حديد الإمارات
emirates steel
a SENAAT company إحدى شركات صناعات

Integrated Management System

Engineering Standards

Piping Engineering Standards

PRD-PI-GS-001

	Name	Title	Signature
Prepared by	Stuart Webster	Manager - Project Engineering	S. Webster.
Reviewed by	Abdel Moneim Tawfik	QA & Env. Manager	
Approved by	Anoop Nair	VP Marketing & Strategy	

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 Basic Design Criteria

5.1.1 SCOPE

This sub-section prescribes the minimum requirements for the design, material selection, construction, inspection and testing of all piping that is located within ES plant, except those excluded as listed below: -

a. Plumbing

b. Air conditioning ducts

c. Tubes, tube fittings and headers for boilers and heat exchangers.

5.1.2 STANDARDS

All pressure piping within ES plant areas shall comply with all mandatory requirements of the relevant DIN/ISO standards.

In addition to the requirements of the DIN/ISO standards, all piping under this Standard shall comply with "ES Site Conditions and Engineering Standards" and all documentation and drawings shall be supplied in accordance with ES Engineering Standard: PRD-ES-110 - Engineering Documentation.

The requirements of the standards and the ES piping specifications are minimum requirements for safe design and construction in most cases. Competent engineering judgment may dictate additional or more stringent requirements for any service condition. Applicable International or National Standards, if of a higher specification shall take preference.

All modifications, without exception, to ES existing Utilities pipework, must be in accordance with ES Utilities Standard: Inter Department Co-ordination Procedure for Utility Service Isolation and Modification – UTD-PR-005

5.1.3 GENERAL

a. Plant Design Standards

The piping design is part of the overall process and plant designs, and as such is governed by applicable EN/DIN standards, by "Emirates Steel Site Conditions and Engineering Standards" and by other applicable recognised international Standards. These Standards, Practices, and Codes include requirements for certain elements of the piping design such as layout, minimum distances, supports, anchors, valving, pressure relief, instrument connections, pipe flexibility, electric bonding, vents, drains and slope.

b. Road Crossing

Above ground piping in plant areas preferably should be placed on overhead bridges at roadways. Alternatively, they may be placed under the road. Buried road crossings where the pipework will be below the water table should be avoided. Minimum cover for buried pipe or sleeves in plant areas is normally 0.9 m. For lines with less than 0.9 m cover a 150 mm thick reinforced concrete armour clearance slab shall be placed over the pipe with a minimum 300 mm clearance from concrete to pipe unless a sleeve is used. The width of the concrete slab is 3 times pipe outside diameter unless a sleeve is used. The width of the concrete slab is 3 times pipe outside diameter or 0.9 m whichever is greater. The concrete slab shall not be considered in calculating the road load stress.

c. Buried Piping

Buried piping in plant areas should be avoided if possible.

The cover over buried piping in areas inaccessible to traffic shall normally be not less than 450 mm.

d. Fluid Properties

Well authenticated data for compositions and properties of fluids shall be used when calculating frictional pressure drops reaction forces, etc. Sources may include published texts, or proprietary information furnished by the design contractor. This data shall be listed in the design documentation.

e. Piping Flexibility

Calculations shall be made in accordance with the requirements of the piping code and shall be submitted by the contractor on request by ES.

f. Vibration

The piping design shall be thoroughly reviewed with respect to vibration problems which may arise from wind, excessive fluid velocity, two phase or slugging flow, reciprocating and rotating equipment, pressure drop in control valves, meters, pressure surges and oscillations, and other causes. The size and configuration of piping shall be designed to avoid vibration or shall effectively dampen induced vibrations by means of proper supports, bracing, or anchors.

Thermal expansion of liquids in piping systems shall be relieved. The preferred method to accommodate thermal expansion is the use of expansion loops. If bellows are deemed the only practical solution, then the contractor shall submit a risk assessment and design justification for approval by ES.

g. Dead Ends

A dead end is defined to exist when the length of an inactive line is greater than three times the line diameter. In any service where corrosion can occur, dead ended piping, with flow or no flow, even on a temporary basis, should be avoided. In cases where dead ending is unavoidable, the dead end should be separated from the active portion of the line by a block valve. The blocked segment should be drained, dried and sealed or should be filled with corrosion inhibiting liquid.

Piping passing through concrete floors or walls shall be provided with a sleeve one nominal size larger than the piping to allow for pipe movement. Normally, the sleeves will be open ended. Where the floor or wall is intended to provide protection against the spread of fire the sleeve openings shall be effectively draft (fire) stopped.

h. Corrosion Control

External and internal corrosion should be prevented and controlled consistent with design requirements and the environment in which the system is located.

Means to prevent or mitigate external corrosion of buried piping system shall be considered in the design and approved by ES. It shall be accomplished through application of an effective protective coating or wrapping and supplemented with cathodic protection. The coated pipe shall be inspected and accepted by an authorised inspector before being buried.

Piping for services where internal corrosion might occur, the piping material and lining shall be selected to be compatible with flowing fluid to minimise corrosion.

If inhibitors are used to control internal corrosion, as used for water cooling system, the piping system shall be passivated. The passivation method shall be proposed by the Contractor and approved by ES.

For protection systems refer to ES painting and protection Standards PRD-ES-100 – General Requirements and PRD-ES-101 – Colour Codes.

i. Pipe spacing's

Where two or more pipes are installed adjacent to each other, the distance between the outer surfaces shall be in accordance with International or National Standards. The criteria that shall influence the category of spacing selected is the system pressure.

Please refer to Appendix A for guideline purposes only.

5.1.4 MATERIALS AND FITTINGS

a. Pipe

Shall be selected in accordance with the applied ASME Standards which shall indicate the applications and limitations for various classes of pipe including carbon steel, alloy steel, cast iron, brass, copper, aluminium, cement lined steel, concrete, and plastic.

b. Pipe Fittings

Shall be selected in accordance with the applied ASME Standards to match

the pipe selected. It contains limitations and requirements applicable to specific types of fittings and pipe connections.

c. Valves

Shall conform to the requirements of the applied ASME Standards for the various service conditions indicated. In addition, the requirements for operation and accessibility of valves, use of by-pass valves, and locking devices, and guidelines for economical selection of types and sizes, shall also be included.

d. Flanges, Gaskets, and Bolts

Shall conform to the applied ASME Standards
requirements, which include material standards, dimensional standards, types of flange facings, and special requirements such as shields, insulating flanges, jack screws, calculation of bolt loads.

5.1.5 FABRICATION, INSTALLATION AND TESTING

a. Pressure Piping:

Fabrication, assembly and erection of pressure piping shall comply
with the requirements of the applied ASME Standard B31.

b. Non-Pressure Piping

The installation of non-pressure plant piping, pipe coating,
insulation, and other elements not covered by the standards shall conform to good construction practices, to applicable ESI specifications, vendor's recommendations, construction notes on applicable Standard Drawings, or project specifications.

c. Welding

Qualification of welders and welding procedures including heat treatment shall
be in accordance with ASME Code Section IX.

Pressure Testing of piping systems shall be in accordance with ES Engineering Standard PRD-ES-127-Pressure Testing.

5.1.6 DRAWINGS

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

5.1.7 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.

5.2 GENERAL REQUIREMENTS

- The Contractor shall submit to ES the piping specifications, for each piping system intended to install, for review and comment.
- The piping specification shall contain a detailed selection of components. Each component must be referred to an International Standard or code for standardisation

purposes. For special parts a drawing or data sheet must be supplied with the specifications.

- The piping specification shall be prepared in line with the design code for the service.
- All modifications, without exception, to ES existing Utilities pipework, must be in accordance with ES Utilities Standard: Inter Department Co-ordination Procedure for Utility Service Isolation and Modification – UTD-PR-005

5.3 PIPE SELECTION

5.3.1 SCOPE

This Engineering Standard covers the selection of pipe and tubing for use in the Plant piping system.

5.3.2 GENERAL

Line pipe and tubing shall be subject to the limitations of the applicable EN/DIN standards, and other International Standards such as ASME.

The selection of pipe and tube shall be compatible with the selection of pipe fittings per ES Engineering Standard: PRD-ES-123, pipe flanges per ES Engineering Standard: PRD-ES-125, and the methods of joining these components in each system.

5.3.3 STEEL PIPE

a. Sizes

Standard dimensions for steel pipe shall be in accordance with DIN 2448 (or ASME equivalent) for seamless pipes and DIN 2458 (or ASME equivalent) for welded pipes, except that larger diameters and intermediate wall thickness may be selected when commercially available.

b. Minimum Wall Thickness

The pipe wall thickness shall be generally calculated in accordance with DIN 2413 (or ASME equivalent). The pipe wall thickness can be taken also from the applicable DIN standard for the service.

The ES minimum wall thickness requirement will be the next higher standard value shown in standards DIN 2448 or DIN 2458, of the wall thickness obtained in accordance with the previous paragraph.

5.3.4 ALLOY STEEL PIPE

Alloy steel piping materials are not in general use so that each installation will require special consideration. A corrosion engineer or metallurgist should review each new application to consider strength and corrosion allowance criteria. The allowance shall be submitted to ES for review.

5.3.5 RUBBER/CEMENT LINED STEEL PIPE

The rubber/cement lining has proven effective in preventing tuberculation inside saltwater piping. This lining is suitable for water with pH in the range of 5.9 to 9.0. Rubber/cement lined steel pipe should be considered for lines handling well water or sea water under pressure for utility or firewater systems.

5.3.6 BRASS AND COPPER PIPE AND TUBING

Brass and copper pipe and tubing are used because of convenience and for fluids where sizes and flows are small, and where steel is not suitable because of corrosion. These materials are not suitable for hazardous service because of their low melting point and possibility of failure during a fire. Small size tubing using flare fittings, solder fittings, "Swagelok" or similar type compression fittings are used for instrument control, for refrigeration systems, and for portions of manufacturer's standard "package" units where the pressure and temperature limitations of the applicable Code are met. No copper or brass pipe or tubing should be used for any service higher than 205°C. Ordinary compression fittings should not be used in process plants or services subject to vibration.

5.3.7 STEEL TUBING

Stainless steel tubing 6 mm to 12 mm O.D. with "Swagelok" or similar, stainless steel, compression type fittings may be used for corrosive materials or environments such as:

a. Instrument air and instrument process connections

b. Sample lines to analyzers

c. Hydraulic fluid lines.

Carbon steel tubing with "Swagelok" fittings may be used as auxiliary piping for water or air in sizes 6 mm O.D. through 38 mm O.D. and as instrument supply lines for non-corrosive fluids in 12 mm O.D. only. Lines larger than indicated above shall be made of steel pipe.

5.3.8 PLASTIC PIPE

a. PVC

Schedule 80 is suitable for buried water, sanitary and industrial waste lines.

b. CPVC High Temperature Pressure Pipe

CPVC is considerably more expensive than PVC and should be used only when its temperature resistant qualities are required.

c. Polyethylene

MDPE and HDPE pipe are suitable for buried water and sanitary services.

d. Applications

Plastic pipe should be installed in accordance with manufacturer's instructions.

Some important points for consideration in design are:

- High coefficient of thermal expansion (design must provide for expansion and include thrust anchors at changes of section).
- Poor resistance to sunlight (vent pipes must be painted with water-base latex paint where exposed to sun).
- Loss of strength at high temperature.
- Limitations on threading (Schedule 40 pipe is not to be threaded. Pressure rating of schedule 80 pipe is reduced by 50% for threading).
- Limited interchangeability of solvent cements.
- Plastic or glass reinforced plastic pipe shall not be used inside plant areas for hazardous services, nor above ground in industrial areas.

