ENGINEERING STANDARD

FOR

PLANT PIPING SYSTEMS

0. INTRODUCTION

This Standard covers the minimum requirements for Design of Plant Piping Systems to be used in Oil, Gas and Petrochemical Industries.

The Standard is based on the following:

a) BP Engineering Codes of Practice
b) ANSI / ASME B 31.3

The Standard consists of the following:

General Design Requirements
Above-ground Piping Systems

1. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor/Executor.

ANSI/ASME (AMERICAN NATIONAL STANDARD INSTITUTE / AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

B-31.3	"Chemical Plant and Petroleum Refinery Piping"
B-36.10	"Welded and Seamless Wrought Steel Pipe"
B-16.5	"Pipe Flanges and Flanged Fittings"

API (AMERICAN PETROLEUM INSTITUTE)

650	"Welded Steel Tanks for Oil Storage"
RP-521	"Guide for Pressure-Relieving and Depressuring Systems"

BP (BRITISH PETROLEUM)

C P-3	"Plant Layout"
C P-14	"Over Pressure Protection Systems"
C P-16	"Passive Fire Protection of Structures & Equipment"
Std.-107	"Forced Drought Burners for Fired Process Heaters"

BSI (BRITISH STANDARD INSTITUTION)

BS 3293	"Specification for Carbon Steel Pipe Flanges (over 24" nominal size) for the Petroleum Industry"
BS 4485	"Water Cooling Towers"

EJMA (EXPANSION JOINT MANUFACTURERS ASSOCIATIONS)

IPS (IRANIAN PETROLEUM STANDARDS / DRAWING)

IPS-E-IN-120	"Temperature Instruments"
IPS-E-IN-130	"Flow Instruments"
IPS-E-IN-140	"Level Instruments"

IPS-E-IN-230	"Analytical Instruments"
IPS-C-PI-350	"Plant Piping Systems Pressure Testing"
IPS-E-PI-200	"Flexibility Analysis"
IPS-E-PI-221	"Piping Material Selection (On Plot Piping)
IPS-G-PI-280	"Pipe Supports"
IPS-M-PI-110	"Valves"
IPS-M-PI-150	"Flanges & Fittings"
IPS-E-PR-190	"Layout & Spacing"
IPS-E-PR-200	"Basic Engineering Design Data"
IPS-E-PR-230	"Piping & Instrument Diagrams"
IPS-E-PR-260	"Detail Design, Engineering & Procurement"
IPS-E-PR-308	"Numbering System"
IPS-E-PR-420	"Process Design of Heat Tracing & Winterizing"
IPS-E-PR-460	"Process Design of Flare & Blowdown Systems"
IPS-E-TP-100	"Paints"
IPS-C-TP-102	"Painting"
IPS-E-TP-700	"Thermal Insulations"
IPS-E-SF-220	"Fire Water Distribution & Storage Facilities"
IPS-D-IN-102	"Piping Arrangement at Orifice Plate"
IPS-D-IN-104	"Instrumentation Installation of Pressure Piping"
IPS-D-PI-102	"Typical Unit Arrangement & Piperack Layout"
IPS-D-PI-104	"Sample Cooler Details"
IPS-D-PI-113	"Y" Type Suction Strainer"
IPS-D-PI-114	"T" Type Suction Strainer"
IPS-D-PI-119	"Pressure Blind Detail"
IPS-D-PI-121	"Hydrostatic Test Blinds Thickness Allowable Test Pressure"
IPS-D-PI-122	"Control Valve Piping Manifolds"
IPS-D-PI-123	"Relief Valve Installations and Relief System"
IPS-D-PI-125	"Steam Trap & Drip Pot Piping Arrangement"
IPS-D-PI-126	"Steam Tracing Details Piping DN 100 (4") & Smaller"
IPS-D-PI-127	"Steam Jacket Detail"
IPS-D-PI-128	"Utility Station, Hose Rack & Emergency Shower Details"
IPS-D-PI-129	"Miter Bends"
IPS-D-PI-140	"Sample Point Assembly for Piping"
IPS-D-PI-148	"Ring & Blind for DN 650 (26") DN 1500 (60") R.F. Flange"

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERS)

MR-01-75	"Standard Material Requirement Sulfide Stress Cracking Resistant Metallic Material for Oil Field Equipment"

NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)

30-12	"Flammable and Combustible Liquids Code"

UK HEALTH AND SAFETY EXECUTIVE GUIDANCE

2. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

GENERAL DESIGN REQUIREMENTS

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1. SCOPE

1.1 This Standard covers minimum requirement(s) for general aspects to be considered in design of piping for petroleum and petrochemical plants to be designed in accordance with ANSI B31.3 which includes but not limited to the following:

a) Loading and unloading terminals.
b) Crude oil & gas gathering central facilities.
c) Production units.
d) Package equipment, in accordance with ANSI-B 31.3.
e) Pump house and compressor stations (booster stations).
f) Tank farms and oil/gas depots.

1.2 This Standard is not intended to be applicable to the following systems:

a) Heating, ventilation and domestic water system within building (HVAC).

b) Steam piping system: within the steam generation unit and power station plant designed in accordance with ANSI B31.1.

c) Non-metallic piping systems

d) Hydraulic systems

e) Offshore facilities

2. DEFINITIONS AND TERMINOLOGY

2.1 Battery Limit

The boundary of a process unit, enclosing all equipment and unit limit block valves.

2.2 Complex

A group of units, the operation of which are interlinked.

(On small plants, the term "complex" may refer to all the process units on the plant).

2.3 Piping System

It covers the overall systems of pipes and piping components, e.g. fittings, valves, nozzles and supports, that are employed to transfer liquid, gas, steam, etc. between the equipment such as tanks, pumps, vessels and so forth.

2.4 Unit (Area)

A main production component of a refinery plant or chemical complex, e.g. distillation unit, utility unit, etc.

2.5 Utilities

Air supply, water supply and treatment, steam generation, power generation and similar services.

2.6 Depot

A storage area with capacity less than 5000 tones with import and export facilities.

2.7 Executor

The party which carries out all, or part of the construction, installation and commissioning aspect for the projects.

2.8 Designer

The person or party which is responsible to the Company for engineering/design of the plants.

Note:

Any specific application of the terms and responsibilities for the parties defined above, are a matter for the conditions of contract on a project.

3. DESIGN PROCEDURE

The Design of Piping is characterized by two successive phases as follows:

3.1 Basic Design

The following documents are minimum requirements for piping design in this stage. (Reference shall be made to IPS-E-PR-200).

- Plot Plan and/or Equipment Layout (IPS-E-PR-190).
- Piping and Instruments Diagrams (IPS-E-PR-230).
- Piping Specifications Relating to Individual Project.
- Line Identification List (IPS-E-PR-308).

3.2 Detail Engineering Design

3.2.1 Layout for erection and Detailed Piping Drawings for construction shall be produced during this stage. (Reference is made to IPS-E-PR-260, Clause 6.4.4, Piping).

3.2.2 Detail design of piping shall include but not limited to the following:

a) Final (detailed) P&ID (Piping & Instrument Diagram).
b) General plot plan.
c) Unit plot plan or equipment layout.
d) Above ground piping layout.
e) Under ground piping and foundation layout.
f) Piping plans (erection drawings).
g) Isometric drawings.
h) Line identification list.
i) M.T.O. (Material Take Off list).
j) Piping material specification.
k) Pipe support schedule.
l) Stress analysis calculation.
m) Design model (optional).
n) Pressure testing P&ID.
o) Tie-in diagram.

3.2.2.1 Piping and instrumentation diagram (P&ID)

3.2.2.1.1 The P&ID shall be completed in accordance with IPS-E-PR-230.

3.2.2.1.2 The following items shall be considered and shown in the P&ID.

a) Data and information of equipment.
b) Line identification.
c) Nozzle's position and size, for vessels and towers.
d) Type of valves.
e) Vents, drains and relief systems for lines and equipment.
f) Insulation and tracing on lines.
g) Pipe class (wall thickness and material).
h) Control systems and loops (Instrumentation).

3.2.2.1.3 The Utility Flow Diagrams (UFD) is a type of P&ID that represents the utility systems within a plant and shows all equipment and piping in respect of utilities (water, air, steam,...).

3.2.2.2 General plot plan

3.2.2.2.1 The general plot plan shall give the layout of the whole plant(s). It should be prepared to one of the following scales: 1:500, 1:1000, 1:2000.

3.2.2.2.2 The following items shall be shown in plot plan:

a) Battery limits of complex (Area boundary).
b) Geographic and conventional or plant north.
c) Elevation, with regard to the nominal plant 0 elevation.
d) Coordinates of main roads,process units, utility units, buildings, storage tanks and main pipe rack.
e) Location of flares and burn pit.
f) Direction of prevailing wind.

Note:

Plant coordinates may be started from point N = O and E = O.

3.2.2.2.3 The arrangement of units areas, storage areas, buildings, and devices for shipment to be provided within the plant, shall be decided on the base of the following factors:

a) Soil characteristics.
b) Main road or rail access ways.
c) Location of pipelines to and from plant.
d) Direction of prevailing wind.
e) Local law and regulation which may affect the location of units and storage facilities.
f) Natural elevation for location of units and equipment (such as storage tanks, waste water unit, oil/water separator, etc.).

3.2.2.2.4 The units shall be separated by roads. Major roads shall have minimum width of 6 m., with maximum length of 400 m. The minor roads shall have minimum width of 4 m. (Minor roads shall not be in an area classified as zone 0 or 1).

3.2.2.2.5 The space and arrangement of unit shall be designed in accordance with requirements of IPS-E-PR-190 "Layout and Spacing" Clause 8.

3.2.2.2.6 A plant may contain one or several process units. Where any unit processes flammable fluids and may be operated independently (i.e. one unit may be shut down with others in operation).The minimum spacing between equipment on the two adjacent units shall be at least 20 m.

3.2.2.2.7 For units processing flammable fluids, the central control building shall be adjacent to a road. It shall not be located in any area classified as zone 0 to 1 (based on IPS-E-EL-110 & Standard BP-CP-39).

3.2.2.2.8 Security fence

a) All sites (plants or complex) shall be within a security fence.

b) Any public building, such as administration office, restaurant, clinic, etc., shall be located outside of the process area boundary.

c) Except for case (d) the minimum space between security fence and units' boundary shall be 20 m, and between security fence and equipment shall be 30 m.

d) In case of special units such as flammable material storage with vapor release and toxic materials, minimum space shall be at least 60 m from site boundaries adjacent to centers of population (domestic, work or leisure).

3.2.2.2.9 Except where they are an integral part of a process unit, site utility units should be grouped together in an area classified as non-hazardous.

3.2.2.2.10 Fire water pumps and equipment shall be sufficiently remote from processing, storage and loading area, where a major fire could occur. Fire fighting system shall be designed in accordance with IPS-E-SF-220.

3.2.2.2.11 The waste water treatment facilities shall be located at the lowest points of plant.

3.2.2.2.12 Loading/unloading areas for road transport shall have adequate space to provide access for filling, parking and maneuvering. A drive through rack arrangement is preferred. The loading and unloading facilities should be downwind or crosswind from process units and sources of ignition, based on the direction of prevailing wind.

3.2.2.2.13 Flares

The location, spacing, orientation and general design consideration shall be in accordance with the Standard BP-CP-14 and IPS-E-PR-460.

3.2.2.2.14 Access requirements

a) Access ways within the plant shall be provided for maintenance, emergency case, and for fire fighting from the road around the plant. Piping system shall be laid in such a way to make possible passage of mobile equipment.

b) Minimum widths of access way shall be as follows:

i) Vehicular access ways within units:	4.0 m
ii) Pedestrian access ways and elevated walk way:	1.2 m
iii) Stairways and platforms:	0.8 m
iv) Footpaths in tankage areas:	0.6 m
v) Maintenance access around equipment:	1 m

c) Minimum headroom clearance for access ways shall be as follows:

i) Over railways or main road:	6.8 m
ii) Over access roads for heavy trucks:	6 m
iii) For passage of truck:	4 m
iv) For passage of personnel:	2.1 m
v) Over fork-lift truck access:	2.7 m

(see also above ground piping systems Par. 3.13.3.1).

3.2.2.3 Unit plot plan

3.2.2.3.1 The unit plot plans shall be designed based on general plot plan, and in accordance with IPS-E-PR-190. For spacing and clearance, reference shall be made to Standard Drawing IPS-D-PI-102.

3.2.2.3.2 The drawing shall be prepared in one of the following scales: 1:200, 1:500.

3.2.2.3.3 The drawing shall show the following items:

a) Conventional north.
b) Coordinates of battery limits and roads.
c) Symbols for equipment and coordinates of their center lines..
d) Finished floor elevation.
e) Equipment index list.

3.2.2.3.4 The area of any unit shall not exceed 20,000 m², and the length of each side should not exceed 200 m.

3.2.2.4 Layout

3.2.2.4.1 Layout of equipment and piping shall be designed in accordance with IPS-E-PR-190 Clause 9 and BP-CP-3 Clause 7.

3.2.2.4.2 The piping layout should minimize piping runs on very high pressure and corrosive/toxic services such as acidic gases, and shall consider economy, accessibility for operation, maintenance, construction and safety. (See above ground piping systems of this Standard Clause 3.13).

3.2.2.4.3 Layout of equipment

a) Compressors

i) Generally, compressors shall be installed outdoors. In case a shelter is required, the ventilation of room shall be taken into consideration.

ii) In so far as it is practical, all compressors shall be positioned under one shelter. This arrangement makes work easier for operators and maintenance crew; in addition one crane may serve all compressors if its deployment becomes necessary.

iii) Minimum spacing between gas compressor and open flames shall be 30 m.

b) Pumps

i) Pumps should generally be located in the open area, at or near grade level. Adequately ventilated shelters shall be provided for large machines requiring in situ maintenance. The pumps should also be located under the piperack.

ii) All pumps shall be accessible for operation and maintenance. Adequate space for lifting and handling facilities for maintenance shall be provided.

iii) Pumps should be located and specified so that an acceptable NPSH can be obtained without undue elevation of suction vessels or columns. Pumps on flammable or toxic duties shall not be located in pits to meet this requirement.

iv) In flammable fluid service, the horizontal distance between the related pump and adjacent heat source of 650°C or more shall be 30 meters min.

c) Fired heaters

i) A heater, or group of heaters shall be located on the periphery of a plot and immediately adjacent to an unrestricted road. There shall be adequate access for fire fighting from all sides of a heater.

ii) The layout and design of heaters shall normally be such that the tube removal can be effected by mobile lifting equipment, for which there shall be proper access.

d) Air cooled heat exchangers (fin fan)

i) The location of air cooled heat exchangers shall be specifically considered with respect to any areas of special fire risk. Such consideration shall include:

- The effect of the exchanger on air movement and increased fire spread.
- The possibility of failure of exchanger tubes releasing more combustible fluid to the fire.

ii) Air cooled heat exchangers may be located above piperacks, where practicable and economical.

iii) Air cooler shall not be located within 7.5 m horizontally from pumps on hydrocarbon service, and where practicable be at least 20 m horizontally from fired heaters, to minimize the possibility of circulation of hot air.

e) Shell and tube heat exchangers

i) Heat exchanger shall be located so that, when their tube bundles are withdrawn, they do not project into an emergency escape route or any road with unrestricted vehicle access. They shall be so arranged that can be readily dismantled for cleaning and maintenance.

ii) Heat exchangers shall be located collectively, at one point as far as possible, and their tube bundle pulling area shall be provided (tube bundle length + min. 2 m)

f) Cooling towers

The direction of the prevailing wind shall be considered in selecting the location of cooling towers. The towers shall be located to minimize any nuisance, both within and outside the site, from the water blow-out, evaporation, drift and ice formation. The requirements of BS-4485 shall be met.

g) Air intakes and discharges

i) Air intakes, including intakes to heating and ventilating system, air compressors for process, instrument, plant and breathing air, and to gas turbines shall be located as far as is practicable away from areas where air contamination by dust or by flammable or toxic material can occur. They shall not be located in any area classified as zone 0, 1 or 2 (except for gas turbine air intakes which shall be in accordance with manufacturer’s requirement), nor located above or below an area classified as zone 0, or 1.

