

PPPL	PRINCETON PLASMA PHYSICS LABORATORY	PROCEDURE	No. ENG-014 Rev 4 page 1 of 6
Subject: Hydrostatic and Pneumatic Testing	Effective Date: December 19, 2014	Initiated by: Associate Director, Engineering and Infrastructure	
	Supersedes: Rev. 3, dated Feb., 18, 2014	Approved: Director	

Management System : 03.00 Engineering (ENG)
Management System Owner: Associate Laboratory Director for Engineering and Infrastructure
Management Process: 03.04 Engineering Programs and Processes
Process Owner: Associate Laboratory Director for Engineering and Infrastructure
Sub-Process: 03.04.10 Hydrostatic and Pneumatic Systems and Testing
Sub-Process Owner: Head, Fabrication and Operations
Subject Matter Experts (SMEs): Head, Fabrication and Operations; Head, Safety; Head, ESH&S

Applicability

This procedure applies to all activities at C and D-Sites of the Laboratory that involve a system, component or part that operates at, or could possibly be exposed to, pressures greater than 15 psig. Any pressure vessel that is designed to operate at less than 15 psig is exempt from Hydrostatic or Pneumatic Testing under this procedure. Pressure testing of vacuum windows is covered by PPPL procedure, PTP-VAC-004 and vacuum leak testing of vacuum vessels is covered by OP-VV-74.

Introduction

This procedure defines the approved method for determining the appropriate type of hydrostatic and pneumatic testing to be used to ensure leak tightness for any system, component or part which could be exposed to the conditions described above. (The actions and precautions of this document should also be applied to pressure testing of a vacuum chamber if a separate procedure for the test has not been developed).

NOTE: Some items may be categorically exempted from this procedure with the agreement of Engineering and the Safety Division. QA should be consulted to assure that the exemption does not impact the integrity of the system. Items identified as exempt shall be added via a minor procedure change to this procedure and updated to the list in attachment 3 in future revisions of the procedure. Also, a separate procedure may be written for a particular pneumatic or hydrostatic test provided that it complies with all of the conditions and requirements of this procedure.

Table 1: Required Leak Test based on Fluid Service

Fluid Service (see Definitions)	Applicable Code (or reference document)	Hydrostatic Leak Test	Pneumatic Leak Test	Alternative Leak Test per ASME B31.3 par 345.9	Initial Service Leak Test	Helium Mass Spectrometer
Excluded Piping	---	Not Required	Not Required	Not Required	Not Required	Not Required
Pressure Vessels	ASME BPVC	Acceptable	Acceptable with RLM approval	Not Applicable	Not Applicable	Not Applicable
Power Piping	ASME B31.1	Acceptable	Acceptable	Not Applicable	Acceptable	Acceptable, use OPO-VV-74 or PTP-VAC-004
Category D Fluid Service (Low Hazard)	ASME B31.3	Acceptable	Acceptable	Acceptable	Acceptable with RLM approval	Acceptable with RLM approval, use OP-VV-74
Normal Fluid Service	ASME B31.3	Acceptable	Acceptable with RLM approval and if hydrotest impracticable	Acceptable with RLM approval, if hydrotest impracticable and pneumatic test too hazardous	Not Applicable	Not Applicable
Category M Fluid Service	ASME B31.3	Acceptable	Acceptable with RLM approval	Not Applicable	Not Applicable	Not Applicable
High Pressure Fluid Service	ASME B31.3	Acceptable	Acceptable with RLM approval	Not Applicable	Not Applicable	Not Applicable
Vacuum Service	ASME B31.3	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Acceptable, use OPO-VV-74 or PTP-VAC-004
Building Services Piping	ASME B31.9	Acceptable	Acceptable	Not Applicable	Acceptable	Not Applicable
Hydrogen Piping	ASME B31.12	Acceptable	Acceptable	Acceptable with RLM approval, if hydrotest impracticable and pneumatic test too hazardous	Not Applicable	Not Applicable

Safety

WARNING: Hydrostatic testing is always preferred, since pneumatic testing is inherently dangerous due to the amount of stored energy in the compressed gas contained within the system during the tests. Hydrostatic tests may have trapped air within the test volume and caution must also be taken when performing these tests.