5.4 PIPE FITTINGS

5.4.1 SELECTION OF PIPE FITTINGS

a. SCOPE

This standard covers the requirements for selection and installation of pipe fittings for all services and conditions; except plumbing and specialized instrument fittings.

5.4.2 THREADED AND SOCKET WELDED CONNECTIONS

a. HAZARDOUS SERVICES

Threaded and socket welded fittings are permitted for all hazardous services above -7°C except when fluid properties create severe problems of crevice corrosion or internal erosion.

- **Sizes**: Threaded and socket weld connections are used for nominal sizes 20mm through 38 mm for new construction and through 50 mm for field modifications. 12 mm connections may be used only for first connections of equipment such as orifice flange. 6 mm may be used only for stainless steel tubing fittings downstream of a valve.
- **Fittings**: Threaded and socket weld fittings shall conform with applicable DIN or equivalent international standard. Material shall be equivalent to the pipe.
- **Pipe Nipples** shall be seamless black not lighter than extra strong pipe.
- **Bushing** with nominal pipe size difference less than 12 mm shall not be used within plant limits. Only hex-headed steel bushings shall be used.
- **Plugs** shall be solid bar-stock steel and when installed in insulated lines shall be long enough to extend through the insulation.
- **Seal Welding (Back Welding)**: The principal purpose of seal welding is to avoid breakage of a nipple or pipe at the root of the last engaged thread. Seal welds may

be used to avoid leakage; however, they shall not be considered as contributing as strength to the joint.

Seal welding or equivalent reinforcement shall be required for all threaded connections in the following services and conditions in plant areas.

- Fuel gas lines involving conditions of personnel or equipment hazard.
- Strong acid, alkali, hazardous, toxic, or expensive fluid.
- Steam at gauge pressures of 17 bar or over, or temperatures of 210°C or above.

- **Exception to above**: Instrument piping for the above items shall be seal welded up to and including the line side of the valve. Seal welding beyond this point is not required.

b. NON-HAZARDOUS SERVICES

- **Scope**: The threaded connections described in this Section are permitted for non-hazardous materials within the temperature range 0 to 175°C and at pressures below 19 bar.
- **Sizes**: Threaded connections are permitted for all nominal pipe sizes through to 80 mm.
- **Fittings**: Use Malleable Iron Screwed Fittings, galvanized, or equivalent with galvanized steel pipe for water, gas and air under pressure.
- **Nipples** shall be butt welded standard weight, galvanized.
- **Threaded Couplings** for non-hazardous services with galvanized pipe, or equivalent couplings shall be used.

c. BUTT WELDING FITTINGS (CARBON AND ALLOY STEEL)

- Butt welded fittings may be used at the pressure and temperature at which the corresponding pipe material is suitable. They are recommended for all services.
- All butt-welding fittings shall be seamless when available. Fusion welded fittings are acceptable in large sizes and special alloys. Welded seams are to be 100% radiographed.
- Elbows shall be long radius, except where space limitations require short radius.
- FLANGED FITTINGS

Flanges and flanged valves are required in hazardous services for nominal pipe sizes 50 mm and larger. Smaller sizes may be used to connect equipment or for specialised design needs. Where connections that are required to be seal welded and must be taken apart frequently, flanges and flanged valves should be considered. Some locations which should be flanged are shut-off devices such as level and pressure switches

mounted directly on process lines or equipment. In such cases the design shall keep the number of flanges to a minimum.

5.4.3 START-UP SCREENS

Start-up screens shall be installed in the piping to equipment particularly pumps, during the initial operation. Flat screens are used only when space prohibits the use of conical screens. Flat screens result in a reduction in flow area and will become plugged quickly with debris.

5.4.4 PLASTIC PIPE FITTINGS

PVC schedule 80 pipe and fittings are the preferred material for buried utility lines. An electrical bond must be provided around the plastic pipe or a separate means provided to ensure that the building electrical system is adequately grounded.

The fittings shall have the solvent-welded interference-type joint except as noted below:

The connections to steel pipe are made of PVC flat face flanges. Threaded connections to steel pipe shall be kept to a minimum because of the difference in thermal expansion of plastic pipe in the field.

5.4.5 SOLDERING TUBING FITTINGS

These fittings are normally used for refrigeration and air conditioning refrigerant lines. They are adaptable to water services. Some types of solder fittings have limited usage for plumbing fixture drain service.

5.4.6 FLARED AND COMPRESSION TUBING FITTINGS

Copper and brass flared and compression fittings for connection to copper alloy tubing are used for refrigeration fluid services for instrument air lines, automotive fuel and lubricating oil lines, and steam tracing. The flared fitting is preferred to be soldered and compression fittings in vibration services such as near compressors and rotating equipment but shall only be used with soft annealed tubing.

Swagelok brand compression fittings type or similar shall be used on steel and stainless-steel tubing. Carbon steel fittings shall not be used on stainless steel tubing.

Standards: There are numerous "standard" types of fittings conforming to various dimensions and manufacturer's standards. The numerous styles or types are required because the various equipment manufacturers have no restrictions on selection for their units.

Compression fittings of different styles are used in some plumbing fixture drain service.

5.4.7 BRONZE FITTINGS AND BRASS FITTINGS

a. Use

These threaded fittings are used in special chemical and water services.

b. Standards

Bronze fittings should not be used for acetylene gas because of the formation of the explosive compound cuprous acetylide. Special fittings with a maximum of 67 percent copper should be used for this service. Bronze pipe plugs are used to close drain lines in water service where steel plugs might rust in place. Brass pipe bushings are used to connect small sized tubing fittings to steel pipe.

5.4.8 EXPANSION JOINTS

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.

Below type expansion joints are subject to fatigue failure and have limited fire resistance. Bellows may be used for steam lines only when sufficient piping flexibility cannot be attached by using conventional welded components. The Contractor shall insure that displacements and/or rotations will not exceed the limitations of the joint and shall provide detailed instructions for installation, removal of any locking devices used for transport, adjustment and testing as applicable to each individual installation.

5.4.9 SWIVEL JOINT FITTINGS

Swivel joint fittings allow flexibility in piping by permitting rotation of joints in various planes. An upper temperature limitation of 105°C is imposed because of the bearings and packings.

5.5 SELECTION OF VALVES

5.5.1 SCOPE

This engineering standard contains basic requirements and guidelines for the application and selection of valves in the plant piping systems.

Excluded are the following services:

- Plumbing and domestic applications
- Air conditioning and ventilating ducts
- Control, safety, relief, surge relief, solenoid and pilot valves.

5.5.2 GENERAL REQUIREMENTS

The valves shall comply with the requirements of a recognised International Standard, such as ASME. All gate, globe, angle and check valves shall have renewable seat rings. Excluded are:

a. All carbon steel and alloy steel valves 50 mm nominal and smaller and all austenitic stainless or higher alloy steel valves with bore sizes 150 mm nominal and smaller. The body seat ring shall be hard faced (Satellite No. 6 or equivalent).

b. Valves used in steam services.

5.5.3 VALVE SELECTION

Valve selection shall be based on functional needs, fluid/gas contained in the system, safety functional requirements, and material requirements. The following list of variables shall be considered:

- Valve function and type i.e. Angle, check, gate, globe, ball, plug.
- Type of connection i.e. flanged, threaded, welding end.
- Sub-type or style.
- Size and pressure rating.
- Body material.
- Trim material.
- Seal and packing materials.
- Fluid or gas contained in the system.
- Safety requirements.
- Maintenance requirements.

a. VALVE FUNCTIONS

- The valve function is designed to be automatically controlled by process or instrumentation.
- The valve function is designed for flow and pressure control, operated manually or power assisted.
- Valve operation is direction controlled (remotely and/or locally), hand operated or power assisted.
- Valves must have a failsafe facility where the system design requires it.

b. VALVE TYPE

- **Manual Flow Control Valve**

The selection of a manual control valve depends mainly on the pressure rating, fluid, and the required pressure drop across the valve. Table I is a guide for selection.

These valves are normally metal seated valves; soft seated valves should be avoided. In cases where a tight shut-off is required, a back-up valve must be installed. This valve may be a soft seated, on-off valve, temperature permitting.

These valves shall have a locking facility to enable the user to adjust and secure the valve to the required setting.

TABLE I

APPLICATION	DP	NOMINAL SIZE	PRESSURE RATING	VALVE TYPE	REMARKS
General Purpose	High	3 to 25 mm	All	Needle	Fine Flow Regulation
Gas and Liquids	Mod / High	12 to 300 mm	< PN 64	Globe / Angle	Flow Regulation
	Low	> 12 mm.	All	Ball	On - Off
Water	Mod.	2 to 2000 mm	PN 10	Butterfly (Regular)	On - Off

Ref:

- DP: Required pressure drop across the valve.
- PN: Nominal pressure (bar)

c. END CONNECTIONS

- **Flanged**

  Valves larger than those permitting screwed or socket welded connections shall be bolted to or between standard pipe flanges except as specified in butt welding ends. Wafer type valves which are sandwiched between pipe flanges may not be used in fire hazardous areas and services unless the bolting is protected by a fire-resistant shield.

  Valve flanges, whether integral or welded on, shall conform to DIN standards (or ASME equivalent), specifically regarding minimum flange thickness, facing and drilling. Any other standard could be used for specific plant requirements with approval from ES.

- **Threaded Ends**

  Valves, 80 mm nominal and smaller in low pressure utility services and 38 mm nominal and smaller in other industrial services up to nominal pressure 100 bar may have female threaded ends.

  Where seal welding of connections is required threaded valves with elastomer seals or seats shall not be used unless the valve-to-nipple joint is shop made and shop tested prior to installation in the piping system.

- **Socket Welded Ends**

  Where permitted by applicable piping code, valves in nominal sizes 38 mm and smaller may have socket welded ends. They are an alternative for services where all threaded connections would need seal welding.

  Valves with elastomer seals or seats shall not be used with socket welding ends unless the valves to nipple welds are shop-made and tested.

- **Butt welding Ends**

  Butt welding end valves shall be used in steam service in nominal pressure 64 bar.

  In nominal pressure 40 bar those valves may be used in locations where valve malfunction does not cause a lengthy major shutdown.

  The end to end dimension of butt-welded end valves shall include suitable welding ends which permit field welding without seat distortion or damage to the soft seals, if any.

5.5.4 VALVE SUB-TYPES AND MINIMUM REQUIREMENTS

a. ANGLE VALVES

The applications, specifications and service conditions for angle valves are similar to globe valves, except that the ports are orientated at a right angle to each other and the stem usually in line with the outlet port. Angle valves are the preferred geometry for severe throttling since the high-velocity fluid has less tendency to impact the downstream piping. In very severe services, the outlet piping needs protection (tungsten carbide sleeves). The pressure drop across an angle valve is less than the pressure drop across a globe valve combined with a 90-degree elbow.

b. CHECK VALVES

The purpose of these valves is to prevent reversal of flow in a piping system. For selection chart for check valves, see Tables II and III.

