ENGINEERING STANDARD

FOR

MACHINERY PIPING

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0. INTRODUCTION

This specification covers the basis for the over-all design of process and auxiliary piping within limits of the packaged process machineries and related facilities.

This standard shall be used in conjunction with the specific standard of each equipment and general plant piping system standards as listed in section 2.

1. SCOPE

This specification contains mandatory requirements governing the design and installation of piping systems associated with pumps, compressors, turbines, etc. as well as the auxiliary piping associated with them.

This standard is intended to be used in refinery services, chemical, petrochemical and gas plants and where applicable in production, exploration and new ventures.

For any deviations the engineering contractors, require the written approval of the Company.

2. REFERENCES

This design of machinery piping systems and elements of such systems and the assembly, installation and testing shall, where applicable, shall be equal to or exceed the minimum requirements as specified by the latest revisions of the following codes, standards and specification:

ANSI (AMERICAN NATIONAL STANDARDS INSTITUTE)

B 31.1 "Power Piping"
B 31.3 "Petroleum Refinery Piping"

API (AMERICAN PETROLEUM INSTITUTE)

610 "Centrifugal Pumps for General Refinery Services"
611 "General Purpose Steam Turbines"
612 "Special Purpose Steam Turbines"
614 "Lubrication, Shaft Sealing & Control Oil Systems for Special Purpose Application"
617 "Centrifugal Compressors for General Refinery Services"
618 "Reciprocating Compressors for General Refinery Services"
619 "Rotary-Type Positive Displacement Compressors for General Refinery Services"
672 "Packaged, Integrally Geared Centrifugal Air Compressor for General Refinery Services"
674 "Positive Displacement Pumps-Reciprocating"
675 "Positive Displacement Pumps-Controlled Volume"
676 "Positive Displacement Pumps-Rotary"
680 "Packaged Reciprocating Plant and Instrument Air Compressors for General Refinery Services"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

"Boiler and Pressure Vessel Code"

IPS (IRANIAN PETROLEUM STANDARDS)

E-GN-100 "Units"
E-IN-170 "Pressure Reliving System"
E-PI-100 "Plant Piping System"
M-PI-230 "Strainers and Filters"
M-PM-105 "Centrifugal Pumps for Process Services"
M-PM-115 "Centrifugal Pumps for General Services"

M-PM-125 "Centrifugal Fire Water Pumps"
M-PM-130 "Positive Displacement Pumps-Reciprocating"
M-PM-140 "Positive Displacement Pumps-Rotary"
M-PM-150 "Positive Displacement Pumps-Controlled Volume"
M-PM-170 "Centrifugal Compressors for Process Services"
M-PM-180 "Packaged Integrally Geared Centrifugal Compressors for Utility & Instrument Air Services"
M-PM-200 "Reciprocating Compressors for Process Services"
M-PM-210 "Reciprocating Compressors for Utility & Instrument Air Services"
M-PM-220 "Positive Displacement Compressors-Rotary"
M-PM-240 "General Purpose Steam Turbines"
M-PM-250 "Special Purpose Steam Turbines"
M-PM-320 "Lubrication, Shaft Sealing & Control Oil Systems for Special Purpose Application"

NEMA (NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION)

SM 23 "Steam Turbines for Mechanical Drive Services"

3. UNITS

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

4. PIPING DESIGN FOR MACHINERIES

4.1 General

4.1.1 Piping at pumps, compressors and steam turbines shall be sufficiently flexible and adequately supported to ensure that under no circumstances the equipment nozzles will be subject to any stress that could disturb the alignment, internal clearances or otherwise affect the equipment and jeopardize its trouble-free operation. For general requirement on piping system See IPS-E-PI-100.

4.1.2 The surrounding piping shall be routed to allow of removal of casing sections and internal elements from the equipment with a minimum disturbance of piping.

Auxiliary piping shall be neatly routed along the baseplate and shall not extend across the operating floor. This piping shall not obstruct operation handling and inspection covers, bearing caps, upper halves of casing, etc.

4.1.3 The allowable forces and moments on equipment nozzles shall be in accordance with the relevant API/NEMA standards for this equipment as listed in section 2, unless the manufacturer states lower figures.

4.1.4 Piping strain (flexibility) analyses shall be based on the design maximum and minimum temperatures. These temperatures, which are determined from the normal operating temperature and the site temperatures, shall be listed in the Line Designation Table.

4.1.5 For computations of reactions on supports and equipment the appropriate installation temperature (See Notes 1 & 2) shall be used as a reference. Proper temperature values for stress ranges and reactions shall be derived from ANSI B31.3, Paragraph 319.3.1.

