UCRL-MI-124999

Welcome to Lawrence Livermore National Laboratory's...

HS5040-W
Intermediate Pressure Safety

Course Design

It is recommended that you have Netscape 4.6 or Internet Explorer 5.5 running on your computer. To see all pages and use all features of this course, your browser must have:

- Javascript enabled;
- Flash 4 plug-in;
- Audio capability (a sound card or built-in sound).

This course is required for all personnel who install or operate gas pressure systems between 150 pounds per square inch gage (psig) and 3000 psig or liquid systems between 1500 psig and 5000 psig. Completing this course qualifies you to work as a pressure operator or installer-in-training in the intermediate pressure range.

Course Goal

The goal of this course is to provide the necessary training so that, with the required practical experience, you will be able to work more safely with intermediate-level pressure.

Course Objectives

After successfully completing this course, you will be able to:

- Describe basic pressure safety principles.
- Select proper intermediate pressure hardware.
- Recognize the importance of pressure testing and documentation.
- Identify pressure safety responsibilities and resources to help you do your work safely.

Course Design

Use the "Exit", "Prev", and "Next" buttons to move through the course. These buttons are located at the top of every screen.

Exits the course and links to the Hazards Control Training Webpage.

Steps back one page.

Steps forward one page.

Notes:

- HS5030-W (Pressure Safety Orientation) is a prerequisite for this course and workers must re-qualify every five years by taking HS5031-W (Pressure Safety Requalification). Please check your training records before you continue.
- You must pass the test at the end of the course with a score of at least 80% to get credit for the training.

Before continuing, it is recommended that you print out two supplements to this course. First, because you will be asked to reference information in these documents throughout the course. And second, because the documents will prove useful in performing your everyday pressure tasks. You can also bookmark the links in your browser for quick reference. Click on each button below to view the documents in a separate window. You will need Adobe Acrobat Reader to view these documents.

Appendix D (Appendix D, ES&H Manual, Document 18.2)

HS5040-W Reference Guide (Conversion charts, compatibility charts, etc.)

Module 1 - The Basics of Pressure

Learning Objectives:

After completing Module 1, you will be able to:

- Identify the different units of pressure.
- Distinguish between types of pressure.
- Apply Pascal's Law (Force = Pressure x Area).
- Categorize similarities and differences of gases and liquids.

Types of Pressure

There are three ways to measure pressure. We will refer to these as the three different *types* of pressure.

1) Atmospheric pressure

2) Gage Pressure

3) Absolute Pressure

Units of Pressure

Following are some units of pressure commonly used at LLNL.

- psig - pounds per square inch gage
- ksi - 1,000 pounds per square inch
- Pascal (Pa) = Newtons per square meter

See the HS5040-W Reference Guide for unit conversion charts.

Types of Pressure

Atmospheric pressure is the force exerted on you by the weight of air. We are most familiar with atmospheric pressure at sea level. Here are several ways that pressure can be identified at sea level:

- 14.7 psi
- 29.92 in. of mercury (unit used in barometers)
- 407 in. of water
- 760 Torr (metric - mm of mercury)
- 1.013 bars (used in physics; temperature-dependent)
- 101.4 kPa

Types of Pressure

Gage pressure is the pressure of a system measured by a pressure gage, which excludes atmopheric pressure.

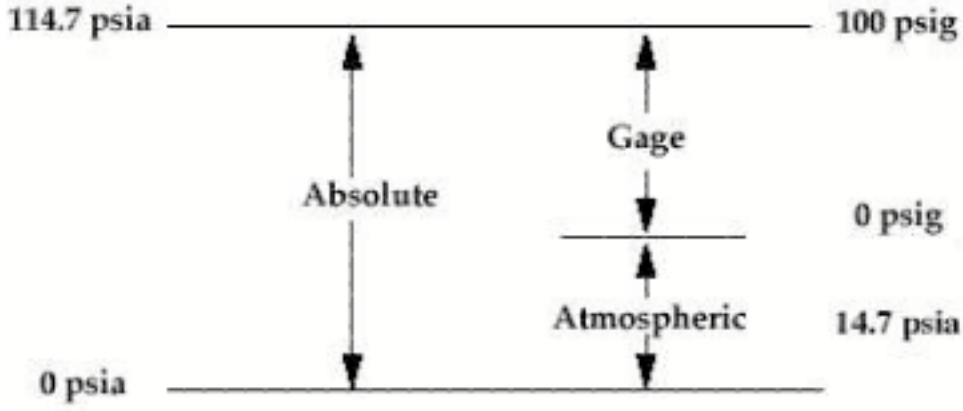
Example pressure gage

Types of Pressure

Absolute pressure is the total pressure exerted on a system; it equals gage pressure plus atmospheric pressure.

Absolute Pressure = Gage Pressure + Atmospheric Pressure

The following diagram illustrates this relationship.



Pascal's Law

The most over-looked hazard when dealing with pressurized systems is the potential force associated with them. Pascal's Law describes this hazard and is the fundamenal concept of this course, the law is defined as:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

OR

$$\text{Force} = \text{Pressure} \times \text{Area}$$

What impact can low pressure have on a large area?