1. **SWING CHECK, REGULAR PATTERN** is commonly used to prevent backflow in horizontal and vertical upward-flow piping. The hinge pin must be in horizontal position. Typical features are medium pressure drop, can slam shut, bolted flat cover plate or pressure seal bonnet in high ratings for clean service, renewable seat, no tight shut off, no limitations as to size, ratings, metallurgies. Recommended minimum velocity for stable disc position is 1.8 m/s for water to 2.5 m/s for light product and about 14.5 m/s for air at 14 bar, 80°C and inversely proportional to density for other gases. Modifications such as resilient seat, external or internal shock absorber or mass are not recommended. A special version of this valve has the hinge pin nearly vertical when installed in a horizontal line. This will reduce pressure drop but can result in severe slamming due to delayed closing.
2. **TILTING DISC, CHECK** has a split body with bolted flanges at approximately 60 degrees to pipe axis and pivoted aero foil type disc, renewable or integral seat. Applications are similar to standard swing checks, except that the tendency to slamming is reduced. Recommended minimum velocity for stable disc position is about 1.8 times that for the swing check. Pressure drop is about the same. The addition of external attachments is not recommended.
3. **LIFT (PISTON) CHECK** has a globe valve body and guided disc for use in small size, horizontal lines only. Pressure drop is high, and velocity needed for full disc lift is high. In Y pattern and angle pattern piston lift check valves which have an equalizer line between zone above disc and valve outlet, the pressure drop is reduced. These can also be used in vertical upward flow.

   The guided piston can stick, particularly in models with internal dash pot function. Spring loaded piston checks shall be used where rapid closure is essential to avoid slamming.

   Piston checks are more rugged than swing checks and are preferred for rough but critical clean service such as boiler feed water pump discharge.
4. **BALL CHECK** is similar to the piston check where a ball is used instead of a piston. It is used for small sizes and is preferred for fluids with high viscosity, available with or without spring as horizontal checks, angle checks and combination horizontal/vertical type.

The latter type is used for general check valve service where the force of gravity is not required in closing.

5. **Stop-check valves** are straightway, Y pattern or angle type piston lift checks with provision to screw down the piston disc hard onto the seat and are mainly used in steam outlet piping and boiler feed water lines of parallel boilers, must be installed so that pressure will be under disc.
6. **Wafer type checks** have spring loaded semi-circular doors centre hinged. These may be used where low-pressure drop is essential, except where severe shock loading can occur. These valves are not to be used in pulsating streams and shall not be used as suction or discharge valves of pumps and compressors.
7. **Intrinsically dampened and spring-loaded piston check valves** shall be used in critical applications where severe shock loading can occur, rather than other types with external damping devices. Because of streamlined construction this valve has very low pressure drop. As this valve is an engineered item all flow must be supplied to manufacturer.

TABLE II

CHECK VALVE SELECTION CHART FOR SIZES 50mm NOMINAL AND OVER

TYPE	MAX. NOMINAL PRESS. (Bar)	MAX. NOMINAL SIZE (mm)	SERVICE	CHARACTERISTICS
Swing-Check Regular Pattern	40	1200	General Purpose Liquid / Gas	Possible Severe Slamming
Piston Lift	160	600	Clean and Non-Corrosive Steam, Boiler Feed Water	Reduced Slamming
Tilting Disc	40	1200	As Regular Pattern Swing Check	Reduced Slamming
Water Type Check. Dual-Plate	40	900	Non-Critical Services	Minimum Space Requirements
Intrinsically dampened spring balanced piston	160	1200	For Critical services and tight Shut-off. Pump and Compressor in/outlet valves	No Slamming

TABLE III

CHECK VALVES

38 mm Nominal and Smaller

TYPE	SERVICE	CHARACTERISTICS
Ball Check	For general services. High viscosity fluids, gas, air, water.	Soft section only when double tight shut off is required.
Piston Check	For clean services, steam, boiler, feed water, dry air	When used in corrosive fluid the piston may get jammed.

Indicative only. Duties to be verified by contractor

8. Gate Valves

These valves are the most commonly used metal seated block valves. Design features which can be used in various combinations are discussed below for closing member, stem, packing, bonnet/body connection, seat rings.

- Swing gate or sliding plate, quick closing simple styles are sometimes used for services such as sludge in sewage systems, etc.
- Parallel slide valves have double discs separated by springs. They seal on the downstream side only. These valves are recommended for steam service as temperature changes have little influence on operation. The types with a gate which has a hole that matches the bore when the valve is fully open are preferred.

This valve may be used for short-term flow control of high-pressure steam and boiler feed water.

9. Wedge Gate valves

The valves can be cast, forged or fabricated. The valves are metal seated with a narrow-angled wedge, so that friction will keep the wedge in place when it has been thrust into the angle of the seats. Temperature changes and differentials can cause large variations in forces on the wedge and consequently variations in friction force and stem thrust. A plain solid wedge gate can become stuck; therefore, flexible wedges are preferred. Application of valve depends on wedge type and seat material.

a) **Plain Solid Wedge** - These are only allowed in valves with nominal sizes under 100 mm in nominal pressure 40 bar and lower. These valves must not be subjected to large temperature changes.

b) **Flexible Wedges** -This is the most commonly used type of gate valve. The wedges may be constructed from 2 or 3 parts (not recommended), which are welded together or made with saw cut or cast in H or inverted U shape. Evaluation of vendor designs must include careful review of the lugs retaining the stem-end. These valves are less suitable at service temperature over 205°C.

c) **Split Wedge or double discs with tapered seating**. The ball and socket joint or other spacer type joints allow the two-disc halves to align to the body seats. Although not generally designed for this feature, the stem will pull one of the disc halves first and retract the discs axially before upward movement.

d) **Double disc wedging gate with parallel seating**. The disc halves are forced outwards against the body seats by a spreader or by a wedge angle machined on the mating sides of discs. This type of wedge is more suitable for higher temperatures. The discs retract axially when opening movement starts. For critical, frequently operated valves which must be tight at low pressures, resilient seats are used.

e) **Seating design**. The seat ring shall be renewable and be threaded into body fitted and seal welded.

f) **Bonnet design**. Bolted flanged bonnet with gasket is normal for flanged wedge gate, globe and angle valves. Pressure seal bonnets are used in high pressure ratings and clean services, especially steam, for economy and more compact design compared to bolted bonnet. Special design locked insert type bonnets with welded corrosion resistant membrane may be considered for high pressure ratings.

g) **Operating Stems**. The outside screw using stem with yoke (OS & Y) shall be used for steel wedge gate, globe and angle valves for all services. When environmental influence such as erosion by sand may cause damage to the exposed stem threads, the internally screwed rising stem (I.S.R.S.) may be used. Because their threads are exposed to the service fluids, utilization of ISRS valves is limited to clean, non-corrosive services.

   The inside screw non-rising stem which screws into a threaded gate is more compact but shall not be used because outwardly there is no difference between the open and closed position.

h) **Stem Packing Arrangement**. The stem packing is contained in a stuffing box and compressed by a gland. A two-piece gland and follower screwed down by

two gland bolts shall be provided on OS & Y valves. The packing may be replaced under pressure with the stem fully raised to seat against the backseat, which may be bushing or integral with the bonnet.

c. Soft seated gate valves

These valves must comply to all requirements of wedge gate valves except:

The seat rings have a resilient insert to improve the tightness of valves. The insert material may be P.T.F.E., Nylon, or other approved material. Valves having this type of insert should not be used in service temperatures above 120°C.

Wedge gate valves having a resilient seating system are recommended for tight shut off and non-frequent operation. If the seat rings are threaded, an O-ring shall be added to ensure tightness between body and seat. In large size valves, floating seat rings with O-rings may be used in conjunction with a plain solid wedge.

Consideration shall be given to the possible degradation of the seating rings or seats etc., in relation to the properties of the fluid or gas in the system.

d. Globe Valves

Flanged and butt-welded globe valves. The sealing arrangements can be as follows:

- **Composite disc**: This disc has a resilient insert to ensure bubble tight shut-off. It is not to be used for flow control. The service temperature is limited by the pressure - temperature rating of the soft seating material.
- **Ball shaped plug** or conical plug making line contact with the seat. This type of disc is recommended for services where flow control is only needed in the range of 50 percent of maximum flow or higher.
- **Tapered plug disc** and taper seat. Due to the larger seating contact area this shape is more suitable for throttling compared to "b", but close throttling for a long time may cause "wire drawing".
- **Flat seating disc**: This shape has also the disadvantage of "wire drawing" at close throttling. The force to close these valves tight can be very high.
- **Needlepoint**: Recommended for use of fine flow control in nominal sizes up to 38mm and in all pressure ratings.
- **Special** shaped discs are available to increase flow control characteristics (e.g. V-port disc).

1. Application

The valves can be used for control of flow except where close throttling for a long time is required. This may cause "wire drawing". The valves are suitable for frequent operation and give a good shut-off in a wide range of temperatures and pressure ratings. Globe valves are not to be used where a low pressure drop across the valve is required.

The use of this type of valve is limited in size and pressure rating because the stem forces tend to be too high.

Technical requirements such as stem sealing, gland packing, bonnet construction, etc. are as the requirements for wedge gate valves.

The needle valves are used where fine regulation of flow is needed but are also used as block valves for pressure gauges.

Ball Valves provide tight on-off control by simple quarter turn operation, through conduit flow, minimum turbulence, low torque, compact design, not to be used for throttling. Alternative design features are discussed below for body construction, ball support, seat rings.

If valves are to be seal welded, they shall be purchased with factory-installed extension nipples or with carbon seats which are inert to welding temperatures.

These valves shall have a locking facility to enable the user to adjust and secure the valve to the required setting.

2. Body Construction

The body can be different types of construction. The user must specify what type is required based on the following:

a) Fully welded body type

Stem seals can be replaced in line. Minor seat leakage can be repaired by sealant injection and if not successful, the valve must be returned to the manufacturer for repair. The only possible leak passage to environment is past the seal where the stem passes through upper body shell.

One fully welded ball valves design provides for the seat rings to rotate 15 degrees every time the valve is closed. This gives an advantage because the last moment throttling wear is divided over the full circumference of seat ring and the sealant injection to restore damaged seats is more effective.

b) Split Body Type

The body is of a bolted construction making it possible to replace all parts when the valve is taken out of the pipeline. Repair of damaged parts can be done in a well-equipped machine shop and replacement of parts can be handled locally.

c) Top Entry Type

Same as above, but body has top cover that can be removed when valve is in-line. All parts can be replaced without the valve being removed from the line.

d) Selection of type

For valves in the following services, it is mandatory that a repairable type (split body or top entry) be specified:

- where a strong leak could create a personnel hazard.
- in areas where significant amounts of debris, e.g. sand, scale, corrosion products, can be expected to accumulate in the valve and cause damage to the seats i.e. at the ends of a long pipeline, etc.
- at critical locations where operating requirements dictate a tight shutoff.

When a split body valve is installed to cover the above services, it is preferred that the ends be flanged to facilitate its removal from the line for repair; with a top entry valve either weld ends, or flanged ends may be used.

In all locations other than the above any of the three body styles may be selected.

- The ball may be seat supported (floating ball) normally up to 250 mm nominal size and nominal pressure 10 bar, 150 mm nominal size and nominal pressure 25 bar, 50 mm nominal size and higher-pressure ratings. Stem must be blow-out proof. This design is more fire safe than trunnion mounted balls but at the expense of shorter seat life and greater turning effort.

  In larger sizes and pressure ratings the ball shall be trunnion supported to reduce torque and wear on the seat. The seat rings shall be floating, spring loaded.

e) Butterfly Valves

The (regular) butterfly valve is a simple valve for use in non-critical services.