With both pneumatic and hydrostatic tests, the test system must be appropriately cordoned off and the pressure reduced prior to approaching system under test for inspection. The pressure shall be reduced to 15 psig or the operating pressure, whichever is less, or to a value as approved by the Safety Division.

Definitions

Excluded Piping - a fluid service in which all the following apply:

1. The fluid handled is nonflammable, nontoxic, and not damaging to human tissues
 2. The design pressure is 0 to 15 psig (105 kPa)
 3. The design temperature is from -20°F (-29°C) to 366°F (186°C)
- A pressure leak test is not required for Excluded Piping

Power Piping- piping typically found in electric power generating stations, in industrial and institutional plants, geothermal heating systems, and central and district heating and cooling systems. Refer to ASME B31.1 Chapter 1 or Attachment 4 for more details.

Normal Fluid Service - a fluid service pertaining to most piping covered by this procedure, i.e., not Category D, Category M, High Pressure Fluid or Vacuum service.

Category D Fluid Service- a fluid service in which all the following apply:

1. The fluid handles is nonflammable, nontoxic, and not damaging to human tissues
2. The design pressure is less than or equal to 150 psig (1035 kPa)
3. The design temperature is from -20°F (-29°C) to 366°F (186°C)

Category M Fluid Service- a fluid service in which the potential for personnel exposure is judged to be significant and in which a single exposure to a very small quantity of a toxic fluid, caused by leakage, can produce serious irreversible harm to person on breathing or bodily contact.

High Pressure Fluid Service- a fluid service for which the RLM specifies the use of Chapter IX for piping design and construction. High pressure is considered to be pressure in excess of that allowed by the ASME B16.5 PN 420 (Class 2500) rating for the specified design temperature and material group.

Vacuum Service- any fluid service with design pressures between 0 psia and 15 psig.

Piping- assemblies of piping components used to convey, distribute, mix, separate, discharge, meter, control, or snub fluid flows.

Piping Components- mechanical elements suitable for joining or assembly into pressure-tight fluid-containing piping systems. Components include pipe, tubing, fittings, flanges, gaskets, bolting, valves, and devices such as expansion joints, flexible joints, pressure hoses, traps, strainers, inline portions of instruments, pressure reliefs and separators.

Repetitive Pressure Test- A Hydrostatic or Pneumatic Test that may be conducted numerous times on the same system or like articles (same drawing number) once the initial setup and system schematic are approved by ES&H and an initial pressure test is performed. Each repetition of the Repetitive Pressure Test must have at least 1 person present who participated in the initial test. A Job Hazard Analysis (JHA) and Sections 1 and 3 of the Pressure Test Record are completed before the

first test and copied for subsequent tests. Section 2 is completed for each repetition thereafter to record test results.

Initial Service Leak Test- When performing an initial service leak test, the piping system shall be gradually brought up to normal operating pressure and continuously held for a minimum time of 10 minutes. Examination for leakage shall be made of all joints and connections. The piping system exclusive of possible localized instances at pump or valve packings shall show no visual evidence of weeping or leaking.

Reference Documents

1. PPPL Health and Safety Manual, Section 9.11, "Pressure Systems".
2. ASME Boiler & Pressure Vessel Code: Section I, Power Boilers; and Section VIII, Pressure Vessels. (basis for procedure)
3. ANSI/ASME B31.1, Power Piping. (basis for procedure)
4. ANSI/ASME B31.3, Process Piping.
5. GEN-003, Document Distribution Control
6. ESH-004 "Job Hazard Analysis"
7. PTP-VAC-004, "Preoperational Test Procedure for Vacuum Windows"
8. OP-VV-74, "Leak Checking Using an HMSLD"

Responsibility

Action

Cognizant
Engineer/Physicist

1. Uses Pressure Test Record Form (Attachment 1) and specifies that systems, components or parts be hydrostatically or pneumatically tested. NOTE: pneumatic testing is only allowed if: a) the piping systems are so designed that they can not be filled with water; b) systems are to be used in operation where traces of the test medium cannot be tolerated; or c) it is specified in Code (e.g., Dry sprinklers may be pneumatically tested per NFPA 13).
2. Specifies test boundary, test conditions, type of test (hydrostatic or pneumatic), test equipment, and test pressure on the Pressure Test Record, Attachment 1- Section 1, in accordance with the requirements provided in Attachment 2. Also completes a JHA for the test.
3. Consults with a Subject Matter Expert (SME) (listed at the top of page 1) to review the proposed pressure test.

