CONSTRUCTION STANDARD

FOR

PLANT PIPING SYSTEMS

PRESSURE TESTING

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1. SCOPE

This Standard covers the minimum requirements of pressure test to be carried out on plant piping systems. Upon completion of piping systems and before commissioning, it shall be pressure tested in order to prove the strength of the system, its tightness (absence of leaks) and the integrity of weldments and materials.

This Standard shall be read in conjunction with the project specifications for any specific piping system.

2. 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 Executor.

IPS (IRANIAN PETROLEUM STANDARD)

D-PI-121	"Hydrostatic Test Blind Thickness-Allowable Test Pressure"
C-IN-100	"General Instrumentation"

ANSI (AMERICAN NATIONAL STANDARD INSTITUTION)

ANSI/ASME B 31.5	"Refrigeration Piping"
ANSI/ASME B 16.5	"Pipe Flanges and Flanged Fittings"
ASME Section V Article 10	"Leak Testing"

3. DEFINITIONS AND TERMINOLOGY

3.1 Executor

Executor is the party which carries out all or part of construction and/or commissioning for the project.

3.2 Vendor

Is the firm or person who supplies and/or fabricates part of pipework.

3.3 Inspector

The inspector referred to in this Standard is a person/persons or a body appointed in writing by the Engineer for the inspection of pipework pressure testing.

3.4 Pressure Rating Class Index

A pressure which is numerically equal to class index of flange.

3.5 Engineer

The Engineer referred to in this Standard is a person or a body appointed in writing by the client.

3.6 Shall and Should

The word "shall" is to be understood as mandatory and the word "should" as strongly recommended to comply with the requirements of this Standard.

4. UNITS

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

5. GENERAL REQUIREMENTS

5.1 Before commencing pressure test, the executor shall prepare and submit for the Company approval a detailed test procedure together with the pressure test flowsheets and hydrotest diagram.

5.2 Atmospheric lines such as flare, vent and nonhydrocarbon drain lines do not require pressure testing unless specifically called for in project specification. These lines shall be inspected to ensure completeness of fabrication and installation.

5.3 Care shall be taken to ensure that the following equipment is not subjected to field test pressures:

a) Pumps, turbines and compressors.
b) Rupture discs, safety valves, flame arrestors, filter elements.
c) Instruments, including gage glasses and pressure gages.
d) Equipment where the internal lining may be damaged by the medium.
e) Equipment such as filters and driers where the contents could be damaged or contaminated.
f) Vessels and exchangers which have hydrostatic test pressures less than the line test pressure.

5.4 Vents shall be provided at all high points in the piping system and drains shall be provided at all low points.

5.5 Fabrication and welding shall be complete prior to system testing.

5.6 Welding cleanup, nondestructive examination, stress-relieving, and other heat treatments shall be completed before pressure testing is performed.

5.7 Insulation shall not be applied over welded or mechanical joints and connections. Screweds or welds shall not be painted before pressure testing.

5.8 Testing shall be performed by qualified personnel of executor who are thoroughly familiar with all equipment and test procedures.

5.9 Pressure testing shall be performed in presence of the Company inspector.

5.10 Pressure testing should be performed when the weather condition is suitable for inspection.

6. HYDROSTATIC PRESSURE TESTING

6.1 General

6.1.1 Where the test pressure of piping does not exceed the test pressures of the vessels, the piping may be left connected to them with due regard to Item 5.3(e).

6.1.2 If a portion of a piping system can not be hydrostatically tested because the presence of water is objectionable, a notation shall be made on the pressure test flowsheets indicating that hydrostatic testing by water is prohibited.

6.1.3 Underground lines inside plot limits shall be completely tested, inspected, drained and approved before coating of field welds and backfilling are carried out.

6.1.4 Cast iron piping with spigot and socket joints shall be intermittently covered, leaving the joints clear and all the bends securely anchored before testing.

6.2 Testing Area

6.2.1 If possible, test equipment including pumps, gages, recorders, and other items shall be located in the same area.

6.2.2 The area shall be continuously monitored by test personnel while testing is being performed so that any change in test procedures or conditions will be noted immediately and corrective action taken as required.