Note:

Intakes and discharges shall be separated to prevent cross contamination by recirculation, taking into account natural wind effects. The distance between intakes and discharges shall be not less than 6 m.

h) Storage tanks (Liquids)

i) Storage tanks in tank farm should be laid out in a separate area (unit) and shall be completely surrounded by a bund or dyke as specified in NFPA 30-12 (for minimum tank spacing) and IP marketing code, part 4, section 7 (for bund).

ii) For tanks with diameter less than 48 m individual bounded compounds are not required, but for each crude oil tank with a diameter of 48 m or greater, a separate bounded compound shall be provided.

In no case shall the number of tanks in any bounded compound exceeds 6; nor the total capacity shall exceed 60,000 m^3. Intermediate walls of lesser height than the main bunds may be provided to divide tankage into groups of a convenient size, to contain small spillage and act as firebreaks.

iii) Tanks shall be laid out to provide access for fire fighting. There should be no more than two rows of tanks between adjacent access roads.

iv) Pumps associated with tankage operation shall not be located inside a bounded tank compound.

v) For distance and spacing in respect of storage tanks reference shall be made to IPS-E-PR-190, (Appendix A, and Table A-8) or BP-CP-3, Clause 9.

i) Pressurized LPG storage

i) LPG storage shall be laid out in accordance with UK Health and Safety Executive Guidance (Par. 15 to 29).

ii) Any site boundary to third party property shall have such a distance that the radiation at ground level, in the event of ignition of the leakage from a single relief valve and/or from a fire in a spill contaminated area, shall not exceed 4.7 kW/m^2.

The ground level radiation shall be calculated using the method in API Recommended Practice 521, Appendix A.

j) Sour NGL storage

In sour NGL storage tanks in addition to heat radiation mentioned in sub Par i)-ii above, safe distance with regard to H_2S contaminated area shall be considered.

3.2.2.5 Isometric drawings

3.2.2.5.1 All lines DN 50 (NPS 2) and larger in the process and utility areas shall have isometric (spool) drawings; utility and instrument piping DN 50 (NPS 2) are exempted.

3.2.2.5.2 Isometric drawings shall be prepared for construction of each pipe (prefabrication or site fabrication), as per piping plan drawings.

3.2.2.5.3 Drawings shall be designed without using scale and shall include graphic part, dimensional tables, list of materials, and plant north, design data, insulation, test, etc.

3.2.2.6 Line identification list

3.2.2.6.1 Line identification list (line list) shall include, but not limited to the following information:

a) Start point & end of line (connected to equipment or other lines).
b) Medium service.
c) Phase of flow (liquid, vapor, etc.).
d) Pressure and temperature (design, operating).
e) P & ID and reference drawing.
f) Line number (in accordance with IPS-E-PR-308)..
g) Piping specification code (line class).
h) Type of insulation.
i) Pipe size.

j) Heat treatment.
k) Branch reinforcement.
l) Special information, if required.

3.2.2.7 Pipe supports

3.2.2.7.1 Design of pipe supports shall be in accordance with IPS-G-PI-280.

3.2.2.7.2 Pipe supports schedule shall be prepared with the following data:

a) Type of support
b) Reference drawing for fabrication and installation.
c) Line number
d) Location of installation (unit, area, coordinates)
e) Piping plan and civil drawing number

3.2.2.7.3 The location and identification of all pipe supports shall be shown on the piping plan and isometric drawings.

3.2.2.8 Stress analysis

Stresses due to expansion and contraction in the piping system shall be in accordance with IPS-E-PI-200.

3.2.2.9 Model

3.2.2.9.1 Model or three dimensional software (if required) shall be made during detail engineering. The model of software shall be reviewed by Company with designer for any necessary modification.

3.2.2.9.2 The scale for construction of model components shall be $1:32^1/_3$ (or 1:30 if approved by Company).

3.2.2.10 Pressure testing P&ID

3.2.2.10.1 This drawing shall be prepared based on final P&ID (s) with the following considerations:

a) Position of valves (closed or open).
b) Isolation of equipment nozzles and limit of test section with the spectacle blind or similar facilities.
c) Installation of vent and drain connections for test.
d) Isolation or removing of all instruments.
e) Test pressure and test medium.
f) Test procedure.

3.2.2.10.2 The test procedure shall be made in accordance with Standard IPS-C-PI-350.

3.2.2.11 Tie-in diagram

a) In case of modification or expansion of existing plants, the tie-in diagram(s) shall be prepared to clarify piping connection points and their tie-ins between the existing plant and its expansion parts.

b) This diagram shall be as detailed as P&ID.

c) The tie-in diagram shall show the location points and procedure of tie-in.

ABOVE-GROUND PIPING SYSTEMS

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APPENDICES:

1. SCOPE

This Standard sets forth minimum engineering requirements for safe design of above ground piping within the property limits of plants handling petroleum and petrochemical products.

2. DEFINITIONS & TERMINOLOGY

2.1

Low pressure service steam	up to 7 barg
Medium pressure service steam	above 7 barg up to 24 barg
High pressure service steam	above 24 barg (normally 40 barg)

2.2 Cold Spring

Cold spring is the intentional deformation of piping during assembly to produce a desired initial displacement and stress.

2.3 Stress Relieving

Uniform heating of a structure or portion thereof to a sufficient temperature and maintaining for a specified period to relieve the major portion of the residual stresses followed by uniform and controlled cooling.

3. PIPING DESIGN

3.1 Design Condition

3.1.1 Design pressure

3.1.1.1 Design pressure for piping system shall be determined in accordance with ANSI/ASME B 31.3 with the following additions:

a) Where the pressure is limited by a relieving device, the design pressure shall not be less than the pressure which will exist in the piping systems when the pressure relieving device starts to relieve or the set pressure of the pressure relieving device, whichever is the greater.

The maximum differences in pressure between the inside and outside of any piping component or between chambers of a combination unit, e.g. a jacketed pipe, shall be considered, including the loss of external or internal pressure.

Piping subject to vacuum shall be designed for a negative pressure of 1 bar unless a vacuum break or similar device is provided, in which case a higher design pressure may be approved.

b) The value of the design pressure to be used, shall include the static head, where applicable, unless this is taken into account separately.

3.1.1.2 Design pressure of a piping system subject to internal pressure shall be defined as one of the following:

a) Design pressure of the equipment to which the piping is connected.

b) Set pressure of relief valve of the piping equipment system (if lower than a).

c) A pressure not lower than the shut off pressure or that resulting from the sum of the maximum. suction pressure plus 1.2 times the design differential pressure, for discharge lines of pumps and/or compressors not protected by a relief valve.

d) The maximum differences in pressure between inside and outside of any piping component or between chambers of a combination unit, e.g. a jacketed pipe, shall be considered including the loss of external or internal pressure.

3.1.1.3 Vacuum piping

The piping subject to vacuum shall be designed for a negative pressure of 100 KPa (1 bar) unless a vacuum breaker or similar device is provided.

3.1.2 Design temperature

3.1.2.1 Design temperature shall be determined in accordance with ANSI/ASME Code B 31.3 with following additions:

a) Design temperature shall include an adequate margin to cover uncertainty in temperature prediction.

b) Design maximum temperature shall not be less than the actual metal temperature expected in service and shall be used to determine the appropriate design stress "S" for the selected material.

3.1.2.2 In case exterior of components are thermally insulated, the lowest metal temperature shall be taken to be the minimum temperature of the contents of the pipe.

3.1.3 Operating temperature

3.1.3.1 The operating temperature of a piping shall be determined as the temperature corresponding to that of the fluid in normal operating conditions.

3.1.3.2 In case of steam-traced piping, the operating temperature shall be assumed as equal to one of the following:

a) Temperature equal to 70 percent of steam operating temperature if conventional tracing is employed without the use of heat-conductor cement, and when steam temperature is higher than the operating temperature of process fluid.

b) Steam operating temperature, in case of tracing with the use of heat-conductor cement.

c) Steam operating temperature, in case of jacketed piping.

3.2 Pipe

3.2.1 Pipe material

Pipe material as cited in ANSI/ASME B31.3. The selection of type and material of pipe shall be in accordance with IPS-E-PI-221. For sour services, requirements of NACE. MR-01-75 shall be considered.

3.2.2 Pipe size requirement

3.2.2.1 Pipe smaller than DN 15(NPS½") should not normally be used, except for instrumentation.

3.2.2.2 The use of steel pipe in sizes: DN 32 (NPS 1¼), DN 65 (NPS 2½), DN 90 (NPS 3½), DN 125 (NPS 5), DN 175 (NPS 7), DN 225 (NPS 9) and DN 550 (NPS 22) should be avoided.

3.2.3 Pipe wall thickness

3.2.3.1 The required thickness of pipes shall be determined in accordance with ANSI/ASME B 31.3.

3.2.3.2 The selection of standard wall thicknesses of pipes shall be in accordance with ANSI/ASME B 36.10.

3.2.4 Branch connections

Branch connections not covered by IPS-E-PI-221 shall be calculated in accordance with ANSI B 31.3.

3.3 Piping Components

For sour services, requirements of NACE-MR-01-75 shall be considered.

3.3.1 Type of piping joints

Piping joints not covered by IPS-E-PI-221 shall be designed in accordance with ANSI/ASME B 31.3.

3.3.1.1 Threaded joints (addition to B 31.3-314):

a) Threaded joints may be used for normal fluid service and when:

i) The fluid handled is non-flammable and non-toxic, non-hazardous, non-erosive and the duty is non-cyclic.

ii) The design pressure does not exceed 10 bar (ga) (150 psig).

iii) The design temperature is between -29°C (-20°F) and 186°C (366°F), except that steam is not included in this category.

iv) The connection is provided for pressure test.

b) Where seal welding of threaded joints is used , the material shall be weldable.

c) Threaded joints and fittings shall not be used for:

i) General chemical service.
ii) Corrosive fluid.
iii) Steam service.

d) To reduce the incidence of leakage, the use of threaded joints and unions where permitted should be minimized consistent with needs of pipework fabrication. Sufficient threaded joints or unions, where permitted, shall be provided to facilitate dismantling of pipework for all operational, maintenance and inspection purposes, including requirements for shutdown and gas freeing.

e) With the exception of connections to instruments and instrument valve manifolds, threaded joints shall not be used in stainless steel, alloy steel or aluminum piping systems.

f) No threaded joints or fittings shall be used between a pressure vessel or main pipes DN 50 (NPS 2) or above, and the first block valve isolating a piping system. This valve shall be flanged or may be socket-welded with a flanged joint immediately downstream.

g) Layout of piping employing threaded joints should in so far as possible, minimize stress on joints.

h) Dimensions of threaded fittings shall be in accordance with IPS-M-PI-150.

3.3.1.2 Socket weld joints (additional to B 31.3):

a) Socket welding connections should be used wherever possible up to the limiting size of DN 40 (NPS 1½) except for water service which could be used up to DN 80 (NPS 3).

b) Where permitted, socket welding joints are preferred to threaded joints, except for non-hazardous service as defined in 3.3.1.1.

c) Socket welding rather than threaded fittings shall be used for searching fluid service (e.g. for glycol service).

d) Socket welded fittings dimensions shall be per IPS-M-PI-150.

3.3.1.3 Flanged joints (additional to ANSI/ASME B 31.3).

3.3.1.3.1 The use of flanged joints should be kept to a minimum particularly on hazardous service. However, sufficient break flanges shall be provided to allow removal and replacement of piping where:

a) Process duties may be fouling.
b) Deterioration of piping or valves is anticipated in service due to corrosion, erosion, etc.

3.3.1.3.2 Flanges, rating and flange facings shall be in accordance with IPS-M-PI-150.

3.3.1.3.3 Flanges types

Flange type shall be in accordance with IPS-M-PI-150 with following considerations:

a) Flanges should normally be welding neck type .

b) Slip-on flanges shall not be welded directly on to elbows or other fittings and shall be double welded for all services.

c) Class 400 flanges shall not be used.

d) Where BS 3293 flanges are required, because of adjacent equipment, a check calculation on the suitability of the flange design for hydrostatic test conditions shall be made.

3.3.1.3.4 Limitation on flange facings

a) The facings of class 150, 300, 600 and 900 flanges shall be raised face except where ring type joints are required as given in Par. (b).

b) Unless otherwise specified, the facings of flanges in classes 1500 and 2500 shall be of ring joint type. Class 900 flanges when used on hydrogen service shall also be of ring joint type.

c) A steel flange shall be plain (flat) face at a joint with a cast iron or non-ferrous flange having a plain (flat) face.

d) Flange finishing in various services is given in IPS-E-PI-221.

3.3.1.3.5 Blind flanges

a) For thickness of blinds for test see IPS-D-PI-121.
b) Blinds size DN 300 (NPS 12) and larger shall be supplied with jack screws.
(All heavy flanges DN 300 (NPS 12) and larger shall be equipped with facilities for jack bolting).

3.3.1.3.6 Limitations on gaskets

a) Selection of gasket shall be made in accordance with Appendix A (Table A.1) of IPS-M-PI-150.
b) The use of asbestos should be avoided. However, if its use is inevitable then the following shall be considered.

i) To avoid galvanic corrosion, graphited caf gasket should not be used in austenitic stainless steel piping on corrosive aquous duties.

ii) Spiral wound gasket for use with class 900 RF flanges shall be provided with both inner and outer guide rings. (For class 600 and lower outer ring would suffice).

iii) Unless required with special properties, caf gasket should be specified oil resistant to be suitable for oil refinery and chemical plant duty.

iv) Caf flat gaskets should be specified 1.5 mm thick for flanges up to DN 600 (NPS 24).

