas at the opposite end**.**

2. **pressure equipment**

   vessels, piping, safety accessories and pressure accessories;

   Where applicable, pressure equipment includes elements attached to pressurised parts such as flanges, nozzles, couplings, supports, lifting lugs etc.

3. **pressure vessel**

   housing and its direct attachments up to the coupling point connecting it to other equipment, designed and built to contain fluids under pressure

   A vessel includes its direct attachments up to the coupling point connecting it to other equipment. A vessel may be composed of more than one chamber.

   NOTE - A vessel may be composed of more than one chamber.

4. **fluid**

   gas, liquid and vapour in their pure phase as well as mixtures thereof

   NOTE - A fluid may contain a suspension of solids.

5. **piping**

   pipe or system of pipes, tubing, fittings, expansion joints, hoses or other pressure-bearing components, intended for the transport of fluid, connected and integrated into a pressure system

6. **assembly**

   several pieces of pressure equipment assembled by a manufacturer to constitute an integrated and functional whole

7. **pipelines**

   piping components intended for the transport of fluids when connected for integration into a pressure system;

   Piping includes a pipe or system of pipes, tubing, fittings, expansion joints, hoses, or other pressure-bearing components as appropriate. Heat

exchangers consisting of pipes for the purpose of cooling or heating air shall be considered as piping.

8. **safety accessories**

   devices designed to protect pressure equipment against the allowable limits being exceeded;

   Such devices include devices for direct pressure limitation, such as safety valves and bursting discs, etc., and limiting devices which either activate the means for correction or provide for shutdown or shutdown and lock out, such as pressure switches or temperature switches, etc.

9. **aftercooler**

   heat exchangers cooling air or gas from compressors.

10. **air receiver**

    a receptacle which serves to store the compressed air for the heavy demands in excess of the compressed air system capacity.

11. **air dryer**

    a device for drying compressed air by means of condensation obtained by means of over-compression or cooling, absorption, adsorption, or the combination of.

12. **reheater**

    heat exchangers for raising the temperature of compressed air to raise its volume.

13. **pressure relief valve**

    a valve actuated by inlet static pressure and designed to open during an emergency or abnormal condition to prevent a rise of internal pressure above a specified value.

14. **silencer**

    a device fitted to reduce and dampen the noise produced when the system is venting.

15. **pressure accessories**

    devices with an operational function and having pressure-bearing housings.

16. **maximum allowable pressure *(PS)***

    maximum pressure for which the pressure vessel is designed as specified by the manufacturer

17. **maximum/minimum allowable temperature (*TS*)**

    maximum/minimum temperature for which the pressure vessel is designed as specified by the manufacturer

18. **absolute pressure**

    the total pressure from absolute zero (i.e. from absolute vacuum**)**

19. **testing group**

one of the four groups designed to specify the extent of non-destructive testing and destructive testing necessary in association with joint coefficient, material grouping, welding process, maximum thickness, service temperature range

NOTE 1 - The testing group of a vessel is not linked to the hazard category.

20. required thickness

thickness excluding corrosion or any other allowances in ASME VIII

21. hazard category

category of the pressure vessel considering the potential hazards

22. testing factor

a factor considering the amount of NDT testing in castings, applied on the nominal design stress

23. material manufacturer

individual or organization that produces material in the basic product form used in the manufacture of pressure equipment

24. manufacturer

individual or organization that is responsible for design, fabrication, testing, inspection, installation of pressure equipment and assemblies where relevant

NOTE 1 - The manufacturer may subcontract one or more of the above mentioned tasks under its responsibility.

NOTE 2 - The manufacturer is responsible for compliance with ASME

25. weldment

weld metal, heat affected zone and adjacent base material(s)

5.6.3 AIR INLET

The air inlet should be positioned such as to inspire cool, clean, dry air. Where appropriate the Contractor shall consider the use of air inlet heat exchangers.

Placement of the air inlet ducting should allow for crane access and to accommodate this underground ducting may be required.

A suitable air filter must be fitted according to the site's climatic conditions, shown on ES Engineering Standard: PRD-ES-003 - Site Information.

In noise sensitive areas consideration should be given to air inlet silencers.

5.6.4 COMPRESSORS

Oil flooded water-cooled screw type compressors are preferred.

Where two or more compressors feed into a single line each compressor's discharge line shall be fitted with an isolating and non-return valve immediately prior to the common line. A pressure relief valve shall be fitted on the compressor side of the isolating valve, or alternatively a self-venting isolating valve may be employed.

Each compressor package will be fitted with a noise attenuation enclosure to ensure noise levels reach the applicable standard.

Adequate standby capacity shall be allowed for to cover maintenance, repair and service periods.

Consideration should be given to the selection of the prime mover:

- Electric motors offer compact installation and ease of control
- Diesel based prime movers are suitable for mobile units and/or emergency standby units only.

Pipes to aftercoolers or air receivers should be regularly cleaned internally to avoid the build-up of combustible oily products.

Consideration shall be given to the maintenance requirement, when two or more compressors are fitted, to allow the safe repair of a compressor whilst the other remain working.

5.6.5 AFTERCOOLERS

The most effective way to remove condensate it to cool the air immediately after it leaves the compressor and to drain the condensate. Coolers shall be of stainless-steel construction not copper.

After-coolers shall be designed according to the ES Engineering Standard: PRD-ES-031 - Pressure Vessels and Tanks Vented to Atmosphere, and International and National Standards.

5.6.6 AIR RECEIVERS

Air receivers should be placed in the coolest location practicable not in direct sunlight. Lagging should not be fitted.

Drain traps shall be fitted at all air receivers.

Air receivers shall be designed according to the ES Engineering Standard: PRD-ES-031 - Pressure Vessels and Tanks Vented to Atmosphere.

Buffer vessels shall be installed wherever high consumption with respect to the peak demand will be required.

5.6.7 DRAIN TRAPS

Automatic drain traps should be selected wherever practicable. Automatic drain traps shall also have a manual drain facility.

Condensate exceeding the maximum allowable level of oil/water shall not be allowed to discharge to ground without further treatment.

Condensate drain lines should be appropriately marked to differentiate them from compressed air lines.

5.6.8 AIR DRYERS

Air dryers can be placed before or after air receivers.

The Contractor shall consider the climatic conditions (see ES Engineering Standard: PRD-ES-003 - Site Information) and the required duty of the air dryer.

5.6.9 RE-HEATERS

Where re-heaters are employed great care must be taken in the selection and use, bearing in mind the risk of explosion.

5.6.10 GAUGES AND OTHER PROTECTIVE DEVICES

Each compressor house will be fitted with standard fire detection and firefighting equipment.

Refer to ES Engineering Standard: PRD-ES-080 – General Requirements (Instrumentation).

5.6.11 PROTECTIVE SWITCHES

For information on thermostatic control switches and flow switches refer to ES Engineering Standard: PRD-ES-080 – General Requirements (Instrumentation).

5.6.12 PRESSURE RELIEF VALVES

Pressure relief valves shall be used to vent the compressed air when excessive pressures are generated.

Pressure relief valves shall reset when the inlet pressure falls below a given value.

5.6.13 AIR DISCHARGE SILENCERS

The Contractor should consider the use of air discharge silencers. Where silencers are employed, they should offer minimum resistance to air flow.

5.6.14 AIR VENT SILENCERS

Where a compressor off-loads through a venting pipe to atmosphere consideration should be given to fitting a coalescing type silencer.

5.6.15 DISTRIBUTION PIPING

Steel piping must be used and be fully welded, ABS or polyethylene pipe are not suitable. Galvanized steel pipe shall be used. The size of pipe used should give a maximum air velocity below 6 m/s.

The pipe distributions system should maintain the appropriate slope to accommodate drainage points.

Flow meters shall be fitted at suitable points to ensure total flow and individual consumer flow can be measured and recorded.

Pipes and electric/control cables shall be ran in separate underground trenches within the compressor house.

Refer to ES Engineering Standards Section 12 - Piping.

5.6.16 COOLING SYSTEMS

Appropriate cooling systems shall be provided, considering the ES Engineering Standard: PRD-ES-003 - Site Information.

5.6.17 CONTROL SYSTEMS

As a minimum each package unit shall have an independent control PLC with the operation logics, safety inter-locks incorporated. Each package is to be connected to the network PLC for LAN control.

Refer to ES Engineering Standards Section 16 - Process Automation.

5.6.18 REDUNDANCY

The system configuration shall be such the Plant has the optimum integrity. Stand by facility must be as follows;

for 3 operational compressors there will be 1 standby.

for 5 operational compressors there will be 2 standby etc.

5.6.19 ACCESS

All Plant and Equipment shall be easily accessible for inspection and maintenance.

Where possible vessels shall be installed in sheltered location. If such a location is not available, then the provision of a protective housing shall be considered in conjunction with the area operations and hazards.

Stairway access shall be provided in preference to cat ladder access. Where cat ladders are necessary, they shall be manufactured with safety hoops and self-closing gate at top of ladder designed to open only onto the platform. Consideration shall be given to the size of the hoops in relation to a person requiring access wearing rescue or BA equipment.

Cat ladder to be securely fixed to ground level allowing concrete plinth on underside. All elevated accessible areas shall be provided with handrails and kick plates.

5.6.20 RATING PLATES

Nameplates shall be made of material suitable for the intended service and with a thickness sufficient to withstand distortion due to the application of the marking and be compatible with the method of attachment. The minimum thickness shall be not less than 1 mm.

Marking shall be done in characters not less than 5 mm high and shall be produced by casting, etching, embossing, debossing, stamping or engraving, including the identification of the Standard applied.

The marking may be applied before the nameplate is affixed to the equipment providing the vessel manufacturer ensures that the nameplate is applied to the correct equipment.

The nameplate shall be attached in such a way that removal would require the willful destruction of the nameplate or its attachment system.

The nameplate shall remain visible and legible for the lifetime of the vessel.

The units of measurement used in marking or stamping the equipment and accessories shall follow the SI units.

The unit “bar” for pressure shall be used.

The nameplate shall contain the following information. As a minimum the requirements of a) and b) below shall be fully marked. Depending on the type of equipment the requirements of c) shall be marked.

a. All equipment
   1) Administrative information
      - vessel manufacturer's name or symbol and address;
      - reference to the International or National Standard applied, i.e. ASME VIII or BS EN 13445, and applicable edition;
      - year of manufacture;
      - type and series or batch identification and serial number identifying the equipment;
   2) Technical data
      - maximum allowable pressure Ps in bar;
      - maximum allowable temperature Tsmax in °C
      - minimum allowable temperature Tsmin in °C;

b. Depending on type of equipment, supplementary information
   - identification of fluids, including warning symbols if applicable;
   - design pressure Pd in bar;
   - design temperature Td in °C;
   - test pressure Pt in bar and date
   - internal volume in L;
   - safety accessories set pressure in bar;
   - equipment output in kW;
   - voltage supply in V;
   - intended use;
   - filling ratio in kg/L;
   - maximum filling mass in kg;
   - tare mass in kg;
   - fluid group;
   - removable parts made traceable to equipment of which they form a part.

c. where necessary, warnings fixed to the pressure equipment drawing attention to foreseeable misuse which experience has shown may occur.

5.6.21 TESTING

Pressure Testing shall be in accordance with ASME VIII, and applicable edition; or the agreed International or National Standard.

NDT testing must conform to the applied Standard.

The method and risk assessment of any Hydrostatic or Pneumatic tests must be carried out with the consultation of ES.

5.6.22 CERTIFICATION

Where applicable it shall be the responsibility to submit the necessary Third-Party certification prior to the Plant being put into production.

All necessary information shall be issued to ES in order that a Written Scheme of Examination can be compiled before the Plant is put into production.

The purchaser reserves the right to witness test all or selected items of equipment. All milestone tests should be included in the Project Programme.

5.6.23 DOCUMENTATION

On successful completion of the project the contractor shall issue to the purchaser the following documentation for the safe operation and maintenance of the Plant:

(a) Manuals -

Operation and Maintenance manuals shall be supplied in electronic format, with a 1 off hard copy. The format shall be in accordance with ES Engineering Standard: PRD-ES-110 – Engineering Documentation, project specific shall be agreed with ES.

(b) Drawings

Drawings supplied shall be in accordance with ES Engineering Standard: PRD-ES-110 – Engineering Documentation as per ESI Drawing Office standard.

(c) QA Documentation

Final Conformity Documentation, which will contain, but not limited to the following: -

- Material Test Certificates
- Welding Material Certificates
- Welders Qualifications
- Welding Map
- Welding Procedures

- Weld Test Records
- Welders Matrix
- Weld Repair Records.
- NDT Testing Records
- NDT Inspector Qualifications
- Non-Conformity Reports
- Third Party Certification
- Pressure Test Certificates.
- Painting Records – specification/application/thickness checks.
- Consumable Test Certificates
- Design Documentation
- Any third-party documentation
- Any Check Lists
- Any Audit Sheets
- Any other documentation submitted in a Quality Documentation Package under the applied International or National Standards.
- CE Mark and documentation.