6.3 Test Equipment

The Engineer approval shall be obtained prior to use of equipment intended for the execution of the pressure test.

6.3.1 Instruments

The required instruments for each test shall be as follows:

a) Pressure gage, accurate to within 1% of its range. The range selected shall be such that the pressure reading occurs between 25 and 90 percent of the full range of instrument.

b) Dead weight tester and temperature indicator, if specified. Instruments shall be suitably protected from all elements. Prior to testing, they shall be calibrated (preferably on site) and a record of the instrument calibration and identification shall be kept as part of the inspection records. The calibration date and identification should be affixed to the instruments. Calibration shall be done according to IPS-C-IN-100.

6.3.2 Pumps

The executor shall be responsible for the supply of suitable pumps for the testing. As a minimum a high volume centrifugal pump for filling and a variable speed positive displacement reciprocating pump with sufficient discharge head and capacity for the pressurization shall be provided.

The executor shall provide chemical injection pump and means necessary for measuring of the inhibitor to be added to test water.

6.4 Test Medium

6.4.1 The test fluid normally shall be fresh water and shall not contain suspended solids which may plug small lines. If it is found necessary water filter shall be used equipped with 100 mesh screen to remove 99% of particles which are 140 microns or more in size.

6.4.2 The water shall have a corrosion inhibitor which meets approval of the Engineer.

6.4.3 If the water temperature is likely to fall to zero degree Centigrade (°C) or below, glycol or another antifreeze approved by the Engineer shall be added.

6.4.4 Carbon and low-alloy steel

Piping manufactured from carbon steel or low-alloy steel may be hydrostatically tested with fresh water. Brackish or sea water may be used provided that prior approval of the Engineer is obtained.

6.4.5 Stainless steels

The chloride content in the water used for the hydrostatic testing of piping manufactured from or containing parts manufactured from austenitic stainless steel (e.g., 18 Cr- 8 Ni or 18 Cr-10 Ni-2 Mo), shall be controlled as follows:

a) If the piping metal temperature does not exceed 50°C during commissioning, operation or non-operation, water containing up to 150 mg/kg (150 mass PPM) chlorides may be used for the hydrostatic test.

b) If the piping metal temperature exceeds 50°C during commissioning, operation or non-operation, the piping shall be tested using condensate water, demineralized water or oil with minimum flash point of 50°C.

6.4.6 In systems where residual moisture can not be tolerated, e.g., in SO_2, acid, ammonia and LPG service and where certain catalysts are used, other test medium shall be selected. If flammable liquid is used consideration shall be given to the test environment.

6.5 Test Pressures

6.5.1 General process piping-test pressure

After completion of fabrication, each section of pipework shall be hydraulically tested to minimum 1½ times the design pressure, adjusted to test temperature as indicated in Equation (1), but in no case to more than hydrostatic body test pressure of the weekest flange or flanged fitting:

$$P_t = \frac{1.5\ P \times S_t}{S} = F \times P \qquad \textbf{(Eq. 1)}$$

Where:

P_t = Minimum hydrostatic test pressure
P = Internal design pressure
S_t = Allowable stress at 38°C (100°F)
S = Allowable stress at design temperature
F = Factor (see Table 1) equal $\frac{1.5\ S_t}{S}$