Example: Let's say a mid-sized car is on a uniform steel platform. Approximately how much pressure (psi) do you think it would take to lift the car? Please select an answer with your mouse.

A) 0.5 psi

B) 5 psi

C) 50 psi

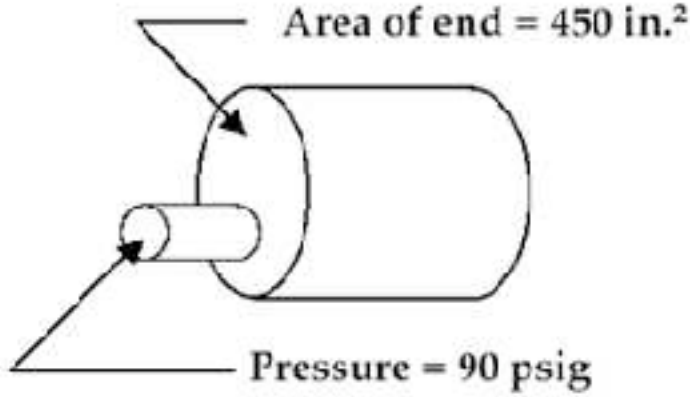
D) 500 psi

That's right! It could take a little as 1/2 psi! (If the car/platform weighed approximately 4000 lbs and the area of the platform was approximately 8000 sq in: P = 4000 lbs/8000 sq in = 0.5 psi). As you can see, it only takes a little pressure over a large area to produce enough force to lift a car!

Here is another example of Pascal's Law and the effect of low pressure on a large area.

How much force is on the end of the drum? Please type your answer here: 90 lbs. *(do not use punctuation)*

Check Answer



That's Right! Relatively low pressure of 90 psig against a drum lid of 450 sq. in. can produce 40,500 lbs. of force! ($P = F/A$, $F = P \times A$, *90lb/sq in x 450 sq in = 40,500 lbs. of force.)* *Wow!*

That's right! As you can see, the potential for stored energy is much higher when working with gas!

Gas - failed at 3,300 psig. 1452 Ft. lbs. of stored energy.

Liquid - failed at 3,200 psig water. 5.19 Ft. lbs. of stored energy.

Take a look at the following Lessons Learned to see an LLNL example of why you should always respect pressure. By clicking on the hyperlink, the document will open in a separate window. When you are finished reviewing the document, close that window and click the continue button below.

Lessons Learned: Lid Blows Off Pressurized Empty Drum (1/5/99)

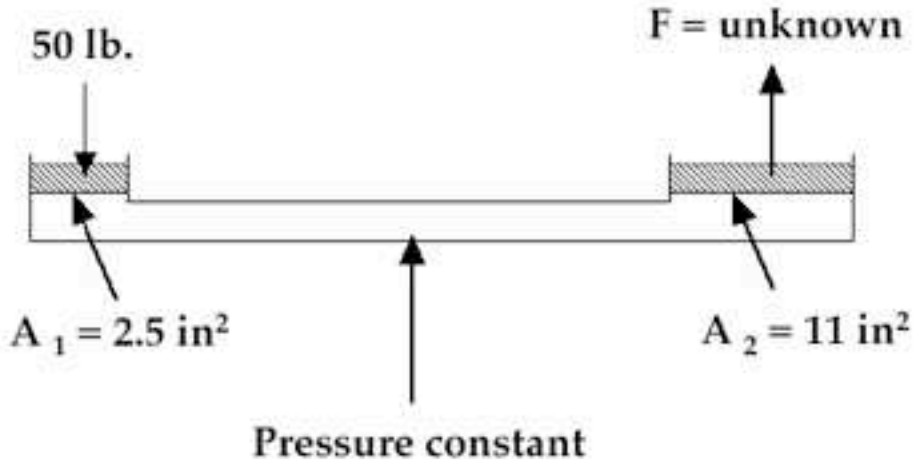
Continue

As you can see from the Lessons Learned, pressure accidents can be unexpected. Again, it doesn't take much pressure to produce a lot of force. That lid was moving at a high velocity after disengaging from the drum. Luckily, the worker wasn't standing in the lid's path.

Another Pascal's Law Example

Here is another example of Pascal's Law. This example is very similar to how a hydraulic jack works.

What is the upward force exerted on the large piston? Please type your answer here: F = 220 lbs.



That's Correct! P = F/A1, 50 lb /2.5 sq. in. = 20 psi. F unknown = P x A2 = 20 psi x 11 sq. in. = 220 lbs.

