PRESSURE AND LEAK TESTING

Piping Design Class

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WHY?

- Pressure testing is required by most piping codes to verify that a new, modified, or repaired piping system is:
  1. capable of safely withstanding its rated pressure
  2. Leak tight.

LEAK-TESTING METHODS

1. **Hydrostatic testing**, which uses water or another liquid under pressure
2. **Pneumatic or gaseous-fluid testing**, which uses air or another gas under pressure
3. A **combination of pneumatic and hydrostatic testing**, where low pressure air is first used to detect leaks
4. **Initial service testing**, which involves a leakage inspection when the system is first put into operation
5. **Vacuum testing**, which uses negative pressure to check for the existence of a leak
6. **Static head testing**, which is normally done for drain piping with water left in a standpipe for a set period of time
7. **Halogen and helium leak detection**

Hydrostatic Leak Testing

- preferred leak-testing method and perhaps the **most often used**.
- **Safety**: Water is a much safer fluid test medium than air because it is nearly incompressible.
- Substantially **Less work** is required to compress the water to a given pressure relative to air.(1000 psig: 2500~1)

Hydrostatic Leak Testing

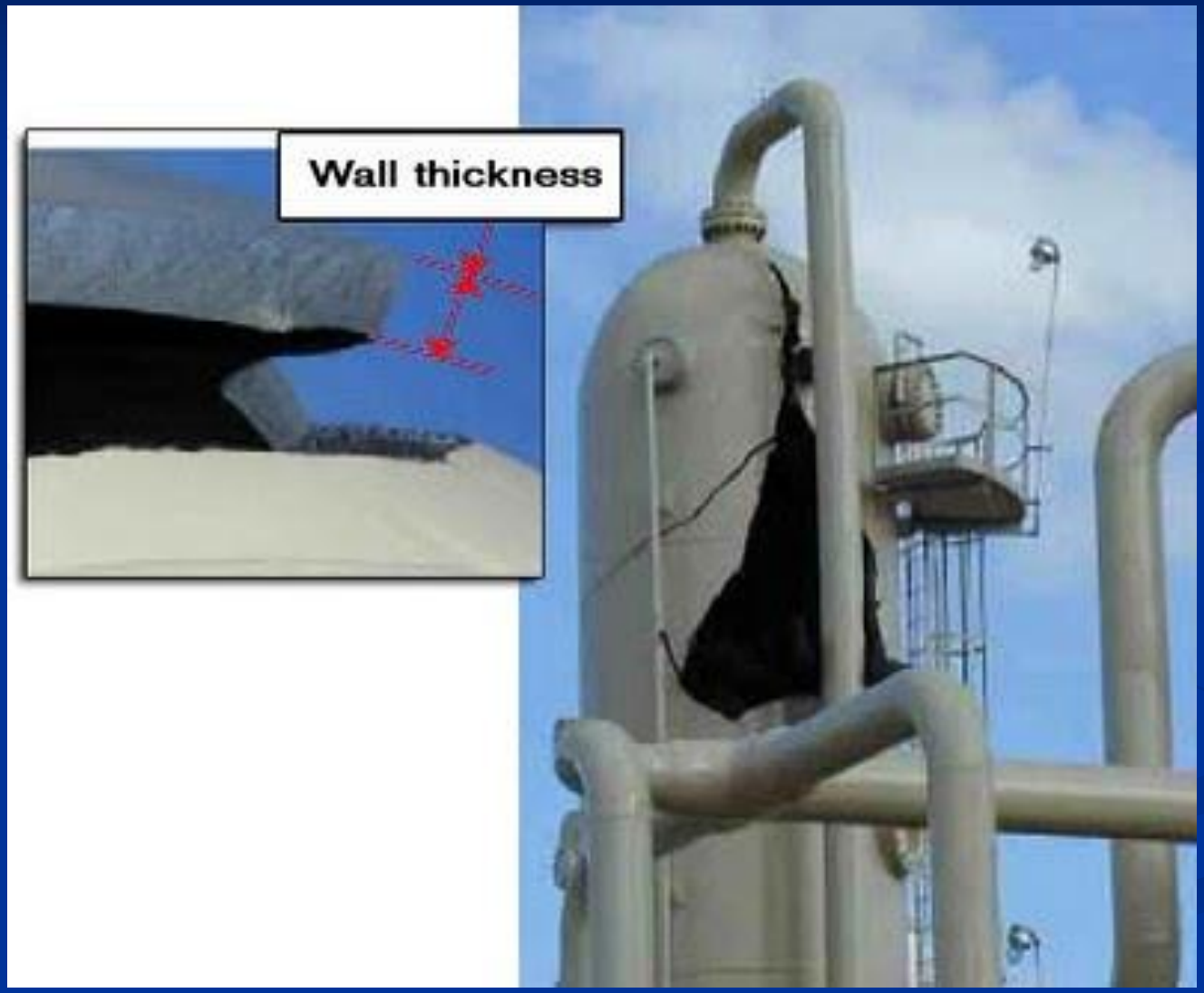
- danger due to air trapped in the piping
- not practical if during normal operation, the piping system cannot tolerate traces of water or its residue. e.g. cryogenic system
- more time to fill and empty the system
- Gas plants: piping may not be strong enough to support the weight of a liquid