3.3.2 Pipe bending

3.3.2.1 General

a) The bending radius shall be given on the isometric drawing, but in principle shall not be less than 5 times the nominal pipe diameter.

b) All bending of stainless steel and nickel alloy pipe should be done cold. Where the size and schedule of pipe is such that cold bending becomes impracticable, a hot bending and subsequent solution heat treatment procedure shall be prepared for the Engineer's review and approval.

c) Stress relieving is not normally considered necessary for cold bended stainless steel and high nickel alloys but, in the case of austenitic stainless steels, it may be necessary to obtain some reduction in the residual stress level after cold bending, e.g. in case where the bend is subject to chloride or polythionic acid attack. Where stress relief is specified by the Engineer, the bend shall be stress relieved by heating rapidly to a temperature of 900 to 950°C and holding for a period of one hour per 25 mm thickness for a minimum period of one hour followed by cooling in still air. Heating shall be either by local electric heating blankets or by the use of a furnace. In the latter case, the furnace gas shall have a controlled sulphur cotent.

d) For ferritic steels with the exception of the quenched and tempered grades, a normalizing heat treatment shall be applied if the cold deformation is more than 15% or when the hardness increase in Vickers or Brinnell is more than 100.

e) For quenched and tempered ferritic steels an appropriate stress relieving heat treatment shall be applied, if the cold deformation is more than 15% or when the hardness increase in Vickers or Brinnell is more than 100. Stress relieving shall be at least 10°C below the tempering temperature.

3.3.2.2 Pull bends

Pull bends with a center line bend radius not less than 5 times Nominal Pipe Size (NPS) may be made in pipe sizes up to and including DN 40 (NPS 1½).

3.3.2.3 Mitre bends (addition to ANSI/ASME B 31.3)

a) Mitre bends shall not be used where the pressure exceeds 5 bar (72.5 psig) or where the stress range reduction factor "f" in the case of thermal or pressure cycling, would be less than 1.

b) In any case, the use of miter bends shall be restricted, according to ANSI/ASME B 31.3. Fabrication detail shall be in accordance with Standard Drawing IPS-D-PI-129.

3.3.3 Bellows expansion joints

3.3.3.1 Guidance on the selection and application of metallic bellows expansion joints is contained in BS 6129, ANSI/ASME B 31.3 and EJMA (Expansion Joint Manufacturers Association) and IPS-E-PI-200 (Clause 6.7 to 6.9).

3.3.3.2 Refer to Clause 6.9.5 of IPS-E-PI-200.

3.3.3.3 Refer to Clause 6.9.4 of IPS-E-PI-200.

3.3.3.4 Vibration

Attention should be given to any expected vibration, e.g. from associated machinery, when specifying the design requirements of the bellows. For further consideration see Clause 6.9.12 of IPS-E-PI-200.

3.3.3.5 External shrouds

External shrouds shall be provided for mechanical protection; the shrouds shall be designed to minimize the ingress, and prevent the retention of water within the convolutions.

3.3.3.6 Internal sleeves

Internal sleeves are required when:

a) Flow induced vibration may occur.

b) It is possible for solid debris to collect in the convolutions. This debris may be due to insufficient flushing of lines or equipment after initial construction or due to internals coming loose because of corrosion, vibration or erosion.

c) The duty is fouling, corrosive or contains solids. In this case purging behind the sleeve should be specified.

When an internal sleeve is provided, the bellows should be installed in the vertical position with the sleeve pointing downwards and the convolutions shall be self-draining.

3.3.3.7 Spool pieces

Bellows to be welded directly into a line, they shall be purchased with spool pieces of the same material as that of the line, welded to the ends of the bellows.

3.3.3.8 Lubricants

The use of molybdenum disulfide lubricants shall be avoided on external tie bars, etc., if the bellows operate at a high temperature.

3.3.3.9 Support

The Executor shall fabricate and install field support as per IPS-G-PI-280.

The supporting and guiding of piping systems containing bellows expansion joints shall be fully assessed at the design stage, preferably also by the bellows expansion joint manufacturer, to ensure that the bellows expansion joint deflects in the manner for which it was designed, and that the system retains structural stability.

3.4 Valves

3.4.1 General

For economy and interchangeability, types of standard valves to be selected shall be kept at minimum.

3.4.2 Selection of valves

3.4.2.1 General

Valves material and design shall comply with IPS-M-PI-110.

3.4.2.2 Appendix "A" may be used as guidance for valve selection.

3.4.2.3 All valves for steam services in piping Classes 600 and higher should be of the butt weld end type, except for instrument isolation valves, and blowdown valves.

3.4.2.4 Low temperature services

a) The following types of valve may be used for services down to minus 20°C:

i) gate, globe and check valves, with metal seats or with soft insert;
ii) ball valves, floating and trunnion mounted ball with soft and metal seats;
iii) butterfly valves, off-set type, soft and metal seated.

b) Gate and ball valves may have cavities where cryogenic liquid could be trapped and cause excessive pressure build up during warm-up of the valve body. For such valves, in services of minus 20°C and lower, a cavity relief shall be provided by drilling a hole of 3-5 mm in the upstream side of the wedge or ball outside of the seat facing area. These valves shall be clearly marked to indicate the cavity relief side.

3.4.2.5 Valves of special types

Many special valves have been developed and proved suitable for process requirements and special services. Care shall be taken to select the correct valves, with a view to the design, materials, fabrication and testing. Reference shall be made to IPS-E-PI-221.

a) Flush bottom valve

Drain valve on piping or equipment without dead nozzle end, for viscous or solidifying products.

b) Plug valves-lubricated

These valves should not be used for general purposes and shall only be used when the product allows the use of a plug lubricant.

Plug valves should not be used as a single item, since they require periodical maintenance by trained staff.

Alternatively, in high pressure gas systems the use of pressure balanced (non-lubricated) plug valves may be considered.

c) Multiport valves

A multiport ball valve or plug valve with sleeve can be selected to divert flows. Use of two normal valves is however preferred.

d) Iris-type valve with flexible diaphragm sleeve

For pneumatic or gravity feed of solids and powders.

e) Steam stop valves and hydrogen valves

Flexible wedge gate valves shall be used in main steam and hydrogen lines, DN 150 (NPS 6) and above. The double disc parallel-seat type is an acceptable alternative.

3.4.2.6 Gear operators are required for valves in accordance with IPS-M-PI-110.

3.4.3 Location of valves

3.4.3.1 General

a) Piping layout shall ensure that valves are readily accessible to allow operation and maintenance at site.
b) Valves for emergency isolation of equipment, and valves which must be frequently operated or adjusted during operation shall be accessible from grade, platform, or permanent ladder.

3.4.3.2 Elevated valves

a) Generally chain operated valves should not be used. Where this in not practical, elevated valves with the center line elevation more than 2.2 m should be chain operated.

b) Hand wheels and stems of valves shall be kept out of operation aisles. Where this is not practical the elevation of valves shall be 2 m from grade to bottom of hand wheel.

c) Valves above roads and in over head pipe rack should be avoided.

3.4.3.3 Control valves

a) Control valves shall be located so as to facilitate their maintenance and manual operation from the operating floor. Unless due to process reason, the valves shall be located at grade level.

b) Control valve shall normally be installed in horizontal piping with the valve stem vertically upward.

c) Sufficient clearance shall be provided above the diaphragm and below the bottom of the body for easy maintenance.

d) Control valves shall not be bolted up against stop valves on both sides.

3.4.3.4 Check valves

All check valves shall preferably be located in horizontal position. The valves may be mounted in the vertical position with upward flow.

3.5 Instrument Piping

3.5.1 General

Piping specification shall apply up to and including the first block valve(s) from the process lines or equipment.

3.5.2 Requirements

Limit and type of piping for instrument connections shall be in accordance with ANSI/ASME B 31.3.

Pressure points shall be as short as possible. Long connections, if unavoidable, and connections to vibrating lines shall be properly braced.

3.5.3 Instrument connections

3.5.3.1 Level and contents (level gages)

a) Connection for external float and displacer chambers shall be in accordance with IPS-E-IN-140. Branch connection should be DN 50 (NPS 2).

b) Level gages shall be connected with block valves to the equipment. Level gages in ANSI 900 pressure rating and higher shall have double block valve.

c) Stand pipe shall be applied if more than two pair of level gage connection are required. The minimum diameter of stand pipe shall be DN 80 (NPS 3) and the equipment connection shall be DN 50 (NPS 2).

d) If the required level gage is too large for a single gage, multiple level gage shall be used. The connection of stages shall have a minimum overlap of 25 mm.

e) Loads on equipment nozzles from the weight of a long stand pipe with level gages and/or thermal expansion forces, shall be considered.

f) There are two alternatives for connecting level gages: (case II is preferred design):

i) with block valves between the level gage and the stand pipe;
ii) with block valves between the stand pipe and the equipment.

g) Connections for internal level instruments and flange mounted differential pressure instruments shall be sized to permit float removal.

h) Drainage from gage glasses, external float and displacer chambers shall be led via a tundish to a suitable drain at grade.

A closed disposal system shall be provided for drainage of vaporizing liquids which evolve H_2S, other toxic gas or large volumes of flammable vapor.

3.5.3.2 Temperature measurement

a) Connection for thermowells shall be in accordance with IPS-E-IN-120.

b) Branches for flanged thermowells shall be DN 40 (NPS 1½) minimum and shall conform to the process duty line specification.

c) Thermowells shall be located at least 10 times the pipe inside diameter downstream from the mixing point of two different temperature streams.

3.5.3.3 Pressure measurement

a) Connections for pressure instruments shall be in accordance with IPS-E-IN-110 and Standard Drawing IPS-D-IN-104.

b) Isolation valves shall be full bore when rodding is specified.

c) Instrument connections shall be orientated horizontally in vertical lines and, on or the top of horizontal lines. Tappings at side or 45 degrees from horizontal will be permitted only where necessary to prevent fouling from adjacent pipework, structure or equipment. The selected orientation shall permit remote mounted instruments to be self-venting or self-draining. Connections for instruments on immiscible fluids shall be horizontal.

3.5.3.4 Flow measurement

a) Orifice flange connections shall be in accordance with IPS-E-IN-130, and Standard Drawing IPS-D-IN-104.

b) For in-line flow measurement devices the manufacturer's installation requirements shall be followed.

c) Piping and primary valving at the orifice fitting or other flow measurement device shall conform to the line specification.

d) Line tap connections shall conform to the requirements for pressure tapping.

e) Orifices flanges shall be installed in horizontal pipes, as far as possible. When it is impossible to find sufficient meter run in a horizontal piping, orifices may be installed in a vertical piping with upwards flow for liquids and downward flow for gas and steam.

f) The minimum meter run required for both upstream and downstream of the orifice, flanges shall be in accordance with Standard Drawing IPS-D-IN-102.

3.5.3.5 Analyzers

a) Process line connections for analyzer sampling systems shall be either:

i) A flanged connection to the line specification, to accommodate a probe as detailed in Standard Drawing IPS-D-IN-230.

ii) A line connection as detailed for pressure instruments on Standard Drawing IPS-D-IN-104.

b) Fast loops up to and including the main sample filter or pressure reducing valve shall be to line specification.

c) Sample lines from the process connection or offtake from the fast loop shall be as specified in BP Std. 170 under instrument impulse lines.

d) For in-line analyzer manufacturer's installation requirements shall be followed.

3.5.3.6 Sample systems

3.5.3.6.1 Manual sampling systems

a) The system shall be designed to minimize the possibility of loss of containment, taking particular account of the process conditions and hazardous nature of the material to be sampled.

b) A representative sample shall be obtained by siting the sample connection at a suitable point on the process line in accordance with IPS-E-PR-230.

c) The effect on area classification shall be considered in positioning sample points.

d) Sample piping shall be as short as possible.

e) All operational parts of sampling systems shall be easily accessible, including the primary isolation valve.

f) Sample points should either be approximately one meter above ground or one meter above an accessible level.

3.5.3.6.2 Sample connections

a) Liquid sample connection shall not be located at the dead ends of piping.

b) Gas sample connections shall be located at the top of a horizontal run piping, or at the side of vertical piping.

c) Minimum size DN 20 (NPS ¾) sample connection in accordance with IPS-E-PR-230 Appendix A and IPS-D-PI-140 shall be provided for non-hazardous duties on feed and product lines, and elsewhere specified by process requirement in P&ID diagrams.

d) Sample points with two valves shall have one valve at the take-off point of the process line with size as standard drain valve, and another one at the sampling point with the size max. DN 15 (NPS ½).

e) Unless otherwise specified sample coolers shall be provided for sample connections where the fluid is above 70°C (160°F). Requirements for sample cooler should conform to IPS-D-PI-104.

3.6 Safety and Pressure Relief System

Location and arrangement of safety and pressure relief valves and relief systems shall be in accordance with standard Drawing IPS-D-PI-123. Consideration shall be given to the followings:

3.6.1 Safety valves shall be located as close as possible to the equipment they are to protect, and be accessible for check and maintenance purposes.

3.6.2 Discharges of relief/safety valves to atmosphere shall be arranged as follows:

a) Min. height from grade : 15 meters.

b) Height higher by 3 meters with respect to any equipment or service platform which are located within a radius of 15 meters. (7.5 meters for steam).

c) Min. distance from open flames 30 meters. (Such as from furnace burners).

d) Each pipe discharging to atmosphere shall have a 6 mm (¼") diameter weep hole at the lowest point.

3.6.3 Safety valves thermal relief shall always be installed on those lines which may be intercepted at ends, when the line internal fluid, at max. ambient temperature, may reach conditions higher than the rating of the line itself.

When discharge of a safety valve is connected to a close circuit (blowdown), such valve shall be higher than the header, so as to create a natural drainage.

3.6.4 The pressure drop between vessel and safety valve shall not exceed 3% of operating pressure of the vessels.

3.6.5 Installation of block valves or spades in any location where they would isolate a vessel or system from its pressure or vacuum relief device shall be in accordance with ANSI/ASME B 31.3.

3.6.6 Discharge piping and overpressure protection system shall be in accordance with BP-CP-14 and ANSI/ASME B 31.3.

3.7 Block and Bypass Valves

3.7.1 Unless otherwise required by process, block and bypass valve shall be provided for control valve installation as per standard drawing IPS-D-PI-122.

3.7.2 Block and bypass assemblies shall have means of depressurizing and draining the associated valve and pipework.

3.7.3 A valved drain connection shall be provided upstream of each control valve between control valve and block valve.

3.8 Vents and Drains

3.8.1 All piping system shall have adequate numbers of vent and drain connections to ensure effective venting and draining of the system.

3.8.2 The sizes of vent and drain valve shall be selected as a function of the characteristics of the liquid to be drained, but they shall not be smaller than those cited in the following :

a) For lines DN 40 (NPS 1½) and smaller : DN 15 (NPS ½).

b) For lines DN 50 (NPS 2) and larger : DN 20 (NPS ¾) (for non-hazardous service).

c) Small connections from hazardous service lines, e.g. nipples for vents, drains, pressure tappings, sample points, (excluding connections from orifice flanges, carriers and other instrumentation) shall be DN 25 (NPS 1) minimum for strength.