Subject Matter Expert

4. Reviews the proposed Pressure Test Record and provides input to determine if the test is applicable and appropriate. Signs the form if there is no requirement for a test.

Cognizant
Engineer/Physicist (for
initial test of Repetitive
Pressure Test)

5. If the test is to be a Repetitive Pressure Test, also completes section 3 of Attachment 1 by generating a schematic sketch that shows the item under test, location of test gages, isolations valves, pressure relief valves and pressure source

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|---|-----|--|
| (for second and subsequent Repetitive Pressure Tests) | 6. | Obtains copy of previously completed Attachment 1 to record results of new test. |
| Field Supervisor | 7. | Verifies test set up, valve lineup and safety precautions. |
| Cognizant Engineer/Physicist | 8. | Notifies the appropriate departments involved with initiating the pressure test so that calibrated test equipment and experienced personnel are available to perform the test. |
| Cognizant Engineer/Physicist | 9. | Notifies the Safety Division prior to pressure testing so that safety precautions can be observed and approved. |
| Safety Division | 10. | Reviews safety precautions and if appropriate, allows testing to begin by signing and dating Attachment 1-Section1. If test is repetitive, indicates so by entering expiration date (normally 1 year) and by signing and dating Attachment 1-Section |
| Cognizant Engineer/Physicist (for repetitive Test) | 11. | Makes at least two (2) copies of completed and approved Attachment 1-Section 1 and forwards one to the Department's/Project's designate files (typically the PPPL Operations Center) in accordance with GEN-003, Document Distribution Control and one copy to PPPL Quality Assurance. |
| Cognizant Engineer/Physicist | 12. | Determine if, the component needs to be witness tested. NOTE: This is at the discretion of the Cognizant Engineer/Physicist. Indicates the need by marking "Witness Test Required" on attachment 1. |
| Quality Assurance (If "Witness Test Required") | 13. | Witnesses component, subsystem, or system pressure test and validates that test was performed correctly and accurately, when requested by the Cognizant Engineer/Physicist. |
| Cognizant Engineer/Physicist | 14. | Documents results of test on Pressure Test Record (Attachment 1-section 2) and forwards to the Department's/Project's designate files (typically the PPPL Operations Center) in accordance with GEN-003, Document Distribution Control. Forwards a copy to PPL Quality Assurance. |

TRAINING (SECTION REQUIRED FOR ALL PROCEDURES)

- | | | |
|----------------------------------|----|---|
| Head, Fabrication and Operations | 1. | Specifies the appropriate training methods and means (below) and obtains concurrence of the Management System Owner and the Management Process Owner.
A. Target Audience: <u>Plumbers, Pipe Fitters, Machine & Water Technicians</u>
Instructor: <u>Head, Fabrication and Operations</u>
Training Method: <u>X</u> Briefing
Frequency: <u>X</u> One time only
B. Target Audience: <u>Supervisors</u> |
|----------------------------------|----|---|

Instructor: Head, Fabrication and Operations

Method: X Standard Email distribution by Best Practices to Supervisors

X Read only

Frequency: X Upon each revision of this procedure

- Head, Fabrication and Operations 2. Notifies the Human Resources Training Office of the training so that they will be aware of the training requirements and be able to provide assistance and guidance in the course development, implementation, tracking, and maintenance.