Hydrostatic Leak Testing

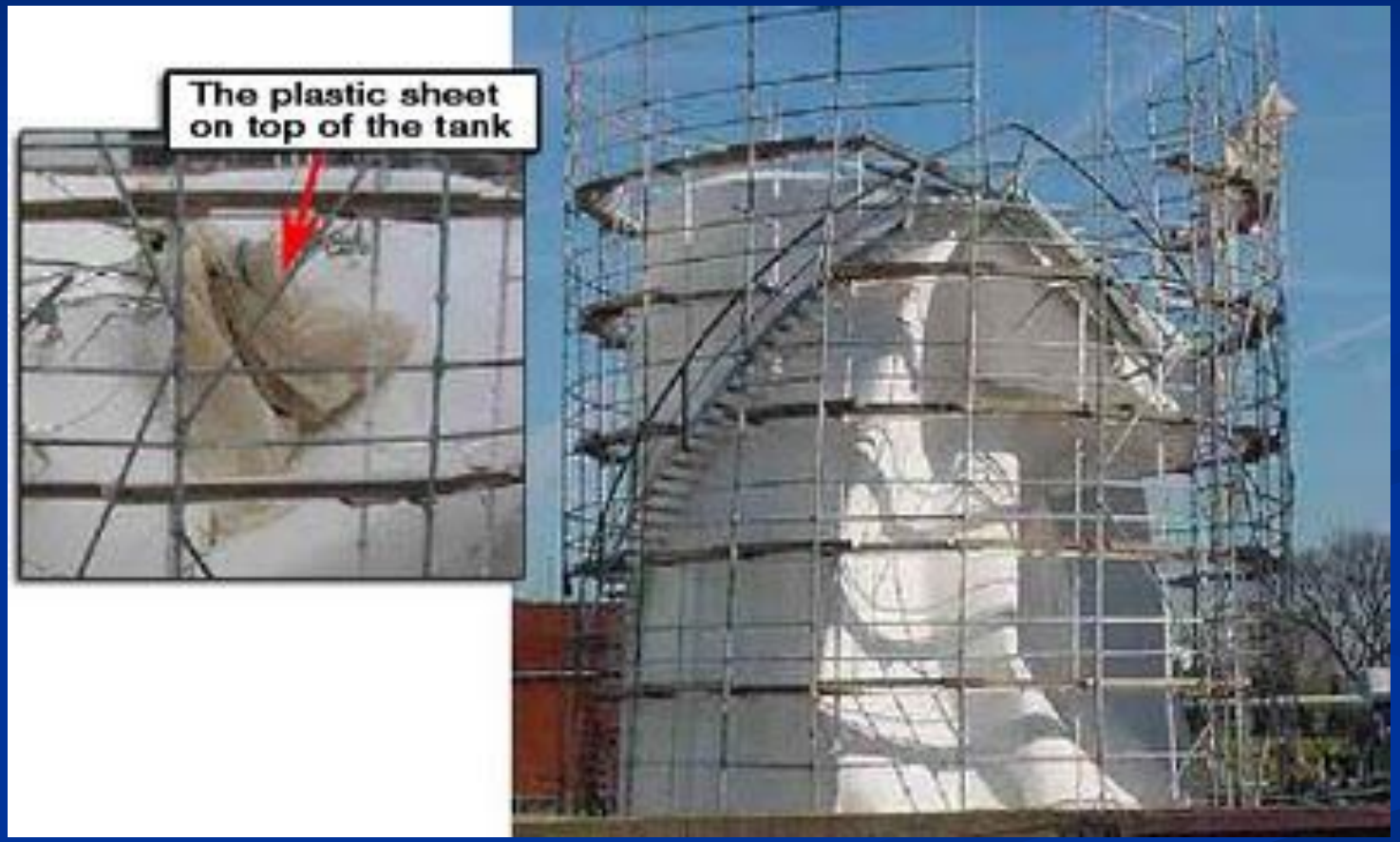
- Inspection for leaks is a visual examination of all joints for signs of water
- leak-detecting: not as good as a pneumatic test
- A hydrostatic test is sufficiently sensitive if the system normally operates with a liquid.
- If the system normally operates with a gaseous medium and slight leakage of this medium is unacceptable, a hydrostatic test may not be sufficiently sensitive to detect a slight gas leak.
- surface tension of water can act as a barrier to a leakage path that has a very small dimension.