Notes:

1) The minimum installation temperature for analysis of loads on sensitive equipment shall be the minimum equipment design temperature or the minimum site temperature, whichever is lower.

2) The maximum installation temperature for analysis of loads on sensitive equipment shall be the maximum equipment design temperature or the maximum site temperature, whichever is higher.

4.1.6 Auxiliary piping connected to pumps, compressors or turbines shall be in accordance with the relevant API Standards and IPS as listed in section 2. Tapped holes for venting, etc., shall have an NPT nipple, schedule 160 to which a valve is connected. The requisitions and process engineering flow schemes shall state when flanged nozzles are required.

4.1.7 Lube oil lines shall be separated from hot process and hot utility lines in order to avoid a fire hazard, e.g. autoignition at 260-320°C. For further information See IPS-M-PM-320.

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

In all cases drain and vent points shall be closed, i.e. provided with a blind flange.

4.2 Pumps

4.2.1 Pump suction piping shall give minimum flow turbulence at the pump nozzle. Appendix "A" gives the minimum straight pipe length upstream of the pump suction nozzle. Suction piping shall not have pockets where gas can accumulate. However, if this is unavoidable, venting facilities shall be provided.

4.2.2 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.

4.2.3 A block valve shall be 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 in the discharge line near the discharge nozzle of centrifugal or rotary pumps, unless there is no possibility of reversed flow or pressure surge under any condition. Highly corrosive or hazardous fluids shall have a drain valve in the discharge line between the block and the non-return valve.

4.2.4 Removable pipespools shall be provided between the block valves and the pumps or drivers. The piping to the suction end of a pump shall be arranged so that the pump impeller may be removed while the suction block valve is in place. Where pump discharge piping goes to an overhead pipeway, the block and check valves shall be installed in the vertical piping section above the pump.

4.2.5 Suction piping to pumps handling at or close to their vapor pressure shall require special care to suppress flashing. Vertical drop as much as possible shall be provided at the suction source before starting the horizontal run to the pump.

4.2.6 Suction lines carrying sensitive fluids such as hot oil, boiler feed water, and the like must be sloped downward to the pump to provide venting of flashed vapors back to the fluid source.

4.2.7 Pumps shall be spaced to allow minimum clearance of 915 mm between flanges of piping and other projections of an adjacent pump.

4.2.8 The discharge valve as well as the 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. 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 piping of the pump.

4.2.9 A bypass with a valve DN 20 (¾ in.) shall be installed around the pump discharge non-return valve for the following criteria:

- pump is spared with common suction and discharge lines
- discharge and suction line design temperatures above 230°C
- Process fluid can solidify at ambient temperature, e.g. water lines in frost areas
- cryogenic service, or fluid temperature considerably below ambient temperature.

4.2.10 Permanent strainers shall be installed in all pump suction lines.

4.2.11 Y-type strainers are required for permanent installation in vertical suction lines. In horizontal suction lines Y-type or bucket- type strainers may be used. For large suction lines bucket-type strainers shall be used.

For carbon steel and alloy steel strainers, see IPS-M-PI-230.

The design and material for strainers in chemical services and for special pumps shall fulfill the process and pump requirements, e.g. metering pumps.

4.2.12 Pumps shall be protected either by temporarily adding a fine mesh (40 mesh) screen on the upstream side of the permanent strainer or by a temporary conical suction strainer with a fine mesh screen for initial start-up and commissioning.

For conical screen strainers, see IPS-M-PI-230.

4.2.13 A spade or spectacle blind shall be inserted downstream of the suction valve and upstream of the discharge valve to isolate pumps from a common suction and discharge line during maintenance, unless the pump can be isolated by other means.

4.2.14 The pump vent shall be connected to the vapor space of the suction vessel for operation under vacuum or with hazardous liquids. This allows of filling the system before the pump is started without opening the discharge valve. The vent line shall have two valves, one at the pump and one at the vessel.

4.2.15 To avoid spillage of hazardous or expensive fluids when a pump is opened, the drain and vent connections shall be connected to a drain or vacuum vessel for this purpose.

4.2.16 Pumps handling fluids with a vapor pressure exceeding 5 bar (ga) shall have a vent line to the flare system or shall discharge into the process system, e.g. for LPG or naphtha. The vent line shall have a spectacle or spade blind, block-and bleeder and thermal relief valve. Downstream of the relief valve shall be a flanged valve for blinding. Pump vent connections for toxic services shall discharge into closed systems.