The maximum pressure differential allowable across the closed valve is generally 10 bar or lower. A flat round disc rotates 90 degrees and makes a seal with a resilient lining of the inside of the body. The resilient lining must be selected to suit the service. Metal seated valves are also available. The valves can be installed and bolted between flanges.

The valves can be of the concentric type or the eccentric type. In the concentric type valves the centerline of the disc is also the centerline of the disc shaft causing wear and tear during closing. In the eccentric type valves, the disc contacts the lining just before the closed position, this reduces the wear and improves the sealing. The eccentric type butterfly valves are preferred.

3. Applications:

These valves (soft-seated) are suitable for tight shut-off in low pressure services. Valves are only to be used in non-critical services such as cooling water systems, A.C. plants, etc.

Valves are not to be used in fire hazardous environments.

a. High Performance Butterfly Valves

The maximum allowable pressure difference across the disc of a high-performance butterfly valve is equal to the maximum allowable working pressure of the body and connecting flange rating. The valves are very light in weight and use little space. The cost of this type valve is very competitive with the cost of a ball or gate valve because less material and less machining is needed. These valves can therefore, under certain conditions, be a good alternative for gate or ball valves. The butterfly valves do not have a body cavity, so stagnant fluid conditions are avoided and over-pressurizing of the body, due to temperature differences, is not possible. The valves cannot be used in lines that need cleaning by means of a scraper.

5.5.5 SIZES AND PRESSURE RATINGS

a. Sizes

Each type of valve has its own limitations in size and pressure ratings. Starting with the 3 mm instrumentation type valve, nominal sizes go up to 1400 mm in high pressure rating

(nominal pressure 40 bar) for use in compressor/pump stations and in transportation systems, while the maximum sizes for low pressure valves go much higher.

Normally, full bore valves are used. Only when a higher-pressure drop is acceptable and when the lines do not need cleaning by a scraper, the reduced/venturi bore valves can be used and are then the most economical selection. The minimum bore sizes for full bore valves approximate the internal diameter of the connecting pipe and are specified in the applicable valve specifications. Reduced bore and venturi bore valves have a bore one or more sizes less than the nominal size of the connecting pipe.

The face to face dimensions for flanged end valves is standardised in the applicable standards.

5.5.6 INSTALLATION

a. Valves shall not be installed with their stems below the horizontal except in clean final product services, and block valves under safety relief valves.

b. Valves shall be installed such that their stems do not extend into walkways.

c. Accessibility for operation shall be considered when locating valves. The horizontal hand wheel of large valves should not be located above shoulder height, 1.4 m when it is not possible to locate the handwheel of a valve less than 1.4 m above grade or operating platform, the valve shall be placed in a horizontal position and equipped for chain operation; in clean final product services the valve may be oriented lower than the horizontal to eliminate the need for a chain wheel.

d. Reasonable access should always be considered at all valve locations for maintenance requirements.

e. When it is necessary to operate a valve from a remote location and this cannot be done by a chain wheel or extension stem an operating mechanism of bend gear joints may be used. The gears shall be installed so that valve closes with clockwise hand operation.

f. Valves in critical service which are to be operated by authorised personnel only shall be installed with a locking device.

g. Where applicable the torque setting for the flange's bolts shall be specified.

h. Care shall be taken to install the valve in the correct direction of flow.

5.5.7 NAMEPLATES

Valve nameplates shall include but not be limited to:

- Manufacturers name.

- Type
- Serial number.
- Size.
- Flange type.
- Pressure rating.
- Temperature rating.
- DSEAR rating.
- CE mark.

5.5.8 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: -

- Material Certificates
- Welding Procedures
- NDT Testing Records
- NDT Inspector Qualifications
- Pressure Test Certificates
- FAT Records.
- Non-Conformity Reports
- Third Party Certification
- Painting Records – specification/application/thickness 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.

The documentation shall be fully traceable.

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

5.6 FLANGES, GASKETS & BOLTS

5.6.1 SCOPE

This Engineering Standard covers the general design requirements for flanges, blinds, gaskets and bolts for flanged joints in piping systems.

5.6.2 GENERAL

- Flanged joints in piping systems shall be subject to the limitations of the DIN EN1092 or equivalent and relevant International Standards (such as ASME).
- The suitability of flanges for service under significant bending and other external piping loads must be confirmed by calculation when the design temperature exceeds 200°C and for all temperatures when the nominal size exceeds 600 mm.
- Flanges, blinds and gaskets shall be made of materials which are compatible with the pipe, the service, and any applicable material selection specification contained in "ES Site Conditions and Engineering Standards".
- A shield shall be installed over flanged joints wherever a leak could spray a hazardous chemical, such as acid or caustic, on personnel.

5.6.3 FLANGE TYPES

- Threaded flanges shall be subject to the limitations on threaded joints. When flanges are needed in screwed piping systems, welded slip-on flanges are preferred.
- Socket welding flanges shall be subject to the limitations on socket welded joints. When flanges are needed in socket welded piping systems, slip-on flanges are preferred.
- Slip-on flanges shall not be used for severe cyclic conditions, nor for design temperature above 230°C, nor for pressure rating 16 bar or higher rating, nor for pipe sizes larger than 600 mm, unless stress calculation indicates that such flanged joint will not be overstressed.
- Slip-on flanges shall be welded on the front or face and at the back of the hub.
- Lap-joint flanges shall not be used for severe cyclic conditions. ES practice limits the use of lap-joint flanges to special applications such as: (a) to avoid welding of dissimilar materials, and (b) to facilitate lining up the bolt holes.
- Welding neck flanges with tapered hub and welding end are the preferred selection for flanged joints in metal piping systems of 50 mm and larger nominal size.

- Orifice flanges shall comply with the mechanical requirements of this standard and shall be installed as required by the applicable instrumentation standards.

5.6.4 FLANGE DIMENSIONAL STANDARDS

- The applicable DIN standard (or equivalent) shall be used for the type of flange concerned.

  Refer to DIN EN 1092 - flanges general information with type of flanges, material and nominal pressure for the applicable dimensional DIN standard (or equivalent such as ASME 16.5, ASME 16.47).

5.6.5 FLANGE FACINGS

The flange face shall be in accordance with DIN EN 1092 - types of contact surfaces (or equivalent).

Flat face flanges, with full face gaskets shall be used when one or both mating flanges in a joint is cast iron or aluminum or plastic or other material that could overstressed by the bolt load.

Raised face is the normal selection in ES practice for steel flanges in pressure ratings up to and including 40 bar and up to a design temperature of 480°C.

Mating of unequal flange facings in a flanged joint using a proper style gasket shall be permitted only in exceptional cases, subject to approval by ES.

Tongue and Groove facing or Male and Female facing shall not be used on piping joints except in special cases when it is necessary to match existing equipment.

When a piping system is lined with plastic or material with a melting point below 370°C and contains a flammable fluid, the flanged joints shall be designed to prevent leakage under exposure to heat sufficient to destroy or melt the lining material (lapped over the flange faces).

5.6.6 BORE OF WELDING NECK FLANGES

The bore of welding neck flanges shall not be larger than the bore of the pipe within the tolerances set for butt welding ends. When the flange bore is less than the pipe bore, the flange welding neck shall be internally taper bored to match the pipe wall.

The design thickness of the flange hub at the welding end shall be at least equal to the pipe wall thickness times the ratio of the specified minimum yields (SMYS) of pipe and flange, provided this ratio is not less than 1 nor more than 1.5.

The bore of welding neck flanges may be equal to the bore of the matching pipe having a higher SMYS, provided that a stress calculation for a full rating pressure indicates that the flanged joint will not be overstressed.

5.6.7 BLINDS

The piping design shall provide for the use of spectacle plates or blanks and spacers at flanged joints as required for pressure testing, for blinding off during repairs or inspection, or other operating reasons. The blinds shall be positioned so that the volume of fluid that must be discharged prior to installations of the blank, is kept to a minimum.

5.6.8 GASKETS

Gaskets shall be suitable for the intended service and shall be compatible with the flange facing, and in accordance with DIN EN 1514-1,1514-6,1514-8, DIN 2695 and 2696(EN or equivalent. Not more than one gasket shall be used between the mating surfaces of flanges and blinds.

5.6.9 BOLTING

Bolting for flanged joints shall be subject to the requirements of the applicable DIN standard. DIN 2507 Part 2 - Bolts for Pipelines (or equivalent International Standard such as ASME 16.5, ASME 16,47), may be used for selection.

Flat washers under the nuts are required for special cases only, such as on insulating flanges and under the nuts bearing against plastic flanges.

5.7 FABRICATION & INSTALLATION OF STEEL PIPING

5.7.1 SCOPE

This specification covers the requirements for fabrication, installation, inspection and testing of steel piping, using carbon steel pipe, and stainless-steel pipe for ES.

5.7.2 REFERENCES

The requirements contained in the latest edition of the following standards and codes shall form an integral part of the requirements of this specification in the manner and to the extent specified herein.

ANSI B 31.3 Chemical Plant and Petroleum Refinery Piping

ANSI B 31.8 Gas Transmission & Distribution Piping Systems (only for N2 and O2 Pipeline)

ASME Boiler and Pressure Vessel Code

SECTION I Rules for Construction of Power Boilers

SECTION V Non-destructive Examination

SECTION VIII Rules for Construction of Pressure Vessels – Div. 1

SECTION IX Qualification Standard for Welding & Bracing Procedures, Welders, Bracers and Welding and Bracing Operators

5.7.3 GENERAL

a. INSPECTION AND TEST PLAN

An Inspection and Test Plan (ITP), defining all inspection and test requirements and procedures, shall be prepared and agreed with ES prior to commencement of pipework installation.

b. CODES AND STANDARDS

1. Fabrication, installation, inspection and testing of all piping shall be in accordance with ANSI B31.3 and B31.8 (only for N_2 & O_2 Pipeline) except where more stringent requirements are made in this specification.
2. If fabricator/assembler has developed alternative techniques or intend to apply alternative methods considered equivalent to those indicated herein, a proposal on such techniques or methods shall be submitted to ES for approval.
3. Piping components shall be used in accordance with the piping service class specification.
4. Piping components shall be checked to confirm the material identification prior to issuing the materials.

c. REQUIREMENTS FOR OXYGEN AND NITROGEN PIPELINES

1. **Preservation of Cleanliness**

   For oxygen pipelines, it is extremely important to remove such contaminants as rusts, oily compounds, organics and whatever materials could become source of ignition under pure gaseous oxygen.

   Along the line of this importance, preservation of cleanliness of the degreased and cleaned materials shall be carefully undertaken during fabrication and installation work.

   In addition to the requirement specified herein, those prescribed in attached specifications shall be strictly applied.

2. Although there is no risk of ignition with pure gaseous nitrogen, removal of contaminants including oil and grease is important to maintain nitrogen purity.

5.7.4 WELDING

a. CUTTING OF PIPES

As a rule, pipes shall be cut mechanically with a pipe cutter or a high-speed cutter. However, the following are permissible: -

1. Carbon steel pipe which has a carbon content not exceeding 0.35 percent in the parent metal may be cut with an automatic or manual oxygen-acetylene gas torch.
2. Only when unavoidable, stainless steel pipe may be cut by a plasma jet or by arc air gouging. In this case, the pipe shall be applied with a coating for preventing adhesion of spatter.

Welding Procedures: -

1. All welding procedures shall be or shall have been qualified in accordance with Section IX of the ASME Code.
2. Procedure qualification tests when required shall be completed prior to starting fabrication under witness of ES's Engineer. Complete specifications including the test results shall be submitted to ES for approval.