Fluids: Gas versus Liquid

Liquid

- Obeys Pascal's Law
- Volume is a function of temperature and pressure (given any 2, the 3rd can be determined)
- Seeks own level
- Relatively incompressible*

Gas

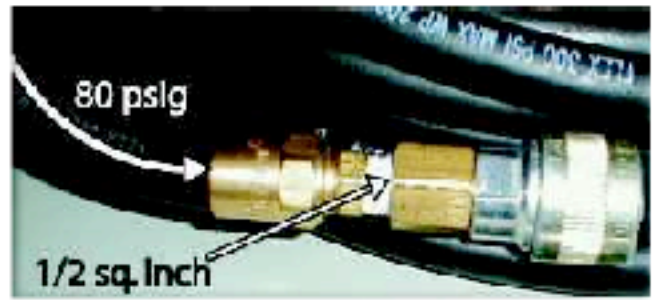
- Obeys Pascal's Law
- Volume is a function of temperature and pressure (given any 2, the 3rd can be determined)
- Fills any container, regardless of shape
- Compressible*

* *Compressibility is important for stored energy considerations. The potential for stored energy is much higher when working with gas than with liquid.*

Module 1 Review - Question 1 of 2

Suppose you have an air line with 80 psig of pressure. If the end fitting has an area of 1/2 sq. in., what would be the potential force to the fitting if it were to disengage from the air line? Please select an answer.

A) 5 lbs.
B) 20 lbs.
C) 40 lbs.
D) 60 lbs.



That's right! (F = 80 psig x 1/2 sq. in. = 40 lbs.) If the fitting weighed just a couple ounces, it would have come off the end of the hose with a lot of velocity and could endanger the safety and lives of people working in the area.

Module 1 Review - Question 2 of 2

Suppose Steve is working with two systems, one with gas and the other with liquid. Which system has a potential for greater stored energy? Pick one with your mouse.

Gas System

Liquid System

Module 2 - Fittings and Equipment

Learning Objectives:

After completing Module 2, you will be able to:

- Recall four ways of determining component Maximum Allowable Working Pressure (MAWP).
- Identify considerations when selecting pressure fittings.
- Recognize types of pressure fittings.
- Identify considerations when selecting valves.

Determining Component Maximum Allowable Working Pressure (MAWP)

There are 4 general ways of identifying MAWP for pressure components. They are:

1) See MAWP rating stamped on part.

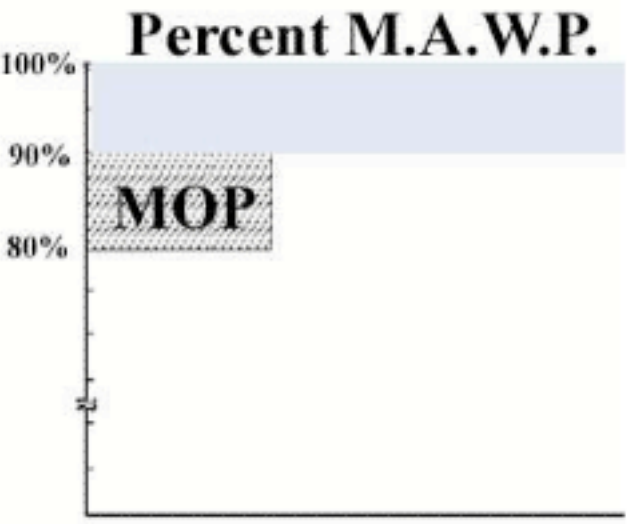
2) Reference Appendix D (*ES&H Manual*, Document 18.2).

3) Reference the manufacturer's catalog/data sheets.

4) Arrange for a lot sample testing.

Relationship of Defined Pressure Terms at LLNL

- Maximum Operating Pressure (MOP) is recommended to be set 10-20% lower than MAWP.
- Lower MOPs are all right; higher MOPs are NOT.
- Remember, you can NOT operate a system at MAWP. Consider this when selecting components.



Why is it important to determine the MAWP of components?

Bottom line: personnel protection.

The lowest rated component equals the MAWP. The MAWP determines your relief device setting and thus protects personnel.

Considerations When Selecting Pressure Fittings

Temperature Considerations:

- MAWP is based on operating temperature.
- Components are usually pressure rated at 70°F (21°C).
- Consider the strength of soldered and welded joints (refer to Appendix D, *ES&H Manual*, Document 18.2).

Other Fitting Considerations

- Ensure compatibility with fittings, seals, lubricants, and other fluids (Refer to the HS5040-W Reference Guide for fluid application details).
- Do NOT interchange different manufacturer's components.
- Do NOT tighten fittings when under pressure

Please look at Appendix D of the *ES&H Manual*, Document 18.2. If you did not print it out, please download a copy now.

As you can see, Appendix D is titled "Piping and Tubing Pressure Ratings". If you follow these component ratings, you can work safer. You will be required to reference Appendix D as you continue through the course.

Pipes versus Tubes

Pipe sizes are based on fixed outside diameter and a nominal inside diameter which varies with schedule number.

Example: Try to locate the MAWP of the following *Threaded Black Steel Pipe* using Appendix D. Type your answers in the blanks below. *(Do not use punctuation in your answers)*.

- IPS refers to nominal pipe size.
- Pressure rating is determined by schedule (SHC).