Records Requirements Specific To This Procedure

Records Custodians must assure records are maintained as follows:

Record Title	Record Custodian	Location	Retention Time
Pressure Test Record	Department/ Project Records Coordinator	Department/ Project Designated File location	Records which would be of significant value in demonstrating capability for safe operation; in maintaining, reworking, repairing, replacing or modifying the item; in determining the cause of an accident or malfunction of the item; and those which provide baseline data for in service inspection. Retain until the item is removed from service. DOE schedule Admin 17 32.a

Attachments

1. Pressure Test Record
2. Requirements for Hydrostatic & Pneumatic Testing
3. Items Exempt from Hydrostatic and Pneumatic Test Under this Procedure
4. Guide to Selecting Applicable B31 Piping Code Sections

PRESSURE TEST RECORD

*When completing Attachment 1 all fields should be completed (using "N/A" if necessary)
Section 1 (see Attachment 2 for requirements):*

WORK PLANNING NO. _____

SYSTEM ID: _____ **DRAWING NO** _____

- SYSTEM FLUID SERVICE:** NORMAL FLUID SERVICE (B31.3)
- PRESSURE VESSEL (BPVC) POWER PIPING (B31.1)
- PROCESS PIPING – CAT. D (B31.3) PROCESS PIPING – CAT. M (B31.3)
- PROCESS PIPING – HIGH PRESSURE (B31.3) BUILDING SERVICES PIPING (B31.9)
- HYDROGEN PIPING (B31.12) BUILDING SERVICES PIPING (B31.9)

WITNESS TEST: REQUIRED NOT REQUIRED

SYSTEM BOUNDARY: _____

This System does not require a Pressure Test Concur

Subject Matter Expert

Date

- TYPE OF TEST:** HYDROSTATIC ALTERNATIVE LEAK TEST PER B31.3
- PNEUMATIC INITIAL SERVICE LEAK TEST

TEST MEDIUM: DEMINERALIZED WATER NITROGEN OTHER

PRESSURE GAGE: NO. _____ **CALIBRATION DATE** _____

RANGE: _____

DESIGN PRESSURE: _____ psig

TEST PRESSURE: _____ psig

PRESSURE TEST RECORD**Attachment 1**

RELIEF VALVE PRESSURE SET POINT: _____ psig

INSPECTION PRESSURE _____ psig (15 psig) or operating pressure,
whichever is less, unless approved by Safety) Safety _____TEST DESCRIPTION: _____

COG ENGINEER: _____

DATE: _____

SAFETY REVIEW OF SETUP: _____ DATE: _____

(FOR REPETITIVE PRESSURE TEST INCLUDE - Section 3 Repetitive Pressure Test Schematic)

Section 2:TEST RESULTS: ACCEPT REJECT_____

TEST PERFORMED BY: _____ DATE _____

WITNESSED BY: _____ DATE: _____

[The COG Engineer/Physicist or QC must witness pressure tests of critical components as determined by the Cog Engineer/Physicist]

**ALLOWABLE TOLERANCE ON ESTABLISHING INITIAL TEST
PRESSURE**

<u>TEST PRESSURE</u>	<u>TOLERANCE</u>
16 TO 50 psig	.0 / + 2 psig
51 TO 100 psig	.0 / + 5 psig
101 TO 250 psig	.0 / +10 psig
251+ psig	.0 / +20 psig

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PRESSURE TEST RECORD			Attachment 1

REPETITIVE PRESSURE TEST SCHEMATIC

Section 3 (see Definitions section):

SYSTEM ID: _____ DRAWING NO _____

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	REQUIREMENTS FOR HYDROSTATIC AND PNEUMATIC TESTING		Attachment 2

REQUIREMENTS FOR HYDROSTATIC AND PNEUMATIC TESTING

Note: All helium leak checking must be completed before pressure testing.

TEST BOUNDARY

Define the boundary that will be tested with the pressure medium on a drawing or the Pressure Test Record, Attachment 1. The entire system, if it is new, or the newly added components or parts of the system must be exposed to the test pressure. The drawing must define which valves of the system are to remain open, as well as those that will remain in the closed position.

The boundary drawing must also specify the test setup. This includes the following:

Location of the connection for the application of the pressure (Note: This connection must have a shutoff valve so that the system being tested can be isolated from the pressure source).

Location and range of the calibrated pressure gauge.

Location of high and low point drains for the test (Required only for hydrostatic tests - high point drain is required to assure that all compressible gas is removed from the system prior to testing. Depending on the system, more than one high point drain may be required. Low point drain(s) are required to assure that the test medium is removed from the system).