WET SURFACE

FAILURES



FAILURES



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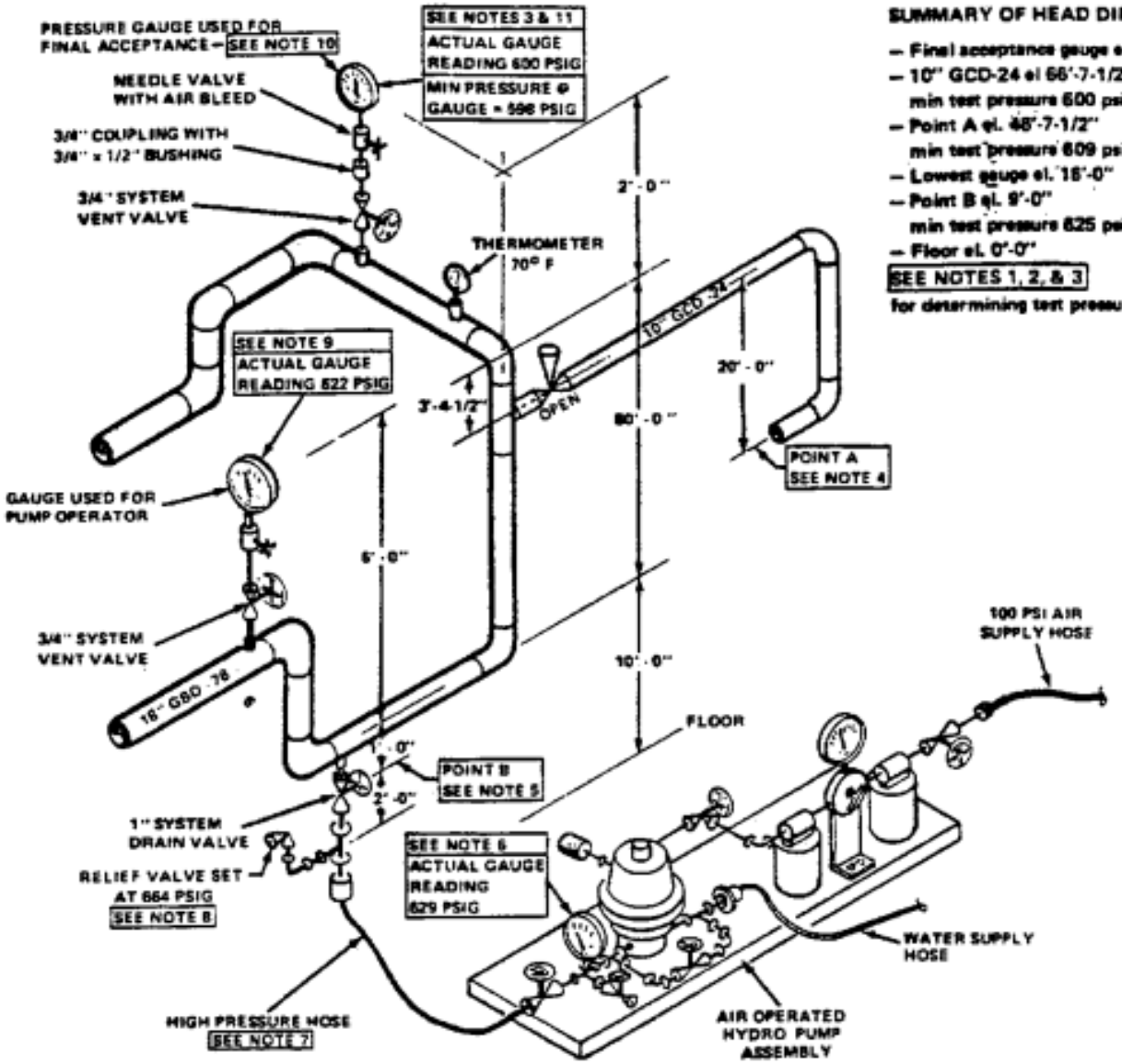