The documentation shall be fully traceable.

The format of the QA Documentation shall be agreed with ES.

ESI reserve the right to audit or request sample documentation through various stages of the project.

5.7 Hydraulic Systems

5.7.1 BASIC DESIGN INFORMATION

All enquiries or orders placed for new industrial hydraulic systems or modifications to existing industrial hydraulic systems shall be accompanied with the information and details as required by this section.

Where a Department within ES is directly contracting out for the supply of a hydraulic system, the information required by this Standard shall be prepared in conjunction with the engineer responsible for fluid power systems at the particular works or works group.

Where a hydraulic system is the subject of a sub-contract by a plant or machinery manufacturer then it shall be the responsibility of that manufacturer in conjunction with the

ES engineer responsible for fluid power systems at the works in which the plant or machinery is to be installed to provide the information required by this Standard to the hydraulic system subcontractor.

1. **Scope**

   This section lists the items of basic design information that shall be provided to a contractor when enquiring and/or placing an order for an industrial hydraulic system or plant and machinery which includes a hydraulic system. The list is not necessarily exhaustive so that further items of special information shall be included as appropriate.

2. **Role of the Hydraulic System**

   A clear description shall be provided of the purpose and function of the hydraulic system to be supplied. A description of the associated plant or machinery shall be provided where it will be useful in interpreting the purchaser's requirements.

3. **Characteristics of the Hydraulic System**

   A clear description shall be provided of the operation of the equipment and, where appropriate, a sequence of operations together with a time cycle. The type of controls e.g. manual, semi-automatic, automatic as agreed by all relevant parties shall be specified. Where the hydraulic system is required to operate equipment compatible with other units in the process, the necessary details shall be provided.

4. **Hydraulic Actuators**

   Details of hydraulic actuators together with their maximum working pressures shall be provided.

   The following details, which the hydraulic system will have to sustain, shall be specified:

   (a) Desired forces torque and corresponding speeds inertias, accelerations and decelerations.

5. **Reliability of the Hydraulic System**

   Through risk assessment the effects of the malfunction and/or failure of the hydraulic equipment shall be considered and indicated within the context of the overall plant or process operation and availability. The envisaged usage of the equipment in hours per week together with the periods available for service and maintenance shall be stated.

6. **Hydraulic Fluid**

   A formal written risk assessment in line with agreed guidelines shall be undertaken prior to the selection of hydraulic fluid. Implementation of the “actions to control the resulting risk” identified by the risk assessment for the chosen fluid shall then be implemented unless exemption is authorized. The purpose of the risk assessment is to

ensure the type of fluid selected is fit for purpose in the environment it is required to operate in. These environments may contain sources of ignition, and this shall be given the utmost consideration in the process of selection.

Zinc based paints are not resistant to HFC fluids.

7. Special Safety Requirements

Special safety precautions that must be taken to protect personnel and equipment shall be stated. This will enable the hydraulic system supplier to build into the system the necessary protection devices and interlocks.

8. Environmental Conditions

Information shall be provided as to where the equipment is to be installed together with an outline of environmental conditions e.g. temperature range, noise, dust, dirt, humidity, shock and vibration. The duration of exposure to environment is important, as also is any cycle of environmental conditions. Where necessary the maximum sound levels for the equipment shall be specified, e.g. where existing sound levels are approaching the maximum levels recommended.

9. Conditions of Use

An indication should be given of the skill of the personnel available both to operate and maintain the equipment. It may be necessary for the contractor to make provision for operation by unskilled labour and for a certain amount of abuse.

10. Site Limitations

Adequate details shall be provided of any limitation concerning space and access for the installation, construction and subsequent maintenance of the hydraulic system. Such factors may affect the design of the system.

11. Supply Services

The following details shall be provided as appropriate:

(a) Electric supply for motors i.e. voltage (V) and frequency (Hz).

(b) Electric supply for controlling and indicating devices i.e. voltage (V) and frequency (Hz).

(c) Water for heat exchangers; pressure in bar, temperature in °C and quality.

12. Extent of Supply

Details shall be provided of equipment to be included in and equipment to be excluded from the contract e.g. items of 'free issue'. Where the tender is to include for installation and or commissioning the services required shall be clearly stated.

13. Functional Systems Documentation (FSD)

Where functional systems documentation is to be implemented, it shall be stated in accordance with Clauses 2.2.3 and 2.2.4 of this standard.

14. Nominated Subcontractors

Details of nominated or preferred suppliers shall be provided as required.

15. Subcontracts

Where a hydraulic system forms part of a major contract i.e. the subject of a subcontract, it shall be clearly identified.

16. Standards

References shall be made to International or National Standards to which the hydraulic system shall comply. The standards applied shall be agreed with ES.

17. Variations from Standards

Details shall be provided of any unavoidable variations to the applied International or National Standards. Such variations shall be authorised in accordance with the appropriate Standard.

5.7.2 SYSTEM REQUIREMENTS 2.1

1. Discussion

This section deals with hydraulic systems and makes requirements concerning design, safety, identification and documentation. The standard shall also be used for industrial hydraulic systems using fire-resistant fluids. The hydraulic system supplied shall satisfy as a minimum, all International and National legislation and standards, plus any other requirements specified by ES and agreed by the supplier.

The hydraulic system shall be designed in compliance with DIN24346.

2. Documentation

a. Language

Documentation, including drawings, diagrams and maintenance manuals shall be in English.

b. Basic Design Information

Information as required by Section 1 of this standard 'Basic Design Information' shall be supplied to the hydraulic system supplier at the time of enquiry for the equipment.

c. Drawings and Diagrams

Unless otherwise specified the following drawings and diagrams shall be supplied for approval to the ES engineer responsible for fluid power systems before the

commencement of manufacture, system designs that have not been approved, and subsequently do not meet the purchaser's requirements shall not be accepted.

Final drawings and diagrams shall include, but not limited to:

1. Hydraulic circuit diagram in accordance with Clause 2.2.4.
2. Arrangement drawing of power units, valve stations and actuator installation drawings.
3. Pipework layout drawing(s) giving details of all pipe runs, trenches, ducts and associated engineering work.
4. Drawing(s) showing detail of pipe connections to components, e.g. valves, manifolds, filters, actuators.
5. Electric circuit diagram or electric control scheme giving necessary information, e.g. control sequences, interlocks.

d. Circuit Diagrams

1. Preparation

Hydraulic system circuit diagrams shall be prepared:

(a) Using graphical symbols from and in accordance with BS 2917.

(b) So that the graphical symbols represent the units at rest.

(c) So that the circuit is easy to follow. The relative positions of the units symbolised need not necessarily correspond to the actual physical position of the units.

(d) So that crossover lines shall be kept to a minimum.

(e) So that each item has a separate and discreet identification.

(f) So that flow lines between power units and machine are identified at both ends.

2. Contents

Circuit diagrams shall contain the following information:

(a) Identification of all equipment and components by their name, manufacturer's name and manufacturer's catalogue number, serial or design number.

(b) Size and specification of pipes and hose assemblies.

(c) Diameter of each cylinder bore, piston rod, length of stroke in m or mm together with details of any stop tube fitted and the estimated force in Newtons (N) for the intended service.

(d) A clear indication of the function of each actuator.

(e) A clear indication of limit switches operated by the system actuators.

(f) Power in kW, the rev/min and type of each pump prime mover.

(g) Pressure setting in bar of each pressure control valve and pressure switch, updated if necessary, after commissioning.

(h) Capacity in litres/min and type of each filter together with the number and reference details and filtration of replacement elements in µm.

(i) Volume, in litres of fluid to fill the system and reservoir to maximum level indicating where necessary the position of the actuators to which the volume refers.

(j) Specified hydraulic fluid, i.e. description, viscosity grade number and commodity code number in accordance with International or National Standards.

(k) See Clause 2.6.5.

All oils used are to be classified to the following specifications:

- DIN 51 524
- ISO

All oils to be designated as follows:

HH, HL, HLP, HM, HV, for mineral oils.

HFA, HFAE, HFB, HFAS, HFC, HFD, for fire resistant oils.

All oils to be classified to ISO viscosity grades (VG).

(l) A clear indication of any circuitry encompassed by circuit manifolds. Where boundary lines or boundary envelopes are used the boundary indicated shall not include any symbol of a component not mounted on or with the circuit manifold.

(m) Pre-charge gas pressure of accumulators in bar.

(n) Rate of flow in litre/min, inlet and outlet temperatures in °C, energy dissipation in joules (J) for both the hydraulic fluid and cooling medium, maximum working pressure and water pipe connection sizes of heat exchangers.

(o) Circuit diagrams shall contain, or have attached thereto, the following information:

(p) Displacement in cm3 per revolution and the estimated torque output in Nm of each hydraulic motor.

(q) Displacement in cm3 per revolution and the direction of rotation of each hydraulic pump.

(r) A volume draw off chart where the correct operation of the system is dependent upon fluid stored in an accumulator.

(s) A time sequence chart, e.g. time range of cycle, data and or description of operations performed including the functions of the associated electrical and mechanical controls and actuating equipment.

(t) Service information for accumulators in accordance with Clause 2.9.5.3.

(u) Size, type, location and function of test points.

e. Engineering Manuals

Final Operating and Maintenance manuals shall be provided not later than the 'Take over' of the hydraulic system. All literature shall be in English.

1 off electronic copy and 1 hard copy shall be provided to the purchaser.

The manuals shall include, but not limited:

1. Hydraulic circuit diagram.
2. A description of the sequence of operations with details of all necessary safety procedures.
3. Start up and shut down procedures.
4. Details of external lubrication points. The lubricant shall be specified, i.e. description, viscosity grade number of NLGI grade number and commodity code number.
5. Service procedures for unique assemblies.
6. Location of those points and items of equipment that require regular maintenance together with a schedule of maintenance requirements and recommended frequency.
7. Further identification of parts in the system components which are commercially available and manufactured to an established standard that provides for uniform coding. The identification shall be either the manufacturer's part number or as provided by a recognised standard coding. This shall include seal sizes, material and original manufacturers name with code number of all rotary shaft seals and all cylinder seals employed within the scheme.
8. A reference list of drawings related to the system including those required in accordance with Clause 2.2.3.
9. For each accumulator shall contain:
10. Material – mechanical test acceptance certificate.
11. Hydraulic – proof pressure test certificate.

f. Recommended Spares

A list of recommended spares shall be provided within 5 (five) working days of the acceptance of the hydraulic schematics. The list shall include the manufacturer, the complete part number, the drawing item number to which the part relates, and the quantity used within the system.

The contractor shall include in the contract for all necessary commissioning spares.

g. Modifications

Where modifications to the hydraulic system are made during the supply and warranty period, they shall be recorded by the contractor and the appropriate documents revised accordingly and re-issued to the purchaser.

h. Supporting Documentation

Where applicable, all documentation in support of the following pieces of legislation must be forwarded to the purchaser:

1. Supply of Machinery (Safety) Regulations, 1992. Equipment and systems supplied as part of the Contract shall comply with the Supply of Machinery (Safety) Regulations 1992, essential health and safety requirements applicable to them, the related standards in support of the Machinery Directives and the technical file requirements as set out in the Department of Trade and Industry publication 'UK Regulations April 1993 Product Standards: Machinery' Annexes B, C and E.
2. Pressure Equipment Directive 97/23/EC, November 1999. Pressure equipment and systems supplied as part of the Contract shall comply with the Pressure Equipment Directive 97/23/EC, November 1999, essential health and safety requirements applicable to them, satisfy appropriate conformity assessment procedures and carry the CE marking and other information.

All supporting documentation to be forwarded to the Purchaser.

3. Identification

a. Equipment and Components - Marking

Equipment and components shall be clearly and permanently marked with the following information:

1. Manufacturer's name and brief address.
2. Type designation.

3. The appropriate symbol from and in accordance with BS 2917.
4. Maximum working pressure or range of operating pressures in bar.
5. Identification of inlet and outlet ports where the flow is unidirectional.
6. CE Mark.

b. Equipment and Components within a System

Hydraulic components shall be identified by a number and/or letter. This identification shall be marked clearly and permanently on the installation adjacent to, but not on, the component. This same identification shall be used to locate the component on all diagrams, lists and layouts (see Clauses 2.2.4.1 and 2.2.4.2).

Where multiple stage valves are used, each stage shall be given a unique identification and the complete information given in the maintenance manual.

c. Component Ports

Component ports, including bleed points, bulkhead connectors and manifold block ports shall be clearly and permanently marked with an identification as used on the circuit diagram (see Clause 2.2.4.1).

d. Test Points

Test points and their functions shall be clearly and permanently identified with the same identification as used on the circuit diagram.