HYDROSTATIC TESTING OF INTERNAL PRESSURE PIPING

TABLE I - "F" TEMPERATURE ADJUSTMENT FACTOR FOR ALLOWABLE STRESSES

MATERIAL		SEAMLESS CARBON STEEL		SEAMLESS ALLOY AND STAINLESS STEEL PIPE								
				CARBON ½ MOLY	1-¼ Cr ½ MOLY	2-¼ Cr 1 MOLY	5 Cr ½ MOLY	9 Cr 1 Moly	12 Cr (ss)	STAINLESS STEEL	STAINLESS STEEL	INCONEL
SPECIFICATION		ASTM		ASTM	ASTM	ASTM	ASTM	ASTM	ASTM	ASTM	ASTM	ASTM
		A 53 OH	A 106 OH	A 335 EF	A 335 OH, EF	A 335 OH, EF	A 335 OH, EF	A 335 OH, EF	A 268 OH, EF	A 312 OH, EF	A 312 OH, EF	800 H
STEEL MAKING PROCESS		GR A	GR B	GR P1	GR P11	GR P22	GR P5	GR P9	TP 405	TYPE 304 L	GR 347	
37.8 °C	100 °F	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50			
93.3 °C	200 °F	1.50	1.50	1.50	1.60	1.62	1.66	1.66	1.63	CONSULT STRESS ENGINEER	CONSULT STRESS ENGINEER	CONSULT STRESS ENGINEER
148.9 °C	300 °F	1.50	1.50	1.57	1.67	1.67	1.72	1.72	1.69			
204.4 °C	400 °F	1.50	1.50	1.62	1.71	1.68	1.74	1.74	1.72			
260 °C	500 °F	1.50	1.59	1.68	1.74	1.68	1.75	1.75	1.74			
315.6 °C	600 °F	1.62	1.73	1.75	1.80	1.68	1.79	1.79	1.79			
343.3 °C	650 °F	1.66	1.76	1.78	1.85	1.68	1.81	1.81	1.82			
371.1 °C	700 °F	1.67	1.82	1.82	1.92	1.68	1.84	1.84	1.85			
398.9 °C	750 °F	2.24	2.31	1.99	1.97	1.68	2.27	2.27	1.91			
426.7 °C	800 °F	2.58	2.78	2.03	2.00	1.97	2.34	2.34	1.99			
454.4 °C	850 °F	3.04	3.45	2.08	2.07	2.07	2.48	2.48	2.88			
482.2 °C	900 °F	3.69	4.62	2.16	2.34	2.34	2.75	2.63	3.09			
510 °C	950 °F	5.33	6.67	3.35	2.73	2.73	3.75	2.83	3.57			
537.8 °C	1000 °F	9.6	12.0	5.72	3.85	3.85	5.17	4.05	7.50			
565.6 °C	1050 °F	15	18.75	6.86	5.45	5.17	7.14	6.00				
593.3 °C	1100 °F	24	30	11.44	7.5	7.14	10.34	9.09				
621.1 °C	1150 °F				12.00	10.0	15.0	13.65				
648.9 °C	1200 °F				25.00	15.0	23.08	20.0				

Note:

"F" is calculated from allowable stress Table A-1 ANSI B31.3, 1990 Edition.

6.5.2 Refrigeration service-test pressure

Refrigerant piping shall be tested in accordance with the provisions of ANSI B 31.5 about "Refrigeration Piping" and the afore-mentioned requirements and be successfully dried out accordingly, or other measures approved by the Engineer shall be applied against freezing.

Note:

However no oxygen or any combustible gas or combustible mixture of gases shall be used for testing within the system. Water should not, if possible, be used for testing of refrigerant piping, but if used, it must be completely removed as described in Paragraph 6.9.9.

6.5.3 Vacuum service-test pressure

Lines in vacuum service shall be tested at a minimum internal pressure of 200 kPa (29 psi) unless limited to a lower pressure by design and/or construction.

6.5.4 Utilities service-test pressure

The test pressure for service air and water piping shall be 1½ times the design pressure or 700 kPa (100 psi) for steel piping, whichever is higher. Flanged cast iron piping shall be tested to 1½ times the design Pressure + Maximum static head of pipe content during operation; but in no case more than the following test pressures:

Size (Dia.)	Class 125 Flange	Class 250 Flange
DN 25-300 (NPS 1-12)	1700 KP (250 psi)	3500 KP (500 psi)
DN 350-600 (NPS 14-24)	1400 KP (200 psi)	2800 KP (400 psi)
DN 750 (NPS 30 & LARGER)	700 KP (100 psi)	1400 KP (200 psi)

6.5.5 Jacketed lines-test pressure

In jacketed lines the jacket shall be tested not less than 1½ times the jacket design pressure. The internal line shall be tested on the basis of internal or external pressure whichever (in the opinion of the Engineer) is critical. When the pressure in the jacket is high it might be advisable or essential to pressurize the inner pipe during hydraulic test of the jacket.

6.6 Stress Exceeding Yield Strength

If the test pressure would produce a stress in excess of yield strength at test temperature, the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature.