Location of a safety relief valve that will be used to assure that the system is not over pressurized during the test. The relief pressure of the valve should be set no more than 25 psig over the test pressure.

Location of each joint or connection which needs to be inspected during the hydrostatic test. (Note: each connection must be readily visible- i.e., no paint on welds, no insulation etc.).

TEST MEDIUM

NOTE: Hydrostatic testing is the preferred method for testing due to the inherent danger of pneumatic testing with the stored energy of a compressible gas.

Hydrostatic Tests

The preferred medium for performing hydrostatic testing is demineralized water. The individual determining what testing is required shall determine the quality of the water introduced to the system. The temperature of the test medium shall be the same as the equipment.

No other test medium for hydrostatic testing other than water is allowed. Review of any other medium will be on a case by case basis, with written approval by the Head of the Engineering and Infrastructure Department for any exceptions.

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Pneumatic Testing

The preferred medium for pneumatic testing is nitrogen. Other noncombustible/non- flammable gases may be used but nitrogen is preferred. In no case shall a flammable gas or oxidizer be used as the test medium for a pneumatic test without the written approval by the Head of the Engineering & Infrastructure Department. The temperature of the test medium shall be the same as the equipment. Compressed air may be used for sprinkler systems.

TEST PRESSURE REQUIREMENTS

1. The test pressure shall not exceed the maximum allowable test pressure of any non-isolated component such as a vessel, pump or valve in the system as determined by engineering calculation or manufacturer's specification.
2. The gage must have been calibrated within one year of the pressure test;
3. The pressure gage must be visible to the person applying the pressure to the system;
4. The range of the gage must be at least 1.5 times the test pressure and preferably 2 times the test pressure so that an accurate reading of the test pressure can be established. The spacing between graduations shall be such that the inspector shall be able to determine that the required test pressure has been applied.

Hydrostatic Testing

The test pressure for a hydrostatic test shall be 1.5 times the maximum allowable working pressure (i.e., system designed for 200 psig, test pressure shall be 300 psig). Pressure for sprinkler systems shall be in accordance with NFPA 13.

Pneumatic Testing

The minimum test pressure for a pneumatic test shall be 1.2 times the maximum allowable working pressure. The maximum pressure shall not exceed 1.3 times the design pressure (i.e., system designed for 200 psig, test pressure shall be 240 psig). Pressure for sprinkler systems shall be in accordance with NFPA 13.

ALLOWABLE TOLERANCE ON ESTABLISHING INITIAL TEST PRESSURE	
<u>TEST PRESSURE</u>	<u>TOLERANCE</u>
16 TO 50 psig	.0 / + 2 psig
51 TO 100 psig	.0 / + 5 psig
101 TO 250 psig	.0 / +10 psig
251+ psig	.0 / +20 psig

APPLICATION OF TEST PRESSURE

The test pressure shall be gradually increased in the system to not more than one - half of the test pressure. Thereafter, the pressure shall be increased in steps of approximately one tenth of the test pressure until the required pressure has been reached. Once the pressure has been achieved and stabilizes (at least ten minutes) the system must be isolated from the pressure source.

Completion of the test can be by one of two methods:

OPTION 1. The test pressure shall be maintained without any change for at least ten minutes from the time the system was isolated from the pressure source, during which time there shall be no change in the pressure reading on the calibrated pressure gage. After the ten minute time period, the pressure may be reduced to the design pressure (or 15 psig, whichever is less) and held for a sufficient time to permit inspection of each of the connections. The inspection pressure may be increased if necessary with the approval of the Safety Division. Any leaks or failure to maintain pressure requires a repair and retesting.

OPTION 2. The test pressure must be maintained for a period not less than one hour during which time there shall not be a pressure drop on the calibrated gage greater than 2 percent of the test pressure for the one hour period. After the time period, the pressure may be reduced to the design pressure (or 15 psig, whichever is less) for inspection. The inspection pressure may be increased if necessary with the approval of the Safety Division. Failure to achieve this criterion would require a reduction in the pressure, examination for leaks, and repair and retesting.

OPTION 3. When testing flexible hoses that exhibit stretching with the application of test pressures the following alternate method may be applied.