IPS	SCH	Outside Diameter (O.D.)	Inside Diameter (I.D.)	MAWP
1"	40	1.315"	1.049"	1080 psi Check Answer
1"	80	1.315"	0.957	2090 psi Check Answer

Tubes versus Pipes

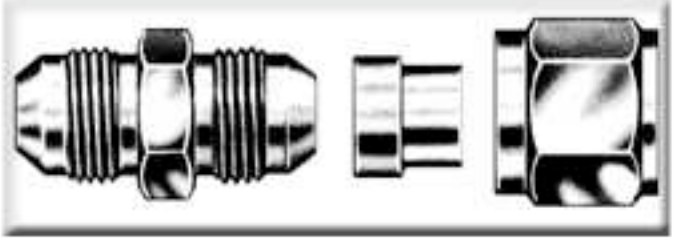
Tube sizes are based on an exact outside diameter and wall thickness.

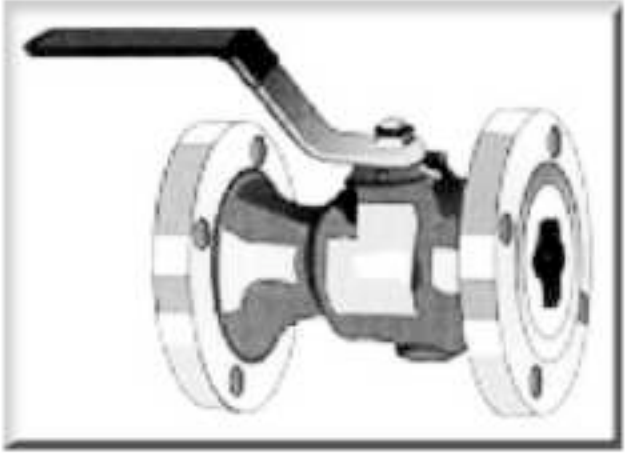
A tube's pressure rating is determined by its wall thickness.

Try to locate the MAWP of the following Stainless Steel Tubing using Appendix D. Type your answers in the blanks below. *(Do not use punctuation in your answers).*

Tube Size	Outside Diameter (O.D.)	Wall Thickness	MAWP	
1/4"	0.250"	0.020"	2790 psi	Check Answer
1/4"	0.250"	0.035"	5110 psi	Check Answer
1/4"	0.250"	0.049"	7470 psi	Check Answer

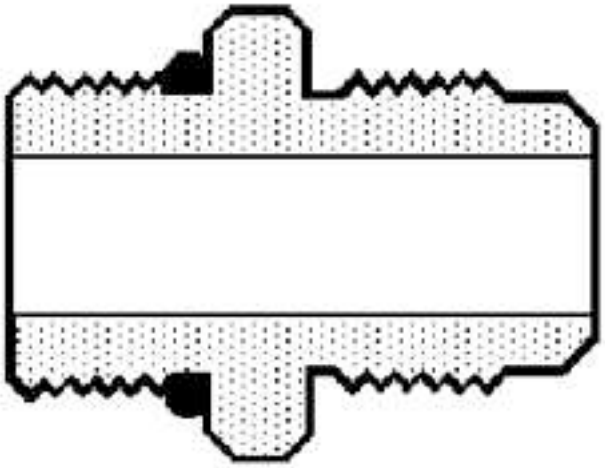
Following is information on pressure hardware. Each type of fitting and valve has a specific application. It is essential that you consider certain factors when selecting your hardware.





Straight Thread Fittings (Face Seal Fittings)

- NOT to be confused with National Pipe Taper (NPT).
- Requires sealing device, such as:
  - Gaskets
  - "O" Rings
- Useful for both vacuum and pressure.
- Well suited to quick assembly and re-assembly.

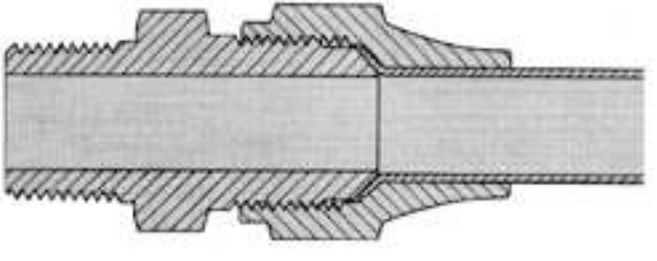


Flare Fittings

There are 2 types of Flare Fittings:
1) 45° Two-Piece
2) 37° Three-Piece

45° Two-Piece (usually used at 500 psig or BELOW)

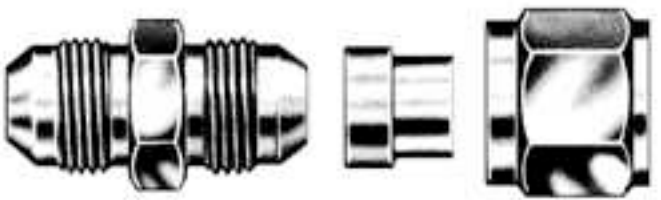
- Tube end flared to seal on mating part.
- Primarily brass construction.
- Common in refrigeration.