6.7 Nonmetallic Piping-Test Pressure

The hydrostatic test pressure at any point in a nonmetallic piping system shall be not less than 1.5 times the design pressure, but shall not exceed 1.5 times the maximum rated pressure of the lowest rated component in the system.

6.8 Test Duration

The test pressure shall be maintained for an adequate time (not less than one hour) to detect small and slow seepage leaks and to permit a thorough inspection.

6.9 Test Preparation

6.9.1 For hydrostatic testing, all pipe supports shall be in position and completed before testing is undertaken.

6.9.2 All piping intended for other than liquid service shall be adequately supported by temporary supports if necessary, particularly on lines using spring or counterweight supports. Large adjacent lines shall not be tested simultaneously where the weight of the combined test water load may overload the structure of supports.

6.9.3 If blind flanges are necessary, the flanges shall be indicated on the pressure test flow diagrams.

6.9.4 If a pressure test is to be maintained for a period of time and the test fluid in the system is subject to thermal expansion, precautions shall be taken to avoid excessive pressure.

6.9.5 All lines should be cleared of debris by flushing with water or blowing with steam or air. Precautions should be taken to ensure that debris is not flushed into associated vessels, equipment or "dead ends".

6.9.6 The executor of test shall consider temporary gaskets when making connections that will be broken for testing or reassembly after testing.

6.9.7 Ball valves and gate valves shall be completely open during the test.

6.9.8 The executor shall take care to avoid contaminating valve seats with foreign particles.

6.9.9 Lines containing check valves shall have the pressure source located on the upstream side. If impossible, the check valves shall be removed from the line or blocked open.

6.9.10 Lines which have spring hangers or are counterweight supported shall be temporarily blocked up during testing in order to sustain the weight of the test fluid. Sometimes spring hangers are provided with stops for carrying the test load and need not be blocked up.

6.9.11 All orifice plates which interfere with filling, venting and draining shall be removed for the test.

6.9.12 Equipment that is not to be included in the test shall be isolated by blinds or shall be disconnected from the piping.

6.9.13 Control valves shall remain in the line for testing. Those which are normally closed shall be opened by clean dry air. The valves shall not be jacked or forced open.

6.9.14 Pressure control valves with internal passages between the process fluid and the diaphragm shall be isolated from the test. External connections shall be disconnected or blocked during the test. The diaphragm pressure shall be bled off.

6.9.15 Expansion joints of the sliding sleeve or bellows type should be provided with temporary means to limit lateral movement.

6.9.16 Expansion joints, instruments, filters and similar equipment for which the maximum permissible cold test pressure is considerably lower than the maximum hydrostatic test pressure permissible for the other components of the system shall be removed or blanked off from the line before testing. Such equipment should be inspected during the commissioning with due regard to the pressure limitation.

6.9.17 Plugs shall be removed from tell-tale holes in compensating rings and reinforcement pads around branches (nozzles) and the holes left open during hydrostatic testing and observed for any leakage.

6.9.18 Prior to commencement of the test a thorough check shall be made to ensure all fittings, flanges, plugs, etc., are in place. All flanges and flanged fittings shall be bolted and bolts properly torqued.

6.9.19 Testing of more than one individual section simultaneously may be carried out by connecting the sections with suitable jumper lines. The materials used in the fabrication of these jumpers shall be of the same quality as the system under test, as a minimum. Threaded piping shall be minimized on jumper lines.

6.9.20 Instrument piping at orifice flanges shall be removed or a drain or vent shall be opened to ensure that the instrument does not become pressurized because of a leaking valve.

6.9.21 Mounted instrumentation shall be isolated from the system during testing.

6.9.22 The supply connection size shall ensure filling of the system within a reasonable time, and it shall have a flanged valve.

6.9.23 A valve shall be used for depressurizing, for which a globe valve is preferred.

6.10 Procedure for Hydrostatic Pressure Test

6.10.1 Pressure test sections shall be chosen by the executor, based on testing as much piping as possible at one time without exceeding the allowable test pressure of the weakest element in the system.

6.10.2 Vents and other connections that can serve as vents shall be open during filling so that all air is vented prior to the application of test pressure to the system.