3.8.3 If vent and drain connections are not provided on equipment, blanked branches shall be provided on the attached piping providing that effective venting and draining of the equipment through piping system is practicable. Minimum sizes of vent and drain connections are given in table below:

EQUIPMENT CAPACITY		VENT		DRAIN	
m^3	ft^3	DN	NPS	DN	NPS
Up to 1.5	Up to 50	25	1	25	1
Up to 6	Up to 200	25	1	40	1½
Over 6 to 17	Over 200 to 600	25	1	50	2
Over 17 to 71	Over 600 to 2500	40	1½	80	3
Over 71	Over 2500	50	2	80	3

3.8.4 Operational vents, sample points and drains which may discharge flammable fluids shall be minimized and shall be not less than 15 m (50 ft) minimum from possible sources of ignition, e.g. furnaces, hot lines, and rotating machinery.

3.8.5 Drainage lines for hazardous or valuable process chemicals shall be accessible for inspection and maintenance. Drainage from such equipment shall be permanently piped to a sump tank provided with means for emptying.

3.8.6 For other services, the drainage from sample points, gage glasses and level controllers should be led via turndishes into an adjacent drain. Sample points and, where necessary, drains shall be protected against static induced ignition of flammable materials.

3.8.7 Where a significant release of H_2S, other toxic gas or large volumes of flammable vapor could occur, vents and drains shall be piped to a closed disposal system.

3.8.8 Separate arrangements should be made for the drainage and the tracing of lines containing materials likely to solidify. Provision should be made for rodding and high pressure water cleaning.

3.8.9 Vents and drains for pressure test purposes shall be sized as follows:

PIPE SIZE	DN	NPS	VENT SIZE		DRAIN SIZE	
			DN	NPS	DN	NPS
Up to	150	6	20	¾	20	¾
Between	200 - 350	8 - 14	20	¾	25	1
Above	350	14	20	¾	40	1½

3.8.10 Vents and drains for custody metering systems shall include double isolation with one lockable valve, and drip-type sight glass for leakage detection.

3.8.11 In cases vent connection is provided for pressure test only, the valve should be replaced with a plug.

3.8.12 On process piping (conveying hazardous fluids), vents and drains shall be designed as follows:

- For piping DN 40 (NPS 1½) and smaller : valve and CAP (plug).
- For piping DN 50 (NPS 2) and larger : valve with blind flange.

3.9 Blowdown

3.9.1 Blowdown header shall run with a minimum slope of 1:500 towards the separator avoiding intermediate piping components restricting flow.

3.9.2 Branching off a discharge pipe to blowdown header shall always be at top of pipe with configuration of 45 degrees in the direction of flow.

3.10 Utility Piping

3.10.1 Utility services (utility stations Standard drawing IPS-D-PI-128)

3.10.1.1 In process areas and where necessary for maintenance and cleaning, the valved hose connections shall be installed for compressed air, low pressure steam, service water and inert gas (when required).

3.10.1.2 Diameter of service connections shall be DN 20 (NPS ¾) and hose length shall be 15 meters.

3.10.1.3 All branch piping from utility headers shall be taken from the top of the header to prevent plugging.

3.10.1.4 Hose connections shall be located with respect to the operator, air on left, steam at middle, water on right.

3.10.1.5 Emergency showers and eye wash fountains shall be provided for process plants handling dangerous chemicals as cited in the relevant IPS safety and fire standard.

3.10.2 Cooling water

3.10.2.1 General

a) Cooling water lines shall have block valves at the unit limit.

b) Restriction orifices shall be installed in open cooling water outlet lines to maintain a slight over pressure, in order to avoid vapor locks at the channel side of coolers and condensers in elevated positions.

c) In freezing areas, a closed cooling water system shall have a bypass with globe valve upstream of the supply and downstream of the return block valve for each unit for winterization purposes.

d) Cooling water system with a cooling tower shall have block valves at the inlet to each cooling tower cell.

3.10.2.2 Cooling water pipework to and from heat exchangers

a) Where sea water or aggressive water is used as cooling medium, the water velocity in the exchanger tubes should be controlled given the design limits to prevent scaling, erosion, corrosion or the formation of deposits. A control or butterfly valve shall be used in the outlet piping to achieve this purpose.

b) Where further means of controlling water velocity in the tubes is necessary some means of measuring device shall be used. If orifice plate is used it shall be of type 316 stainless steel, monel or incoloy 825.

c) Where the water pipework is associated with elevated condensers or coolers, irrespective of the type of water used, the control shall be positioned on the outlet side of the equipment, to ensure that the equipment and pipework always runs full of water to avoid vacuum conditions leading to boiling, impingement and scale formation.

3.10.3 Fuel oils and fuel gas

a) For low flashpoint fuel, a separate all-welded supply system shall be provided with steam connections for purging.

b) Fuel gas pipework shall be provided with a condensate knockout drum with means of disposal of the condensate to a closed system.

c) If necessary fuel gas lines shall be steam traced and insulated downstream of the condensate knockout drum.

d) Burner piping below fired heaters shall not restrict access or exit from the area, for reasons of safety and for the removal and cleaning of gas and oil burners.

e) Fuel oil piping loops to burners should be fully steam traced, the steam supply being kept separate from the atomizing steam. It is not permissible to insulate the fuel oil and atmozing steam lines in a common jacket in lieu of providing steam tracing. Pressure tappings to fuel oil pressure controllers shall also be adequately traced.

3.10.4 Hydrogen service

a) Leakage shall be minimized by the use of welded joints and the exclusion of threaded connections. Vents and drains shall be kept to a minimum and their valves blanked.

b) Purging connections permanently piped to a supply of nitrogen shall be provided on all units on hydrogen service and on separate pieces of equipment which may have to be isolated during operation of the unit. Such connections shall incorporate double block valves with a valved bleed between.

c) Flange facing in hydrogen service shall be smooth finish to 250 AARH.

3.10.5 Instrument air

a) Main instrument air supply shall be an independent self-contained system in accordance with IPS-E-IN-200.

b) Headers or manifolds shall be fitted with isolation valves and removable caps, plugs or flanges to allow for blowdown.

c) Main header isolating valves shall be socket weld or flanged gate type. Isolating valves local to each individual instrument offtake may be threaded and of brass construction.

d) All low points on main and subheaders shall be provided with an accessible drain valve DN 25 (NPS 1) or header size whichever is less. Individual supply lines will not normally require drain valves.

e) Distribution offtakes shall be taken from the top of horizontal headers.

f) The specification of tubing for use downstream of the air header isolation valve and for control lines is detailed in IPS-D-IN-105.

3.10.6 Process air

a) Process air shall be supplied by permanently installed compressors which may also supply service air.

b) Process air header shall be taken from the upstream of air dryer with the separately piping from instrument air system.

3.10.7 Service air

a) Service air may be supplied by means of portable compressors. Where a permanent system is specified, materials shall comply with the requirements of IPS-E-PI-221.

3.10.8 Breathing air systems

Breathing air system used for prevention of vacuum in non-pressurized vessel shall be of high integrity type.

3.10.9 Steam system

3.10.9.1 General

a) Main steam distribution header shall have a block valve at the main header offtake. The line-up shall allow for spading.

b) Main steam distribution header, entering process units shall have a double block and bleed valve on the easily accessible location at the unit battery limit.

c) Steam distribution header(s) shall have a block valve with a spectacle spade at the offtake of the main steam distribution header. The offtake shall be located on the top of the line.

Instruments and recorder connections for flow, pressure and temperature shall be installed downstream of the block valves to the plant or unit.

d) Steam required for smothering, snuffing, tracing and similar services shall be supplied through separate distribution header(s).

e) Block valves shall be of parallel slide type on the main steam distribution system serving the refinery or works together with those at the battery limit of any other area, e.g. a tank farm, administration area.

Within any process unit where any section can be taken out of service for maintenance with normal operation continuing on the remaining sections, the section isolating valves shall also be of the parallel slide type.

f) If it is necessary to discharge large quantities of steam, noise suppressors shall be provided.

g) The draining facilities of a steam supply line shall not discharge into sewer systems. They shall run to a safe location such as collecting condensate pits, contaminated water rundown systems, gravel pits, gullies, etc., and be combined as far as practical. Situations jeopardizing personnel and goods shall be avoided. In cold areas iceing-up of personnel access surfaces shall be avoided.

h) Stagnant and reverse flow conditions shall be avoided in steam distribution systems.

i) For steam services, valves DN 150 (NPS 6) and larger with ANSI rating 600 and higher shall have a bypass valve for preheating and pressure balancing. The bypass size shall be:

NOMINAL SIZE OF MAIN VALVE IN		BYPASS VALVE, NOMINAL SIZE, DN (NPS)			
DN	(NPS)	FOR WARMING-UP OF PIPE AND PRESSURE-BALANCING OF LINES WITH LIMITED VOLUMES		FOR PRESSURE-BALANCING	
150	6	20	¾	25	1
200	8	20	¾	40	1½
250	10	25	1	40	1½
300	12	25	1	50	2
350	14	25	1	50	2
400	16	25	1	80	3
450	18	25	1	80	3
500	20	25	1	80	3
600	24	25	1	100	4

j) Steam lines connected to process lines shall be fitted with a block valve. A check valve shall be installed upstream of the block valve, with a bleeder in between. Block valve and check valve shall be close together and close to the process line.

k) In-line silencers shall be fitted with a small drain line at the bottom of the silencer to prevent accumulation of condensate.

l) Vent facilities shall be installed to permit warming-up of the lines prior to commissioning.

m) All steam supply lines shall have drain facilities at the low points and at the end to remove condensate (e.g. during commissioning).

3.10.9.2 Steam connections

a) Branch connections for steam systems at 45 bar (ga) (650 psig) and above should be DN 25 (NPS 1) minimum and, shall be taken off the top of main steam distribution system. A block valve between branch and steam mains shall be provided.

b) Process steam connections to fired heaters should be provided with a check valve and block valve in series; the check valve shall be located between the block valve and the fired heater.

c) Process steam connections to fractionating columns and similar process equipment shall be provided with a check valve and a block valve in series, the block valve being located at the column.

d) Utility connection up to DN 50 (NPS 2) shall not be connected permanently to the steam header.

e) Steam lines to groups of pumps shall have individual block valves for independent shut-off.

3.10.9.3 Steam out connections

a) Piping installed for steaming out fractionating columns and similar process equipment shall be provided with two valves (one gate and one check valve). The gate valve may be that required by 3.10.9.1 (a) and a drain valve shall be installed between them.

b) The steaming out connection, shall be independent of the drain from the vessel and shall be provided with a spade for positive isolation.

Steam out connection sizes shall be as follows:

VESSEL CAPACITY		CONNECTION	
m^3	(ft^3)	DN	NPS
Up to 28	Up to 1000	25	1
Over 28 to 57	Over 1000 to 2000	40	1½
Over 57 to 1400	Over 2000 to 50000	50	2
Over 1400	Over 50000	80	3

c) Process steam and steam-out connections shall be provided with drainage arrangements.

3.10.9.4 Exhaust lines

a) Exhaust lines from steam machinery discharging to atmosphere should be fitted with an exhaust head suitably drained.

b) Exhaust steam lines shall enter in the top of the exhaust steam collecting header.

3.10.9.5 Steam trapping

a) Steam traps should not be installed in superheated main steam headers or superheated main steam distribution headers. For saturated steam service steam traps shall be fitted to drain pockets at low points of main steam headers and main steam distribution headers.

b) Sections of steam distribution headers, heating elements, coils, tracers, etc., shall each have a steam trap.

c) Steam traps shall be as near as possible to the condensate outlet of the unit to be drained, unless a cooling leg is required. Traps shall be at all low points or at natural drainage points, e.g. in front of risers, expansion loops, changes of direction, valves and regulators.

d) Steam traps shall have a bypass arrangement if the system can not accommodate replacement and/or repair time without causing a process problem.

e) Steam traps shall be easy to maintain and replace. The connecting piping up to and including the first down-stream block valve shall be designed for the full steam pressure and temperature. Steam traps inside buildings shall have a bypass and shall not discharge into an open drain inside the building.

f) Open steam trap discharges shall be located away from doors, windows, air intakes, ignition sources, stairs and access ways.

g) Steam trapping arrangements should conform to standard drawing IPS-D-PI-125. All trap pipework shall be designed to provide flexibility to allow for thermal movement between the main, trap and condensate return main.

h) Trap size shall be based on the maximum quantity to be discharged at the minimum pressure difference between inlet and outlet.

i) Traps shall be fitted with a strainer on the inlet, unless it is an integral part of the trap and shall be of cast or forged steel, according to the duty.

j) Socket weld trap assemblies shall be provided with flanges to allow for maintenance. The flanges shall be so arranged that the upstream atmospheric blowdown will be effective whilst the trap assembly is removed for maintenance.

k) No steam trap should be connected to more than one steam line nor to more than one section of the same steam line.

l) Open tail pipes should terminate 75 mm (3 in.) above ground level and shall not discharge on to stanchions, pipe supports, or directly into salt glazed drains, etc., which might be adversely affected by the discharge. They shall be directed in such a way as not to present any hazard and in paved areas should be directed so that the condensate does not run across the paving.

m) Traps discharging to atmosphere should be mounted to be self draining to avoid frost damage.

n) Traps operating on different steam pressures may discharge into the same header, providing the condensate line is adequately sized to accommodate the flash steam.

o) Traps should be located adjacent to the equipment they serve, and shall be accessible for maintenance and firmly supported.

p) Multiple traps shall be grouped together and installed in enclosures so that the operation of each trap can be checked and prevent frost damage to traps not in use. Tail pipe discharges shall be arranged to allow maintenance on any one trap whilst all others are operating.

q) Trapping systems not detailed on the pipework drawings shall be site run, ensuring that steam and condensate lines do not interfere with normal operation and maintenance, and in particular with access to valves and other equipment.

r) Drainage from large steam consumers such as heaters, condensers, reboilers, should get use of level controlled collection pots.

s) Condensate pots shall be sized as follows:

MAIN SIZE	POT SIZE
DN 100 (NPS 4) and below	Main size
DN 150 (NPS 6)	DN 100 (NPS 4)
DN 200 (NPS 8) and above	DN 150 (NPS 6)

t) Valves on condensate pots shall be DN 25 (NPS 1) in nominal bore minimum, they may be of gate, parallel slide or globe type. For high pressure, superheated steam, large or important steam mains, globe or parallel slide types should be used. Globe valves should be used where it may be necessary to control flow.

u) All globe valves shall be capable of passing the full rated flow of condensate.