For low temperature service, procedure qualifications for welds shall include impact tests of both the weld metal and the heat affected zones.

b. WELDERS AND WELDING OPERATORS

Welders and welding operators shall be qualified in accordance with Section IX of the ASME Code prior to fabrication, with records available to ES on request.

c. FILLER MATERIALS AND FLUX

1. When joining two different ferritic steels, the filler metal shall conform to the nominal chemical composition of either base metal or to an intermediate composition with preheating and post weld heat treatment applied for the higher-grade steel.
2. When joining two different austenitic stainless steels, the filler metal may match either steel.
3. When joining base metals exceeding 19mm in thickness, a filler metal producing low hydrogen deposits shall be used. However, cellulose or rutile type coated electrodes may be used for root passes regardless of wall thickness.

d. JOINT PREPARATION AND ALIGNMENT

1. Weld bevels shall be suitable for the welding process to be used, and the contour shall permit complete fusion throughout the joint. Bevels shall conform to those used in the procedure qualification.
2. Pipe having a nominal thickness less than 4.8 mm may have a slight chamfer or be square depending on the fabricator's practice.

3. Weld bevels shall be made by machining, grinding or thermal cutting, and the surfaces shall be reasonably smooth and true.
4. Materials that require preheating for welding shall be preheated at the same temperature for thermal cutting or gouging.
5. Radial misalignment at the joining ends of piping components shall be such that full penetration can be attained.
6. Internal radial misalignment exceeding 1.6 mm shall be taper trimmed. However, the resulting thickness of the welded joint shall not be less than the minimum design thickness plus corrosion allowance.
7. All surfaces to be welded shall be clean and free from paint, oil, dirt, scale; and other materials detrimental to welding.
8. The fit-up may be made by tack welding or using lugs.
9. Tack welds not using lugs shall be made by a qualified welder under a qualified welding procedure. Tack welds which are part of the root pass shall be made with the same electrodes as to be used for the first pass. Tack welds which have cracked shall be removed.
10. The clear distance between centerlines of adjacent girth butt welds shall not be less than 100 mm.
11. When seam welded pipe is used, the longitudinal welds in adjacent pipes shall be offset by at least 100 mm.
12. When welding oxygen pipes, the end seals or covers shall only be removed
13. from each pipe just prior to welding alignment. If using internal clamps for fit up, these shall not be lubricated, and if pneumatic clamps, the medium shall be dry oil free or nitrogen.

e. WELDING PROCESS

1) All welds shall be made by the shielded metal arc, inert gas tungsten arc, inert gas metal arc, or the submerged arc process.

The CO_2 gas metal arc process may be used for carbon steel piping. The oxy-acetylene process may be used for carbon steel piping of nominal sizes 2 inches and smaller. All other processes shall be subject to the approval of ES's Engineer.

2) Single welded butt joints in carbon-molybdenum, chromium-molybdenum and austenitic stainless steel shall have the root pass made by the inert gas tungsten arc process with inert gas backing or with CO_2 gas backing.

f. WELD CONTOUR AND FINISH

Penetration requirements for longitudinal and girth welds shall be as follows:

1) All longitudinal welds shall have 100 percent penetration to the root of the joint.

2) Penetration requirements of girth butt welds shall be within the acceptable limits specified in ANSI B31.3 and sub-sections 4.6(2), 4.6(3) and 4.6(4) hereunder.

3) Internal welds at the joint of orifice flange to pipe shall be ground smooth and flush with the inside diameter of the pipe.

4) For non-oxygen pipelines, concavity of the root surface for single-welded butt joints shall not reduce the total thickness of the joint, including reinforcement, to less than the thickness of the thinner of the components being joined. By radiographic image shall be the same or lighter than that of the adjacent base metal. For this examination, the weld reinforcement shall not exceed 1.6 mm.

5) For oxygen pipelines, all the welds shall have full penetration, but protrusions into the pipe bore shall be strictly limited.

g. IDENTIFICATION OF WELDER AND WELDER'S PERFORMANCE

1) When carrying out welding, each welder shall be properly identified from the other welders and other kinds of craftsmen with the welder's number shown on an arm band or other suitable items of clothing.

2) The welder's number shall be applied in an approved manner near each welders work for identification. Die stamping of the component shall not be permitted.

5.7.5 BENDING

a. The centerline radius of pipe bends shall be equal to at least 5 times the nominal pipe diameter.

b. When bends are made on seam welded pipe, the seam shall be on the neutral axis of the bend, or at 45° to it.

c. Pipe bends shall be free from cracks, wrinkles and bulges and excessive wall thinning after bending and heat treatment.

d. Carbon steel shall not be hot bent at temperatures exceeding 1,038°C (1,900°F). After hot bending, if the hardness of the carbon steel exceeds 225 BHN, the bends shall be stress relieved.

Ferritic Stainless Steel, the temperature must be less than 800°C (1500°F).

In Austenitic Stainless Steel, must be cooled rapidly and uniformly through the temperature range of 900 to 427°C (1650 to 800°F).

e. Miter bends may be used on services other than oxygen pipelines where the pipe diameter exceeds 12 in. nominal pipe size (NPS) and it shall be purpose designed and shall comply with the following:

1. Bends exceeding 45 degrees shall consist of at least 3 segments (2 mitre cuts), with not less than 4 times the pipe wall thickness between the centerlines of the welds at the crotch, or 25 mm whichever is greater.
2. Bends shall have a centerline radius at least equal to the nominal pipe size.
3. The maximum mitre angle (half the change of direction) shall be 221/2 degrees up to 1.4 MPa (210 psi) design pressure, 15 degrees up to 2.8 MPa (420 psi) and 111/4 degrees over 2.8 MPa (420 psi).

f. End preparation of each segment shall be made in accordance with sub-section 4.4 of this Standard.

g. After welding is completed, the internal of the pipe shall be inspected and any projection of weld shall be removed.

h. Heat treatment shall be made in accordance with sub-section 6 of this Standard.

i. Radiographic inspection and pressure testing will be at the discretion and approval of ES's Engineer.

5.7.6 HEAT TREATMENT

a. PREHEATING

1. Carbon steel shall be preheated to a range of 80°C and be maintained at that temperature if the maximum specified carbon content is in excess of 0.25 percent, or if the thickness at the weld joint is in excess of 20 mm.
2. All other P-1 group materials shall be preheated to a minimum temperature of 10°C unless welded with low hydrogen type electrodes with a minimum preheat temperature of 0°C. Low Hydrogen electrode should be dried with a temperature of 200°C.

b. POSTWELD HEAT TREATMENT

1. All machined surfaces shall be protected by a suitable paint or compound to prevent damage from scaling during heat treatment.
2. In case of furnace heat treatment, all piping shall be supported properly during heat treatment to minimize areas and other distortions.
3. The exothermic method for heat treating may be used provided the materials are designed for the application with consideration given to the thickness of the piping and the configuration of the components heat treated. The process and material used shall be subject to the approval of ES's Engineer.
4. The heating and cooling rate above 315°C shall not be more than 220°C per hour divided by the wall thickness in inches, but in no case more than 220°C per hour.

5. For local heat treatment of welded joints, the heating zone shall be brought to a uniform temperature over the entire circumference of the heated pipe section with a gradual diminishing of the temperature outward from the zone.
6. The minimum width of the zone for local heat treatment on either side of the circumferential weld shall be minimum 100 mm.
7. Hardness tests shall be made with a Brinell testing machine or a portable hardness tester such as a Telebrineller using a 10 mm ball. The hardness test for the heat affected zone shall be made with the ball centered in the heat affected zone.
8. After the final heat treatment, subsequent welding or heating shall be prohibited.

5.7.7 ASSEMBLY AND ERECTION

a. GENERAL

Valves shall be installed in the closed position and shall not be opened during the construction period except for pressure testing. The additional special cleaning requirements for oxygen service are detailed in ES Engineering Standard: PRD-ES-129 – Cleaning & Test Procedure for Oxygen Pipeline.

b. FLANGED CONNECTION

1. Slip-on flanges shall be positioned so that the distance from the face of the flange to the pipe end shall be between t and t + 3.2 mm, where it is the nominal pipe wall thickness, or 6.4 mm, whichever is smaller.
2. The back weld shall be applied in a manner that will not require refacing of the flange.
3. Flange bolt holes shall straddle the established centerlines (horizontal, vertical, or layout centerlines), except only at equipment flanges when required for matching the orientation.
4. Gasket compound materials shall be subject to the approval of ES's Engineer.
5. Special Requirements for Oxygen Service.

When piping systems for oxygen service are assembled at initial stage, the compressed fibre gaskets shall be installed for temporary use.

After pressure test and chemical cleaning, they shall be replaced by specified spiral wound gasket suitable for oxygen service.

c. BOLTING PROCEDURE

1. Flanged joints shall be fitted up so that the flange face bear uniformly on the gasket, and then be tightened up with relatively uniform bolt stress.

2. In bolting gasketed flanged joints, the gasket shall be properly compressed according to the design principle applied to the type of gasket used.
3. Steel-to-cast iron flange joints shall be assembled with care to prevent damage to the cast iron flange.
4. All bolts shall extend completely through their nuts.
5. If realignment of machinery is necessitated after connecting piping, the pipe erector shall realign the piping system accordingly.

d. THREADED CONNECTIONS

1. Teflon seal tape may be used for threaded joints for design temperature up to 65.6°C (150°F). Hemp, jute, lead scraps, white paint or other fillers shall not be used.
2. When seal welding is required, the connections shall be made without using sealing compound or Teflon tape, all machine oil shall be removed after the joint has been tightened to full thread engagement, and the seal weld shall cover all exposed threads.
3. Seal welding shall be done with electrodes not exceeding 3.1 mm in diameter, using amperage in the low range to avoid distortion of the connection or part being welded.
4. Threaded joints for instrument air piping shall not be made until scraps of metal and machine oil from the cut threads are removed.

e. GALVANISED PIPING

1. When galvanized pipes are welded, galvanising on the internal and external surfaces of the joint to be welded shall be removed by grinding before welding.
2. The area to be removed shall include about 10mm from the edge of the joint.
3. After welding, all external damaged surfaces shall be repaired with "ZINC RICH". No touch-up need be applied on the internal surfaces that are inaccessible from the open end of the pipe.

f. PIPE SUPPORTS

1. Prior to pipe installation, pipe supports shall be erected accurately, and shall be levelled and plumbed so that pipes can be aligned easily. Temporary supports may be used only when more practical than installing permanent supports but shall be minimized.
2. Temporary supports shall be used during hydrostatic testing, flushing, and/or solvent cleaning of piping not designed to carry the weight of the piping full of water.
3. Support permitting pipe movement shall be assembled to allow the necessary movement of pipes as caused by thermal expansion and contraction or as directed by the ES Engineer.

g. DIMENSIONAL TOLERANCES

1. The tolerances on linear dimensions (intermediate or overall) apply to the face to face, face to end, and end measurements of fabricated straight pipe and headers; centre to end or centre to face of nozzles or other attachments; or centre to face of bends. These tolerances are not accumulative.
2. Linear tolerances are ±3.2 mm for pipe sizes 10 inches nominal and under, and ±4.8 mm for pipe size 12 inches through 36 inches nominal.
3. Linear tolerances for pipes sizes over 36 inches nominal are subjected to tolerances of ±4.8 mm, plus or minus 0.8mm for each 12 inch in diameter over 36 inches.
4. Due to the cumulative effects of tolerances on fittings or flanges, when joined without interviewing pipe segments, deviations in excess of those specified in Part (2) and (3) may occur.
5. The tolerances for mating flanges of pumps and compressors shall be within the following range:
   a) Angularity alignment across the face of flanges: 0.8 mm.
   b) Clearance between flanges: Space required for gasket ±0.8 mm.