- a. Apply the test pressure, isolate and hold. Record the rate of pressure drop for a fixed amount of time (psi/minutes).
- b. Reapply the test pressure, isolate and hold for the time period used in (a.) above. Record the amount and rate of pressure drop.
- c. Repeat b.
- d. A test is successful if the rate of pressure drop in steps b and c are each lower than the preceding step.

OPTION 4. The test may be performed according to the manufacturer's specification or an alternative method approved by the Cog Engineer as long as the pressures do not exceed either the test pressure or inspection pressure specified in this procedure.

SAFETY PRECAUTIONS

The following safety actions are mandatory during the application of a test pressure, when appropriate to the test being performed (consult with the Safety Division if assistance is needed to determine appropriate safety actions for a specific test):

REQUIREMENTS FOR HYDROSTATIC AND PNEUMATIC TESTING**Attachment 2**

Before approaching the pressurized system to examine the system for a leak, the system test pressure must be reduced to the design pressure (or 15 psig, whichever is less). This pressure can be raised with the approval of the Safety Division.

Each member of the test team shall wear goggles, a full face shield and ear protection whenever pressure is applied to the system being tested.

Each valve which has been closed to contain the pressure shall be appropriately tagged to prevent inadvertent operation and assure that it will be returned to its normal position after the test.

The area where the test is being performed shall be roped off to prevent access to the general work force with signs posted on the ropes warning about the test.

Joints in the system which would be subjected to failure or flexible tubing shall be restrained during the test to prevent personnel injury.

Requirements of PPPL ES&H Directives Manual Section 9.11 "Pressure Systems" shall be complied with.

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ITEMS EXEMPT FROM HYDROSTATIC AND PNEUMATIC TESTING			Attachment 3

ITEMS EXEMPT FROM HYDROSTATIC AND PNEUMATIC TESTING

The following items are exempt from Hydrostatic or Pneumatic Testing under this procedure:

1. Any pressure vessel that is designed to operate at less than 15 psig

SELECTING APPLICABLE B31 PIPING CODE SECTIONS

SELECTING THE APPLICABLE ASME PIPING CODE

It is the RLM's responsibility to select the Code Section(s) that apply to a proposed piping installation. Factors to be considered by the RLM include: scopes of the Code Sections; jurisdictional requirements; and the applicability of other codes and standards. Each B31 Code Section is intended to be applied as a whole to a given piping system; however, for some installations, more than one Code Section may apply to different parts of a piping system or to different parts of the installation, and the RLM shall clearly identify where any transition points occur. The RLM is also responsible for imposing requirements supplementary to those of the Code if necessary to assure safe piping for the proposed installation. This document provides guidance in the form of descriptions of the ASME B31 Code Section scopes to assist the RLM in making an appropriate selection. Most of the experimental systems at PPPL fall into the B31.1 and B31.3 piping codes. If there are any questions concerning the selection of the appropriate Code section the Subject Matter Expert should be consulted.

ASME B31 CODE SECTION DESCRIPTIONS

The ASME B31 Code for Pressure Piping consists of a number of individually published Sections. The rules contained in each Section reflect the kinds of piping installations that the responsible subcommittee had in mind during development of that Section. The kinds of piping system to which a Section is intended to apply is found in the beginning of each Section under the heading of "Scope." Following are abbreviated scopes of all Sections to assist in the Owner in selection of the appropriate Section.

B31.1 Power Piping: piping typically found in electric power generating stations, in industrial and institutional plants, geothermal heating systems, and central and district heating systems. B31.1 is intended to be applied to:

- Piping for steam, water, oil, gas, air and other services
- Metallic and nonmetallic piping
- All pressures
- All temperatures above -29°C (-20°F)

B31.1 is mandatory for piping that is attached directly to an ASME Section I boiler up to the first isolation valve, except in the case of multiple boiler installations where it is mandatory up to the second isolation valve.

B31.3 Process Piping: piping typically found in process facilities such as petroleum refineries, chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants, and related processing plants and terminals. B31.3 is intended to be applied to:

- Piping for all fluid services
- Metallic and nonmetallic piping
- All pressures
- All temperatures

The owner is responsible for designating when certain fluid services (i.e. Category M (toxic), high purity, high pressure, elevated temperature or Category D (nonflammable, nontoxic fluids at low pressure and temperature) are applicable to specific systems and for designating if a Quality System is to be imposed.