3.10.9.6 Steam tracing

a) Steam tracing of piping should be installed generally in accordance with IPS-E-PR-420 and IPS-D-PI-126.

b) Materials for steam tracers shall comply with the appropriate line specification.

c) Flattening or crimping of the tracer line shall be avoided.

d) Fittings between steam supply pipes or condensate drain pipes and the copper tracer should be carbon steel adaptors socket welded to the carbon steel pipe and brazed to the copper tube. The fittings shall be separately insulated from the traced line.

e) Fittings shall be used only where necessary to join or tee the longest possible length of tracer and not only for ease of installation. Essential joints shall be located at the pipe flanges. Loops shall be provided adjacent to pipe flanges to allow for future use of compression fittings.

f) Piping DN 40 (NPS 1½) and smaller may be grouped together with a single tracer. Piping DN 50 (NPS 2) and larger should be individually traced.

g) Piping on corrosive services and piping liable to blockage due to deposition of solids or to the formation of solid polymers shall have individual steam tracing, irrespective of the pipe size, and not be grouped together with other pipes.

h) External tracing should consist of a single steam line, run at the bottom of the line to be traced, and the pipe and tracer insulated with the standard insulation for the next larger size pipe. Where heat requirements dictate, however, multiple tracers should be provided. Tracers for vertical lines may be coiled around the lines.

i) Expansion loops shall be installed where necessary in tracers, and should coincide with flanged joints in traced lines. Loops coinciding with flanges shall be such as to allow flanges to be sprung apart, and at spaded flanges shall allow the spades to be swung.

j) Expansion loops should be installed in the horizontal plane and pockets shall be avoided.

k) Each steam distribution or supply point should be located above the highest point of the piping system being traced. Each condensate collection header should be located at an elevation low enough to permit gravity flow of condensate from all connected lines.

l) Each individual tracing line shall be provided with a block valve located at the steam header or sub header. Valves should be steel socket welding type.

Valves shall be readily accessible from ground or platform level and positioned on the sub header for ease of maintenance. Each tracer or leg of parallel tracers shall be provided with its own trap except that groups of tracers which are self draining may be drained to a level controlled condensate pot or a collection header. Tracing on control valves and bypasses should allow control valve removal without interfering with the tracing of the bypass.

m) Tracers shall be attached to lines by strapping or binding wires. Heat transfer cement may be used to improve the transmission of heat from tracer to traced line.

n) Where degradation of a product or metallurgical deterioration of the pipe may occur due to local hot spots pipe or where an internal lining may be damaged, direct contact with an external tracing line shall be prevented by a suitable insulating strip between the pipe and the tracing line.

o) For pipework on which moisture may form due to low temperature operating conditions or intermittent service which would allow the pipework to cool down during idle periods, corrosion due to a galvanic couple between the pipe and/or support clamps and the tracing line should be avoided by use of an insulating strip e.g. compressed asbestos fibre jointing.

p) Steam heated pumps and other equipment shall have their own individual steam supply independent of the line tracing. On pumps, valves or other equipment requiring removal for maintenance, steam tracing and condensate connections should be flanged.

q) Each tracing circuit should be labeled clearly and permanently immediately upstream of the supply isolating valve and immediately before the steam trap.

The label should be in stainless steel and should have the following information:

- **i)** Steam supply identification code.
- **ii)** Line designation.
- **iii)** Steam trap designation.

r) A steam or condensate line shall not be attached to, or supported from, any line other than the one it is tracing.

3.10.9.7 Electrical tracing

The use of electrical tracing system shall be in accordance with IPS-M-EL-190.

3.11 Jacketed Piping

This part of the standard shall be read in conjunction with IPS-D-PI-127.

Jacketed piping is classified as "partly jacketed" and "fully jacketed".

3.11.1 General points common to all jacketed piping.

a) The design of the piping and flanges shall consider differential expansion between the inner pipe and jacket during start-up, shutdown, normal operation or any abnormal conditions. The design shall ensure no buckling of the inner pipe due to external pressure or differential expansion. Jacket, connections and inner pipe should all be of the same material of construction to avoid problems due to thermal stresses or welding of dissimilar metals.

b) Line/jacket sizes should be as follows:

LINE SIZE		JACKET SIZE	
DN	NPS	DN	NPS
20	¾	40	1½
25	1	50	2
40	1½	80	3
50	2	80	3
80	3	100	4
100	4	150	6
150	6	200	8
200	8	250	10
250	10	300	12

c) Spacers shall be used to ensure that the inner pipe is concentric with the jacket.

d) The radius of pulled bends should not normally be less than five times the jacket nominal I.D.

e) Forged elbows may also be used for the fabrication of bends in certain instances where the radius of the bends coincide and where the tangent lengths allow assembly.

f) Where the main process line is sectionalised by block valves, the supply and trapping arrangement shall be similarly arranged, to facilitate maintenance on isolated sections.

g) Transfer of stream from one jacket to another shall be arranged as follows:

A single jump-over connected into the jackets by radial branches shall be used on vertical jacketed pipe. These shall be positioned as low as possible on the upper jacket and as high as possible in the lower one. where the jacketed pipe run is not vertical, one of the following alternatives may be used:

i) Single jump-over from lowest part at up-stream to the highest part of down-stream of steam.

ii) Single jump-over connections branched into the highest part of the jackets where absence of condensate is ensured.

iii) Double jump-over connections one for steam at highest point and one for condensate at lowest point.

h) Jump-over connections at main line flanges shall include break flanges. Jump-over at other locations shall be all welded.

i) Main line flange bolt holes positioned on center to allow bolt access may be necessary at tangentially branched jump-over.

j) Heat transfer cement may be used on any unjacketed parts between tracer and pipe to eliminate cold spots.

k) Steam jacket supply valves and traps shall be identified by labels as required for steam tracing circuits.

3.11.2 Partly jacketed piping

a) Partial jacketing is suitable for lines carrying materials where there is no risk of blockage at cold spots and may be specified where contamination of the process fluid with water can not be tolerated and all butt welds on the jacketed line are required to remain uncovered by the jacket.

b) Jackets should be swaged on to the inner pipe adjacent to flanges and at inner line butt welds where these are required to remain uncovered. Alternatively, butt welded caps bored to suit the outside diameter of the inner line may be used. Where branch welds on the inner line remain uncovered, the main jacket shall be locally swaged to the inner line and the branch separately jacketed.

c) Main line flanges shall be standard raised face slip-on flanges to ANSI/ASME B 16.5 (inch dimensions) sized to suit the inner line.

3.11.3 Fully jacketed piping

a) Full jacketing shall be used for duties where it is essential that cold spots are eliminated and butt welds on the inner line may be covered by the jacket.

b) The jacket shall be welded to the back of the main line flange. Main line flanges shall be raised face slip on weld flanges to ANSI/ASME B 16.5 (inch dimensions) sized to suit the jacket but with a bore to suit the inner line.

c) Reducing orifice-type flanges complete with a tell-tale hole drilled radially through the rim may be used where leak detection at flange welds is necessary.

d) The use of blinds or blanks bored out for this duty is not acceptable.

e) Split forged tees shall be used for the jackets of branch connections.

3.12 Piping Adjacent to Equipment

3.12.1 Isolation of equipment

3.12.1.1 General

In this Standard, isolation is sub-divided into two categories:

a) Positive isolation. Where no leakage can be tolerated, e.g. for safety or contamination reasons.
b) General isolation. Where the requirements are less critical than (a) above.

In certain circumstances, it may be necessary for operational reasons or additional security to provide a combination of (a) and (b) above.

3.12.1.2 Positive isolation

a) Positive isolation shall be by one of the following:

i) The removal of a flanged spool piece or valve and the fitting of blind flanges to the open ended pipes.

ii) Line blind.

iii) A spade in accordance with IPS-D-PI-119 and IPS-D-PI-148. The arrangements of spading points, together with venting, draining and purging facilities, shall enable a section of line containing a spade to be checked as free from pressure before spade insertion or removal.

b) Positive isolation methods shall be provided:

i) To permit isolation of major items of equipment or group of items for testing, gas freeing, making safe etc. A group of items containing no block valves in the interconnecting pipework may be considered as one item of equipment.

ii) To isolate a section of plant for overhaul.

iii) To isolate utility services e.g. fuel gas, fuel oil, atomizing, snuffing, or purge steam to individual fired heaters.

iv) To prevent contamination of utility supplies e.g. steam, water, air and nitrogen where permanently connected to a process unit.

v) Steam and air connections for regeneration and steam/air decoking should be positively isolated from the steam and air systems, preferably by spool pieces or swing bends.

3.12.1.3 General isolation

a) General isolation shall be by one of the following:

i) A bi-directional block valve.

ii) A uni-directional block valve, where isolation in only one direction is required for all conditions and where internal relief of the valve cavity is required.

iii) Double block valves with a bleed valve mounted on the pipework between them in following cases and Par. (d) below:

- Drain connection in gas services when ice formation or freezing can occur.
- All steam piping entering or leaving process units.
- High pressure steam supply lines 44.4 bar (600 psig) to turbines over 400 Hp (300 kW).
- All manifolds in the tankage area shall have a double block and bleed valve in cases where there is a possibility of product contamination.

iv) Double valves without a bleed valve mounted on the pipework between them shall be provided for sample connection, drains and vents:

- In hazardous fluid service.
- In class 900 piping or higher.
- An unmanned installation where vibration is anticipated.
- Where freezing due to cooling on expansion may occur.

The block valves shall be far enough apart to allow safe access to the upstream valve with material discharging from the point of emission.

For fluids such as LPG, the valves shall be separated by at least 1 m to reduce the risk of simultaneous obstruction of both valves by ice or hydrate formation.

b) Block valves shall be provided:

i) In all lines at recognized separation of process units or limits of operating areas.
ii) At vessel branches, excluding:

- Connections for overhead vapor lines, transfer lines, reboiler lines and side stream vapor return lines.

- Pump suction and reflux line connections on vessels which have a block valve located within 10 m (30 ft) in a horizontal direction from the vessel branch. This exception shall not apply where there is a particular process requirement to isolate a vessel inventory.

- Vents on tanks and vessels open to atmosphere.

- Relief device connections and/or connection to other vessels or piping systems fitted with relief devices that protect the vessel in question (see 3.6.5).

- Overflow connections.

iii) At suction and discharge of pumps and compressors, but not at suctions of air compressors taking suction from atmosphere.

iv) For isolating equipment, e.g. individual or groups of heat exchangers as requiring servicing during plant operation.

v) For isolation of instruments.

vi) Where required to prevent flow at vents and at drains, sample points, steam out points and for diverting flow through alternative routes and bypasses.

vii) At inlets, outlets and drains of storage tanks.

viii) To isolate utility services i.e. fuel oil, fuel gas, atomizing, snuffing and purge steam to individual fired heaters.

ix) On supply lines to road and rail car filling stations handling toxic or flammable materials; the block valve shall be located remote from the filling point for emergency shut off.

x) In all utility services at:

- Each branch on the refinery or process plant main.
- The inlet at each individual user.
- The outlet of each cooling water user.

xi) In steam and condensate systems at each branch on the header in each plant or unit if the length of pipe between header and user is 5 m (16 ft) or greater.

xii) At vents placed in piping for operational purposes. These vents shall be spaded or blanked in accordance with the line specification. Vents for testing purpose only shall not be valved.

xiii) At drain connections in the low point of piping systems, where the arrangements shall be as in (xii) above.

xiv) At suitable points in ring, main or distribution systems to allow sectionalizing.

xv) At the outlet from each non-condensing steam user, where the user discharges to a pressurised system.

c) Process area limit block valves for relief and blowdown piping shall be provided with a purpose-built locking device, for locking valves open. Gate valves fitted on this duty, should be installed in the horizontal or inverted position so that the valves tend to fail in the open position.

d) Double block valves with intermediate valve to vent the space between the block valves shall be provided:

i) Where frequent isolation is required and temporary, not positive isolation is acceptable for operational safety e.g. in segregating products.

ii) For temporary isolation between permanently connected utility supplies and process units where the utility requirement is in frequent use and there is a need to make the utility readily available for injection into the process, e.g. stripping steam where the system has to be made condensate free right up to the point of injection. (Non-return valves will also be required in all utility services connected directly with process equipment).

iii) Where equipment may be taken out of service whilst the unit remains in operation e.g. compressors or where there is a requirement to isolate equipment yet hold it readily available for use with the operating unit e.g. hydrogen storage vessels.

3.12.1.4 Pump emergency isolation

a) Except for glandless type pumps, an emergency isolation valve shall be provided in the suction line between a vessel and a pump when any of the following apply:

i) The suction inventory at normal operating level is 30 m^3 (1060 ft^3) or greater and the pumping temperature is greater than the auto-ignition temperature (210°C).

ii) The liquid is toxic.

b) Where a pump is paired or spared, the common line shall be fitted with the valve.

c) The valve shall be located as close to the vessel as possible outside the vessel supports and not less than 3 m (10 ft) from the pump.

d) The valve should be remotely operable when it is less than 15 m (50 ft) horizontally from the pump, unless a fire wall is installed between the valve and the pump.

e) For remotely operated valves, the valve control station shall be located not less than 15 m (50 ft) from the pump and, if practicable, within sight of the valve. The control station shall not be located in a special fire risk area (see BP-CP-16), and shall be accessible through a low fire risk area.

3.12.2 Provision of strainers and filters

Provision of strainer shall be in accordance with IPS-G-PI-230, IPS-D-PI-113 and IPS-D-PI-114 with following considerations:

a) Permanent strainers or filters shall be fitted in the following instances if they are not already an integral part of the equipment:

i) In a fuel oil supply to burners and for each set of gas pilots.
ii) Hydraulic systems for remote control of valves.

iii) At the inlet of steam turbines, jet ejectors and trapping systems.
iv) Loading installations, when necessary to maintain product quality.
v) In the suction lines of pumps, where the liquid may contain solids liable to damage pumps.
vi) In compressor suction lines.
vii) In any lubricating system i.e. sealing oil, gland oil and gear coupling lubricators.
viii) Any flushing oil system.

b) Permanent strainers in compressor suction lines shall be provided with isolation to permit easy removal. Maximum design pressure drops and flow direction shall be indicated by a nameplate permanently attached to the strainer.

c) Temporary strainers should be fitted in other cases between the suction valve and the equipment and should ensure that the debris is completely removed from the system when the strainer is cleaned, and be cleaned easily without disturbing the main pipework. Pipework shall be designed to incorporate the strainer, and no pipe springing shall be allowed for retroactive installation. A suitable spacer shall be provided for use on removal of the strainer.

d) Strainers (temporary, if permanent ones are fitted) should normally be located between the pump or compressor and its associated suction-side block valves. On main crude oil charge pumps, twin strainers arranged in parallel and each having its own block valve should be installed upstream of the suction header.

e) Twin parallel filters should be provided on vital process pumps which do not have a standby and the shutdown of which for strainer cleaning could lead to a shutdown of the refinery or works, or of an important unit.

f) Pressure tappings shall be provided for measuring pressure-drop at all permanent and temporary strainers.