5.7.8 CLEANING AND PROTECTION FROM DAMAGE

a. Protection of Openings: After completion of inspection, all shop-fabricated and field prefabricated piping requiring relatively long storage at the pipe spool storage area shall be prepared for shipment and installation respectively as follows:

1. Flanges for shop fabricated piping shall be protected over the entire gasket surface with metal, hardboard or wood protectors securely attached applying rust preventive on the flange surface.
2. Flanges and any openings for field fabricated piping shall be protected over the entire gasket surface and the opening against entry of any foreign matter by covering with PVC sheets, plastic plugs or caps, hardboard, wood protectors or other suitable materials securely attached after applying rust preventive on the flange surface.
3. Piping with J-beveled ends shall be protected by firmly attached covers.
4. Threaded end connections shall be fitted with metal, wood, or plastic plugs or caps for shipment.

b. Storage of austenitic stainless steel shall be as follows:

1. All piping materials and fabricated piping shall be stored so as not to be in contact with the ground.
2. All openings shall be blanked to prevent entry of moisture.

3. Austenitic stainless steel shall never be exposed to saltwater or salt spray.

c. Intake and inter stage piping for compressors shall have openings protected completely after cleaning.

5.7.9 INSPECTION

a. GENERAL

1. Inspection standards to be applied shall be in accordance with ANSI B31.3 and ANSI B31.8 for N_2 and O_2 pipelines except where more stringent requirements are made in this specification or in the Inspection and Test Plan (ITP).
2. Unless otherwise specified in the relevant codes and Job Specification, the extent of radiographic, magnetic particle, and liquid penetrant examinations for welds shall be as shown in Table 1.
3. Other piping, using specialist materials, shall be inspected in accordance with the appropriate manufacturer's standard.

Design Pressure kPa (psig)	Design Temp. °C	Carbon Steel	Austenitic Stainless Steel
P > 1050 (152)		A + C + E + F	A + C + E + F
1050 ≥ P ≥ 2000 (152 ≥ P ≥ (290)	T > 186	A + C + E + F	A + C + E + F
1050 ≥ P ≥ 2000 (152 ≥ P ≥ (290)	186 ≥ T ≥ -29	A + E + F	A + E + F
2000 (290) ≥ P (Blow-off / Drain out)		(Visual)	(Visual)
Fuel Oil / Lube Oil		A + C + E	A + C + E
Seawater (Cement-Lined)		A + E	Not applicable

Note: D should be used instead of **C**, if the pipes are used for oxygen or other hazardous fluids.

Note A: Minimum 10 percent magnetic particle examination or liquid penetrant examination for branch connection welds, fillet weld joints of slip-on flanges, reinforcing pads and hanger support welds.

Note B:100 percent magnetic particle or liquid penetrant examination for branch connection fillet welds, reinforcing pads and hanger support welds.

Note C: Random radiography -minimum 5 percent of the butt-welded joints, plus 100% X-ray of the first five (5) production welds made by each welder.

Note D: 100 percent radiography for all butt welds.

Note E: Minimum 10 percent magnetic particle examination or liquid penetrant

examination of the butt-welded joints.

Note F: 100 percent magnetic particle or liquid penetrant examination for pipe bosses.

b. RADIOGRAPHIC EXAMINATION

1. The radiographic procedure shall be as stated in API 1104 for oxygen/nitrogen pipelines and in ASME Sect. 5 for other piping.
2. Spot radiography shall be performed for every pipe thickness and material grouping, and for each welding process, procedure and welder or welding operator, progressively throughout the entire job.
3. The length of film for each spot radiograph shall be 250 mm or half the pipe the pipe circumference, whichever is less.
4. Unless otherwise permitted by ES's Engineer, the combination of fine grain film and lead screen shall be used.
5. Wire type image quality indicators (IQI) equal to those meeting International Institute of Welding (IIW) requirements may be substituted for UW-51 of Section VIII, Division 1, of the ASME Code. The wire type IQI shall be placed across the weld.
6. Additional radiographs (tracer examination) for spot radiograph for each weld found to be defective, and two additional welds made by the same welder that produced the defective weld shall be given spot radiographic examination. These additions shall be made immediately after the defective weld is found and are in addition to the minimum spot examination of 5 percent of the welded joints.
7. Spot examination by sectioning is prohibited, except as directed by ES's Engineer to confirm contentions of excessive weld projections, depressions, or lack of penetration at otherwise inaccessible joints.

c. OTHER EXAMINATION

The codes and standards listed in Table 2 shall be used for other examination procedures and acceptance criteria.

TABLE 2

METHOD	SPECIFICATION OR STANDARD
Magnetic Particle Examination	ASME Code, Section VIII-Div. 1, Appendix VI
Liquid Penetrant Examination	ASME Code, Section VII-Div. 1, Appendix VIII
Ultrasonic Examination	ASME Code, Section VIII-Div. 1, Appendix U

Visual Examination	ASME Code, Section V, Article 9

5.7.10 TESTING AND FLUSHING

a. EXTENT OF PRESSURE TESTING

For pressuring testing, refer to ES Engineering Standard: PRD-ES-127 – Pressure Testing.

The following piping and equipment shall not be subjected to field pressure testing:

1) Rotating machinery, such as pumps, turbines, and compressors.

2) Pressure relieving devices, such as rupture discs and pressure relief valves.

3) Vessels which do not satisfy impact requirements at the piping test temperature.

4) Equipment lined with castable materials unless approved by ESI or the lining material manufacturer.

5) Piping which is normally open to the atmosphere such as drains, vents, discharge piping from pressure relieving devices, downstream of last block valve for flare piping, stack downstream of seal drum, and sewer piping.

6) Locally mounted pressure indicating gauges, where the test pressure would exceed their scale range.

7) Any other equipment designated by ES.

b. INSTRUMENT PIPING

1) Instrument take off piping up to the first block valve and/or first flanges shall be tested with the piping or equipment connected.

2) In-line instruments except thermowells shall be pressure or leak tested with the instruments disconnected. Instrument supply lines with a design pressure equal to or greater than 700 kPa (102 psi) shall be subjected to the same test pressure as the piping or equipment to which they are connected. Instrument lead lines with a design pressure less than 700 kPa (102 psi) shall be leak tested with air or nitrogen to a pressure of 700 kPa (102 psi). Testing may be performed separately or at the same time the piping or equipment is tested.

c. TEST PROCEDURES

1) Calibration records for gauges used for testing shall be submitted to ES.

2) Two pressure gauges, generally, shall be installed for each testing system. Gauges used for testing shall be installed as close as possible to the low point of the piping system.

3) All vents, and other connections which can serve as vents, shall be open during filling so that all air is vented prior to applying test pressure to a system.

4) The test pressure shall be maintained for a sufficient length of time to detect small seepage type leaks and to permit a thorough inspection, the test shall not be less than 10 minutes and consider fluctuations in ambient temperature.

5) Each test of the lines or systems shall be inspected and approved by the ES Engineer.

d. HYDROSTATIC TESTING FLUIDS

Water used for testing austenitic stainless-steel materials shall be essentially free from chloride not to exceed 30 ppm. After testing, all water shall be drained immediately. Pipework to compressors shall be as a minimum vacuum dried to remove water.

e. PNEUMATIC TESTING

1) Oxygen/nitrogen pipelines, instrument air piping and other services specified in the manufacturer's standards or procedures shall be tested with oil-less dry air or nitrogen.

2) Pneumatic testing of other piping is acceptable only if the test procedure and the test pressure have been approved by the ES Engineer.

f. PIPING SYSTEM CLEANING

1) Piping systems shall be flushed until all lines are thoroughly cleared of loose scale and debris.

2) Special cleaning by chemical or mechanical means is required for:

a) Compressor suction and inter stage piping
b) Lube and seal oil piping
c) Oxygen pipeline
d) Nitrogen pipeline.

5.7.11 REPAIRS

a. Materials such as gaskets, bolting etc., damaged during tests and flushing shall be replaced.

b. Any welded joint which is defective shall be repaired with a qualified procedure and shall be heat treated after repair if originally required. Repaired components shall be re-examined by the original method to determine freedom from defects and all repaired joints shall be retested.

5.7.12 TEST RECORD

a. Each test of a line or system shall be approved by ES's Engineer, and witness where requested by ES.

b. Records shall be made for each piping installation in accordance with the Inspection and Test Plan (ITP).

5.7.13 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
- NDT Testing Equipment calibration Certificates.
- 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 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.

5.7.14 DRAWINGS

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

5.8 PRESSURE TESTING

5.8.1 SCOPE

This standard covers general principles applicable to pressure testing of plant equipment, plant piping, and piping that are subject to fluid, gas or air pressure/vacuum while in service. The pressure testing requirements are applicable to newly installed (in place), as well as existing equipment and piping.

5.8.2 GENERAL REQUIREMENTS

A pressure test shall be applied to each item of piping and equipment:

a. Before it is initially placed in service at final position.

b. After repairs or modifications have been made that affect the strength or integrity of the equipment.

c. At scheduled intervals as specified by Equipment Inspection Schedules.

d. After hydrostatic testing of pipework to compressors pipework shall as a minimum be vacuum dried.

PRESSURE TESTING

All equipment and piping shall be tested after they have been installed in final position even though certain items may have been previously shop tested except as noted in special cases.

The number of flanged joints to be made after the pressure test shall be kept to a minimum. In exceptional cases it is practical to only hydrostatically test a spool before installation. All flanged joints which are made after the pressure test shall be inspected during a leak test conducted before or during start up.

Hydrostatic tests of new equipment and piping shall be conducted in two increments:

1. Strength Test: The strength test shall be held for a minimum of 10 minutes. During the strength test the equipment under test will not be subjected to impact and all the personnel shall remain at a safe distance. For strength test pressure see sub-section 3 – Test Pressure.

2. Tightness Test: Following the application of the strength test pressure an inspection shall be made of all joints and connections. Hydrostatic test and Pneumatic test pressures shall be in accordance with ASME Section VIII.

When hydrostatic tests are applied to existing installations, and the tests are being conducted to ascertain total equipment integrity, the test shall be as per previous paragraph.

For all cases involving the testing for tightness only, the pressure shall be equal to the release pressure of the safety valve having the highest setting.
Hydrostatic test diagrams and test procedures are required.

- Pumps, Turbines and Compressors shall be isolated from the pressure test with slip blinds. Only in special instances involving case repairs, shall the equipment cases be pressure tested.
- Power boilers shall be given a tightness test after a shutdown for cleaning or for inspection. The pressure applied is usually the maximum that can be developed by the feed water pump. As this will be higher than the setting of the relief valves on the boiler the valves must be removed, blinded off, or gagged to prevent relieving.
- Drains on the steam lines between the first valve from the boiler and the first valve from the steam header must be opened to prevent water which may leak through the main or auxiliary stop valves from entering pipes containing steam, or from touching closed valves of steam headers.
- Tube and header installations shall be tested to determine the strength and tightness of the headers, the tubes, the rolled joints or the complete assembly, depending on the nature of the equipment and its intended service.
- It is recommended that the temperature of water used to apply a hydrostatic test should not be less than 16°C (60°F) and not more than 66°C (130°F).