6.10.3 For convenience, exchangers and/or vessels may be tested simultaneously with connected piping, provided, the test pressure of both the connected piping material and equipment does not exceed the maximum allowable pressure. Vessels shall not be tested with the piping when the following conditions apply:

a) Large vessel which would overload the foundation or support if filled with water.
b) Large vessels requiring too much water to fill.
c) Vessels with internals which would be damaged by water.
d) Vessels which are extremely difficult to drain or vent.

Note:

When vessels or tanks are drained, vent shall be opened to avoid pulling any vacuum.

6.10.4 Test pressures shall be taken at the lowest point of a line or test system.

6.10.5 During hydrostatic testing, care must be exercised to limit the applied pressure to the particular portion of the system designated on the field pressure test flow diagram.

6.10.6 Care must also be taken to avoid overloading any parts of supporting structures.

6.10.7 Where conditions require a test pressure to be maintained for a period of time, during which the test medium in the system might be subject to thermal expansion, provision shall be made for the relief of excess pressure due thereto. (By either installation of a proper relief valve or discharging excess pressure.)

6.10.8 Test pressure shall not be applied against any closed valve unless the maximum allowable working pressure (MAWP) of the valve exceeds the test pressure.

6.10.9 If the test pressure is the same upstream and downstream of a control valve, the block and by-pass valves shall be left open, with the control valve open or closed (whichever is most convenient).

6.10.10 If the test pressure is different at upstream and downstream of a control valve, the test on the upstream portion shall be made with the upstream block valve and control valve open, downstream block valve and by-pass valve open and blinded off.

6.10.11 All plain test blanks required for field testing shall be provided and/or made in the field according to IPS-D-PI-121.

6.11 Measures to be Taken after Hydrostatic Testing

6.11.1 After hydrostatic testing is completed and approved by the Engineer, the system shall be depressurized.

6.11.2 After depressurizing, lines and equipment shall be completely drained. The equipment should be cleaned, if necessary (in the opinion of the Engineer).

6.11.3 While draining, the system shall be vented to avoid a vacuum.

6.11.4 Special attention shall be given to points where water may be trapped such as valve bodies or low points.

6.11.5 Systems shall be dried after draining. The drying process may be accomplished by blowing warm compressed air through the system or by another method approved by the Engineer.

6.11.6 All temporary blanks and blinds shall be removed. Valves, orifice plates, expansion joints and short pieces of piping which have been removed shall be reinstalled with proper and undamaged gaskets in place. Valves which were closed solely for hydrostatic testing shall be opened. Temporary piping supports shall be removed so that insulation and painting may be completed.

6.12 Leaking Welds

Welds or portions of welds that leak during hydrostatic test shall be cut out, rewelded, radiographed and line shall be hydrostatically tested again at the executor's expense. The cut out may be replaced by repair and retesting of the line may be omitted at the discretion of the Engineer.

7. PNEUMATIC PRESSURE TESTING

7.1 General

With prior approval by the Engineer pneumatic testing may be substituted for hydrostatic testing if the following conditions apply:

a) When special supports or other special arrangements would be required on large, low-pressure lines.

b) When hydrostatic tests are uneconomical or impractical.

c) When the possibility exists that piping, insulation, refractory material, or attached equipment might be damaged by water.

d) When even a small amount of water left in a system, such as a refrigerant system, could be injurious.

Pneumatic test should be specified in pressure test flow sheets when it is substituted for hydrostatic testing.

7.1.1 The following lines are usually excluded from hydrostatic testing, and are usually tested with compressed air and soap suds:

a) Instrument air lines (test with dry air if possible).
b) Air lines to air-operated valves. (Test with dry air only).
c) Very large (usually over DN 600-NPS 24) gas or steam overhead line.
d) Pressure parts of instruments in gas or vapor service.

7.1.2 If investigation determines that testing is required for relief or blowdown header systems or individual pipe stacks more than 15.2 m in height which are open to atmosphere, they need only be tested for tightness with soap suds at 0.4 bars (5 psi) air pressure.

7.1.3 Piping with linings subject to damage by water, shall be subject to pneumatic pressure test.

7.1.4 Lines over DN 200 (NPS 8) from tank tops will be air tested in order to minimize excessive loads, and/or the need for special designed supports or foundations. This also includes flare lines if testing is required.