4. Safety of Personnel and Protection of Equipment

a. General

Equipment, components and pipework shall be so located and suitably protected to prevent damage from external forces, heat and any other hostile environment.

b. Fail Safe Concept

When hydraulic systems are being designed all aspects of possible means of failure shall be considered. Components shall be selected, applied, mounted and capable of adjustment so that in the event of a failure maximum safety to personnel shall be the prime consideration.

Hydraulic systems shall:

1. Operate within the component manufacturer's specifications.
2. Be protected against over pressure, see Clause 2.4.7.
3. Be so designed and applied that surge pressure and loss of pressure cause neither hazard nor damage to personnel, equipment or material being processed.

c. Guarding

All dangerous parts of a hydraulic system shall be securely guarded and comply with the relevant statutory requirements.

Attention is drawn to the information concerning the guarding of machinery contained in BS 5304.

d. Plant Immobilisation

Hydraulic systems shall be so designed as to facilitate safe immobilisation of the equipment or plant of which it forms a part. This is to allow safe access for personnel and maintenance.

Plant immobilisation procedures shall be supplied for each individual function.

For every potential volume within the hydraulic system, which may be separated from any other volume by the location or position of a valve; or by other means. Then a means of dissipation and for the verification and dissipation of that volume, such as a drain valve and pressure gauge or a test point for example must be provided.

Consideration to be given to the supply of isolation valves with locking devices where applicable. Each valve must have a separate and unique identification. This identification shall be clearly displayed local to the valve position and on all drawings and diagrams.

This document shall be supplied to the relevant ES engineer responsible for the item of plant.

e. Noise

Hydraulic systems as installed shall not cause personnel to be exposed to sound levels in excess of those recommended in International standards. In assessing sound levels emanating from lubrication systems equipment, the sound levels of other plant, equipment and the effect of structures in the immediate vicinity shall be considered. Sound level measurements shall be made in accordance with best international codes practice, before and after the new installation.

All pumps/motors are to be mounted on acoustic packings.

f. Emergency Controls

Equipment shall incorporate readily accessible emergency controls. The emergency condition and the position of emergency controls shall be agreed between the purchaser and the contractor considering relevant statutory and local safety requirements.

g. Emergency Pressure Relief

1. Pumps

A pressure relief valve capable of relieving the maximum flow at the outlet of the pump shall be provided on the delivery side of each pump. There shall be no other valve between the pumps and the relief valve.

Where multi-stage pumps are used or pumps are connected in series, pressure overload protection shall be provided for each stage where individual stages can be overloaded.

2. Control Valves

Where control valves in a closed position or in any other circumstances could result in excessive hydraulic pressure in any component or circuit, pressure overload protection shall be of a form which will relieve the full flow of fluid without exceeding the maximum working pressure.

3. Accessibility and Security

Relief valves shall be easily accessible for testing and adjustment. Where specified by the purchaser provision shall be made to restrict unauthorised access and/or adjustment to safety devices.

4. Decompression

Consideration shall be given to controlling the decompression of large volumes of fluid in actuators and pipework at the time of control components operation.

h. Pressure and Flow Control

1. Limit of Adjustment

Pressure and flow control shall be constructed so that they are not adjustable outside the safe working range of the hydraulic system of which they form a part.

2. Loss of Pressure

Where loss of fluid pressure may result in danger to personnel, damage to equipment or material being processed, means shall be provided to prevent operation. A warning system giving a visual and/or audible alarm of such conditions shall be provided.

3. **Relief Valve Return Lines**

   Main return lines from pressure relief valves shall not contain a shut-off valve and shall return directly and individually to the reservoir.

i. **Actuators**

1. **Prevention of Uncontrolled Movement**

   Circuits shall be designed to prevent uncontrolled movement and improper sequencing of hydraulic actuators particularly in vertical and inclined motions during all phases of the equipment cycle which shall include start up, shut down, idling, setting up and hydraulic failure.

   Where there is a risk of injury to personnel or damage to plant due to hose failure, counterbalance or pilot operated check valves shall be surface mounted directly onto the hydraulic cylinder. The valves used shall be of the seated type and are to be leak free, mounted within a steel block.

2. **Trapping Points**

   Trapping points between moving parts of hydraulic cylinders, attachments and fixed parts of machinery and equipment shall be securely guarded or means of access prevented.

   Machine design shall accommodate easy and safe access for adjustment and maintenance of valves, locking pins shall be incorporated as a safety measure, when adjustments to valves must be made where there is a risk of injury to personnel due to trapping points.

5. General Design Requirements

a. Maintainability

1. **General**

   Hydraulic systems shall be designed, constructed and installed so that they can be safely and easily maintained.

   There shall be a minimum loss of fluid when any component or pipe is removed from the system.

   Components shall be capable of removal without disturbing pipework.

2. **Accessibility**

   Components and pipework shall be safely and easily accessible. They shall be mounted and positioned so as not to interfere with the adjustment and maintenance of other equipment.

3. **Isolating Actuator Function**

   Provision shall be made to isolate each actuator function and group of associated functions for safety and maintenance purposes.

   Socket weld or flange type shut-off valves shall be fitted to each actuator function and be sized to give full flow with minimum pressure drop.

4. **Fault Diagnosis**

   Provision shall be made for logical fault diagnosis, using test points, to a level of detail that will locate a fault preferably to one component, but to no more than a choice between two components before it becomes necessary to remove any component from the system. See Clause 2.5.2.

5. **Test Points and Test Equipment**

   Test points shall be provided where necessary to assist in the effective maintenance of the equipment and to meet the requirements of Clause 2.5.1.4. They shall be safely and easily accessible to provide easy connection of test equipment and recording of data. Special test points shall be provided where necessary, e.g. to record heat exchange media data.

   Pressure test point selection shall be specified by or agreed with the purchaser. Where high water-based fluids are employed consideration shall be given to the use of stainless-steel test points. Where applicable, seals shall be compatible with the system fluid.

   A test point shall be provided in the suction line to all pumps adjacent to the pump inlet.

6. **Pressure Gauges**

   Pressure gauges shall be provided to indicate key system pressures. They shall be of the Bourdon tube type in accordance with BS EN 837-1:98 and, unless otherwise specified be filled with glycerine. Maximum scale reading shall be 50% higher than the maximum working pressure. Gauge scales shall be calibrated in bar and selected from the range specified in BS EN 837-1:98.

Pressure gauges shall be protected by isolating valve and a surge damping device. Where gauge selection and push button isolating valve are used, they shall be of the 3-way type such that the pressure source is blocked, and the gauge is vented to the reservoir when the valve is in the normal position.

Other pressure test points shall provide for the easy and quick installation of pressure gauges and should be proprietary quick connecting self-sealing type coupling.

6. System Design Requirements

a. Fluid Leakage

Hydraulic systems and equipment shall be designed so that there shall be no external fluid leakage.

A guarantee against agreed tolerable system leakage losses will be sought before placement of contract and levied at the system builder and/or pipework installation contractor.

Zinc based paints are not resistant to HFC fluids.

b. Flow Lines

Drain lines shall be independent of other return lines. Pilot return lines shall be independent of power return lines.

c. Flow Rates

Fluid flow rates shall be such that induced pressure drops are compatible with the system requirements.

For hydraulic fluids the following flow rates shall not be exceeded:

1. Pressure lines: 4.5 m/s.
2. Return and drain lines: 3.0 m/s.
3. Suction lines: shall not exceed 0.7 m/s or a Reynolds number in excess of 2000, whichever is the less.

Pipework for a fluid less than 32 cSt at 40°C shall be sized as per mineral oil at 32 cSt at 40°C.

d. Compatibility

Full consideration shall be given to the environment in which the hydraulic system is required to operate.

Materials shall be compatible with or adequately protected against hostile environments.

The manufacturer's recommendations for the maintenance of the hydraulic fluid shall be clearly stated and the system designed to allow their implementation. Components and materials shall be compatible with the hydraulic fluid and be in accordance with the manufacturer's recommendations.

Adequate precautions shall be taken to eliminate trouble due to unavoidable incompatibility between the hydraulic fluid, other fluids materials and protective finishes associated with the system in accordance with the manufacturer's recommendations.

e. Hydraulic Fluids - Grade

It is important that from the first conception of equipment design involving hydraulics that the fluid selection shall be discussed with the ES engineer responsible or his representative. (See also Clause 1.6)

Hydraulic fluid shall be selected from and in accordance with the Risk Assessment carried out and International or National Standards.

Unless otherwise specified by or agreed with the purchaser the fluid should be to the ES commodity code number.

f. Standby Pumps and Multi-Pump System

Where the continuous operation of the hydraulic system is critical to the operation of the plant, machinery or process lines it serves, standby pumps or multi-pump systems shall be provided. Each pump in a multi-pump system shall have their individual prime mover, suction filter, pressure line filter, fluid pressure control and associated loading valve where required. Standby pumps and associated controls shall be identical to the main system pumps. An isolating valve to be fitted each side of the pump to allow its removal with the minimum loss of fluid. See also Clause 2.4.7.1.

7. Energy Conservation

a. Pumps and Hydraulic Motors

1. Inlet Conditions

Conditions at the inlet to the pump shall be in accordance with the manufacturer's recommendations in respect of cleanliness, pressure, viscosity and temperature. If there is any doubt, then the pump manufacturers should be consulted for advice.

2. Mounting

Pumps shall be mounted:

(a) Externally to the reservoir.

(b) So that they are adequately protected from damage.

(c) So that when running the pressure at the inlet is positive within the limits of Clause 2.7.1.1.

(d) Where pumps, hydraulic motors and prime movers are in excess of 22 kg weight

(e) they should be fitted with lifting attachments the use of which should not be restricted by any overhead obstruction.

3. Isolation

Means shall be provided to isolate each pump from the hydraulic systems to allow its removal with the minimum loss of fluid.

b. Hydraulic Cylinders

1. General

It is expected that all cylinders manufactured and supplied are capable of safe and reliable operation in the environmental conditions relevant to the application. The design of a cylinder shall be adequate for its intended duty, and:

(a) Its suitability as a strut to withstand imposed axial loads.

(b) Its suitability to accept external loads/impacts as specified.

(c) Its suitability to withstand intensified pressure by load acceleration, deceleration, load reversal and flow controlling effects.

(d) On R 58 H series cylinders all bore, rod and mounting dimensions shall be in accordance with the following standards:

CETOP R 58 H, ISO 6020

On R 73 H series cylinders all bore, rod and mounting dimensions shall be in accordance with the following standards:

CETOP R 73 H, ISO 6020

(e) On applications up to 100 bar, cylinder construction shall be in accordance with CETOP standard R 58 H, or R 73 H if specified by the ES engineer responsible. On applications up to 210 bar, cylinder construction shall be in accordance with CETOP standards R 73 H.

(f) Maximum working pressure of a cylinder shall include intensified pressure on the annulus area when metering out, i.e. a system pressure of 100 bar would require R 73 H standard cylinders, if there is a differential area above 1.5.

(g) Be limited on linear speed to 300 mm/s normally, with 500 mm/s being the maximum with agreement.

2. Sealing

When selecting the material and type of seals the following factors shall be considered:

(a) Ambient temperature.

(b) Speed and frequency of piston reversals.

(c) Constant pressure holding requirement.

(d) Compatibility with the system hydraulic fluid

(e) Hydraulic fluid temperature.

(f) Local environmental conditions

It is acceptable that the same seals used for mineral oils can be used for fire resistant fluids except for HFD fluids. Viton seals must be used for HFD fluids.

The following list provides a summary of different types of seal material for different fluids.

Fluid Group	**Suitable Elastomer**
HL & HLP	NBR, Viton
HFA	NBR, Viton
HFB	NBR, Viton
HFC	NBR, SBR, EPDM, IIR, NR
HFD-R	Viton, EPDM, IIR

8. Valves

a. Mounting Interfaces

Functional valves shall be of the following specifications:

Directional control: CETOP 3, 5, 7, 8 to RP 35 H DIN 24340 ISO 4401. Above CETOP 8 cartridge valves to DIN 24342 should be used

Pressure control: RP 69 H see Appendix J1-J2. NG6, NG10, NG16, NG25 (size 06, 08). Above NG25 cartridges to DIN 24342 should be used.

b. Valves for Use with HWB Fluids

Valves shall have seated or sealed spools that prevent internal leakage and erosion when used with these fluids. Where a spool of conventional design is essential, test data and life expectancy before replacement shall be provided.

Pilot controls shall have the necessary controls for smooth opening/closing under load when using either hydraulic or pneumatic pilots.

c. Electrical Connections

Connection shall be made using a standard 3 pin connector in accordance with BS 6361 or/and DIN 43650.

9. Energy Transmission and Conditioning

a. Piping

1. Design Pressure

The design pressure for steel pipes shall be at least 15 times in excess of the maximum working pressure of the system including intensification.