Flare Fittings

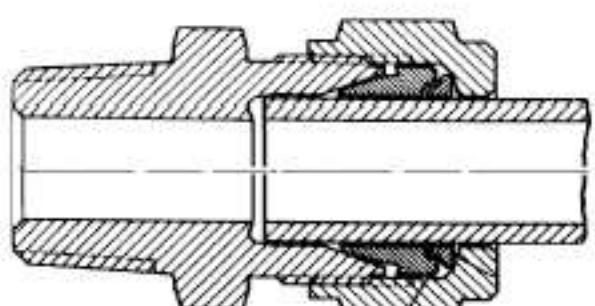
37° Three-Piece (up to 10,000 psig)

- Common in automotive (brake systems).
- Again, refer to Appendix D (ES&H Manual, Document 18.2) for tubing minimum/maximum wall thickness.



Compression Tube Fittings (Bite-Type)

- Pressure seal achieved by a ferrule system that either bites or deforms tube outside diameter.
- Used for simple make-up and assembly.
- Consider tubing minimum/maximum wall thickness. (refer to Appendix D).



Valves

- Used to control the flow of fluids.
- Many types and manufacturers are available.
- Applications frequently overlap.
- Before selection, define requirements and match according to manufacturer recommendations.

Valve Selection Considerations

Consider the following when selecting valves:

- Operating pressure and temperature.
- Flow requirements for your system.
- Body material/stem packing versus fluid.
- End connection type and size.
- Flow pattern.
- Flow control
  - Shut off
  - Regulating
  - Metering

Valve Types

Mouse over any of the blue phrases below for a photo of each item.

Ball valve

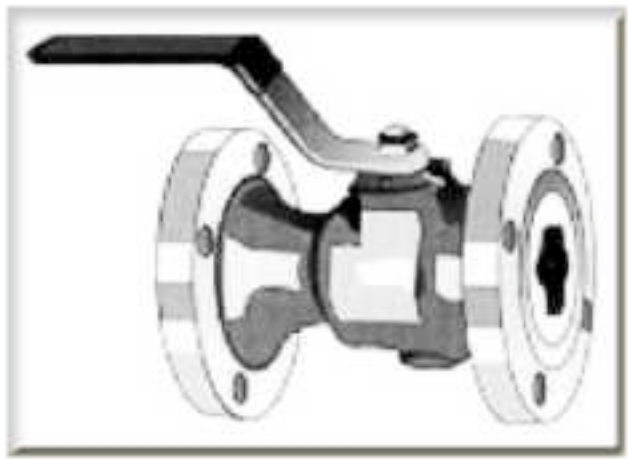
Plug valve

Regulating (needle) valve

Metering valve

Diaphragm valve

Bellows valve



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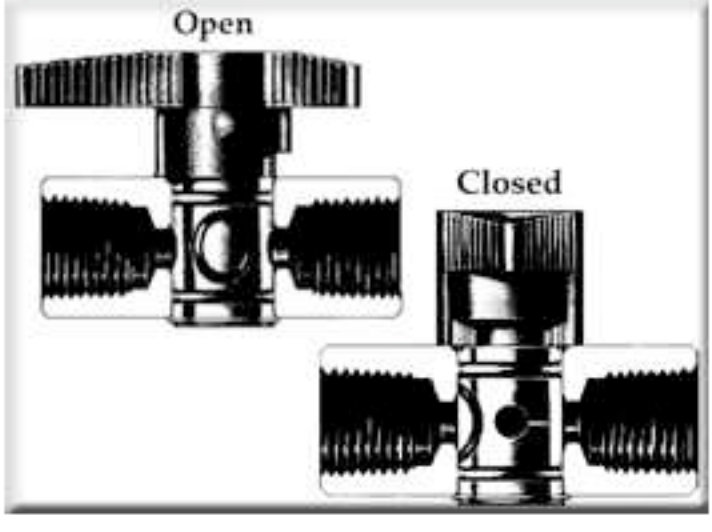

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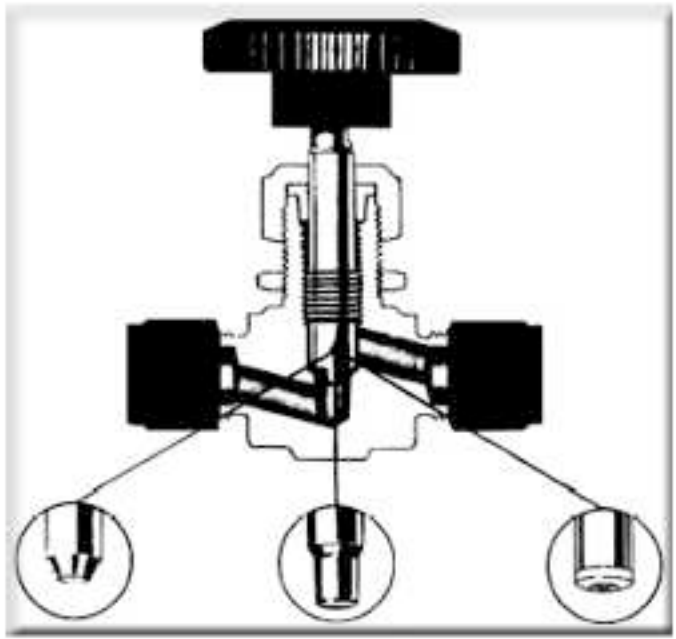