FIGURE B14.7 Hydrostatic test setup.

Pneumatic Leak Testing

- The fluid normally used is compressed air, or nitrogen if the source is bottled gas.
- Rupture could result in an **explosive** result of energy
- Greater danger: the pressure to be used for visual examination for leaks is **lower** for some piping codes than is the case for a hydrostatic test.
- ASME B31.1 permits the pressure to be reduced to the lower of 100 psig or the design pressure.
- Leak detection: soapy-water mixture, sonic listening (High pressures)
- 60m of NPS 36 air at 500 psi ~35 kg of TNT

مجتمع فنی نوین پارسیان

Shanghai LNG explosion

Mississippi -July 2009
1 dead,3 air lifted& injured

Combination Pneumatic and Hydrostatic Testing

- A low air pressure, most often 25 psig, is first used to see if there are major leaks.
- very effective in saving time: if it takes a long time to fill a system.
- If leaks are found in a hydrostatic test, it will take longer to remove the water and dry the piping sufficiently to make repairs.

Initial Service Leak Testing

- ASME B31.3 limits the use of this technique to category D fluid service. Category D fluid services are defined as non-hazardous to humans and must operate below 150 psi and at temperatures between 20F and 366F
- this test is usually run when the system is first put into operation. The system is gradually raised to normal operating pressure as required in ASME B31.1 or design pressure as required in ASME B31.3. It is then maintained at that pressure while an examination for leaks is conducted

Vacuum Leak Testing

- effective way to determine whether or not there is a leak anywhere in the system
- A leak is indicated if the trapped vacuum rises toward atmospheric pressure
- it is very difficult to determine the location or locations of a leak if one exists.
- Smoke generators have been used to determine the piping location where smoke is drawn into the piping.
- this method is not suitable for testing the piping at or above the operating pressure unless the piping is to be operated at a vacuum.