Pipes up to and including 20 mm outside diameter shall be suitable for a design pressure of 400 bar. Pipes above 20 mm outside diameter up to and including 38 mm outside diameter shall be suitable for a design pressure of 250 bar (unless system pressure exceeds these ratings). See Table 1.

The design pressure for pipes above 38 mm outside diameter shall be selected from the following range:

- 100 bar
- 160 bar
- 250 bar
- 400 bar

Reference shall also be made to ASME VIII/ASTM

2. Dimensions

Pipes shall be specified in terms of their outside diameter and thickness in mm. The resultant bore size shall allow flow rates in accordance with Clause 2.6.3.

Pipes up to and including 38 mm outside diameter shall have outside diameter and thickness selected from the range as specified in Table 1 of this standard and shall be suitable for use with mechanical couplings (see Clause 2.9.3.3) and in accordance with BS 3600 Table 4 or DIN 2391 Part 1.

Pipes above 38 mm outside diameter shall have outside diameter and thickness in accordance with BS 3600 Table 1 and selected from the range as specified in Table 2 of this standard. This table indicates current pipe sizes commercially available within the O/D range of 42.4 mm to 273.0 mm inclusive.

Reference shall also be made to ASME VIII/ASTM

3. Materials

a. Pipes up to and including 38 mm outside diameter shall be cold drawn seamless carbon steel having a minimum tensile strength of 360 N/mm_2 and supplied in the annealed / normalised condition, descaled, oiled and plugged.

   Selection shall be made from either:

   (i) BS 3601
   (ii) BS 3602
   (iii) DIN 2391 Part 2 (to minimum of St 35.4 NBK)
   (iv) DIN 1630 (to minimum of St 37.4 NBK).

b. Pipe sizes above 38 mm outside diameter shall be either cold drawn or hot finished seamless carbon steel having a minimum tensile strength of 360 N/mm_2 and supplied in the normalised condition and supplied descaled, oiled and plugged.

   Selection shall be made from either:

   (i) BS 3601
   (ii) BS 3602
   (iii) ASTMA 106, Grade B
   (iv) API 5L, Grade B
   (v) Hollomek 510/ST 52 – for larger size thick wall pipe.

c. In special circumstances of extreme environmental conditions, the use of stainless steel or copper alloy tubing may be specified by the purchaser. In such cases the ES engineer or his representative shall be contacted to discuss the pipe selection and the specialised subjects of fittings and welding/silver soldering procedures.

Notes:

1. Material grade 360 N/mm2, or better, when selected by thickness from Tables 1 and 2 provides for a minimum designed 3:1 factor of safety.
2. When commercially available BS 3601/BS 3602 Grade 430 pipe shall be used in preference to alternatives specified in 2.9.1.3(a) and (b).
3. Hot finished seamless carbon steel pipe, Clause 2.9.1.3(b) will require in its process to be pickled and passivated prior to being oiled and plugged.

It must be strictly observed that aluminium alloys are not resistant to HFC fluids.

TABLE 1

PIPE THICKNESS WITH 3:1 FOS (mm)

Grade 360 N/mm2 or Higher	Pipe Thickness (t) for Stated Design Pressures			Max. Deviation on Outside Diameter (±mm)
Outside Diameter (mm)	250 bar Design (mm)	400 bar Design (mm)		
10		2.0	10 x 2	0.10
12		2.5	12 x 2.5	0.10
16		3.0	16 x 3	0.10
20		4.0	20 x 4	0.10
25	4.0		25 x 4	0.10
30	4.0		30 x 4	0.10
38	5.0		38 x 5	0.15

Notes on Table 1

1. Permissible deviation on outside diameter suitable for couplings of the compression ring type.

TABLE 2

PIPE THICKNESS WITH 3:1 FOS (mm)

Grade 360 N/mm2 Plus Grade 410 N/mm2 or Better	Pipe Thickness (t) Commercially Available							
	100 bar		160 bar		250 bar		400 bar	
Outside Diameter (mm)	Min. t (mm)	Max. t (mm)	Min. t (mm)	Max. t (mm)	Min. t (mm)	Max. t (mm)	Min. t (mm)	Max. t (mm)
42.4	a	a	4.0	5.5	5.5	7.0	8.5	10.0
48.3	a	a	4.0	6.0	6.5	7.5	10.0	12.0
60.3			5,5	6.5	8.0	9.5	12.0	15.0
76.1	4.0	6.5	6.5	8.0	10.5	12.5	15.5	20.0
88.9	4.75	8.0	7.5	9.5	12.0	16.0	18.0	22.0
101,6	5.5	8.0	9.0	11.0	13.5	16.0	21.0	25.0
114.3	6.0	9.0	10.0	12.5	15.5	19.0	23.0	28.0
139.7	7.5	9.5	12.0	16.0	18.5	25.0	30.0	35.0
168.3	9.0	12,5	14.5	19.0	22.5	32.0	34.0	40.0
219.1	11.75	15.0	18.5	25.0	29.5	36.0	b	b
273.0	15.0	20.0	23.0	30.0	36.5	45.0	b	b

a = use minimum size available or select from the next higher-pressure rating column

b = pipe thickness beyond commercially available stock range

Notes on Table 2

1. Pressure that falls between rated columns shall require pipe thickness selection from the next higher pressure rated heading.
2. Thickness of pipes in Tables 1 and 2 are selected in accordance with the design pressure requirements of Clauses 2.9.1.1 and the material requirements of Clause 2.9.1.3.

   They are based on the formula $= \frac{1.70pD}{f+p}$

   which allows for a 3 to 1 safety factor and a 12.5% bending allowance. Selection takes account of maximum permissible minus deviation in pipe thickness.

   t = pipe thickness in mm

   p = design pressure in N/mm2 (plus 20% as per Clause 2.9.1.1) f = minimum tensile strength in N/mm2

   D = pipe outside diameter in mm

3. When ordering pipe always quote the outside diameter and thickness.
4. 1 bar = 0.1 N/mm2 = 105N/m2

4. Welding

a. Quality

Welded joints in steel pipe shall be to Class 1 quality in accordance with BS 2633 or BS 1821. Welding shall only be carried out by welders who are approved in accordance with BS 2633.

b. Procedures

Welding process and procedures shall be selected and used which avoids or minimises the formation of scale in the bore of the pipe and ensures the quality of weld in accordance with Clause 2.9.1.4.1. Appendix B to this standard provides guidance for the preparation of such welding procedures.

The contractor shall provide as appropriate:

1) Procedures for socket welded joints in accordance with Appendix B of this standard.
2) Procedures for butt welded joints using the pro forma procedure document in Appendix B of this standard.

c. Fault Limitation

Fault limitation of welded joints, further examination, rectification preparation for and rewelding of joints shall be in accordance with BS 2633.

5. Fabrication

a. General

1) All pipework routing shall be discussed and agreed with the ES engineer or his representative and shall be rigidly clamped.
2) Pipe supports shall be of the plastic clip type with a rubber insert. The baseplates shall be made of weldable steel which will be secured to an adequately strong sub structure.
3) The spacing of the pipe clips shall be in accordance with DIN 24346
4) Pipe connections shall be of the weldable nipple threaded type to DIN 3865
   (a) Threaded type fittings shall be used up to DN 40. Above DN 40 DIN flanges are to be used for connecting pipes.
   All flanges shall be assembled using a butt weld.
   (b) Pipe runs shall be as short as possible.

(c) Dead legs in the system shall be avoided. Where this is unavoidable sufficient valved cross connections shall be provided for routine flushing of the pipework.

(d) Sudden changes in pipe bore sizes shall be avoided. Changes in bore sizes shall be affected by use of proprietary reducer fittings.

(e) Pipework in unavoidable hostile environments shall be adequately protected.

(f) On the completion of any or all welding or assembly process the pipework must be duly cleaned. The cleaning process shall be carried out in a bath process or a system circulation process to suit the method of installation. i.e. workshop and site fabrication

(g) The contractor must perform adequate cleaning treatment (pickling, mechanical debris removal, passivation or other procedures) to the satisfaction of the ES engineer prior to cold testing the system.

(h) All pipework shall be free from stress after installation.

b. Bends and Offsets

Formed bends shall be used wherever possible. Swept elbow or elbow fittings shall only be used where space restrictions are unavoidable. Formed bends and offsets shall be cold formed in a standard pipe bending machine. They shall have an inside radius of not less than 4 times the outside diameter of the pipe. Where hot forming is unavoidable the section of pipe involved shall be bath pickled, water rinsed, passivated, dried and immediately protected against corrosion by oiling.

The required wall thickness on the inside and outside of the bend is to be calculated in accordance with ASME VIII/ASTM

c. Flushing, Drain and Air Bleed Connections

Flush and drain connections shall be made using proprietary welded fittings with G series internal parallel threads to BS 2779 which shall be immediately sealed with steel hexagon headed shouldered plugs and bonded seals. Holes thus made in the pipe shall have any burrs removed and be finally pulled through to remove loose particles. Air bleed connections shall be of the captive type.

6. Examination, Inspection and Testing

a. General

The extent and the method selected for the testing of welded joints shall depend upon the degree of complexity of the pipework system, the number of welded joints involved, working pressure of the system, accessibility of the installed pipework and the extent of the potential hazard due to failure.

b. Methods

Where specified by the purchaser welded joints and pipework shall be examined or tested by one or more of the following methods:

1) Radiographic examination of butt-welded joints in accordance with BS EN 1435:97 using technique No. 13, 14, 16 or 17 and to the extent specified by or agreed with the purchaser as follows:
   (i) One welded joint selected at random from each group of 10 welded joints. The full circumference of the selected joint shall be radiographed.
   (ii) The full circumference of every welded joint.
2) Penetrant testing in accordance with BSEN571.
3) Magnetic particle inspection in accordance with BSEN1290.
4) Visual inspection of the bores of pipework selected at random for the presence of scale and corrosion.
5) Pressure testing for leaks e.g. pin holes, using nitrogen gas which shall be maintained at a pressure of 7 bar for a period of time sufficient to examine each joint.
6) Proof pressure testing using a hydraulic fluid maintained at a constant pressure equal to not less than 1.5 times the working pressure of the system for a length of time sufficient to inspect the pipework system for leaks and any other damage. The hydraulic fluid shall either be identical to that used in the operation of the system or a straight mineral oil.

7. Pipe Supports

Pipework shall be adequately supported and clamped and the clamps securely fixed:

a. At regular intervals of not more than:

1 m for pipes up to and including 20 mm outside diameter

2 m for pipes above 20 mm outside diameter and up to and including 38 mm outside diameter

3 m for pipes above 38 mm outside diameter

b. Immediately before and after a bend or offset. Where multiple bends occur, it may not be necessary to fix and secure at both sides of each bend; sufficient clamps shall be provided to adequately support and secure the configuration.

c. Immediately before a change to a flexible hose.

d. Be of the heavy-duty type.

Pipe supports shall incorporate suitable vibration damping material and the support assembly shall in no way damage or induce any significant stress in the pipe e.g. by misalignment and temperature change. Pipe supports shall not be welded to the pipe. Any one pipe shall not be supported by another pipe.

10. Hoses

a. Design and Construction

1) Hose selection shall depend upon flow rates, system working pressures, intensified pressures and the operating environment.

The operating pressure shall not exceed 25% of the hose burst pressure.

2) Hoses shall be of the following specification, shown in Table 3, unless otherwise agreed with the Corus engineer and the supplier.

(i) 2-wire braid construction with BS EN 853:97, ISO 1436, DIN 20022 or SAE 100 standards. SAE 100 R2AT is acceptable in instances where abrasion does not take place, and for in-house swaging of replacement hoses for repairs.

(ii) Multi-spiral 4-wire or 6-wire construction in accordance with BS EN 856:97, ISO 3862, DIN 20023 or SAE 100 standards.

3) All hoses shall be of standard lengths increasing in increments of 0.5 m. Steel pipework shall, therefore, be terminated accordingly to accommodate these lengths.

4) For applications where a fire hazard is likely to cause hose damage, i.e. coke oven machines, furnace bleeders etc., a 'firesafe' hose shall be considered. An example being Dunlop/BTR Firesafe hose, this does not conform to any recognised standard, but the fireproof category BS3G100 is exceeded.

5) Hose assemblies shall have machine swaged end fittings with female running nuts at each end.

6) Consideration may be requested for supply of hose with low electrical conductivity or for hoses to operate within corrosive environments.
7) End connector thread forms shall comply with BS 5200 and their rated working pressure shall meet or exceed those as specified in the standard.
8) The bore size of hose fitting after swaging shall be adequate for the application intended and shall allow flow rates in accordance with Clause 2.6.3.
9) After crimping the external diameter of the sleeve shall be checked with a micrometer against manufacturer's standards, also the internal diameter of the sleeve and hose shall be checked with a 'no-go/go' gauge*. Every sleeve assembly shall be checked and units out of tolerance shall be rejected.