5.8.3 TEST PRESSURE

a. MINIMUM TEST PRESSURE

Except as specified in paragraph 8.6, each hydrostatic test shall be conducted at the maximum pressure allowable (as per the next paragraph) for the weakest element included in the test; however, for new equipment, at no time shall the test pressure be below that specified as the minimum for the applicable Code.

The pressure shall clearly be made known by the Contractor to ES.

b. MAXIMUM TEST PRESSURE

The maximum test pressure permissible for pipe and fittings shall be that which produces a hoop stress of 90% of the specified minimum yield stress of the pipe material.

The maximum test pressure permissible for flanges and valve bodies shall be the test pressure specified in the applicable standard for the pressure rating involved.

The maximum differential pressure across the seat of closed valves during the test shall be limited to the maximum operating pressure at 38°C or the maximum pressure specified in the applicable valve standard.

The maximum test pressure must consider the liquid head in vertical vessels and long vertical legs of the piping system.
Because of hydrostatic head vertical drums and columns may have elements in lower portions of the vessel subjected to test pressures greater than 11/2 times the maximum allowable working pressure to satisfy minimum test pressure requirements at or near the top of the vessel. Such higher component test pressure is acceptable provided there is no detrimental damage to the material integrity of the item tested.

The pressure shall clearly be made known by the Contractor to ES.

5.8.4 HYDROSTATIC TEST SYSTEM DESIGN

The limits of each pressure test which may include various piping selections as well as plant equipment, shall be established and indicated on the hydrostatic test diagram so that the number of such tests are a practical minimum. The designer is cautioned to assure that such an integrated system has a uniform design pressure and fluid requirement and that adequate emergency pressure relief protection is provided for all parts of the system.

Normally, the limits of each pressure test are flanges, plugs, slip blinds or spectacle blinds. Closed block valves (gate, globe, plug, ball) may be used in lieu of blinds to block off equipment or piping sections provided the valve seat does not limit the test pressure.

The piping or equipment on the low-pressure side must be protected by a relief valve or drained and vented to atmosphere to prevent overpressure due to possible leakage past the valve seat.

If the required test pressure is higher than the maximum valve seat pressure of a segregating valve between two sections with different test pressures, both sections may first be tested at the lower test pressure with the valve open. The valve may then be closed,

and the pressure raised to the higher test pressure on one side of the valve, while maintaining the lower test pressure on the other. The differential pressure must not exceed the maximum seat pressure. Both sections must be protected by relief valves.

Check valves shall have their discs and flappers removed before test pressure is applied.

Expansion joints shall be provided with temporary restraint, if required to prevent excess travel of the joint under test pressure load.

Vents shall be provided at all high points in the system.
Drain: A method of drainage shall be provided at all low points in the system. Drains shall also be provided immediately above check valves in vertical lines, or the disc shall be provided with a drain hole (if the process conditions permit).

Ball valves and pipeline gate valves; when used for plant piping and when not used for isolating piping sections or equipment during the pressure test, shall be partially opened in order to equalize pressure between the body and body cavity.

IMPORTANT: During commissioning, the body cavity must be drained of hydrostatic test water and thoroughly flushed with service product.
Instruments shall normally be included in the pressure test. The hydrostatic Test

Diagram shall show the method of isolating any instrument components such as floats which may be damaged by the effect of the test pressure. Control valves shall be set in the open position or the by-pass opened. Orifice plates shall not be installed until after the lines have been thoroughly flushed. Pressure gauges shall not be subjected to pressures in excess of 80% of their scale range. Positive displacement and turbine meters shall not be installed until after the lines have been thoroughly flushed and shall only be subjected to pressure testing with the agreement of the ES Engineer.

Pressure Sewers shall be tested under the same conditions as for pressure piping.

5.8.5 PREPARATION AND PERFORMANCE OF TEST

Equipment and piping for new installation shall be tested before applying insulation or tape wrap.

For existing facilities, on previously insulated portions a 24-hour recorded test shall be conducted.

a. **Equipment with internal coating** shall be tested before coating is applied even though it will be retested in the field.
b. **Piping with internal coatings** may be tested after coating is applied.
c. **Equipment and piping with external coatings** may be tested after coating is applied.
d. **Pressure gauges and pressure recorders** shall be calibrated before use. Calibration interval shall not exceed one (1) month. A minimum of two pressure gauges are preferred in the system and verified that they are within 5% of each other when in use. Stickers shall be applied indicating the latest calibration date. Recording gauges shall be used where it is advisable to keep a permanent record or otherwise as required by this standard. All gauges shall have a range such that the test pressure is within 30% to 80% of the full range. Calibration certificates shall be made available to inspection personnel prior to commencement of the pressure test.
e. **Buried Lines other than fire water lines shall be tested prior to back filling.** In case it becomes necessary that the line be backfilled prior to hydrostatic testing, then a 24-hour recorded test would be satisfactory, with prior ES approval.
f. **Relief valves**: All systems (piping and equipment), while under test, shall be protected from overpressure by relief valves of adequate capacity set to relieve at 5% above strength test pressure. Relief valves shall be calibrated immediately before each use.
g. **Bleed valve** shall be provided to protect piping and equipment from overpressure, even though there is a provision of a pressure relieving device. This bleed valve shall be readily accessible during the test and shall be pre-piped to the nearest sewer drain.
h. **Isolation valve** shall be provided at the point where the temporary test piping connects to the equipment or piping under pressure test. The isolation valve shall be closed, and the pump disconnected after the test pressure is reached before commencement of inspection of the system.
i. **Flushing**: Prior to conducting a pressure test, all piping systems shall be flushed and cleaned. Inspection is to witness and accept all flushing procedures prior to commencement of pressure testing.
j. **Preliminary Pneumatic Test** of not more than 173 kPa (25 psig) may be made with approval of the ES Engineer prior to a hydrostatic test in order to locate major leaks.
k. **Filling**: When filling, the test fluid shall be injected at the lowest point in the system to minimize the risk of entrapped air. All vents shall be opened. Filling shall take place

upstream of any check valves, unless the disc has been removed, and upstream of any positive displacement of turbine meters where the reverse rotation could cause damage.

l. **Temperature Equilibrium** must be attained between test fluid and system after filling and before applying pressure.

m. **Gaskets** on all joints disturbed during or after the pressure test shall be replaced with the new gasket.

n. **Draining the system**: All vents shall be opened before draining the system to prevent formation of a vacuum.

o. **Duration of Test**

Test pressure shall be maintained on piping and equipment long enough to examine all points for leakage and shall not in any case be less than 10 minutes. Actual duration shall be determined by the ES Engineer. If there are any reinforcing pads, shop as well as field fabricated, the test shall be held for a minimum of 2 hours to check weep hole for leakage.

Should leakage occur during the test, the system shall be depressurized, repairs made, and a retest conducted for the same duration.

p. **Test Records** shall be made of each test on Pressure Test Report Form or equal as required. (Refer to Section 9 of this Standard for guidance).

Verification of hydrostatic test fluids shall be documented noting as much of the detail of the water chemistry as possible.

5.8.6 SPECIAL CASES

a. **Service test**: Low pressure equipment and piping for water, instrument air, plant air, inert gas (Nitrogen, Argon, etc.), and steam systems operating at 1035 kPa (150 psig) or less may be tested with its own media at its operating pressure. The hydrostatic test diagram is required for equipment and piping under service test.

b. **Freon Systems** should be pneumatically tested. In case water is used, proper dry out is essential.

c. **Low pressure blow down lines** designed for less than 690 kPa (100 psig) shall be pneumatically tested, however, testing shall be done to 110% of design pressure and welds soap tested at a reduced pressure of 21 to 35 kPa (3 to 5 psig).

d. **Fire water systems regardless of material** shall be hydrostatically tested to 1380 kPa (200 psig) or 345 kPa (50 psig) higher than operating pressure, whichever is the greater and held for 2 hours in accordance with NFPA.

e. **Equipment and piping in vacuum service** shall be pneumatically tested at an internal pressure by the design, followed by 21 to 35 kPa (3 to 5 psig) soap solution film test for tightness.

f. **Exceptions to Hydrostatic Test**

Welded connections of new equipment and piping to existing in-service equipment and piping that is impractical to pressure test may be 100% radiographed in lieu of a hydrostatic test if approved by ES.

Welded connections of new equipment and piping to previously hydrostatically tested non-commissioned equipment and piping may be 100% radiographed in lieu of a hydrostatic test if approved by ES.

Written requests for either deviation shall be submitted to the approval authority on a form that includes all pertinent information such as locations, originator, present situation, justification conditions for approval/disapproval and appropriate signatures.

5.8.7 PNEUMATIC TESTING

A pneumatic or inert gas test may be used when it is not practical to use a test liquid or as allowed by this standard, however, prior approval to use a pneumatic or inert gas must be obtained from ES.

For Pneumatic test procedure for oxygen pipeline, refer to “ES Engineering Standard – PRD-ES-128 - Pneumatic Test Procedure for Oxygen Pipeline”.

5.8.8 SAFETY PRECAUTIONS

Since the pressure during the pressure tests is higher than normal operating conditions, task related safety precautions must be taken. Safety instructions shall be included with the testing procedure regarding the removal of entrapped air to minimize the risk of high energy release in the event of a failure. Horizontal lines and valve bodies are possible locations for entrapped air. Close visual inspection for leakage during the test should be made with caution.

Only trained and competent persons shall be permitted to carry out the test.

The testing area shall be securely cordoned off. Only authorised persons shall be allowed to enter the area. The Contractor shall provide manning to perform this specific responsibility.

Oxygen equipment and piping must not be tested with hydrocarbons.

a. Hammer testing shall not be done while the system is under pressure.

Any manifold fabricated for hydrostatic test purposes (either for permanent or temporary usage) shall be tested separately from any other piping before it is used in conjunction with testing of any system. The manifold shall be tested to a pressure not less than 20% above the test pressure to be applied on the system to be tested.

b. Pneumatic Testing

Special safety precautions shall be taken during pneumatic testing because of the high energy release in the event of a failure.

The area shall be cleared of all personnel during the maximum pressure test and no personnel shall approach the area. (Refer to Section 8 of this Standard).

A preliminary check at not more than 200 kPa (30 psig) shall be made. Following the preliminary test, the test pressure shall be increased in 20% increments to full test.

Each increment shall be held for approximately ten (10) minutes to permit examination for leaks by reviewing recorder/pressure gauge remotely located at an approved safe distance. No unauthorized person should approach any portion of the system under test. When the system has withstood full strength test pressure the pressure shall be lowered to tightness test pressure prior to being approached to check for leaks or for any reason.

5.8.9 RECORDS

Evidence of the successful test shall be submitted by the Contractor to ES in the form a Test Certificate. This Certificate shall include, but not be limited to:

- Name of Contractor
- Designation of Certificate.
- Project Title.
- Contract Reference / Order Number.
- Equipment undergoing test
- Relevant drawings and revisions.
- Contractor / 3rd Party / ES – Representative title, name and signature, and date.
- Standard to which Test is being carried out under.
- Test medium.
- Pressure gauge number.
- Pressure Recorder number

- Temperature Recorder number.
- Calibration references for all instruments used for Test.
- Duration of Test.
- Pressure at start and completion of Test.
- Pressure drop.
- Water temperature (if applicable)
- Ambient temperature.
- Comments.
- Acceptance signatures from Contractors, 3rd Party, and ES Representatives.
- Issue history.