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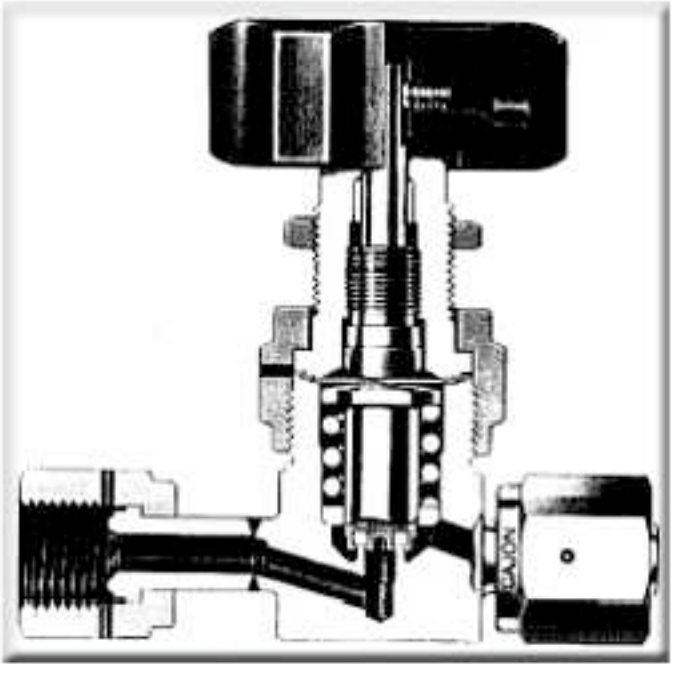

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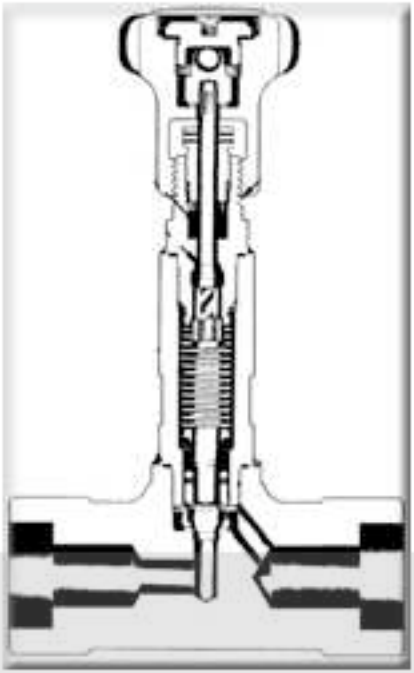


Module 2 Review - Question 1 of 4

Suppose Steve needs to determine the relief device setting for a piece of equipment. What designates the relief device setting? Please select an answer.

A) MOP

B) dPa

C) MAWP

D) MOWP

That's right! The Maximum Allowable Working Pressure (MAWP) identifies the relief device setting.

Module 2 Review - Question 2

How can Steve determine MAWP of a given component?

A) Check the part for MAWP.

B) Reference Appendix D, *ES&H Manual*, Volume II, Part 18.

C) Reference the manufacturer's catalog/date sheets.

D) Arrange for a lot sample pressure testing.

E) All of the above are correct.

That's right! The Maximum Allowable Working Pressure (MAWP) can be determined by doing any of the four above.

Module 2 Review - Question 3 of 4

Steve is a little concerned about the minimum/maximum wall thickness of the steel tubing he is using. Where can Steve find information on tubing pressure ratings?

A) Appendix D, *ES&H Manual*, Document 18.2.

B) HS5040-W Reference Guide.

C) Appendix A, *ES&H Manual*, Volume II, Part 18.

That's correct! Appendix D has piping and tubing pressure ratings.

Module 2 Review - Question 4 of 4

Steve is also concerned about the operating temperature of his system and the pressure fittings he has chosen. What information is true about temperature and pressure fittings? (choose the best answer)

A) MAWP is based on operating temperature.

B) A change in operating temperature will not affect the components.

C) Components are usually pressure rated at 70° Fahrenheit.

D) Both A and C are correct.

Right! Both A and C are correct statements. Steve should be aware that MAWP is based on operating temperature and components are usually pressure rated at 70° Fahrenheit.

Module 3 - Pressure Testing and Documentation

Learning Objectives:

After completing Module 3, you will be able to:

- Recognize why systems are tested, labeled, and reinspected at LLNL.
- Identify the requirements for pressure testing in the field.
- Identify pressure documentation requirements.

Pressure Testing

Why do we pressure test?

1) Safety

2) Reliability

3) To ensure leak tightness

Leak Testing

Leak testing is often required after pressure testing. Leak testing is:

- Usually done at MAWP.
- Best done as a manned area operation.