   *No-go/go gauge dimensions (which set the tolerances for internal sleeve collapse) must be supplied by the fitting manufacturer.

   NB. It is preferred that hose end fittings are sourced to be of same manufacturer as hose.
10) Each hose assembly shall be marked for identification purposes with the following information:
    (i) Hose - manufacturers name
        the hose specification, e.g. DIN 20023-4SH
        the nominal bore diameter
        the month and year of manufacture (last two digits, e.g. 09/92)
        the design working pressure
    (ii) End fittings - manufacturers name or identification (which ideally should be of the same manufacture as the hose) the size of the corresponding hose bore
11) All hoses, when supplied as loose items, shall be delivered with protective bore blanking plugs or caps.
12) Quick release couplings may be used for the quick coupling and release of sections of hydraulic systems. The male part of the coupling is to be permanently attached to the pipework system and the female to the hose. All quick release hoses shall have a restraint to prevent whipping of the hose in the event of pressure still being in the system at time of release.
13) Expansion fittings are to be used in the pipework system to accommodate for the following:
    - Expansion - Contraction

- Stress and movement caused by fluctuations in temperature, movement of foundations
- Fluctuating loads and vibration
- Isolating structure-borne noise and shock
- Accommodating minor inaccuracy in installation.

TABLE 3

British Standard	Wires	Duty	SAE/DIN Standard	Size Range	Comments	Max. System P on Largest Hose
BS EN 853:97	2	Medium	SAE 100 R2AT DIN 20022	Up to 1"	Where flexibility required	160
BS EN 853:97	2	Heavy	SAE 100 R2A DIN 20022-2ST	Up to 1"	Thick outer cover hose	160
BS EN 853:97	4	Light	SAE 100 R12	Up to 1"	Where flexibility required	275
	4	Medium	SAE 100 R9R	1" to 1.5"	Mid-size range series	260
	4	Heavy	DIN 20023-4SH	0.5" to 2"	For full size range series	250
	6	Heavy	SAE 100 R13	0.5" to 2"	For full size range series	345
						P in bar

b. Installation

Hose assemblies shall be installed to DIN 20066, and that:

1) The hose is of the correct length.
2) Motion is preferably in one plane and torsional stresses are avoided.
3) Short radii and 'S' bends are avoided. Wherever possible the minimum bend radius should be greater than that specified in the appropriate British Standard.
4) They are securely supported and are not allowed to become twisted or compressed.
5) They do not rub against other hoses, machinery or structures. Where hose reels are used, they shall be arranged to roll and unroll.
6) They are protected against damage and are suitably restrained if their failure would constitute a hazard.
7) They are easily and safely accessible for inspection and maintenance.

8) Under normal working conditions that part of the hose immediately adjoining the end fittings shall not flex for a distance equal to eight times the outside diameter of the hose.
9) If they run horizontally (a situation that should be avoided) supports shall be provided at regular intervals and the hose length increased by 4%.

11. Pipe Connections

a. General

Wherever possible pipe connections shall be welded. The use of breakable fittings shall be kept to a minimum and preferably only at equipment terminations and where it is necessary to 'break' the run of pipe for purposes of inspection, maintenance or cleaning.

Pipework to hose termination should be a female BSPP weld socket machine recessed to locate a bonded seal.

b. Welded Joints

For pipes up to 38 mm outside diameter welded joints shall be made using socket welded fittings which shall be in accordance with BS 3799 in all respects except that the bore diameter of the socket shall be suitable to accept pipes in accordance with Clause 2.9.1.2 and Table 1.

For pipes above 38 mm outside diameter, that is in accordance with Clause 2.9.1.2 and Table 2, welded joints shall be made using socket welded fittings of the appropriate pressure rating in accordance with BS 3799. Beyond the available range of socket welding fittings welded joints shall be made by butt welding. Where necessary butt-welding fittings shall be in accordance with BS 1965 Part 1.

Note: BS 3799 provides for two ratings of socket welding fittings. Care shall be taken in the selection of the correct rated fitting, i.e. Series 3000 lb. and Series 6000 lb. available.

c. Breakable Fittings

Breakable fittings shall be selected from the following as specified by or agreed with the purchaser:

1) Steel welding neck flanges in accordance with BS 4504 Section 3.1 using metallic spiral wound gaskets with inner and outer guide rings dimensionally in accordance with BS EN 1514 Part 2 for pressures below 40 bar.

2) Steel welding neck flanges in accordance with BS 1560 Section 3.1 using metallic spiral wound gaskets with inner and outer guide rings dimensionally in accordance with BS 3381 and BS EN 12560 Parts 2 and 4 for pressures above 40 bar.

3) Square steel socket welding flanges using a 4-bolt fixing and a captive 'O' ring seal.

4) Steel socket welding flanges of the SAE design for pipes up to 60.4 mm diameter SAE series 3000/6000 socket weld flanges shall be used. Pipework above 60.4 mm diameter shall be with SAE series 3000 socket weld flanges, unless system pressure dictates otherwise

NB: Series rating does not indicate pressure rating through full SAE flange range. Check with manufacturers specifications.

Breakable fittings both in the form of couplings and flanges shall be suitable for design pressures in accordance with Clause 2.9.1.1.

12. Reservoirs

a. General

Reservoirs shall be separate and removable from the equipment frame. Components shall not be mounted inside the reservoir such that access for maintenance and replacement requires entry into the reservoir.

Anti-syphoning devices shall be incorporated in all lines returning fluid to the reservoir, these may be positioned as bleed-points in each returning line connection on the reservoir face.

The drip-tray for the reservoir/power unit should be capable of where possible holding the maximum reservoir volume and shall be of a sensible height from the floor for draining purposes.

Oil reservoirs shall be of sufficient size to accommodate all the fluid in the system when there are no devices in the circuit.

Any air entrained in the hydraulic fluid shall be able to escape from it within the reservoir. Suction and return lines must be kept as far apart as possible

The flow velocity in the reservoir itself is to be kept as low as possible to allow any contamination suspended in the fluid to settle out.

Hydraulic power units design is to indicate:

- the energy flow of the hydraulic fluid.
- the pressure settings.
- the pipe sizes.

The parts list must contain all the components in the hydraulic circuit diagram with precise details of type, supplier or manufacturer.

b. Construction

Materials for reservoir construction shall be discussed with the ES engineer or his representative. Due to the increasing requirements to select high water base fluids, or consideration for future fluid conversion, it is probable that stainless steel be the selected material. In such circumstances the reservoir shall be constructed from welded stainless-steel plate in accordance with BS 1449 Grades 304S15, 321S31 or 347S31 with a minimum thickness of 6 mm.

If the tanks are to be hot-galvanized, good accessibility to the interior is essential. The interior is to be ventilated during the process so vent holes and drain holes must be provided.

The galvanizing bath temperature must be approximately 480 ºC.

The zinc in the reservoir and in other voids must be able to run away quickly and without any major drop in temperature.

Reservoirs otherwise constructed should be from weldable rolled mild steel plate in accordance with BS 4360. All internal welds shall be continuous to prevent lodgment of foreign matter, e.g. grit.

All reservoirs must be of adequate size so that there is a long dwell time for the fluid. In the case of mineral oil, a guide figure is 3 to 5 times the pump delivery per minute. For HFC and HFD fluids the reservoir should be at least 5 to 8 times the pump delivery per minute.

The design must clearly specify in each case the form of the joint, the method of welding and the filler metal used. In the case of fillet welds, the thickness must also be stated.

The symbols for the weld must be entered against each seam. Methods and soundness for welds and the classes of weld quality are to be tabulated on the drawing.

For butt weld preparation the type of groove must be shown on the drawing. The soundness of welds is to be assessed to ASME 9.

Access holes of adequate size must be provided for internal inspection and cleaning purposes.

With larger tanks the design must consider the fact that their length will change with variations in temperature. Therefore, cylindrical tanks must have one fixed and one sliding support.

A permeable expanded metal separator/baffle is to be fitted between the suction and return chambers. This separator/baffle is to be fitted at an angle to improve air separation. The bottom one third of this separator/baffle is to be a fully welded plate to prevent contamination being carried from the return chamber along to the suction chamber.

Section corners inside reservoirs are to be avoided. All such section joints are to be rounded off. The interior of the reservoir must always be easy to clean thoroughly.

Reservoir construction is to prevent any dirt gaining access to them. Any necessary openings through the tank e.g. pipe connections, must be carefully and thoroughly sealed. All sealing materials must compensate for any unevenness in the structure and must be resistant to the particular fluid being used.

Electric motor and pump sets are to be assembled using construction IEC 60034-7 V1, B5 and B3/B5.

Flexible drive couplings up to 15 kW electric motor size are to be assembled with a grub screw in the feather key to prevent coupling slide. Above 15 kW electric motor size both half couplings are to be secured with a retaining disc.

Device mounting frames and front panels are to be standardised and manufactured from square steel tube into which standard to accept components can be welded. The size of the square tube is to be standardized as follows:

- Square tube of 20 x 30 x 2 for valves of size 6
- Square tube of 30 x 60 x 3 for valves of size 10 & 16
- Square tube of 60 x 60 x 4 for valves of size 25 and larger.

Angled struts are to be used to brace the frame

13. Accumulators

a. General

Accumulators shall:

1) Not be used with back up bottles.
2) Only inert gases such as nitrogen may be used in accumulators. It is mandatory that work will not be allowed on accumulator pressure vessels until the fluid has been drained, and it has been depressurised on the gas side. Therefore, facilities shall be provided to affect the above.

   Be capable of being replenished with an inert gas, such as nitrogen. Where the pre-charging pressure exceeds normal bottle supply pressure the purchaser shall be advised accordingly at the time of the quotation.

   3) Be pre-charged with an inert gas, preferable nitrogen.

   4) Have means for safety relieving nitrogen and fluid pressure before dismantling.
5) Each accumulator shall be protected by its own individual relief valve, situated between the accumulator and its isolating valve.
6) Separate and independent blow-down return lines to the reservoir, the only other return lines that may be connected into this line are from other accumulator blow-down valves.
7) When the accumulators form a delivery as a pre-assembled station with the units pre-charged, the following requirements shall be met:
   (i) Affix a temporary label stating; 'accumulators delivered nitrogen pre-charged'.

(ii) If system pressure tested on build, then all stored oil volume shall be discharged prior to dispatch.

8) (h) Where accumulators delivered as loose items and nitrogen pre-charged, then due regard shall be given to the above.

9) Hydraulic accumulators may only be put into service after an authorized inspector (i.e. TÜV or equivalent) has inspected them (initial inspection, design inspection and pressure test) and certified that they are in satisfactory condition. This inspection can be waived if type-test approval has been obtained.

10) The design, installation and operation of accumulators are subject to and are to be covered by the pressure vessel regulations.

11) Hydraulic accumulators may only be put into service after an authorized inspector (i.e. TÜV or equivalent) has inspected them (initial inspection, design inspection and pressure test) and certified that they are in satisfactory condition. This inspection can be waived if type-test approval has been obtained.

12) The manufacturer is to certify satisfactory manufacture and successful pressure testing. The operator's authorised inspector is to perform an acceptance test and is to provide appropriate certification.

13) A safety and shut-off valve block are to be provided for protecting, isolating and depressurising hydro-pneumatic accumulators. It is to conform to the relevant safety regulations which require suitable devices for:
    - measurement of pressure. Pressure range must be at least 1.5 times the operating over pressure of the hydraulic system.
    - protection against over-pressure.
    - isolation.
    - de-pressurising valve.

14) A charging and testing valve are to be provided for charging the accumulator, checking the gas pressure complete with adjusting facility.

15) The recommended test intervals for gas charging pressure are to be at least once during the first week after installation, once more after a further 4 months and then annually. These intervals are to be stated on the rating plate or accumulator body.

16) The accumulator mounting arrangements must be such that no stresses or strains are transmitted to the pipework from the accumulator. Proprietary mounting bracket assemblies are to be used.
17) All accumulators are to be fitted with durable and easily readable labels showing:
    - Manufacturer or supplier
    - Manufacturer number
    - Year of manufacture
    - Permissible operating pressure
    - Internal volume
    - Permissible operating temperature if more than 50 ºC or less than 10 ºC.
    - Official test approval number (for officially tested accumulators).
18) The supplier will observe applicable official regulations and acceptance specifications to be.
    - German Federal Republic - TÜV (Technical Monitoring Association)
    - Great Britain - LRIS (Lloyds Register Industrial Services)

b. Isolation

Provision shall be made to:

1) Positively isolate each individual accumulator from the hydraulic system and in the isolated condition to be able to safely drain the fluid in the accumulator back to the reservoir.
2) Positively isolate the hydraulic system from banks of accumulators.
3) Automatically vent accumulators upon system shut down except where power conservation or standby supply is required.

c. Safety Notice

Complete and adequate information for the safe servicing shall be clearly and permanently provided on or immediately adjacent to the accumulator. This information shall include the words 'caution – pressurised vessel'.

d. Testing/Identification (Permanent Marking)

All relevant statutory and local safety requirements for accumulators shall be complied with.