4.2.17 Cooling water connections and the hook-up of required water lines, if specified on the data/requisition sheets and shown on the diagrams and flow schemes, are generally in accordance with API 610, with the following additional requirements.

Cooling water harnesses may be connected in series for pumps with the same function.

Cooling water lines to stuffing boxes and pump bearing houses can be lined up in series. However, for pumps operating above 300°C this shall be in parallel.

Cooling water harnesses shall have a thermal relief valve to safeguard the cooling jackets of pumps standing idle in a hot climate, e.g. spare pumps.

Fresh water is preferred for cooling.

For sea water or other untreated water a duplex strainer shall be installed in the cooling water supply header.

4.2.18 Pumps for high-pour-point products require flushing facilities on the stuffing box.

4.2.19 Pumps for vacuum service require a sealing liquid on the stuffing boxes and a vent line to the process system to secure against dry-running.

4.2.20 Positive displacement pumps shall be safeguarded against a blocked outlet with a reliable pressure-relief device. This shall not be an integrated part of the pump and be in accordance with IPS-E-IN-170. The relief valve should be installed in a bypass between the discharge line upstream of the block valve and the suction vessel. Alternatively the relief valve may be installed in a bypass between the discharge line upstream of the block valve and the suction line downstream of the block valve. However, this may not create an over pressure of the suction system.

4.2.21 Provision shall be made for draining on suction and discharge lines. Suction lines may be drained through pump casing. If discharge line is vertical, the line shall be drained by a bypass around discharge block valve. Pressure gage connection, shall be made in the piping between pump nozzle and the discharge valve.

4.3 Compressors

4.3.1 General

4.3.1.1 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.

4.3.1.2 Pipe and butt-welding fitting shall be lined up accurately and welds shall be internally ground smooth.

4.3.1.3 Interstage and discharge piping shall be sufficiently flexible to allow of expansion from the heat of compression.

4.3.1.4 Block valves shall be in the suction and discharge lines, except for air and inert gas compressors, which have discharge valves only.

4.3.1.5 Except for reciprocating compressors, discharge lines shall have a check valve between block valve and discharge nozzle.

4.3.1.6 A suction strainer shall be installed in all compressor suction lines located between the suction nozzle and the block valve on the compressor. Screens and filters shall be reinforced to prevent failure and subsequent entry into the compressor, see IPS-M-PI-230. Provision shall be made to measure the pressure difference.

4.3.1.7 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. When a continuous slope is not possible, low points shall be provided with a drain to remove any possible accumulation of liquid.

4.3.1.8 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 the discharge of that stage, including valves and suction pulsation dampener.

4.3.1.9 Suction lines shall be connected to the top of the header. Suction lines at least one pipe size smaller than the header may be connected concentrically with the side of the header.

4.3.1.10 Compressor lube oil and seal oil piping over the full length shall be of austenitic stainless steel, including valve trim and flange bolting.

4.3.1.11 The stainless steel piping can be limited to piping downstream of the filters, if for practical or economic reasons the use of stainless steel is restricted and the compressor operation is not jeopardized by failing oil systems.

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

4.3.2 Reciprocating compressors

4.3.2.1 The piping shall have as much free clearance as possible around each machine.

4.3.2.2 Main pipe supports shall be independent of compressor foundation, walls and other equipment foundation that may have vibration.

4.3.2.3 Piping and supports shall be designed to prevent excessive vibration and thermal stresses.

4.3.2.4 For wet gas or gas at dew point conditions, compressor suction piping shall be designed to avoid liquids at compressor inlet. Consideration shall be given to suitable scrubbers, heat tracing of suction header, etc.

4.3.2.5 No cast iron valves shall be used on compressor process piping.

4.3.2.6 Crank case vents and distance piece vents shall be piped to the outside of the compressor building.

4.3.2.7 All compressor piping shall be checked for the natural frequency of support lengths. If required by Company, pulsation or analog study of suction and discharge piping shall be undertaken for all reciprocating process compressors.

4.3.2.8 Suction and discharge volume bottles greater than 750 mm diameter shall have a 200 mm minimum blinded opening for cleaning and bottle inspection.

4.3.2.9 Reciprocating compressors shall be safeguarded against a blocked outlet with a reliable pressure-reliving device, preferably installed in a bypass between the discharge line upstream of the block valve and the suction vessel. Alternatively, the relief valve may be installed in a bypass between the discharge line upstream of the block valve and the suction line downstream of the block valve, the latter only when no danger exists of overpressure in the low-pressure suction system. Interstage sections shall also be protected by relief valves See IPS-E-IN-170.