B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids: piping transporting products which are predominately liquid between wells, plants, and terminals, and within terminals, pumping, regulating, and metering stations. B31.4 is intended to be applied to:

- Piping transporting liquids such as crude oil, condensate, natural gasoline, natural gas liquids, liquefied petroleum gas, carbon dioxide, liquid alcohol, liquid anhydrous ammonia, and liquid petroleum products
- Piping at pipeline terminals (marine, rail, and truck), tank farms, pump stations, pressure reducing stations, and metering stations, including scraper traps, strainers, and prover loops;
- All pressures
- Temperatures from -29 to 121°C (-20 to 250°F) inclusive.

B31.4 covers the design, construction, operation, and maintenance of these piping systems, B31.4 does not have requirements for auxiliary piping, such as water, air, steam, and lubricating oil.

B31.5 Refrigeration Piping and Heat Transfer Components: piping and heat transfer components containing refrigerants and secondary coolants including water when water is used as a secondary coolant. B31.5 is intended to be applied to:

- Refrigerant and secondary coolant piping
- Heat transfer components such as condensers and evaporators
- All pressures
- Temperatures at and above -320°F (-196°C)

B31.8 Gas Transportation and Distribution Piping Systems: piping transporting products which are predominately natural gas between sources and end-use services. B31.8 is intended to be applied to:

- Onshore and offshore pipeline facilities used for the transport of gas
- Gathering pipelines
- Gas distribution systems
- Piping at compressor, regulating, and metering stations
- All pressures
- Temperatures from -29 to 232°C (-20 to 450°F) inclusive.

B31.8 covers the design, construction, operation, and maintenance of these piping systems, but it does not have requirements for auxiliary piping, such as water, air, steam, or lubricating oil.

B31.9 Building Services Piping: piping typically found in industrial, institutional, commercial, and public buildings, and in multi-unit residences. B31.9 is intended to be applied to:

- Piping for water and anti-freeze solutions for heating and cooling, steam and steam condensate, air, combustible liquids and other nontoxic, nonflammable fluids contained in piping not exceeding the following
- Dimensional limits
 - Carbon steel: NPS 42 (DN 1050) and 0.500 in. (12.7 mm) wall
 - Stainless steel: NPS 24 (DN 600) and 0.500 in. (12.7 mm) wall
 - Aluminum: NPS 12 (DN 300)
 - Brass and copper NPS 12 (DN 300), 12.125 in. (308 mm) for copper tube.
 - Thermoplastics: NPS 24 (DN 600)
 - Ductile Iron: NPS 24 (DN 600)

REQUIREMENTS FOR HYDROSTATIC AND PNEUMATIC TESTING**Attachment 4**

- Reinforced Thermosetting Resin: NPS 24 (DN 600)
- Pressure and temperature limits, inclusive:
 - Compressed air, steam and steam condensate to 1035 kPa (150 psi) gage
 - Steam and steam condensate from ambient to 186°C (366°F)
 - Other gases from ambient to -18 to 93°C (0 to 200°F)
 - Liquids to 2415 kPa (350 psi) gage and from -18 to 121°C (0 to 250°F)
 - Vacuum to 1 Bar (14.7 psi).
- Piping connected directly to ASME Section IV Heating Boilers.

B31.11 Slurry Transportation Piping Systems: piping transporting aqueous slurries between plants and terminals and within terminals. B31.11 is intended to be applied to

- Piping transporting aqueous slurries of nonhazardous materials
- Piping in pumping, and regulating stations
- All pressures
- Temperatures from -29 to 121°C (-20 to 250°F) inclusive

B31.11 does not have requirements for auxiliary piping, such as water, air, steam, lubricating oil, gas, and fuel.

B31.12 Hydrogen Piping and Pipelines: This Code is applicable to piping in gaseous and liquid hydrogen service and to pipelines in gaseous hydrogen service. This Code is applicable up to and including the joint connecting the piping to associated pressure vessels and equipment.