Your attention is also drawn to the Health and Safety procedural documents 'The Pressure System and Transportable Gas Container Regulations Approved Code of Practice', and the Pressure Equipment Directive.

14. Filters and Filtration

a. Contamination Class

The contamination class for the fluid in the hydraulic system shall be as specified by or agreed with the purchaser and be in accordance with and selected from the British Standards BS ISO 4406 and CETOP RP70H. Details of the hydraulic system contamination classification and comparisons with previously used classes, is contained in Appendix A.

b. Filter Type

Only depth type filters are to be used.

All filter elements are to be Hydac Betamicron standard or equivalent with an absolute micron rating and degree of separation (ß).

All filter elements are to be disposable type.

c. Filter Performance

Verification of filtration performance is to conform to ISO 16889

Filters are to be provided that are effective for the following kinds of contamination:

- Hard and sharp particles.
- Soft and gelatinous particles.
- Dissolved substances in the fluid.

All filters must perform the following tasks:

- Remove solid particle contamination from the hydraulic fluid.
- Prevent functional disturbance due to solid particle contamination.
- Prevent variations in switching times due to damaged control lands.
- Reduce downtime between maintenance shutdowns.
- Increase component life.
- Permit preventative maintenance.
- Prevent aging of the fluid due to chemical processes.
- Maintain the lubricity of the fluid.
- Extend the life of the fluid.
- Maintain high reliability between maintenance shutdowns.
- Ensure long maintenance intervals for the filter.
- Ensure continuous filtering of solid particle during service.
- Have a high dirt holding capacity.

- Ensure reliability and availability of the hydraulic system.
- Ensure proper functioning of the filter under changing pressure and flow conditions in the system.
- Maintain a highly stable ß value over a wide pressure drop range.

Filter housings must satisfy the following requirements:

- Low pressure drops across the housing.
- Durable housing construction. This means that the housing must successfully withstand a pulsation test.
- Bursting pressure of the housing.
- The housing material and seals must be suitable for the hydraulic fluid to be filtered.

d. Filter Design

The following criteria is to be used for filter design:

- **Sensitivity to dirt**. The filtration rating or specified cleanliness class must be appropriate for the hydraulic components.
- **Application area of the total system**. This must take into accounts the possible contamination of the surroundings.
- **Volumetric flow through the filter**.
- **Recommended pressure drop at normal viscosity** with a clean element (housing and element).

  Pressure line filters

  Without by-pass valve : 1.0 Bar

  With by-pass valve : 0.5 Bar

  Return line filters : 0.3 to 0.5 Bar.
- **Permissible maximum pressure drop**. This must be appropriate for the system conditions at the place of installation.
- Compatibility of filter materials.
- Design pressure of the filter housing.
- Operating temperature or design temperature

All filters are to be fitted with an electrical contamination indicator. The signal is to be processed by the machine control system or transmitted to a control room to give a visual and audible indication.

A breather/air filter is to be fitted to the hydraulic reservoir to prevent ingress of contaminated air being drawn into the reservoir. The filtration rating of the breather must be matched to the filtration rating of the finest filter installed in the system.

The viscosity/temperature characteristics for fluid lubricants needed for designing hydraulic filters are to be to DIN 51 519.

The contamination of hydraulic fluids by solid particles is to be classified by the ISO DIS 4406 standards.

Means shall be provided for taking oil samples: -Taking a sample from a moving fluid to ISO 4021 - Taking a sample from a stagnant fluid to CETOP RP 95H Section 3.

The position of filters in the hydraulic system are to be situated to provide the following:

- Protecting the hydraulic fluid against contamination.
- Protecting components sensitive to contamination.
- Protecting the system against environmental contamination.
- Protecting the system against component failure.

All filters are to be fitted with by-pass valves.

Filtration is to be provided in the hydraulic system typically as per Figure 1 on page 53.

15. Identification of Pipelines

Hydraulic pipework shall be identified using the ES Painting Standard and RAL Charts. The colours are to be agreed with the ES engineer.

The entire pipe is to be painted in the base coat colour and the paint is to be applied using one coat of the appropriate primer followed by two coats of alkyd gloss.

Identification banding shall be 100 mm wide and applied at intervals not greater than 2 m apart. Banding shall also be placed before and after every bend or offset, at both sides of valves, service appliances, bulkheads, wall penetrations and at any other place where identification is deemed necessary.

16. Information to be Supplied to the Contractor

The purchaser shall provide the contractor with the following information:

(a) The basic design information in accordance with Section 1 of this standard.

(b) The information as required in Appendix C to this standard.

17. INSTALLATION AND COMMISSIONING

a. Safety

1. Personnel working on or involved in the installation and commissioning of hydraulic systems shall comply with the relevant statutory and local safety requirements and procedures e.g. site regulations, permit to work systems.
2. The safety advisor shall be informed in advance of any work so that the appropriate instructions and regulations concerning the situation can be made available.
3. Mechanical parts operated by hydraulic actuators shall be positively chocked or rested in a safe position so that no inadvertent movement of the actuator can take place before commissioning.

b. Approved Drawings

The installation shall be carried out in accordance with the approved drawings as required in Clause 2.2.3 and revised as necessary in accordance with Clause 2.2.7 of these standards.

Copies of these drawings shall be available on site and are: (a) Hydraulic circuit diagram.

1. Arrangement drawing of power units, valve stations and actuator installation drawings.
2. Pipework layout drawing giving details of all pipe runs, trenches and associated civil engineering work.
3. Drawing showing details of pipe connections to components e.g. valves, manifolds, filters and actuators.
4. Electrical circuit diagram or electrical control scheme giving necessary information e.g. control sequences and interlocks.

c. Modifications

Where modifications are made to the hydraulic system during installation they shall be diligently recorded by the supplier and the appropriate drawings and documents revised and reissued to the purchaser and to the site.

d. Installation of Pipework

1. Inspection for Scale and Corrosion

Pipework and fittings shall be inspected for scale and corrosion immediately prior to forming and/or installation. Severely corroded pipework shall, at the discretion of the Corus engineer or his representative, be rejected or scrapped.

Where the bores of pipe or fittings are found to be contaminated or have become slightly corroded, they shall be either mechanically cleaned or bath pickled and passivated depending upon the extent of the contamination and its accessibility for cleaning. After cleaning, the bores of the pipework shall be immediately oiled, and if not to be used immediately; be securely capped or plugged.

Refer to Section 2.9 for other pipework requirements.

e. Cleaning

1. Contamination Class

1.1 The contamination class for the fluid in the hydraulic system shall be as specified by, or agreed with the purchaser and be in accordance with and selected from the hydraulic system contamination classification contained in Appendix A.

1.2 The hydraulic system shall be considered clean when representative samples of the flushing fluid have achieved the specified contamination class. A representative sample shall be taken from the hydraulic system. The sample of fluid shall be examined, and the results reported as soon as practically possible.

f. Bath Pickling

Bores of pipes and fittings shall be free from corrosion and scale. Where corrosion has taken place or scale formed the section of the pipe so contaminated shall be removed and bath pickled, water rinsed, passivated, dried and immediately protected against corrosion by oiling.

g. Flushing

Assembled and installed hydraulic systems shall be flushed clean to within the specified contamination class. See Clause 2.12.5.1.

Where pipework has been pickled by circulation in situ and, unless otherwise specified by or agreed with the purchaser, interconnecting pipework shall be initially flushed in accordance with Clause 2.12.7.1.

All assembled and installed hydraulic systems shall be final flushed clean in accordance with Clause 2.12.8

1. Initial Flushing

a) Items not Included in the Operation

Pump sets, valve manifold block assemblies and line mounted valves, accumulators and actuators shall not be included in the initial flushing operation. Such items of system equipment shall be delivered to site cleaned and tested. Suitable make-up pieces shall be provided to bypass these items of equipment.

b) Flushing Fluid

Where pipework has been pickled by circulation in situ a separate flushing fluid shall be used which shall have an ISO Viscosity No. 22 and be in accordance with a straight mineral oil to PAS 3 Grade TLS (Commodity Code No. 1/42/40/02214). In all other circumstances unless otherwise specified the flushing fluid shall be identical to that hydraulic fluid which will be used in the operation of the hydraulic system. Consideration shall be given to the temperature of the flushing fluid to give reasonable dirt capacity of the non-bypassed filter element before indication of blocking takes place.

c) Contamination Level

The pipework shall be considered clean when representative samples of the flushing fluid have achieved the specified contamination class in accordance with Clause 2.12.5.1 as mutually agreed by the purchaser and contractor. The representative sample shall be taken from the top of a horizontally disposed pipe returning to the flushing rig reservoir, at a point where turbulent flow conditions exist and before the flushing rig filter.

h. Final Flushing

1. Final flushing shall be carried out using the system pumps, filters and valves; except where contamination sensitive components i.e. servo valves, are used. An adequate supply of replacement filter elements of the specified rating shall be available. Filters shall be regularly inspected during the flushing operation and replaced as necessary. During the final flushing operation, no filter in the system shall be allowed to bypass fluid.

2. The hydraulic system shall be considered clean when representative samples of the fluid have achieved the specified contamination class in accordance with Clause 2.12.5.1.

i. Setting up the System for Normal Operation

1. General

The hydraulic system shall be so set up to ensure the correct operation of its function and the machinery it powers and controls in such a manner that no hazard to personnel is created and no damage to equipment results.

2. Component Setting Up

Components shall be set up as follows:

(a) Actuators shall be reconnected into the system and filled with fluid with the relief valve at its minimum setting and ensuring that all air is evacuated.

(b) Actuators requiring priming or prefiling, e.g. motor casings, shall be so primed or prefilled before filling from the system.

(c) Accumulators, where fitted, shall be pre-charged with an inert gas e.g. nitrogen to the specified pressure before fluid is admitted.

3. External Controls

It shall be confirmed that 'external' control supplies, e.g. electrical and pneumatic, are available, that they are of the correct value, correctly orientated and sequenced correctly to control the system.

4. Testing of Actuators

Actuators shall be operated several times under minimum pressure and speed settings checked for:

(a) Correct mechanical alignment which should be done without applying hydraulic power wherever practicable, e.g. smaller cylinders.

(b) Adequate clearance between adjacent machine parts.

(c) Complete evacuation of air.

(d) Security, i.e. all fasteners have been suitably tightened.

5. Static Pressure Test

A static pressure test shall be applied to the complete hydraulic system using the system fluid after final flushing. The test pressure shall be the maximum working pressure for the system and shall be developed using the system pumps.

The system shall be checked for any external leaks. All faults shall be rectified after which the system retested. Leaking breakable pipe connections shall only be retightened when the system is fully depressurised.

The pressure test shall be in accordance with the relevant International or National Standards and shall be clearly specified prior to the test taking place.

j. Records

The following data shall be recorded in the maintenance manual or in the functional system documentation (see Clause 2.2.5 of the standard) for use during maintenance and fault diagnosis. Such data shall be checked against the specification and circuit diagram and where necessary all documentation amended accordingly.

1) Pressure and/or flow at all appropriate test points under specified conditions of operation.
2) Actuator speeds under specified conditions of operation.
3) Final settings of all adjustable valves.
4) Normal operating temperatures of the fluid.
5) Contamination level.
6) Pressure and functional test certification.

k. Final Clean Up

The hydraulic installation shall be left in a clean condition. Materials of construction, parts surplus to requirements shall be disposed of in an environmentally friendly manner.

Oil spillage and debris shall be disposed of in an environmentally friendly manner.

Housekeeping shall be of a high standard. A joint inspection of the site on completion of the work shall take place with ES and the contractor.

5.7.3 DRAWINGS

Drawings supplied shall be in accordance with ES Engineering Standard: PRD-ES-110 – Engineering Documentation as per ESI Drawing Office standard.

5.7.4 QA DOCUMENTATION

Final Conformity Documentation, which will contain, but not limited to the following: -

- Material Test Certificates
- Welding Material Certificates

- Welders Qualifications
- Welding Map
- Welding Procedures
- Weld Test Records
- Welders Matrix
- Weld Repair Records.
- NDT Testing Records
- NDT Inspector Qualifications
- Non-Conformity Reports
- Third Party Certification
- Pressure Test Certificates.
- Painting Records – specification/application/thickness checks.
- Consumable Test Certificates
- Alignment checks.
- Profile checks.
- Design Documentation
- Any third-party documentation
- Any Check Lists
- Any Audit Sheets
- Any other documentation submitted in a Quality Documentation Package under the applied International or National Standards.
- CE Mark and documentation.

The documentation shall be fully traceable.

The format of the QA Documentation shall be agreed with ES.

ESI reserve the right to audit or request sample documentation through various stages of the project.