Simplest methods include:

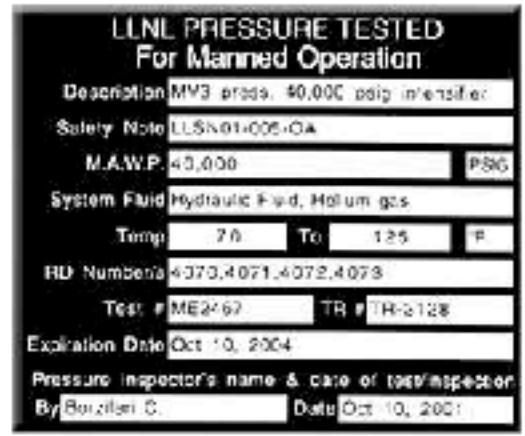
- Pressure drop on a gage for a given time.
- Soap bubble indications.
- Under water bubble techniques.

Labeling Pressure Equipment

Why do we label pressure equipment?

- Identification
- Tracking

Click the "Next Label" button to view more examples of LLNL pressure labels.



Pressure Tested Label: Pressure vessels and systems that require an Engineering Safety Note will have an this label attached by an LLNL Pressure Inspector. NOTE: EXPIRES EVERY THREE YEARS.

Next Label

Labeling Pressure Equipment

Why do we label pressure equipment?

- Identification
- Tracking

Click the "Next Label" button to view more examples of LLNL pressure labels.

Relief Device Tag - Pressure relief devices will have a metal tag wire-sealed to the relief device. NOTE: EXPIRES EVERY THREE YEARS.

Next Label

Labeling Pressure Equipment

Why do we label pressure equipment?

- Identification
- Tracking

Click the "Next Label" button to view more examples of LLNL pressure labels.

Remote Operation Label: This label will be attached to systems that will be operated remotely and not in a manned area.

Next Label

Labeling Pressure Equipment

Why do we label pressure equipment?

- Identification
- Tracking

Click the "Next Label" button to view more examples of LLNL pressure labels.

Out of Test Label: Pressure vessels or systems with this label attached have expired. They shall not be used until the system is retested or reinspected by an LLNL Pressure Inspector.

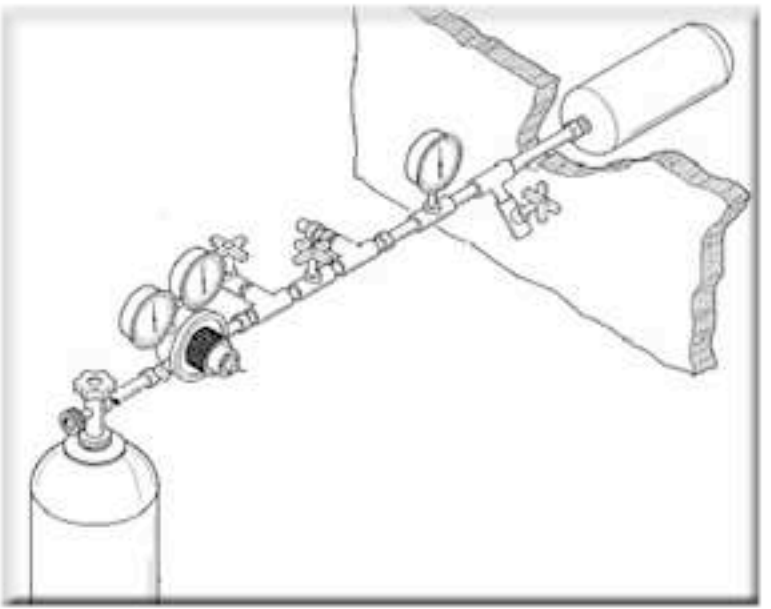
Retesting and Re-inspecting

Why retest and re-inspect pressure equipment?

1) Safety

2) Maintenance

3) Reliability



Note: Pressure systems that require an Engineering Safety Note are re-inspected every 3 years and retested every 6 years.

Select the Next button to continue.

Requirements for Pressure Testing in the Field

1) An Engineering Safety Note/test procedure must be written.

2) Document your individual proof/leak test requirements.

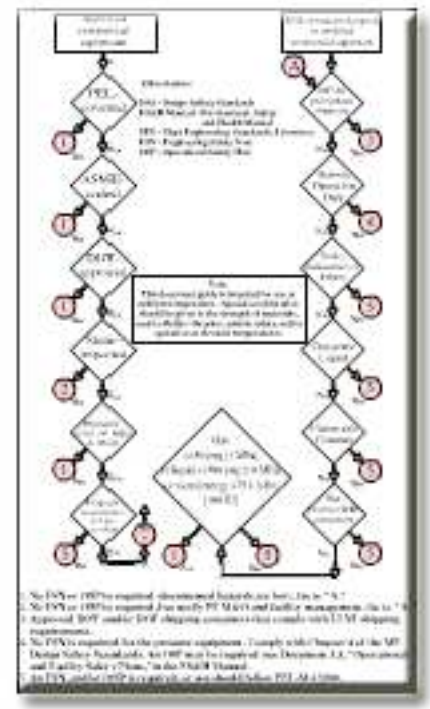
3) Initial pressure tests of new systems are ALWAYS conducted remotely.