3.12.3 Piping to equipment

3.12.3.1 Pumps

a) Pump suction piping shall cause minimum flow turbulence at the pump nozzle. Suction piping shall not have pockets where gas can accumulate. However, if this is unavoidable, venting facilities shall be provided.

b) If the suction nozzle of a pump is smaller in size than the connecting piping and a reducer is required in a horizontal line, it shall be eccentric, installed with the belly down (top flat). This may require an additional drain.

c) If the discharge line size differs from the pump discharge nozzle, a concentric reducer shall be applied.

d) A block valve shall be installed in the suction line of each pump upstream of the strainer. The discharge line shall also have a block valve. A non-return valve shall be installed upstream of the discharge block valve.

e) The discharge valve, suction strainer and suction valve may be of the same size as the pump nozzles for economic reasons and also to avoid comparatively heavy attachments, unless the pressure drop is too high.

f) For spared pumps which have common suction and discharge lines, a DN 20 (NPS ¾) bypass with throttling valve shall be installed around the discharge non-return valve in the following cases:

- if discharge and suction line working temperatures are above 230°C;
- if process fluid can solidify at ambient temperature, e.g. water lines in frost areas;
- if discharge/suction line working temperature is below -100°C;
- if draining of the space upstream of the non-return valve is required.

g) When the discharge and suction lines are working at ambient or below ambient temperatures, a 3 to 5 mm hole in the closing member of the non-return valve may be considered instead of a bypass around the non-return valve. Valves with such a hole in the closing member require marking on the valve body and on the process engineering flow schemes and isometric drawings.

h) Permanent strainers shall be installed in all pump suction lines. Y or T type strainers shall be used for permanent installation in vertical suction lines, in services of high content of impurities use of Y type is preferred. In horizontal suction lines, Y-type or bucket-type strainers may be used. For suction lines ≥ DN 450, (NPS 18), bucket-type strainers shall be used. The installation of the Y-type strainer of double suction pumps shall not disturb an even flow to the two suction nozzles of the pump. In a vertical suction line the Y-type strainer shall be installed pointing away from the pump. In a horizontal suction line the Y-type strainer shall be installed pointing downwards.

i) Warming-through connections shall be supplied for pumps working above 260°C (500°F).

j) For multi-stage pump fitted with pressure relief device for pump casing protection, the suction side design pressure need not be greater (but shall not be less) than the relief set pressure.

k) Pump vents shall be connected to the vapor space of the suction vessel for operation under vacuum. This allows filling of the pump before start-up. The vent line shall have two valves, one at the pump and one at the vessel. Pump vent and drain nozzles shall be fitted with valves; if not connected to a drain system the valves shall be fitted with plugs. Pump handling butane or lighter process fluids shall have a vent line to the flare system. The vent line shall have a spectacle or spade blind.

l) In order to avoid a fire hazard, lubricating oil, control oil and seal oil lines shall not be routed in the vicinity of hot process and hot utility lines.

m) Cooling water lines to pumps and compressors shall not be less than DN 20 (NPS ¾). Lines DN 25 (NPS 1) or less shall have the take-off connection from the top of the water main line so as to prevent plugging during operation.

n) Pumps for vacuum service require a sealing liquid on the stuffing boxes and a vent line to the process system to prevent dry-running.

o) Reciprocating, positive displacement pumps and also centrifugal pumps (if required) shall be safeguarded against a blocked outlet with a pressure-relief device. This shall not be an integrated part of the pump. The relief valve should be installed in a bypass between the discharge line upstream of the check valve and the suction vessel. Alternatively the relief valve may be installed in a bypass between the discharge line upstream of the check valve and the suction line downstream of the block valve. However, it shall be assured that this will not create an overpressure of the suction system.

p) Spools shall be provided between pump suction strainer/pump suction connection and pump discharge nozzle/non-return valve to facilitate easy removal of pump for maintenance.

3.12.3.2 Compressors

a) To prevent fatigue failure of compressor piping, the effect of vibrations and pressure surge shall be considered. Piping shall have a minimum of overhung weight.

b) Suction line shall be designed with special consideration for straight and minimum length. Interstage and discharge piping shall be sufficiently flexible to allow expansion due to the heat of compression.

c) Block valves shall be in the suction and discharge lines, except for air compressors, which shall have block valves in the discharge lines only.

Discharge lines shall have a check valve between block valve and discharge nozzle. In case of reciprocating compressors check valve may not be required.

d) In each compressor suction line, a suction strainer shall be installed downstream of the block valve of the compressor and as close as possible to the compressor suction nozzle. Screens and filters shall be reinforced to prevent failure and subsequent entry into the compressor. Provision shall be made to measure the pressure difference across filter.

e) Reciprocating compressors shall be safeguarded against a blocked outlet with a pressure relieving device installed in a bypass between the discharge line upstream of the block valve and the suction vessel. Interstage sections shall also be protected by relief valves.

f) The suction line between a knock-out drum and the compressor shall be as short as practicable, without pockets, and slope towards the knock-out drum.

g) In the single stage compressor, the pressure rating of the suction valve and piping between this valve and the suction nozzle shall be equal to the rating of the discharge line.

The pressure rating of the suction piping of a reciprocating compressor shall have the same rating as the discharge of that stage, including valves and suction pulsation dampeners.

h) In case of multi-stage compression, the suction design pressure shall be equal to the highest design pressure of the equipment from which it takes suction.

If the design pressure turns out to be lower than the maximum shut-in pressure and/or the discharge pressure, then the suction piping must be relief protected.

i) The two design pressure system is not preferred for less than three stage station.

j) Suction lines shall be connected to the top of the header, except for suction lines at least one pipe size smaller than the header, which may be connected concentrically at the side of the header.

k) Compressors in hydrocarbon or very toxic service shall have purge facilities. Possibility of spading shall be provided by spectacle blinds, removable spool pieces or elbows.

3.12.3.3 Steam turbines

a) The set pressure of the relief valve in the turbine exhaust system shall not exceed either the turbine design pressure or the pressure of the exhaust piping.

The calculation for the relief valve orifice shall be based on the turbine inlet nozzle.

b) Warming-up facilities for the turbine shall be provided.

c) Piping shall be designed to permit steam-blowing up to the inlet and outlet flanges of the turbine before start-up.

d) Steam vents shall be routed to a safe location and shall not be combined with any lubricating oil, seal oil or process vent.

3.12.3.4 Heat exchanger

a) The nozzle positions of heat exchangers shall allow an optimum piping layout.

b) Sufficient space shall be kept between adjacent heat exchanger inlet and outlet (control) valve manifolds as per IPS-D-PI-102.

c) Heat exchanger piping shall not be supported on the shell and shall not hamper the removal of the tube bundle and shell/channel covers. A removable pipe spool may be required.

d) When shell-and-tube exchangers can be blocked in by valves, causing trapped liquid attention shall be paid to:

- Preventing exposure of the low-pressure side piping to the maximum pressure of the high-pressure side, irrespective of whether caused by internal failure or otherwise;

- potential increase of pressure due to thermal expansion of the trapped liquid on the cold side or due to solar radiation;

e) The equipment and the connected piping shall be protected by thermal expansion relief valves, if pressures and/or pressure differences can increase beyond the design limits.

f) Steam heat exchangers shall have a non-return valve in the steam inlet if the normal steam pressure is less than 110% of the process relief valve set pressure or, without relief valve, 110% of the process design pressure.

g) Where contamination is critical in heat exchangers, a check valve shall be installed in the inlet of low pressure side if the normal pressure of low pressure side is less than 110% of the design pressure of high pressure side.

3.12.3.5 Pressure vessel

a) Piping to columns should drop or rise immediately after the nozzle and run parallel and close to the column. For ease of support a number of lines can be routed together, parallel in one plane.

b) If a tall slender vessel ($L/D \geq 10$) is susceptible to aerodynamic oscillations, the piping platforms and ladders of the top of the vessel shall be located such that the platform projected area against wind is kept at minimum.

c) Pressure vessels which are grouped together should have platforms and interconnecting walkways at the same elevation. The number of stairways and ladders to the platforms shall be sufficient to meet safety requirements.

d) If not controlled in another way process steam lines to pressure vessels shall have a regulating globe valve direct to the pressure vessel nozzle. A check valve to prevent the product from entering the steam line shall be installed close to and upstream of the regulating valve with a valved low point drain between them. A gate valve upstream of the check valve shall isolate the line from the main steam header.

e) The steaming out pressure for columens should be 3.5 barg (50.8 psi) for tall columns, a higher pressure may be considered if the design permits.

f) Pressure vessel drain valve shall be located outside of skirt.

3.12.3.6 Fired heaters (furnaces)

a) Burner utilities headers (fuel oil, fuel gas, atomization steam) shall be arranged with a vertical bundle along furnace walls.

b) The set of valves controlling the feeding of smothering steam shall be located in a safe location at least at a distance of 15 meters from the furnace.

c) A throttling balance valve shall be provided in the inlet to each coil of a set of parallel coils.

d) Outlet lines shall be provided with the following:

- **i)** A check valve shall be installed in the outlet from each heater with the check valve nearer to the furnace.
- **ii)** Drain valves shall be provided to drain each coil.

3.13 Piping Layout Design

3.13.1 General

3.13.1.1 Generally all process and utility piping should be installed above ground.

3.13.1.2 Inside plants (process units and utilities areas) piping should be routed on overhead pipe bridges (piperack).

3.13.1.3 Equipment that is a potential source of fire, should not be located under pipe rack.

3.13.1.4 Fire fighting water lines if installed above ground, shall not run along pipe bridges or pipe tracks.

3.13.1.5 Outside plants and in the interconnection areas (manifold, tank farms, flares, etc.) piping shall preferably be installed on the ground on concrete sleepers in pipe tracks.

3.13.1.6 Pipe trenches close to process equipment should be avoided. Where it is not practicable to run pipe over rack, and trenches below paving level are unavoidable, such trench should be divided into sections about 10m min. length by fire break.

3.13.2 Slope in piping

Except for branch and equipment connections, all lines shall run in horizontal direction. Where lines need to be drained completely, the piping shall be sloped and provided with drainage points:

Minimum slope of lines shall be as follows:

a) Process lines on sleeper	1: 120
b) Process lines on pipe racks	1 : 240
c) Service lines	1: 200 to 1: 240
d) Drain lines	1: 100

The slope of lines shall be indicated on P&ID.

3.13.3 Pipe racks

Overhead racks may contain more than one level. For steel pipe racks, the height of levels shall have one of the following elevation.

a) Main pipe racks	: 4.60, 6.20, 7.80 m
b) Individual or secondary pipe rack	: 3.80, 5.40, 7.00 m.

Arrangement of pipe rack shall be made in accordance with Standard Drawing IPS-D-PI-102 (see Appendix C).

In special case for large size pipes or concrete pipe racks, the distance between the various floor may be increased.

3.13.3.1 The elevation of overhead pipe rack shall be such to provide minimum free height access as per Par. 3.2.2.2.14 C of "General Design Requirements" of this Standard.

3.13.3.2 Except for special cases minimum width of pipe rack shall be 6 m. The width of pipe rack shall be designed to accommodate all pipes involved plus 20% space for future expansion or modification. Where the pipe rack support air coolers, the preferred width shall be the width of air coolers.

3.13.3.3 In multi-level pipe racks, pipe carrying corrosive fluids shall be on the lower level, and utility lines should be at the upper floor. Large size or heavy weight pipes shall be located at the lower level and on extreme sides.

3.13.4 Pipes space

3.13.4.1 The space between the axis of two adjacent pipes shall be at least equal to the sum of ½ O.D of flanges (with higher rating) or ½ O.D. of each pipe plus 25 mm. This dimension (25 mm) shall be increased to 50 mm for insulated pipes.

3.13.4.2 Sufficient space shall be allowed between adjacent lines at points of change in direction to prevent damage of one line by another, due to expansion or contraction (see Standard Drawing IPS-D-PI-102).

3.13.4.3 At crossings, lines shall have a minimum clearance of 25 mm, after allowing for insulation and deflection.

3.13.4.4 Hot lines in pipe racks should be grouped together and consideration shall be given to the expansion loops.

3.13.5 Pipe branches

3.13.5.1 For gases or vapors, the branches shall be taken from the top of the main lines.

3.13.5.2 Where main trunk lines for steam, water and other common systems run through a number of process units, off takes to the users in any single unit shall not be taken directly from the main trunk lines. Offtakes shall be from a header or headers supplying each unit and should be provided with a valve at their junction with the main trunk lines.

3.13.5.3 Where the main trunk lines run in offsite pipe tracks, offtakes into each unit shall be fitted with a valve at the plot limit of each unit.

3.13.5.4 Type of branches shall be in accordance with piping specification conforming to IPS-E-PI-221.

3.13.5.5 Take-offs from pipe track to process areas should rise from track level, run low, and rise at the battery limit to the elevation of the piping within the process area.

3.13.6 Instruments location

For instrument location refer to relevant IPS Standards in instrumentation.

3.13.7 Battery limits

3.13.7.1 All process and utilities piping at the battery limits of one unit or groups of units linked, shall be equipped with block valves and a spectacle blind.

3.13.7.2 Battery limit valves, spades and blinds shall preferably be located in the vertical riser.

3.14 Piping Flexibility (Additional to ANSI B 31.3)

3.14.1 Expansion and contraction

Piping system shall be designed for thermal expansion or contraction in accordance with IPS-E-PI-200 taking the following into consideration as minimum:

a) Depressurizing temperature.
b) Drying-out temperature.
c) Minimum/maximum working temperature.
d) Defrosting temperature.

3.14.2 Flexibility design

Consideration and calculation of stress analysis shall be made in accordance with IPS-E-PI-200 with following requirements:

a) Start-up, shutdown, steam-out, where applicable and upset conditions, including short term excursions to higher temperatures or pressure as well as normal operating conditions, shall be considered in flexibility analysis.

b) Sufficient flexibility shall be provided in the piping to enable spade, line blinds or bursting discs to be changed.

c) Vessels or tanks at which piping terminates should be considered inflexible for the initial piping analysis.

d) Only where it is impractical to increase flexibility sufficiently, to reduce the stress range or anchor loads to acceptable levels, use of bellows or expansion joints should be considered. (see Par. 3.3.3 of this Standard).

e) Specific attention should be given in the design and flexibility analysis of piping connecting to machinery to ensure that piping loads transmitted to the machine are within the acceptable limit under all operating conditions. Hanger supports shall be used on these lines wherever practicable. Where impractical, low-friction pads (e.g. PTFE) may be used.

f) A flexibility analysis for pipework connecting to machinery should include mismatch to the allowed tolerance between pipework and the machine to ensure that the calculated loads represent the worst loads which might be generated. A number of calculations may be necessary to determine the conditions of mismatch which will generate the maximum loads. Specific attention shall be given to mismatch in flexibility analysis of smaller lines where such lines are unusually rigid.

3.15 Piping Supports (Additional to IPS-G-PI-280)

3.15.1 General

a) Piping should not be supported off other pipes, particularly if either or both pipes are subject to thermal expansion or vibration. Nor shall it be supported from vessels or other equipment, except where brackets have been specifically provided. Piping shall not be placed in direct contact with concrete, nor be supported from removable flooring, flexible flooring, deck plating or hand rails.

b) Stainless steel piping shall be protected at pipe supports against galvanic and crevice corrosion.

c) The line shall be designed to be self-supporting when pressure relief valves are removed. In case of spades, line blinds, bursting discs and others temporary support may be used.

d) Pipes in a pipe rack or pipe track should be grouped according to size to permit longer spans for the larger pipes.

e) Local stresses in piping due to pipe support shall be considered.