5.8 Welding

5.8.1 SCOPE

This section relates to the general requirements for welding. It shall not supersede the requirements of task specific standards should they be of a higher specification.

5.8.2 MATERIALS OF CONSTRUCTION

All materials of construction supplied shall be in accordance with the appropriate specification from the International and National Standards nominated for the plant area and equipment concerned. The CONTRACTOR shall on request, submit to ES certification to confirm compliance. The CONTRACTOR shall facilitate material traceability upon request of ES Inspector.

100% of materials shall be visually inspected, with the addition of non-destructive testing as stated in the applied International and National Standard.

The materials shall be free from surface and internal defects which can impair their intended usability.

Where plates are formed during the construction process, this shall be done by machine. The CONTRACTOR shall demonstrate that the material's specified mechanical properties have been maintained, and that the material has not been rendered otherwise unsuitable.

Materials shall be selected to be compatible with anticipated fabrication steps and to be suitable for the internal media and external environment. Both normal operating conditions and transient conditions occurring during fabrication, transport, testing and operation shall be considered when specifying the materials.

General fabrication and construction shall conform to:
BS EN ISO 13920:1997 – Welding – General Tolerances for Welded Constructions – Dimensions for Lengths and Angles – Shape and Position.

A robust identification system shall be applied to all materials and to facilitate the ease of tracing the materials to the point of origin.

Material certificates shall be included in the QA documentation.

The manufacturer may subcontract work, but shall ensure that the subcontractor carries out the work in accordance with the requirements of the International or National Standards

Where welding operations are subcontracted, the manufacturer shall also either obtain copies of the welding procedure and welding operator qualification records or take other action to ensure that they comply with the applied International or National Standards.

The contractor may sub-contract elements of the work out, but this does not absolve them of any responsibilities in ensuring the applied standards are fully adhered to. Sufficient surveillance of the sub-contractor is a requirement of this Standard. ES reserve the right to visit or audit the sub-contractors at agreed times with the main Contractor.

Where a manufacturer is producing equipment that requires the intervention of a responsible authority, the manufacturer should inform the responsible authority of his intention to subcontract so that the responsible authority can take part in the subcontractor surveillance.

5.8.3 WELDING CONSUMABLES

All welding consumables shall be in accordance with the appropriate specification from the International and National Standard nominated for the plant area and equipment concerned.

All welding consumables shall be selected, stored and used in accordance with the manufacturer's requirements.

Different grades and, when specified, different batches of electrodes and filler materials shall be individually identifiable and be completely separated. Electrodes shall be stored in accordance with the manufacturer's recommendations. The electrodes and filler materials shall always be stored and handled during construction to avoid damage to them and to the containers in which they are transported. Storage and handling procedures shall be fully documented.

Electrodes, filler wires and fluxes that show signs of damage or deterioration, for example coating breakage, shall not be used.

All welding consumables shall adhere to:

BS EN 13479:2004 - Welding consumables. General product standard for filler metals and fluxes for fusion welding of metallic materials

The weld metal shall contain properties consistent with the design requirements for the fabrication. Where dissimilar metals are to be joined, consideration should be given to the use of transition pieces so that such welds are performed in the factory. These welds should be matched to the lower strength component properties, although care must be taken with parent metal dilution when high alloy components are used.

The type of consumable used shall be determined by the material thickness, strength and composition and the welding procedure used.

The CONTRACTOR shall provide ES consumables certificate and keep a log of heats and locations/joints where each batch is used.

5.8.4 PREPARATION FOR WELDING

The parent materials should be free from heavy rust and scale in the weld and adjacent areas. Shot blasting, grinding, flame descaling or rotary brushing may be used for cleaning. Castings shall be proof machined or ground in the weld area before welding, to remove or expose sub-surface defects.

Weld preparations shall be formed by flame cutting, machining or chipping and grinding, and shall be free from all extraneous matter immediately prior to welding.

Weld profiles shall be detailed on the weld procedure specification in use.

All flame cut and air-arc gouged edges shall be machine/or ground 2mm to remove all hard heat affected zone.

For piping, branch connections and branch openings in the main pipe shall be cut either by machining or by thermal cutting. The cut edges of the pipe shall then be dressed by filing or grinding to obtain the dimensions given in the approved welding procedure.

Base material surface defects (plate/pipe) shall not be repaired by welding. Dented pipe and damaged pipe ends shall be discarded by cutting.

5.8.5 WELD PROCEDURE SPECIFICATION (WPS)

The WPS shall be or shall have been qualified in accordance with ASME Section IX, AWS D1.1 (latest edition) or equivalent International Standard.

The weld procedure used shall be determined by the material thickness, composition and mechanical properties, joint geometry and welding equipment.

All welding procedure specifications (WPS's) shall be backed by procedure qualification records (PQR's) and shall be submitted to ES for approval prior to start of production/construction welding.

The procedure requirements regarding set up, pre-heating, tack welding, weld sequence, back gouging, cleaning, intermediate inspection and post weld heat treatment shall be adhered to.

The correct amount of pre and post heating, and rate of cool down shall be applied to the weld, in accordance with the applied Standard.
The WPS shall contain, but not be limited to:
Contractor Name and Address
WPS Specification/Standard
Weld Title
Material
Wall Thickness
Diameter
Joint Design
Welding Sequence
Welding Parameters and Consumables
Qualification Reference / Issue Details
Additional Information

5.8.6 WELDER QUALIFICATION

All welders shall be qualified to perform the welds as specified, in accordance with the appropriate International and National Standards nominated for the plant area and equipment concerned.
All structural welders shall be qualified to AWS D1.1 Structural Welding Code, latest edition.

As long as there are no harmonized standards for the approval of welding procedures or personnel, it is appropriate to follow the "welding section" of harmonized product

standards, ASME Section IX (EN 13445 (unfired pressure vessels), 13480 (piping), 12952 (water tube boilers) and 12953 (shell boilers) for respective fields of application. These standards use as a basis for qualifying welding procedures standard EN 288 and for personnel standard EN 287.

A welder's qualification shall remain valid for a period of 2 years from the date of completing a successful test, provided the relevant certificate is signed at 6-month intervals by the employer/coordinator and that the following conditions are fulfilled.

a) The welder is engaged with reasonable continuity on welding work within the current range of qualification. An interruption for a period no longer than 6 months is permitted.
b) The welder's work is in general accordance with the technical conditions under which the qualification test is carried out. If any of these conditions are not fulfilled, the qualification shall be cancelled.

Records of welder's qualifications and of welds performed shall be kept as appropriate and shall be submitted to ES as part of the QA Documentation, and maybe audited at the request of ES.

5.8.7 NON-DESTRUCTIVE TESTING

Where specified, the joint shall be non-destructively tested using the recognised methods and quality levels taken from the appropriate National/International Standards nominated for the plant area concerned.

The method or combination of methods and frequency of visual inspection and NDT of welds shall be as specified by applied International or National Standard. This shall be agreed with and clearly conveyed to ES.

Prior to the start of welding, detailed written NDT procedures to be used for inspection and testing shall be prepared and submitted to the employer for approval.

If ES require completed welds to be ground, this shall be stated in the enquiry, and grinding shall be performed in accordance with an approved procedure.

Records shall be kept as appropriate and submitted to ES upon request.

All joints shall be 100% visually inspected.

Where specified, plate butt welds above 40mm thick shall be ultra-sonically tested (UT).

Where specified, plate/pipe welds below 40mm thick shall be tested by radiography and or UT.

Dye penetrant test (PT) and magnetic particle test (MT) shall be carried out as per fabrication specification requirements and as mentioned on fabrication drawings.

Only ASNT Level II or CSWIP (or equivalent) qualified operators can perform appropriate tests.

Operator's qualifications and CV shall be submitted with the QA documentation and maybe audited at the request of ES. Only operators with current and valid qualifications shall be used.

The extent of the acceptable level of weld defects shall be in accordance with the applied International or National Standard. Records of acceptable defects shall be included in the QA documentation, and audited on the request of ES.

ES reserves the right to witness test a sample of the NDT to be carried out both in the fabrication workshop and on site.

5.8.8 QA Documentation

Final Conformity Documentation, which will contain, but not limited to the following: -

- Material Test Certificates
- Welding Material Certificates
- Welders Qualifications
- Welding Map
- Welding Procedures
- Weld Test Records
- Welders Matrix
- Weld Repair Records.
- NDT Testing Records
- NDT Inspector Qualifications
- Record of Accepted Weld Defects.
- Workshop Fabrication Records (tracking sheets, instructions, etc.)
- Non-Conformity Reports

- Pressure Test Certificates.
- Consumable Storage Records
- Consumable Test Certificates
- Design Documentation
- Any third-party documentation
- Any Check Lists
- Any Audit Sheets
- Any other documentation submitted in a Quality Documentation Package under the applied International or National Standards.
- CE Mark.

The format of the QA manuals / books shall be in accordance with ES Engineering Standard: PRD-ES -110 – Engineering Documentation, and project specific agreed with ES.

The documentation shall be fully traceable.

ESI reserve the right to audit and request sample documentation through various stages of the project.

ES require this documentation to be supplied in electronic format, with 1 off hard copy.

5.8.9 DRAWINGS

Drawings to be supplied in accordance with ES Engineering Standard: PRD-ES -110 – Engineering Documentation.

5.9 Roller Table

5.9.1 GENERAL

The Contractor shall meet the requirements specified hereunder, in addition to any special requirements outlined elsewhere in ES contractual documentation.

All individually driven roller units shall conform to the following requirements, this applies to both solid roller and tubular roller units: -

The roller unit shall be an integrated system containing: -

(a) Conveying roller.

(b) Bearings.

(c) Gearbox.

(d) Flange mounted motor.

(e) Drive shaft.

One end of the roller shall be fixed axially, the other allowed to float. The roller units shall be constructed with attention to the following points.

5.9.2 ROLLERS

Rollers shall be solid forged up to the finishing mill and thick wall seamless drawn tube with heavy duty journal bosses at either end for the remainder. Rollers shall be statically balanced and surface machined. Rollers shall be sufficiently robust to accept only two connections from the material being conveyed without damage to the rollers and assemblies.

The supplier shall state the roller life expectancy.

The installation tolerances for line and levelling shall be agreed with ES.

Evidence of the required and achieved installation tolerances shall be issued to ES.

5.9.3 BEARINGS

Anti-friction self-aligning bearings shall be fitted to the roll journals and shall be rated to withstand impact loading expected in steel mills.

Bearing block shall be of cast steel and the securement designed to accommodate typical loads from the Plant operation.

5.9.4 GEARBOXES

Straight cut spur gears with 20° pressure angle shall be fitted. Gears shall be designed for high impact loading without resort to heat treatment of teeth.

The gearbox shall be mounted on a machined bed surface. Tolerances for the surface level and finish shall conform to International or National Standards.

If holes must be slotted in the base plate at site due to misalignment, they shall be machined. If washers are used on bolts fitted into a slotted hole the washer shall be of sufficient diameter and thickness to prevent the washer being deformed into the slot.

Each gearbox shall be of cast steel and accept a flange mounted motor. Each gearbox shall have a lubrication dipstick.

Labels must be attached to the gearbox where it is supplied without lubrication. These labels shall be easily noticeable, clear to read, and securely attached to the gearbox.

5.9.5 SEALS

Seals on both roll bearings and gearbox shall be designed to prevent ingress of scale and water.

5.9.6 LUBRICATION

Bearings for the rollers shall be grease lubricated from automatic central systems. It is essential that the correct amount of grease is given to each bearing at the correct frequency.

Consideration shall be given for grease spillage containment around the bearing area.

The type of lubricant used shall have the correct temperature rating for the environment it is expected to work in.

Lubrication pipework shall be solid and permanent. The route of the pipework shall take into consideration access required to the roller assembly and the drive chain. Trip hazards must be avoided wherever possible.

5.9.7 MOTOR BEARING – DRIVE END

The overhang of the motor pinion from the motor bearing shall be kept to a minimum.

5.9.8 DRIVE SHAFT

The drive shaft and bolts shall be correctly rated to drive the roller under all Plant operating conditions.

5.9.9 NOISE

Consideration shall be given for sound deadening inserts between bearing assembly and sub-frame.

5.9.10 MOTOR AND CONNECTIONS

As specified in ES Engineering Standards: PRD-ES-050 - Electrical Equipment General Requirements; PRD-ES-059 – Electrical Motors.

The motor shall be mounted on a machined bed surface. Tolerances for the surface level and finish shall conform to International or National Standards.

5.9.11 ACCESS

For maintenance purposes consideration shall be given to ease of access to the bolts securing the bearing block to the sub frame. Sufficient room shall be given for the use of spanners, torque wrenches etc. that may be required for the correct and safe installation of the roller assembly.

5.9.12 TESTING

The roller body shall undergo the necessary hardness test.

The manufacturer will provide evidence that these tests have been carried out and shall provide a copy of all documents.