5.9 Pneumatic Testing of Oxygen Pipelines

5.9.1 SCOPE

a. This document covers the procedures for performing the pneumatic test and leak test for oxygen pipeline.

b. This document must be read in conjunction with "ES Engineering Standard:PRD-ES-129 - Cleaning and Test Procedure for Oxygen Pipeline".

5.9.2 APPLICABLE CODE

The following code shall be applied to these tests unless otherwise specified in this document:

- ANSI B 31.8 Gas Transmission and Distribution Piping System.

5.9.3 SAFETY

a. CONTRACTOR shall prepare work permit request in restricted areas.

b. ES will be informed thoroughly at least two days in advance of the date the pressure test will be performed.

5.9.4 ORGANISATION FOR PNEUMATIC TEST

To proceed with the test safely and successfully, an organisation shall be established in the manner shown below:

a. Each crew shall consist of a supervisor and workers.

b. All persons involved shall be thoroughly instructed as to their responsibilities during the tests and actions to be taken in the event of emergencies.

5.9.5 PRELIMINARY MEETING BETWEEN CONTRACTOR AND ES

a. A preliminary meeting should be held between the ES engineers and CONTRACTOR staff to clarify the scope of the test and to coordinate the work.

b. The following documents will be available for review before this meeting:

1. Inspection and Test Plan (ITP)

2. Organization Chart
3. Marked-up P & IDs and plans.

5.9.6 TEST AREA

During the test, the test area shall be identified with safety sign boards in English and Arabic. Entry of persons other than those concerned into the test area shall be strictly prohibited during the test.

The Contractor responsible for carrying out the test shall provide personnel specifically responsible for this task.

5.9.7 OTHER PROVISIONS

The area surrounding the test area shall be thoroughly checked beforehand, especially for flow of flammable gases or liquids through other pipelines. However, even if another pipeline is live, the pipeline does not need to be shut down during the test, provided adequate precautions are observed.

5.9.8 PREPARATION FOR TEST

a. Prior to the test, the portion of the pipeline to be tested shall be confirmed to have been constructed in accordance with the drawings, and the welds confirmed to have been inspected in accordance with the codes and specifications and the Inspection and Test Plan (ITP). Valves shall be confirmed to have been tested according to the specifications.

b. Instrument connections shall be blinded off by means of blind flanges or plugs.

c. Pressure gauges for the test shall be calibrated prior to testing. Two pressure gauges of 10 MPa (1500 psig) graduated in 100 kPa (15 psig) steps for the acceptance leak test, shall be installed at pressurizing point and one at the remote end of the pipeline portion to be tested.

5.9.9 TEST MEDIUM

Dry oil-free air or nitrogen gas shall be used as the test medium.

5.9.10 TEST PRESSURE AND HOLDING TIME

The following test pressure and holding time shall be applied:

a. Pressure test = 1.25 x design pressure, minimum 30 min.

b. Acceptance leak test = design pressure, minimum 24 hours (if the remaining pressure after 24 hours will be recorded, the ambient temperature shall be recorded as well over the test period.

c. Leak check = 200 kPa (30 psig), minimum 10 min. (with soapy water).

5.9.11 PIPELINE PORTIONS TO BE TESTED

According to installation schedule of the pipeline, at first underground portions of the pipeline shall be tested. Then, after installation of above ground portions of the pipeline, the entire pipeline shall be tested at the same time prior to the commissioning.

5.9.12 PRESSURISING AND TEST

In all cases, test gas shall be fed into the line slowly. After 1.5 MPa (218 psig) is reached, additions shall be in increments of 700 kPa (102 psig) or less.

a. UNDERGROUND PORTIONS

1. Leak check

At the pressure of 200 kPa (30 psig), no leaks shall be detected at the field-weld portions, flanges, valves and plugs when soapy water is applied. Duration shall be a minimum of ten minutes.

2. Pressure test

No abnormal conditions shall be observed at the test pressure for a minimum of thirty minutes. Additional nitrogen may be added to maintain this pressure if necessary.

b. ENTIRE PIPELINE

1. Leak check

At the pressure of 200 kPa (30 psig), no leaks shall be detected at the field-weld portions, flanges, valves and plugs when soapy water is applied. Duration shall be a minimum of ten minutes.

2. Pressure test

3. No abnormal conditions shall be observed at the test pressure for a minimum of Thirty minutes. Additional nitrogen may be added to maintain this pressure if necessary.

4. Acceptance leak test

5. After pressure test, the pipeline shall be subject to an acceptance leak test at design pressure. The test shall be for a minimum of 24 hours but may be extended at the discretion of the ES engineer.

5.9.13 PRESSURE RELEASE

a. The point of exhausting the test medium shall be located at a minimum elevation of three meters above ground, shall be in a safe location and shall be directed vertically upwards.

b. Depressurizing shall be performed slowly until the indication of the pressure gauges becomes zero. Noise shall be controlled during this process to avoid nuisance.

The blind flanges or plates at both ends of the pipeline portion must not be removed until after confirming that no integral pressure remains in the pipeline portion.

5.9.14 RECORDS

Evidence of the successful test shall be submitted by the Contractor to ES in the form a Test Certificate. This Certificate shall include, but not be limited to:

- Name of Contractor
- Designation of Certificate.
- Project Title.
- Contract Reference / Order Number.
- Equipment undergoing test
- Relevant drawings and revisions.
- Contractor / 3rd Party / ES – Representative title, name and signature, and date.
- Standard to which Test is being carried out under.
- Test medium.
- Pressure gauge number.
- Pressure Recorder number
- Temperature Recorder number.
- Calibration references for all instruments used for Test.
- Duration of Test.
- Pressure at start and completion of Test.
- Pressure drop.
- Ambient temperature.
- Comments.
- Acceptance signatures from Contractors, 3rd Party, and ES Representatives.
- Issue history.

5.10 CLEANING OF OXYGEN PIPELINES

5.10.1 SCOPE

This standard covers the requirements for cleaning and test procedure of an oxygen pipeline.

5.10.2 OBJECTIVE

To ensure that degreasing where required is carried out to a consistent and satisfactory quality level using a standard, safe and appropriate method.

5.10.3 SAFETY CAUTION

The importance of careful degreasing and cleaning cannot be over emphasized, since the remainder of oil, grease and small solid particles in the presence of oxygen can cause the possibility of ignition and subsequent combustion. Great attention must therefore be paid to the cleanliness of oxygen systems.

5.10.4 CLEANING METHOD

a. CLEANING MATERIAL

Only approved ES solvent shall be used. Appropriate precautions must be taken when using these agents.

b. CLEANING AND WORKING CLOTHES

Tools, clothes, gloves and shoes of personnel working for oxygen systems must completely be free from oil and grease. Clothes used for wiping components or equipment surfaces shall be clean, lint-free from traces of oil and grease. Cotton, linen or paper may be used.

c. CLEANING PROCEDURE

Cleaning may be carried out by solvent degreasing. The method used shall be immersion in solvent and wiping. Inside of each pipe shall be degreased by immersion or flushing with solvent.

Flanges, fittings, bolts and nuts shall also be degreased by immersion or wipe method.

After cleaning the components should be allowed to drain and dry before use or packaging.

5.10.5 CLEANING INSPECTION

a. VISUAL INSPECTION WITH NATURAL LIGHT

A visual inspection shall be performed using natural light to ensure that no rust, dust, dirt or other particles is present in the pipes, flanges and fittings.

No visible evidence of moisture, cleaning agents, flux residues from welding, rust or loose scale, weld spatters, particles, fibres and organic material such as oils, grease, paint, etc.

b. VISUAL INSPECTION USING ULTRAVIOLET LIGHT

This method is applicable to exposed surfaces. Ultraviolet light of about 3700 Angstroms is used in the dark or in near darkness.

When shone onto the surface from 100-200 mm, bright fluorescence will be an indication of possible contamination. The surface shall be free from any fluorescence caused by oil, lint and dust, detectable by black light when viewed in the dark. The surface should then be inspected to determine if the fluorescence is due to contamination or to a harmless deposit. If in doubt the surface should be degreased again.

c. WIPE TEST

This test is useful when direct visual inspection has been inconclusive.

The surface is rubbed lightly with a clean lint-free cotton or linen cloth or with a white filter paper. This cloth or paper is examined under white and/or ultra-violet light to find any traces of contamination. Since it is not acceptable to leave paper or cloth particles on the equipment, this method is not suitable for rough or cast materials.

Acceptance standard: A light oxide discoloration is in some cases acceptable. Any stain from the presence of oil or grease is unacceptable.

5.10.6 CONSERVATION OF CLEANLINESS (PROTECTION)

a. GENERAL

If the items degreased are not to be used immediately, they shall be protected.

After cleaning and inspection, the elements or components shall be protected from any contamination or deterioration during the time of storage and transport until they are fitted or put into service in the installation.

Protection shall be assured against exposure to adverse weather and moisture.

b. PACKING

Small items such as fittings, bolts shall be packed in sealed plastic bags.

c. SEALINGS OF COMPONENTS

The opening of components and prefabricated pipework shall be sealed by means of blind flanges, polyethylene or polypropylene plugs, caps, etc. Small holes shall be sealed by means of metal, plastic or rubber plugs. Adhesive tape can be used to hold such covers but not touch with the cleaned metal surface.

d. SEALING PIPES

The pipes or sections of pipework without flanges, cleaned in accordance with Section 4 of this Standard, shall be sealed by means of strong plastic covers. The plastic covers

shall be securely held by strong adhesive tape. The tape should be applied to the outside of the pipe only. Clear of the weld preparation area.

5.10.7 CONTROL DURING INSTALLATION

a. CONTROL OF CLEANLINESS

Control of absence of foreign matter, dust, oil, grease, textile waste, etc. during installation shall be affected by visual inspection with white or natural light. Cleanliness shall be considered adequate if no trace of impurities can be detected visually.

b. CONTROL OF DEGREASING

Visual inspection according to paragraph.7.1 is not adequate for verification of the absence of trace residues of oil or grease for oxygen pipelines.

During the installation the method below shall be used:
Wipe test, lightly rubbing highly porous paper over the surface to be controlled.

No permanent stain resulting from the presence of oil or grease on the surface shall be show on this paper.

5.10.8 SUPERVISION DURING INSTALLATION

The Contractor's supervising personnel shall verify:

- That the pipes are properly furnished with end covers when they arrive on the site.
- That the end covers are not removed until the pipes are aligned for welding.
- That there is nothing left inside the pipes when they are placed alongside for welding or flanging.
- That each section of pipe is properly plugged tight before and after the work. **Non-Destructive Examination**

  All butt welds shall be subject to 100% X-Ray examination as well as visual inspection. Refer to "ES Engineering Standard: PRD-ES-126 - Fabrication and Installation of Steel Piping.

5.10.9 BLOWING

The pipeline shall be cleaned by blowing with clean dry oil free air or nitrogen to remove dust and foreign matter. The blowing method may be either by direct blowing or by pressuring and releasing. It shall be continued until the pipeline is clean.

5.10.10 PNEUMATIC AND LEAK TEST

The pneumatic strength test and leak tightness test shall be performed in accordance with ES Engineering Standard: PRD-ES-128 - Pneumatic Test Procedure for Oxygen Pipeline.

6. SUPPORTING DOCUMENTS

NA

7. REVISION HISTORY

Issue No.	Date	Page/s	Cause of Revision
0	17.11.2019	All	First Issue