4.4 Steam Turbines

4.4.1 If the exhaust side of a turbine cannot withstand the supply steam pressure, a relief valve adequate capacity shall be installed directly downstream of the turbine.

4.4.2 Warming-up provisions for the turbine shall be made. This is less important for the impulse-type turbine, but stringent for the reaction-type turbine.

4.4.3 The set pressure of the relief valve shall exceed neither the turbine design pressure nor that of the exhaust piping.

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

4.4.4 A suitable strainer shall be installed in the steam inlet line close to the turbine, if not supplied with the turbine.

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

4.4.6 Steam vents shall be routed to a safe location.

4.4.7 Turbine lube oil and seal oil piping should over the full length be of austenitic stainless steel, including valve trim and flange bolting. The stainless steel piping can be limited to pipework downstream of the filters, if for practical or economic reasons the use of stainless steel is restricted and the turbine operation is not jeopardized by failing oil systems.

4.4.8 For general and specific requirements for steam turbines See IPS-M-PM-240 and IPS-M-PM-250.

5. TESTING

5.1 Prior to initial operation, installed piping shall be pressure tested to assure tightness.

In the event repairs or additions are made following the test, the affected piping shall be retested, except that in the case of minor repairs or additions, the Company may waive retest requirements, or may request alternate methods of determining the "soundness" of fabrication.

5.2 Inspection and testing shall be in accordance with Chapter VI of "ANSI B31.3, Latest Revision, Petroleum Refinery Piping" and with IPS-E-PI-100, "Plant Piping System".

5.3 All piping other than open drain lines, sewers and air lines less than DN 20 OD shall be pressure tested.

5.4 All tape shall be removed from flanges at conclusion of testing.

APPENDICES

APPENDIX A
MINIMUM STRAIGHT PIPE LENGTH UPSTREAM OF THE PUMP SUCTION NOZZLE

The minimum suction length, which shall not include any strainer or stop-flow valve, shall be as stated below:

A.1 Vertical, close-coupled pumps

The straight length shall be a minimum of 1½ pipe diameters when the elbow is in the same plane as the pump shaft.

If the elbow is in a plane at right angles to the pump shaft, the straight length shall be a minimum of 4 pipe diameters.

A.2 Single-suction pumps, end-suction type

The straight length shall be a minimum of 3 pipe diameters.

A.3 Single-suction pumps, top-top connections

Two arrangements are possible:

a) Where the suction nozzle is on the top of the pump casing, the requirements of Al shall apply.

b) Where the suction nozzle is a long radius elbow connected to the pump end cover, the straight length shall be a minimum of 1½ pipe diameters when the elbow is in the same plane as the pump shaft and suction nozzle.

If the elbow is in a plane at right angles to the suction nozzle, the straight length shall be a minimum of 4 pipe diameters.

A.4 Double suction pumps

Elbows in suction lines to double suction pumps shall be installed in a plane at right angles to the pump shaft. A minimum straight length of 3 pipe diameters is then required.

If elbows have to be installed in any plane other than at right angles to the pump shaft, straight lengths of from 5 up to 10 pipe diameters may be required. In this event, a careful investigation shall be made into the avoidance of unequal flow to the impeller eye. The advice of the pump manufacturer should be sought in this respect.

APPENDIX B
PIPE COMPONENTS NOMINAL SIZE

The purpose of this Appendix is to establish an equivalent identity for the piping components nominal sizes in Imperial system and SI unit.

TABLE B1

NOMINAL SIZE		NOMINAL SIZE		NOMINAL SIZE		NOMINAL SIZE	
DN (1)	NPS (2)	DN	NPS	DN	NPS	DN	NPS
15	½	100	4	500	20	1000	40
20	¾	125	5	600	24	1050	42
25	1	150	6	650	26	1100	44
32	1¼	200	8	700	28	1150	46
40	1½	250	10	750	30	1200	48
50	2	300	12	800	32	1300	52
65	2½	350	14	850	34	1400	56
80	3	400	16	900	36	1500	60
90	3½	450	18	950	38	1800	72

1) Diameter nominal, mm

2) Nominal pipe size, inch

APPENDIX C
PIPE FLANGES PRESSURE TEMPERATURE RATING

The purpose of this Appendix is to establish and equivalent identity for the pipe flange nominal pressure temperature ratings in Imperial system and SI unit.

TABLE C1

PN (1)	ANSI RATING CLASS
20	150
50	300
68	400
100	600
250	1500
420	2500

1) Pressure Nominal, bar