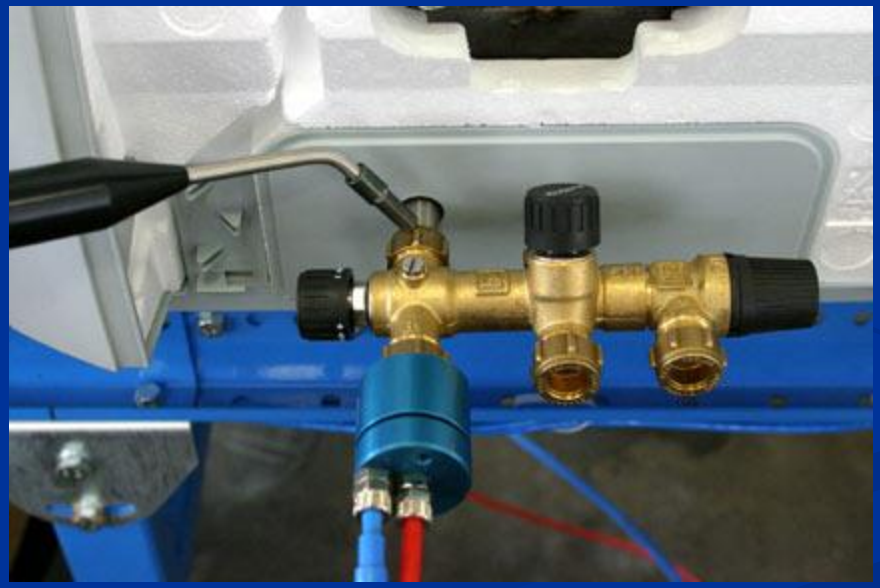

MAIN DISCONNECT
208 VAC, 3 PH, 30 AMP
CONTROLS
VACUUM GAUGES
GAUGE ONE
GAUGE TWO
Helium Leak Testing, Inc.

Static-Head Leak Testing

- Also called a drop test
- Once the system and standpipe is filled with water, the standpipe level is measured and noted. After a required hold period, the height is rechecked and any decrease in level and the hold period are recorded. Any leak location is determined by visual inspection.

Halogen and Helium Leak Testing

- use a tracer gas to identify leakage location and leakage quantity
- halogen detector probe is used to sense leakage of the tracer gas from any exposed joint.
- capable of sensing leaks as small as 1e-10 cc/sec
- Helium leak detectors will not be successful in finding leaks unless the component or piping system is completely dry-sealing the cracks.



SELECTION OF A TEST METHOD AND FLUID TEST MEDIUM

- The test method and fluid test medium to be used are most often **known at the early stage of design** of the piping system. The piping system **contract** will usually specify the applicable **codes**.
- The **codes** in turn specify the allowable pressure and leak-testing methods.

Test Pressures

- In most cases a pressure greater than the design pressure rating is applied for a short duration, say at least **10 minutes**. The magnitude of this initial test pressure is often at least **1.5 times** the design pressure rating for a hydrostatic test.
- the test pressure must never exceed a pressure that would cause **yielding**, or the maximum allowable test pressure of some **component** exposed to the test

TABLE B14.1 Test and Examination Pressures

Code	Test type	Test pressure minimum	Test pressure maximum	Test pressure hold time	Examination pressure
ASME B31.1	Hydrostatic[1]	1.5 times design	Max allowable test pressure any component or 90 percent of yield	10 minutes	Design pressure
ASME B31.1	Pneumatic	1.2 times design	1.5 times design or max allowable test pressure any component	10 minutes	Lower of 100 psig or design pressure
ASME B31.1	Initial service	Normal operating pressure	Normal operating pressure	10 minutes or time to complete leak examination	Normal operating pressure
ASME B31.3	Hydrostatic	1.5 times design[2]	Not to exceed yield stress	Time to complete leak examination but at least 10 minutes	1.5 times design

ASME B31.3

- Prior to initial operation, and after completion of examinations
- test shall be a hydrostatic leak test except:

1-Category D, Owner's Option

=>initial service testing

2-Owner considers a hydro-test impracticable

=>pneumatic or combination

3-Owner considers Both Hydro. And Pneum. Impracticable

=>Alternative Leak Test

Alternative Leak Test

1. a hydrostatic test would damage linings or internal insulation, or contaminate a process which would be hazardous, corrosive, or inoperative in the presence of moisture, or would present the danger of brittle fracture due to low metal temperature during the test.
2. a pneumatic test would present an undue hazard of possible release of energy stored in the system, or would present the danger of brittle fracture due to low metal temperature during the test.