An Integrated Work Sheet (IWS) would point to additional documentation requirements (e.g. Engineering Safety Note, Operational Safety Plan, Plant Engineering Standard).

Documentation Guide for Pressure Safety

When do you need an Engineering Safety Note/test procedure? Refer to the Documentation Guide for Pressure Safety (Part 18 - *ES&H Manual*) to determine what documentation is necessary for your system.

Click on the diagram at the right for a review of how the documentation guide works.



Documentation Guide

The LLNL Documentation Guide for Pressure Equipment is an important element of the Pressure Safety Program. Therefore, an audio-visual presentation has been prepared to review the use of this document.

Please take a moment to glance at a complete copy of the documentation guide. Click on the picture below for a full-scale view in a new window.

At any time, you can use these buttons to play and pause the presentation.

Module 3 Review

Roger is a pressure operator. His coworkers just completed assembly of a 3000 psig system and would like to put it into service immediately. Should Roger begin using the system right after assembly? Please select an answer.

That's right, Roger shouldn't begin work on the system. What should he do next?

A) Roger should do a pressure test on the system.

B) Roger should check to see if the necessary documentation is in place and schedule a pressure inspection by a qualified Pressure Inspector.

C) Roger should double check all components for tightness and correct application.

Module 3 Review

Roger is a pressure operator. His coworkers just completed assembly of a 3000 psig system and would like to put it into service immediately. Should Roger begin using the system right after assembly? Please select an answer.

That's a good idea! He should check to see that all documentation is in place. In addition, a pressure inspection by a qualified Pressure Inspector is necessary and would ensure employee safety.

Module 4 - User Responsibilities and Resources

Learning Objectives:

After completing Module 4, you will be able to:

- Explain your responsibilities as a pressure operator.
- Locate pressure system guidance.

Operator Responsibilities

You are responsible for:

- System operation, maintenance, and safety.
- Assuring pressure inspections/retests are performed every 3-6 years as required by Document 18.3 of the *ES&H Manual*.
- Knowing how to contact our Pressure Safety Manager and the High Pressure Lab.

Operator Responsibilities

You are also responsible for reporting any changes in system status to the LLNL Pressure Safety Manager or the High Pressure Lab. This includes reporting systems that:

- Have been altered.
- Have changed locations.
- Have changed responsible user.
- Have been destroyed, salvaged or stored-in-place.

Pressure System Guidance

As mentioned earlier, Appendix D of the *ES&H Manual*, Document 18.2 is a valuable resource. It covers "Piping and Tubing Pressure Ratings". If you haven't already done so, please download a copy to have as quick reference when working with pressure.

Pressure System Guidance

We have also assembled the HS5040-W Reference Guide for your convenience. This document contains:

- Sealant and lubricant applications for pipe and straight threads.
- Fluid versus sealant material compatibility charts.
- Pressure conversion charts.
- Volume conversion charts.
- Conversion factors.
- Temperature conversions.

If you haven't already done so, please download a copy or bookmark the link in your browser for quick reference.

Pressure System Guidance

If you have questions regarding your system or any aspect of pressure and/or your safety, please feel free to contact the Pressure Safety Manager or your ES&H Safety Team. These individuals are here at the Lab to assist you.

Contact the Pressure Safety Manager

Contact your ES&H Team

Contact the Instrument Shop

- Onsite: (x - 23614)
- Site 300: (x - 35247)

Contact the High Pressure Lab (x - 32745)

Module 4 Review - Question 1 of 3

You and your coworkers are qualified to work in the intermediate pressure range and your supervisor, a qualified sytem installer, adds a series of valves and fittings to a 2500 psig system. Should you and your coworkers begin using the system after your supervisor gives the ok? Select an answer.

That's right! The change to the system must be reported to the Pressure Safety Manager or the High Pressure Lab.

Module 4 Review - Question 2 of 3

Who is responsible for reporting the change in system status in the previous example?

That's right! You are responsible for reporting the change to the system to the Pressure Safety Manager or the High Pressure Lab.

Module 4 Review - Question 3 of 3

If an Engineering Safety Note is required for your system, when can you expect a retest/reinspection of that equipment?

That's right! You should expect a retest-re-inspection every 3-6 years, as required by Volume II, Part 18 of the *ES&H Manual*.

Pressure System Guidance

We have also assembled the HS5040-W Reference Guide for your convenience. This document contains:

- Sealant and lubricant applications for pipe and straight threads.
- Fluid versus sealant material compatibility charts.
- Pressure conversion charts.
- Volume conversion charts.
- Conversion factors.
- Temperature conversions.

If you haven't already done so, please download a copy or bookmark the link in your browser for quick reference.

This concludes the Lesson portion of the course. To obtain credit for HS5040-W, you need to take the test and pass with 80% correct or better. Select the "Next" button to continue to the test.