7.2 Test Equipment

7.2.1 Instrument

See Clause 6.3.1 of this Standard.

7.2.2 Compressors:

a) The executor shall be responsible for the supply of suitable compressors for the testing.
b) Air compressors with oil lubricated construction shall not be used for purging and testing instrument air lines.

7.3 Test Medium

7.3.1 Unless otherwise specified, pneumatic testing shall be performed with clean dry air or nitrogen.

7.3.2 Air for instrument air lines shall be oil-free.

7.3.3 If other gases are used as a test medium, it shall be nonflammable and nontoxic.

7.4 Pneumatic Test Pressure

The pneumatic test pressure of any piping system shall be equal to 110% of the design pressure of the system. If the test pressure exceeds 150 psig written approval of the Engineer shall be obtained.

7.5 Precautions to be Taken in Pneumatic Pressure Testing

7.5.1 Due to the large energy stored in compressed gas and, hence, the potential hazard of a sudden release of this energy, pneumatic testing shall be carried out in small sections to minimize the risk involved.

7.5.2 Materials involved in testing which their resistance to brittle fracture at low temperatures has not been enhanced, test temperatures above 16°C may be considered to reduce the risk of brittle fracture during the test.

7.5.3 Flange joints shall be masked with tape. One small hole shall be punched in the tape to indicate leaks.

7.5.4 Welds of piping subjected to pneumatic strength test above 150 psig shall be 100% radiographed.

7.5.5 In view of its hazardous nature, pneumatic pressure test shall only be undertaken with the presence of the Engineer and inspector.

7.5.6 All non-essential personnel and members of the public, when necessary, shall be evacuated from the test area.

7.6 Pneumatic Testing Procedure

The following steps shall be taken in performing pneumatic test:

a) Gradually bring piping system pressure up to 100 kPa (ga), 14.5 psig, maximum and make a preliminary inspection. Carry out a leak test using a sonic detector or soapy water. Hold pressure for at least 10 minutes.

b) The test pressure shall be increased gradually in increments of 100 kPa (14.5 psig) to provide time for stress in the piping to equalize. The gradual increase also provides sufficient time to allow the Company inspector to check for leaks.

c) When the full test pressure has been reached, the pressure shall be held for a sufficient time to permit inspection of piping welds and connections. The time shall never be less than 1 hour.

d) The pressure shall be gradually reduced to atmospheric at the end of the test.

8. MANUFACTURING CERTIFICATE FOR FABRICATED PIPING

The Engineer shall make sure that prefabricated piping which are not included in the pressure test are certified by an inspectorate authority.

9. DOCUMENTATION REQUIREMENTS

Test procedures, reports and test results shall be submitted to the Engineer on completion of tests and prior to start up of unit. The documents include followings.

9.1 Diagrams

9.1.1 Pressure test flow diagrams shall be prepared by the Executor.

9.1.2 Pressure test flow diagrams shall show the systems to be tested, the valves to be opened, and the equipment to be blanked with blind flanges.

9.1.3 Pressure test flow diagrams shall provide a record of the systems tested.

9.1.4 A reproduced copy of the mechanical flowsheets may be marked to produce the required pressure test flow diagrams.

9.2 Recorder Charts (if Required)

9.2.1 Charts are required on all tests performed by executor.

9.2.2 Each chart shall depict only one system test.

9.2.3 Charts shall be signed by the executor and the Engineer on completion of the test to certify that the test was performed.

9.3 Test Record

Actual line and equipment test pressures shall be accurately recorded by the executor. These records shall be made of each piping installation during the testing and shall include the following information:

a) Date of test.
b) Identification of piping or equipment tested (equipment included in the test of piping system).
c) Design pressure and temperature.
d) Test pressure.
e) Test medium used (if not water).
f) Water temperature and chloride content (if applicable).
g) Test duration.
h) Applicable remarks concerning defects.
i) Inspector's approval signature. The approval signature certifies that the piping system has been tested as required.

9.3.1 The executor shall collect, check, and furnish all information required to enable the Engineer to maintain a complete test record.