3.15.2 Design and selection

In general, the location and design of pipe supporting elements may be based on simple calculations and engineering judgment. However, when a more refined analysis is required and a piping analysis, which may include support stiffness, is made, the stresses, moments, and reactions determined thereby shall be used in the design of supporting elements.

3.15.2.1 General requirements

Piping shall be supported, anchored or guided to prevent line deflection, vibration or expansion/contraction which could result in stresses in excess of those permitted by ANSI/ASME B 31.3 in the piping or in-line connected to equipment.

In design of supporting element the following considerations shall apply:

3.15.2.1.1 Each support assembly, including the spring supports, shall be designed to sustain the hydrostatic test load.

3.15.2.1.2 Field welding of pipe supports to piping shall be kept to a minimum. Structural provisions to connect pipe supports shall be made as much as possible during the civil and mechanical engineering phase (e.g. concrete plinths, inserts, cleats and brackets to steel structure, clips to vessels). Welded guides and other welded support elements in hot dip galvanized steel structures (e.g. pipe racks/bridges) should be attached to steel members before they are hot dip galvanized.

3.15.2.1.3 Pipes should be supported in groups at a common support elevation of the supporting structure. Inserts shall be poured in vertical and horizontal concrete beams, allowing supports and hangers to be bolted. Since civil design is often well ahead of the pipe support design, provision shall be made to incorporate these inserts at standard locations.

3.15.2.1.4 To prevent galvanic corrosion, carbon steel calmps on pipes of other metallic materials shall be separated from the pipe by using synthetic rubber, glass fibre paper tape or other insulating material between the clamp and the pipe.

3.15.2.1.5 Individual lines may be suspended by hanger supports only when no other methods of support are practical. Suspending of one line from another should be avoided.

3.15.2.1.6 Special attention shall be given to locations with potentially high load concentrations such as valves, strainers, in-line instruments, and equipment, etc. The supports shall be suitable for these high loads and shall facilitate maintenance exchange of the heavy valves/equipment.

3.15.2.1.7 For piping containing gas or vapor, weight calculations need not include the weight of liquid if the designer has taken specific precautions against entrance of liquid into the piping, and if the piping is not to be subjected to hydrostatic testing at initial construction or subsequent inspections.

3.15.2.1.8 In addition to the weight effects of piping components, consideration shall be given in the design of pipe supports to other load effects introduced by service such as pressure and temperatures, vibration, deflection, shock, wind, earthquake, and displacement strain.

3.15.2.1.9 The layout and design of pipe supporting elements shall be directed toward preventing the following:

a) Excessive thrusts and moments on connected equipment (such as pumps and turbines);

b) excessive stresses in the supporting (or straining) elements;

c) resonance with imposed or fluid-induced vibrations;

d) excessive interference with thermal expansion and contraction in a piping system which is otherwise adequately flexible;

e) unintentional disengagement of piping from its supports;

f) excessive heat flow, exposing supporting element to temperature extremes outside their design limits.

3.15.2.1.10 Design of the elements for supporting or restraining piping systems, or components thereof, shall be based on all the concurrently acting loads transmitted into the supporting elements.

In load calculations, where required, consideration shall be given to the following:

a) Weights of pipe, valves, fittings, insulating materials, suspended hanger components, and normal fluid contents.

b) Weights of hydrostatic test fluid or cleaning fluid if normal operating fluid contents are lighter.

c) Additional loading that may occur during erection.

d) Intentional use of restraints against normal thermal expansion.

e) The effects of anchors and restraints to provide for the intended operation and protection of expansion joints.

f) Reaction forces due to operation of safety or relief valves.

g) Wind, snow or ice loading on outdoor piping.

h) Additional loadings due to seismic forces.

3.15.2.2 Additional requirements for lines connected to equipment

3.15.2.2.1 Lines connected to columns and other vertical vessels shall have a resting support as close as possible to the column or vessel nozzle, and be guided at regular intervals to safeguard the line against wind load and/or buckling.

Maximum guide distance shall be 6 m for lines smaller than DN 200 (NPS 8), and 10 m for lines DN 200 (NPS 8) and larger.

3.15.2.2.2 Pipe supports on equipment shall be bolted to cleats welded to the equipment. The cleats shall be supplied by the equipment manufacturer. The executor shall use standard cleats for the connection of pipe supports, ladders and platforms.

3.15.2.2.3 To support piping systems connected to equipment, maximum use shall be made of platforms, fire decks, etc.

3.15.2.2.4 To allow adequate clearance for the removal of covers, heads, channels, bundles and shells, lines shall not be supported on heat exchanger shells and heads.

3.15.2.2.5 Onshore reciprocating compressors and integral piping should be supported on a common slab.

3.15.2.2.6 Piping connected to rotating equipment shall have adjustable supports to facilitate alignment, spading and equipment exchange. The supports shall allow for thermal expansion and vibration and shall be modeled in the pipe stress analysis.

3.15.2.2.7 To prevent damage to lines and tank connections caused by settlement of the tank, the first pipe support shall be located sufficiently far away from the tank. The following distances shall be adhered to:

NOMINAL PIPE SIZE DN	DISTANCE BETWEEN TANK AND FIRST SUPPORT (m)
100 and smaller	5
150	6
200	7
250	8
300	9
350	10
400	10
450	10
500 and larger	12

3.15.2.3 Allowable stresses, load ratings and temperatures

This section is supplement to reference standard ANSI/MSS-SP-58 1988, section 4. For ease of reference the clause or section numbering of reference standard has been used for supplement. Abbreviations noted in the following paragraphs are defined as below:

3.15.2.3.1 (Add.) - Addition

A new clause with a new number is added.

3.15.2.3.2 (Sub.) - Substitution

The clause in reference standard is deleted and replaced by a new clause.

3.15.2.3.3 (Mod.) - Modification

Part of reference standard clause is modified and/or a new description and/or statement is added to that clause.

3.15.2.3.4 (Del.) - Deletion

The clause in reference standard is deleted without any replacement.

4.1 Allowable stresses for materials commonly used in the design of pipe supporting elements are listed in Table A1. Materials may not be used above the highest temperature for which a stress value appears. **(Mod.)**

4.2 Allowable stresses for materials not listed in Table A1 with known physical properties shall be determined as the lower of the following values:

a) $^1/_4$ of minimum tensile strength at service temperature.
b) $^5/_8$ of minimum yield strength at service temperature. **(Mod.)**

4.3 Minimum design load rating for rigid pipe hanger assemblies are listed in Table 1. **(Sub.)**

4.9 Seismic Loadings **(Add.)**

4.9.1 When the region is designated as susceptible to earthquakes, the anticipated earthquake loadings shall be established.

4.9.2 A properly designed piping system will have sufficient inherent flexibility to absorb large movements without leading to excessive strains or failure. The following aspects, however, shall be carefully examined and, where necessary, adequate measures shall be taken.

4.9.3 Piping shall be provided with sufficient flexibility between two anchor points, taking into account that the two anchor points might respond in different modes during an earthquake.

4.9.5 Piping offsets, expansion loops, etc., are normally only provided for absorbing thermal movements. Suitable limit stops shall be provided to restrict this movement in case of a seismic shock.

4.9.6 Supports for branch-off lines and supports for vital control equipment shall be determined by careful scrutiny.

4.9.7 Instrument lead lines shall have sufficient flexibility to absorb seismic movements of the columns, pipe rack and/or structures to which the instrumentation lines are attached.

4.9.8 Piping going through bund walls, building walls and floors shall be provided with sleeves large enough to allow for the anticipated differential movements due to seismic loadings. Dampening and sealing material shall be provided where it is required to maintain a liquid tight connection.

4.9.9 In earthquake areas the following pipe supporting aspects require further scrutiny:

a) Providing additional limit stops for both horizontal and vertical lines with horizontal thermal displacements, thus preventing further movement in case of a seismic shock force;

b) providing restraints for risers (vertical piping, usually with wind load guides) in the longitudinal pipe direction, thus restraining the pipe against jumping in case of a seismic shock force;

c) providing additional guides at column resting supports;

d) providing sway braces or sway struts;

e) providing snubbers;

f) providing jump restraining pipe clamps or clips, thus preventing the lines from jumping off their support member (especially for horizontal lines, running along pipe racks or pipe tracks in places where no branch-off lines are holding the line in place).

3.15.2.4 Material selection

3.15.2.4.1 Permanent supports and restraints shall be of material suitable for the service conditions. If steel is cold-formed to a center line radius less than twice its thickness, it shall be annealed or normalized after forming.

3.15.2.4.2 Cast, ductile and malleable iron may be used for rollers, roller bases, anchor bases, and other supporting elements subject chiefly to compressive loading. Cast iron is not recommended if the piping may be subject to impacttype loading resulting from pulsation or vibration. Ductile and malleable iron may be used for pipe and beam clamps, hanger flanges, clips, brackets, and swivel rings.

3.15.2.4.3 Steel of an unknown specification may be used for pipe supporting elements that are not welded directly to pressure containing piping components. (Compatible intermediate materials of known specification may be welded directly to such components). Basic allowable stress in tension or compression shall not exceed 82 MPa and the support temperature shall be within the range of -29°C to 343°C.

3.15.2.4.4 Attachments welded or bonded to the piping shall be of a material compatible with the piping and service.

3.15.2.4.5 Materials commonly used in the design of pipe supporting elements shall be selected from Table A1.

TABLE A1 - STEEL MATERIALS MAINLY USED FOR PIPE SUPPORTS BASIC ALLOWABLE STRESSES IN BAR (kSi) AT METAL TEMPERATURE °C (°F) SUB*

MATERIAL	min. TEMP. °C (°F)	TENSILE STRENGTH BAR (ksi)	YIELD STRENGTH BAR (ksi)	min. TEMP. to 37.8°C (100°F)	93.3°C (200°F)	148.9°C (300°F)	204.4°C (400°F)	260°C (500°F)	315.6°C (600°F)	371.1°C (700°F)
A-36	-28.89 (-20)	3979 (58)	2482 (36)	1227 (17.8)	1165 (16.9)	1165 (16.9)	1165 (16.9)	1165 (16.9)	1165 (16.9)	1165 (16.9)
A-53 Gr. B	-28.89 (-20)	4137 (60)	2069 (30)	1379 (20)	1379 (20)	1379 (20)	1379 (20)	13.3 (18.9)	1193 (17.3)	1138 (16.5)
A-105	-28.89 (-20)	4827 (70)	2482 (36)	1607 (23.3)	1510 (21.9)	1469 (21.3)	1420 (20.6)	1338 (19.4)	1227 (17.8)	1193 (17.3)
A-106 Gr. A	-28.89 (-20)	3310 (48)	2069 (30)	1103 (16)	1103 (16)	1103 (16)	1103 (16)	1103 (16)	1020 (14.8)	993 (14.4)
A-106 Gr. B	-28.89 (-20)	4137 (60)	2413 (35)	1379 (20)	1379 (20)	1379 (20)	1379 (20)	1303 (18.9)	1193 (17.3)	1138 (16.5)
A-106 Gr. C	-28.89 (-20)	4827 (70)	2758 (40)	1607 (23.3)	1607 (23.3)	1607 (23.3)	1579 (22.9)	1489 (21.6)	1358 (19.7)	1324 (19.2)
A-283 Gr. B	-28.89 (-20)	3448 (50)	1862 (27)	1055 (15.3)	1007 (14.6)	965 (14)	917 (13.3)	862 (12.5)	814 (11.8)	765 (11.1)
A-307 Gr. B	-28.89 (-20)	4137 (60)	-	945 (13.7)	945 (13.7)	945 (13.7)	945 (13.7)	945 (13.7)	-	-
A-515 Gr. 60	-28.89 (-20)	4137 (60)	2206 (32)	1379 (20)	1345 (19.5)	1303 (18.9)	1262 (18.3)	1193 (17.3)	1089 (15.8)	1062 (15.4)
A-516 Gr. 60	-28.89 (-20)	4137 (60)	2206 (32)	1379 (20)	1345 (19.5)	1303 (18.9)	1262 (18.3)	1193 (17.3)	1089 (15.8)	1062 (15.4)
A-387 Gr. 11	-28.89 (-20)	4137 (60)	2413 (35)	1379 (20)	1379 (20)	1379 (20)	1358 (19.7)	1303 (18.9)	1262 (18.3)	1214 (17.6)
A-387 Gr. 22	-28.89 (-20)	4137 (60)	2069 (30)	1379 (20)	1276 (18.5)	1241 (18)	1234 (17.9)	1234 (17.9)	1234 (17.9)	1234 (17.9)
A-387 Gr. 5	-28.89 (-20)	4137 (60)	2069 (30)	1379 (20)	1248 (18.1)	1200 (17.4)	1186 (17.2)	1179 (17.1)	1158 (16.8)	1124 (16.3)
A-240 TP 304	-253.89 (-425)	5171 (75)	2069 (30)	1379 (20)	1379 (20)	1379 (20)	1289 (18.7)	1207 (17.5)	1131 (16.4)	1103 (16)
A-240 TP 347	-253.89 (-425)	5171 (75)	2069 (30)	1379 (20)	1379 (20)	1379 (20)	1379 (20)	1372 (19.9)	1331 (19.3)	1282 (18.6)
A-312 TP 304	-253.89 (-425)	5171 (75)	2069 (30)	1379 (20)	1379 (20)	1379 (20)	1289 (18.7)	1207 (17.5)	1131 (16.4)	1103 (16.0)

3.15.3 Pipe hangers (selection and application)

3.15.3.1 This section is supplement to reference standard MSS-SP-69 (1966) Sections 3,6 and 7. For definition of abbreviations used in the following paragraphs refer to Item 3.15.2.3 of this Standard.

3.3 **(Del.)**

6.2 Where negligible movement of pipe occurs at hanger locations, simple rod hangers should be used for suspended lines. **(Sub.)**

6.5 Pipe, straps, or bars of strength and effective area equal to the equivalent hanger rod may be used instead of hanger rods. **(Add.)**

6.6 Hanger rods, straps, etc., shall be designed to permit the free movement of piping caused by thermal expansion and contraction. **(Add.)**

6.7 Welded link chain of 5.0 mm or larger diameter stock, or equivalent area, may be used for pipe hangers with a design stress of 62 MPa maximum. **(Add.)**

7.3 Adjustable supports shall be used where differential settlement between equipment and piping may occur. **(Sub.)**

3.15.3.2 Counterweight supports

Counterweights shall be provided with stops to limit travel. Weights shall be positively secured. Chains, cables, hangers, rocker arms, or other devices used to attach the counterweight load to the piping shall be subject to the requirements of this Standard.