5.9.13 ALIGNMENT

For coupling alignment tolerances see ES Engineering Standard: PRD-ES-038 - Laser Alignment Standards.

5.9.14 NAME PLATES

Nameplates shall be made of material suitable for the intended service and with a thickness sufficient to withstand distortion due to the application of the marking and be compatible with the method of attachment. The minimum thickness shall be not less than 1 mm.

Marking shall be done in characters not less than 5 mm high and shall be produced by casting, etching, embossing, debossing, stamping or engraving.

The marking may be applied before the nameplate is affixed to the equipment providing the manufacturer ensures that the nameplate is applied to the correct equipment.

The nameplate shall be attached in such a way that removal would require the willful destruction of the nameplate or its attachment system.

The nameplate shall remain visible and legible for the lifetime of the equipment. The name plate information shall include, but not be limited to:

Motors:

- Manufacture identification
- Type
- Serial number
- Rated volts and full load amps
- Rated frequency and number of phases

- Rated full load speed
- Rated temperature rise or the insulation system class
- Time rating
- Rated horsepower
- Service factor
- Efficiency
- Frame size
- Design code

Gearboxes:

- Manufacture identification
- Type
- Serial number
- Ratio
- Rpm in/out
- Maximum torque
- Mounting position
- Direction of rotation
- Type and grade of lubrication

5.9.15 PAINTING AND PROTECTION

This shall be in accordance with ES Engineering Standards: PRD-ES-100 – General Requirements & PRD-ES-101 – Colour Codes.

Adequate protection shall be made for transportation and storage purposes for the:

- Roller body and journals
- Bearings and housings.
- Gearbox internals and shafts.

5.9.16 DOCUMENTATION

The supplier shall provide the following information, with every consignment of belting:

1. Purchaser's Order Number.
2. Supplier's Order Number.
3. Individual/combined weights of roller assembly, gearbox, and motor.
4. Certificate of Compliance to this Standard.
5. Identification plates on

6. Roller body:
   material certification.
   hardness test certification.
   top coating thickness certificate (if applicable)
7. Roller body refractory documentation (if applicable)
8. Inspection and test records
9. FAT documentation.
10. CE Documentation.

Operation and Maintenance manuals to be supplied in an electronic format and 1 off hard copy, and in accordance with ES engineering Standard: PRD-ES-110 – Engineering Documentation, project specific shall be agreed with ES.

Drawings supplied shall be in accordance with ES engineering Standard: PRD-ES-110 – Engineering Documentation.

5.9.17 PERMISSIBLE ALTERNATIVES

Alternative methods for driving and mounting the rolls can be considered only at: -

(a) At furnace discharge.

(b) Ingoing and outgoing working and breast roller tables at reversing mills.

5.10 Laser Alignment

5.10.1 GENERAL

The Contractor shall meet the requirements specified hereunder, in addition to any special requirements outlined elsewhere in ES contractual documentation.

5.10.2 PRECISION ALIGNMENT DEFINITION

Laser shaft alignment is the procedure of positioning two or more machines so that the rotational shaft centrelines are perfectly collinear. This may for example include several assets such as motor, gearbox and pump.

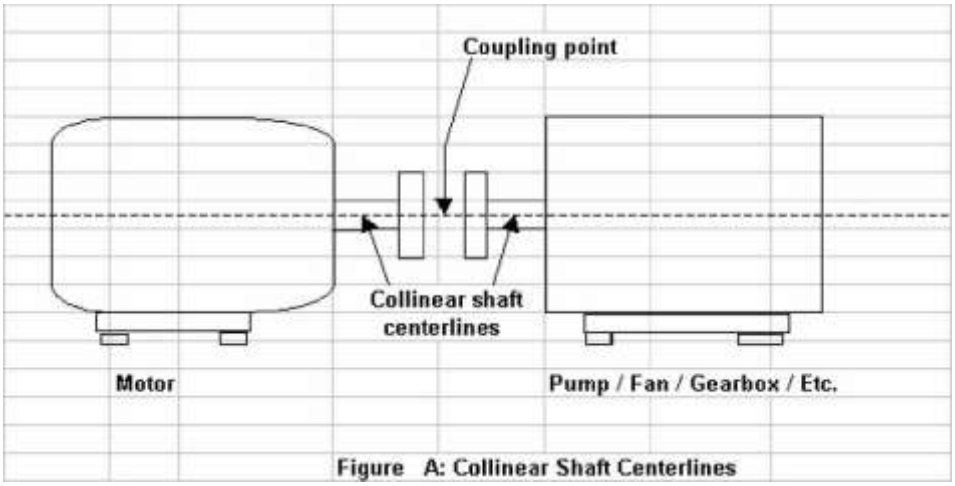

Figure A: Collinear Shaft Centerlines

5.10.3 MISALIGNMENT TYPES

Shaft misalignment can occur in the following ways, parallel and angular misalignment. These are the two basic types of conditions that can exist in either the vertical or horizontal directions. Misalignment can occur in any combination of parallel, angular or both.

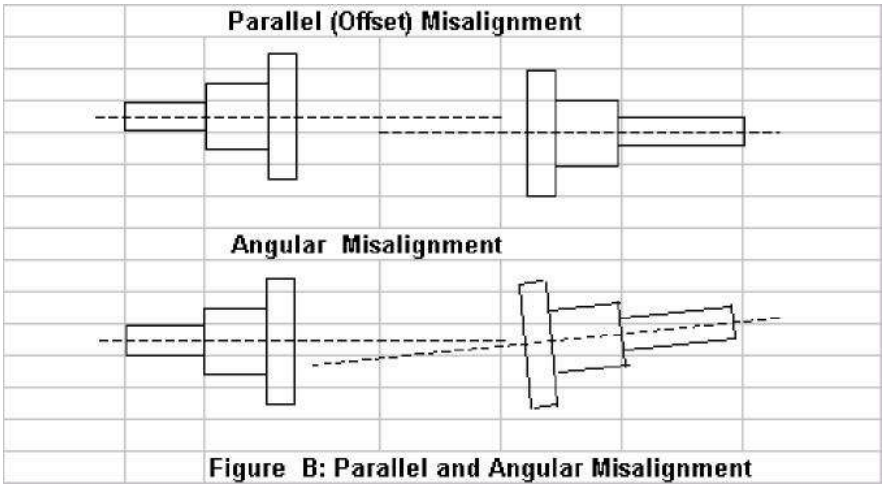

Figure B: Parallel and Angular Misalignment

5.10.4 SHAFT ALIGNMENT TOLERANCES

Shaft to shaft alignments shall be carried out to within the tolerances specified in the table below, unless a more precise tolerance is specified by the manufacturer or because of special conditions depicted by a supplier's process.

The tolerances specified are the maximum allowable deviations from zero-zero specifications or an intentional targeted offset and/or angularity.

Vertical & Horizontal Offset						Angularity (Gap)				
						Coupling Diameter				
RPM			Offset			10” (250mm) or less			10” (250mm) or greater	
Imperial	Metric		Imperial	Metric		Imperial	Metric		Imperial	Metric
600	600		0.005”	0.13mm		0.005”	0.13mm		0.0005”/in	0.05mm/100mm
900	750		0.003”	0.08mm		0.003”	0.08mm		0.0003”/in	0.03mm/100mm
1200	1000		0.0025”	0.06mm		0.0025”	0.06mm		0.00025”/in	0.03mm/100mm
1800	1500		0.002”	0.05mm		0.002”	0.05mm		0.0002”/in	0.02mm/100mm
3600	3000		0.001”	0.03mm		0.001”	0.03mm		0.0001”/in	0.01mm/100mm
7200	6000		0.0005”	0.01mm		0.001”	0.03mm		0.0001”/in	0.01mm/100mm

5.10.5 EXCESSIVE RUN-OUT CONDITIONS

When carrying out coupling laser alignment any non-perpendicular run out in the shafts must be considered. There are three types shown below and any combination of the three may occur at any time.

The permitted tolerances for this type of run out are detailed below:

RPM	MAXIMUM ALLOWABLE TIR (Total Indicator Run-out)	
	Imperial	Metric
0 - 3,600	0.002”	0.05mm
3,600 and over less than	0.002”	0.05mm

5.10.6 CASING TO BASE PLATE INTERFERENCE PROBLEMS (SOFT FOOT)

Soft foot is the term used to describe the condition where poor surface contact is being made between the underside of the machines base or feet and the contact with the base plate or frame. Or where there is an unequal quality of contact on all feet.

The maximum allowable tolerances for soft foot are detailed below:

RPM	MAXIMUM TOLERANCE	
	Imperial	Metric
All	0.002”	0.05mm

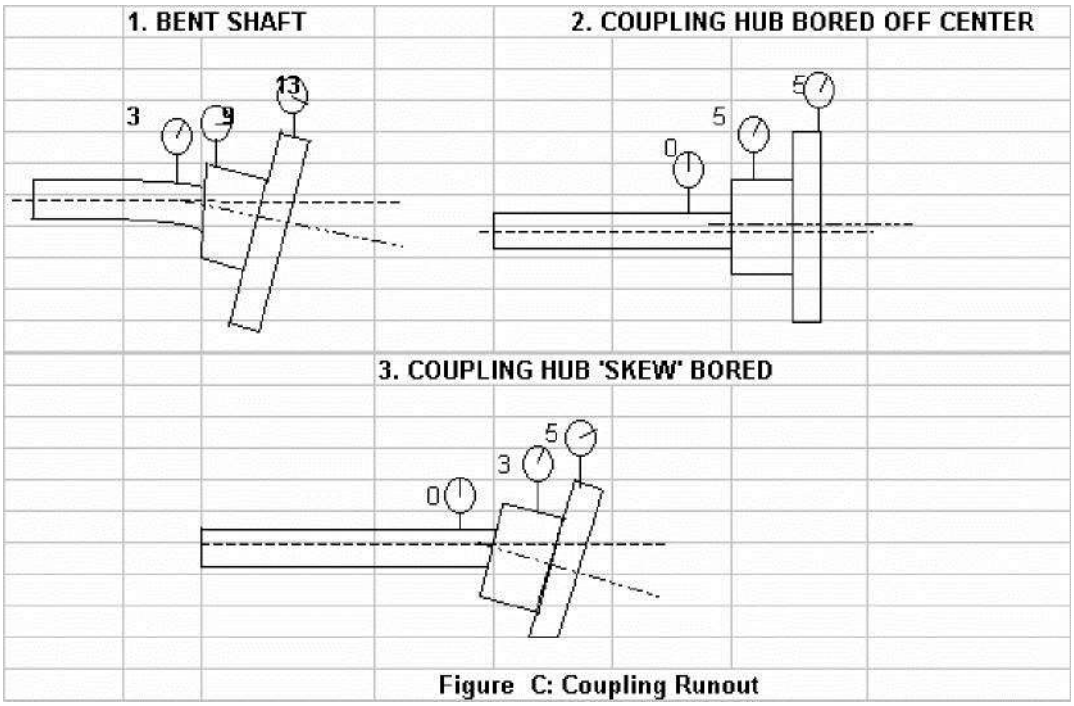

Figure C: Coupling Runout

5.10.7 SHIMS

Shims used to align equipment must meet the following specifications:

1. Made of corrosion resistant stainless steel which is dimensionally stable when subjected to high compression over long periods of time.
2. Consistent over the whole shim area, without any seams or folds from bending.
3. Clean, free from burrs, nicks and dents of any kind.
4. The smallest commercial shim that will fit around the holding down bolt without binding shall be used.
5. The overall shim pack shall not exceed a total of four (4) shims.
6. Shims must rest on bare machined metal, not on paint or other coatings.

5.10.8 EXCESSIVE STATIC PIPING STRAIN (STRESS)

Consideration must be given to excessive forces on a machine from pipe work. If the force of the pipe work exceeds 0.05mm in any direction rectification measures must be taken before the machine can be aligned.

5.10.9 DOCUMENTATION

On successful completion of the project the contractor shall issue to the purchaser the following documentation for the safe operation and maintenance of the Plant:

(a) Manuals

Operation and Maintenance manuals to be supplied in an electronic format and 1 off hard copy, the format shall be in accordance with ES Engineering Standard: PRD-ES-110 – Engineering Documentation, project specific to be agreed with ES.

(b) Drawings

Drawings supplied to be in accordance with ES Engineering Standard: PRD-ES-110 – Engineering Documentation.

(c) QA Documentation

Final Conformity Documentation, which will contain the following: -

- Installation Check Sheets
- Non-Conformity Reports
- Instrument Calibration Certificates.
- Audit Sheets
- Any other documentation submitted in a Quality Documentation Package under the applied International or National Standards.

The documentation shall be fully traceable.

ESI reserve the right to audit or request sample documentation through various stages of the project.

6. SUPPORTING DOCUMENTS

NA

7. REVISION HISTORY

Issue No.	Date	Page/s	Cause of Revision
0	17.11.2019	All	First Issue