Alternative Leak Test

1-Examination of Welds Welds, including those used in the manufacture of welded pipe and fittings, which have not been subjected to hydrostatic or pneumatic leak tests in accordance with this Code, shall be examined as follows:

(a) Circumferential, longitudinal, and spiral groove welds shall be 100% radiographed or 100% ultrasonically examined

(b) All welds, including structural attachment welds, not covered in (a) above, shall be examined using the liquid penetrant method or, for magnetic materials, the magnetic particle method

2-Flexibility Analysis

3- sensitive leak test

General Requirements for Leak Tests

1. Stress shall not exceed Yield Strength
2. Test Fluid Expansion
3. Preliminary Pneumatic Test: no more than 25 psig
4. Examination for Leaks: at least 10 min, and all joints and connections
5. Heat Treatment: after any heat treatment
6. Low Test Temperature

Special Provisions for Testing

(a) Piping Subassemblies. Piping subassemblies may be tested either separately or as assembled piping.

(b) Flanged Joints. A flanged joint at which a blank is inserted to isolate other equipment during a test need not be tested.

(c) Closure Welds. The final weld connecting piping systems or components which have been successfully tested need not be leak tested provided the weld is examined in-process and passes with 100% radiographic examination or 100% ultrasonic examination

Repairs or Additions After Leak Testing

If repairs or additions are made following the leak test, the affected piping shall be retested, except that for minor repairs or additions the owner may waive retest requirements when precautionary measures are taken to assure sound construction.

Test Records

(a) date of test

(b) identification of piping system tested

(c) test fluid

(d) test pressure

(e) certification of results by examiner

Preparation for Leak Test

- **Joints Exposed**. All joints, including welds and bonds, are to be left **uninsulated** and exposed for examination during leak testing, except that joints previously tested in accordance with this Code may be insulated or covered. All joints may be primed and **painted** prior to leak testing unless a sensitive leak test is required.
- **Temporary Supports**. Piping designed for vapor or gas shall be provided with additional temporary supports, if necessary, to support the weight of test liquid.

Limits of Tested Piping

- **Equipment** which is not to be tested shall be either disconnected from the piping or isolated by **blinds** or other means during the test. A valve may be used provided the valve (including its closure mechanism) is suitable for the test pressure.

Hydrostatic Leak Test

Test Pressure. the hydrostatic test pressure at any point in a metallic piping system shall be as follows:

(a) **not less** than 1/2 times the design pressure;

(b) for design temperature above the test temperature, the **minimum test pressure** shall be calculated by Eq. (24), except that the value of ST/S shall not exceed 6.5:

(c) if the test pressure as defined above would produce a nominal pressure stress or longitudinal stress in excess of the 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.

$$P_T = \frac{1.5PS_T}{S}$$

Pneumatic Leak Test

- **Pressure Relief Device**. set pressure not higher than the test pressure plus the lesser of 50 psi or 10% of the test pressure.
- **Test Pressure**. The test pressure shall be **110%** of design pressure.
- **Procedure.** The pressure shall be gradually increased until a gage pressure which is the lesser of one-half the test pressure or 25 psi is attained, at which time a preliminary check shall be made, including examination of joints. Thereafter, the pressure shall be gradually increased in steps until the test pressure is reached, holding the pressure at each step long enough to equalize piping strains. The pressure shall then be reduced to the design pressure before examining for leakage.

Initial Service Leak Test

- This test is applicable only to piping in Category D Fluid Service, at the owner's option.
- **Test Fluid**. The test fluid is the service fluid.
- **Procedure**. During or prior to initial operation, the pressure shall be gradually increased in steps until the operating pressure is reached, holding the pressure at each step long enough to equalize piping strains. A preliminary check shall be made if the service fluid is a gas or vapor.

Sensitive Leak Test

- **Sensitivity** of the test shall be not less than 1e-3 atm. ml/sec
- The **test pressure** shall be at least the lesser of 15 psig, or 25% or the design pressure.
- The pressure shall be **gradually increased** until a gage pressure the lesser of one-half the test pressure or 25 psi is attained, at which time a preliminary check shall be made. Then the pressure shall be gradually increased in steps until the test pressure is reached, the pressure being held long enough at each step to equalize piping strains.

REFRENCES

1-Nayyar-Piping Handbook

2-ASME B31.3 chapter VI (345 TESTING)