3.15.3.3 Spring hangers

Where significant vertical movement of the pipe occurs at the hanger location, a resilient support shall be used. Selection of resilient supports shall be based on permissible load variation, as illustrated in Table 1. Load and movement calculations shall be made for the proper selection of spring hangers other than spring cushion types. The effect of vertical movement transfer from the top of risers along horizontal runs shall be taken into consideration when applying spring hangers.

3.15.4 Spring supports and sway braces

This section shall be in accordance with Section 10 of MSS-SP-58 1983.

TABLE 1 - SPRING SUPPORTS

VERTICAL EXPANSION	ALLOWABLE LOAD CHANGE	SINGLE SPRING HANGER	DOUBLE SPRING HANGER	STANCHION SUPPORT
	Note 1	Note 2		Note 3
Max. 6 mm	Nominal - 25% Medium - 15% Critical - 6%	48, 51 SS 48, 51 SS 51 S	49, 51 SS, 53 SS 49, 51 SS, 53 SS 51 S, 53 S	49, 52 SS 49, 52 SS 52 S
Max. 25 mm	Nominal - 25% Medium - 15% Critical - 6%	51 S 51 S 54, 55	51 S, 53 S 51 S, 53 S 54, 55, 56	52 S 52 S 54, 55
Max. 50 mm	Nominal - 25% Medium - 15% Critical - 6%	51 LS 51 LS 54, 55	51 LS, 53 LS 51 LS, 53 LS 54, 55, 56	52 LS 52 LS 54, 55
Max. 75 mm	Nominal - 25% Medium - 15% Critical - 6%	51 LS 54, 55 54, 55	51 LS, 53 LS 54, 55, 56 54, 55, 56	52 LS 54, 55 54, 55
Over 75 mm	Nominal - 25% Medium - 15% Critical - 6%	54, 55 54, 55 54, 55	54, 55, 56 54, 55, 56 54, 55, 56	54, 55 54, 55 54, 55

Notes:

1) Load change at Maximum spring working capacity not to exceed percentages given herein.

2) Numbers in these columns are type numbers from Fig. 1 of MSS-SP-58.

3) Variable spring types 51, 52, and 53, i.e. standard spring, short spring and long spring models are identified above as S, SS & LS, respectively.

3.15.5 Anchors and guides

3.15.5.1 Anchors and guides for pipework

3.15.5.1.1 A supporting element used as an anchor shall be designed to maintain an essentially fixed position.

3.15.5.1.2 To protect terminal equipment or other (weaker) portions of the system, restraints (such as anchors and guides) shall be provided where necessary to control movement or to direct expansion into those portions of the system which are designed to absorb them.

The design, arrangement and location of restraints shall ensure that expansion joint movements occur in the directions for which the joint is designed. In addition to the other thermal forces and moments, the effects of friction in other supports of the system shall be considered in the design of such anchors and guides.

3.15.5.1.3 Where corrugated or slip-type expansion joints, or flexible metal hose assemblies are used, anchors and guides shall be provided where necessary to direct the expansion into the joint or hose assembly. Such anchors shall be designed to withstand the force specified by the manufacturer for the design conditions at which the joint or hose assembly is to be used. If this force is otherwise unknown, it shall be taken as the sum of the product of the maximum internal area times the design pressure plus the force required to deflect the joint or hose assembly.

Where expansion joints or flexible metal hose assemblies are subjected to a combination of longitudinal and transverse movements, both movements shall be considered in the design and application of the joint or hose assembly.

Flexible metal hose assemblies, shall be supported in such a manner as to be free from any effects due to torsion and undue strain as recommended by the manufacturer.

3.15.6 Bearing type supports

Bearing type supports shall permit free movement of the piping, or the piping shall be designed to include the imposed load and frictional resistance of these types of supports, and dimensions shall provide for the expected movement of the supported piping.

3.15.6.1 Support feet

Selection, design and application of supports feet shall be according to Standard Drawing IPS-D-PI-130.

3.15.6.2 Roller type supports

Selection, design and application of roller type supports shall be in accordance with BS 3974 Part 1 1974, Section 7.

3.15.6.3 Slider type supports

Selection design and application of slider type supports shall be in accordance with BS-3974 Part 1 1974, Section 6.

To ensure unrestricted movement of sliding supports, bearing surfaces shall be clean.

3.15.7 Structural attachments

External and internal attachments to piping shall be designed so that they will not cause undue flattening of the pipe, excessive localized bending stresses, or harmful thermal gradients in the pipe wall. It is important that attachments be designed to minimize stress concentration, particularly in cyclic services.

3.15.7.1 Non-integral attachments

Non-integral attachments, in which the reaction between the piping and the attachment is by contact, include clamps, slings, cradles. U-bolts, saddles, straps, clevises and pick-up supports, (see IPS-D-PI-130). If the weight of a vertical pipe is supported by a clamp, it is recommended to prevent slippage that the clamp be located below a flange, fitting, or support lugs welded to the pipe.

In addition riser clamps to support vertical lines should be designed to support the total load on either arm in the event the load shifts due to pipe and/or hanger movement.

3.15.7.2 Integral attachments

3.15.7.2.1 Integral attachments include ears, shoes, lugs, dummy supports, rings, and skirts which are fabricated so that the attachment is an integral part of the piping component. (see IPS-D-PI-130). Integral attachments shall be used in conjunction with restraints or braces where multiaxial restraint in a single member is to be maintained.

Consideration shall be given to the localized stresses induced into the piping component by the integral attachments. Where applicable, the conditions of Paragraph 3.15.6.1 are to apply.

3.15.7.2.2 The design of hanger lugs for attachment to piping for high temperature service shall be such as to provide for differential expansion between the pipe and the attached lug.

3.15.7.2.3 To prevent lines subjected to thermal expansion/contraction moving off their supports, consideration shall be given to the actual length of the cradle or pipe shoes to be used.

3.15.7.2.4 Pipe stanchions, pipe dummies and trunnions shall have welded end plates. Before the end plates are welded, the inside of the pipe stanchions, pipe dummies and trunnions shall be (spray) painted.

3.15.7.2.5 Weld-on support attachments, such as cradles or pipe shoes, pipe stanchions, pipe dummies, trunnions and lugs, should not be attached to tees, reducers and elbows. When stress analysis permits, pipe stanchions, pipe dummies and lugs may be attached to elbows.

3.15.7.2.6 Field welding to pipes for pipe supporting purposes shall be limited as far as possible. Field welding for pipe support purposes shall not be performed on the following pipe materials:

- Materials requiring post weld heat treatment;
- lined carbon steel (glass, PTFE, rubber, cement, etc.);
- nonferrous materials.

3.15.7.2.7 For pipes requiring post weld heat treatment, attachments required for supporting purposes shall be indicated on the piping isometric drawings, and welding shall be executed at the pipe shop before post weld heat treatment.

3.15.7.2.8 All welds of support elements and of supports to piping shall be continuous. The fabricated and supplied supports shall conform the "Bill of Material for Supports" drawings and standards shall be able to withstand the allowable loads.

3.15.7.2.9 Welds shall be proportioned so that the shear stresses do not exceed either 0.8 times the applicable S values for the pipe material shown in the allowable stress tables, or the allowable stress values determined in accordance with Paragraph 3.15.2.3.

3.15.7.2.10 If materials for attachments should have different allowable stress values than the pipe, the lower allowable stress value of the two shall be used.

3.15.8 Supports for insulated pipes and attachments

Insulated lines running in pipe trenches shall be supported high enough to assure the insulation will remain above the highest expected storm water levels.

Clamped cradles or pipe shoes shall be used on the following insulated lines:

- Piping lined with glass, rubber, plastics, etc.;
- piping requiring post weld heat treatment;
- piping requiring approval of the Engineer;
- expensive materials such as titanium, hastealloy, monel, etc.;
- piping with corrosion resistant coating (e.g. galvanized piping).

For all other insulated lines welded cradles or pipe shoes should be used.

3.15.8.1 Insulated lines for hot service

Reference shall be made to IPS-D-PI-130.

3.15.8.1.1 Piping DN 40 (NPS 1½) and smaller shall be supported directly from the insulation by addition of a load-bearing metal sleeve or saddle outside of the insulation.

3.15.8.1.2 Piping DN 50 (NPS 2) and larger shall be supported on pipe shoes or saddles that allow for the full insulation thickness.

3.15.8.1.3 The lines shall be set above the supporting structure by cradles or pipe shoes to provide adequate clearance for painting and insulation. The clearance between the insulation and the supporting structure shall be at least 50 mm.

3.15.8.1.4 To maintain common support levels the back or underside of pipes (or underside of supports) shall be on the same plane or level, irrespective of pipe size or insulation thickness.

3.15.8.1.5 Supports for lines with heat tracing, shall be shaped such that they will not obstruct with the tracing or impede dismantling of supports and tracing.

3.15.8.1.6 To limit water ingress into insulation, welded, rather than clamped, cradles/pipe shoes should be used where the latter could pierce through the insulation.

3.15.8.1.7 Cradles and pipe shoes of lines operating at temperatures above 400°C shall be isolated from the supporting structure by incombustible insulating blocks of sufficient load bearing and insulation capabilities.

3.15.8.1.8 Alternatively, clamped cradles or pipe shoes can be installed around the insulation. At the location of these supports the insulation shall have sufficient load bearing capabilities.

3.15.9 Uninsulated lines

3.15.9.1 Uninsulated lines should rest directly on the supporting structure. However, cradles or pipe shoes shall be considered if:

- The operating temperature of the line is below ambient and therefore the line will often have surface condensation;

- the line is a permanently operating transport line, operating at ambient temperatures, without switch-over possibilities;

- the line requires a slope;

Note:

This is only for small slope corrections. The height of cradles or pipe shoes measured from underside of pipe shall be maximum 400 mm.

- the line may operate (even temporarily) at such a low temperature that this may cause embrittlement of the supporting member;

- they are needed to avoid unacceptable pipe corrosion in high corrosion areas (e.g. due to coating damage caused by movement and water collection on top of the supporting structure).

Note:

The application of cradles or pipe shoes in these situations does not alleviate corrosion problems of the supporting members themselves. In very corrosive environments saddles may be considered instead of cradles or pipe shoes.

3.15.9.2 If the span between the supports (e.g. where the economic span is dictated by a majority of bigger lines) is too big for a pipe, the size of that pipe may be increased to meet an acceptable deflection and stresses, provided an economic evaluation justifies such an increase versus the cost of intermediate supports. Such decision is subject to Purchaser's approval.

3.15.10 Spacing (span)

a) Maximum allowable span shall be in accordance with Standard Drawing IPS-D-PI-102.

b) Where line self draining is essential the deflection of the pipe due to self weight at the point of maximum deflection shall not exceed the vertical fall over the span due to the set slope.

3.15.11 Threads

Where supports have vertical adjustment, any bolt projection below the foot plate shall not exceed two bolt diameters. The use of metric threads on pipe supporting elements is permitted. (Additional to ANSI/ASME B 31.3).

3.15.12 Fixtures

Inextensible supports other than anchors and guides.

a) Pipe support clips for carbon steel lines should be made from round bar (i.e. U bolts) rather than flat strip to reduce corrosion. (Addition to ANSI/ASME B 31.3).

b) Shoes shall be provided at supports, on insulated lines where the normal operating fluid temperature exceeds 100°C (212°F). Shoes should be sufficiently large to prevent disengagement from the supporting structure under abnormal temperature cycle or hydraulic shock conditions. (Additional to ANSI/ASME B 31.3).

3.16 Insulation

3.16.1 General

a) Insulation shall be calculated as a function of piping operating temperature and ambient conditions. Ambient reference temperature shall be deduced as the average of the minimum values occurred in the coldest month of the year for hot insulation, and average of the maximum values occurred in the hottest month of the year for cold insulation.

b) Design for thickness and type of various insulation shall be made in accordance with the IPS-E-TP-700.

c) To reduce the possibility of condensation within the bellows, thermal insulation or screening may be used, but the bellows material shall not be subjected to a continuous high-temperature which would lead to an unacceptable fatigue life.

3.16.2 Winterization

3.16.2.1 Equipment and piping shall be winterized if any of the following conditions applies in a stagnant system for the fluid being handled:

a) The lowest ambient temperature is below the pour point or freezing point.

b) Undesirable phase separation, deposition of crystals or hydrate formation will occur at any ambient temperature.

c) In gas systems where condensation, hydrate or ice formation can occur at any ambient temperature (or due to cooling caused by expansion of the gas).

d) Viscosity at low ambient temperature is so high that an inadequate flow rate is obtained with the pressure available for starting circulation.

e) Lines which are normally dry, e.g. flare lines or instrument air lines, but which may carry moisture during an operating upset.

3.16.2.2 Design of winterization shall be made in accordance with Standard IPS-E-PR-420.

3.17 Painting

a) Painting shall be applied to uninsulated piping in order to protect them from the corrosion due to environmental agents.

b) Any piping component shall be furnished completely painted by the manufacturer as specified by purchase order.

c) Painting shall not be applied to galvanized and stainless steel pipes.

d) Painting system shall be designed in accordances with IPS-E-TP-100 and IPS-C-TP-102.

3.18 Inspection

Type(s) and extent of inspection shall be in accordance with IPS-E-PI-221.

3.19 Pressure Test

Pressure test of piping and piping component shall be made in accordance with IPS-C-PI-350.

3.20 Piping Connections to Existing Plant (Additional to ANSI/ASME B 31.3)

a) Cut-ins and tie-ins shall be designed so that:

i) Fabrication and field work is minimized consistent with plant operating and shut-down limitation requirements.

ii) "Hot work" (field welds etc.) should be minimized in restricted areas.

b) The method and the location of cut-ins and tie-ins shall be approved by the operating management at the design stage.

APPENDICES

APPENDIX A
TYPES OF VALVES

TYPE	SIZE	SERVICE
Ball valves	DN 15 and larger	General service
Gate valves	DN 15 and larger	General service
Butterfly valves, lined	DN 100 and larger	General (water) service, class 150#
Butterfly valves, lined	DN 100 and larger	150# and 300# corrosive service
Butterfly valves, soft or metal seated (high performance)	DN 80 and larger	General service and special applications, e.g. cryogenic, high temperature
Diaphragm valves, lined	DN 15 to DN 300	150#, corrosive service
Ball valves, lined	DN 15 to DN 150	150# and 300# corrosive service
Plug valves (pressure balanced)	DN 15 and larger	High pressure gas systems (e.g. hydrogen)
Needle valves	DN 15 to DN 40	Accurate control
Globe valves	DN 15 to DN 200	General service
Diaphragm valves, lined	DN 15 to DN 300	Low-pressure corrosive service
Butterfly valves, lined	DN 50 and larger	Moderate pressure corrosive service
Choke valves	DN 50 to DN 200	For high pressure difference and/or erosive service
Butterfly valves (high performance)	DN 80 and larger	General service
Check valves	DN 15 to DN 40	Piston type, horizontal flow
	DN 15 to DN 40	Ball type, horizontal flow
	DN 50 and larger	Swing type
	DN 50 and larger	Dual plate type, spring energized