UCRL-MI-1 26381

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HIGH PRESSURE SAFETY

Developed by Hazards Control

Safety Education & Training

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Course Logistics

There are several requirements that you must be aware of before proceeding any further. Please check your training records before you continue.

- HS5030-W (Pressure Safety Orientation) and HS5040-W (Intermediate Pressure Safety) are prerequisites for this course.

- Plus, you must re-qualify every five years by taking HS5031-W (Pressure Safety Requalification).

- To get credit for this training, you must pass the test at the end with a score of at least 80%.

Introduction

This course is required for all personnel who will install or operate gas pressure systems in excess of 3,000 psi (pounds per square inch) or liquid pressure systems in excess of 5,000 psi. The course covers hazards, equipment, and precautions. After completing this training, you may work as a pressure operator or installer-in-training in the high-pressure range.

Course Goal

Provide knowledge that, when combined with the required practical experience, will enable you to work more safely with high pressure.

Course Objectives

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

- Recognize the importance of gas relationships.
- Select proper high-pressure hardware and components.
- Identify proper pressure system design.
- Identify high-pressure safety resources to help you do your work safely.

Before continuing, please print out the HS5050-W Reference Guide. You will be asked to reference information in this document throughout the course. In addition, the reference guide will prove useful in performing your everyday pressure tasks. You can also bookmark the link in your browser for quick reference. Click on the button below to view the guide in a separate window. (You will need Adobe Acrobat Reader to view the guide. For best results, view at 100%.)

The HS5050-W Reference Guide contains temperature conversion charts, instructions on maintaining Autoclave 30VM valves, and TNT stored-energy equivalents.

HS5050-W Reference Guide

Module 1 - Gas Relationships

Learning Objectives

After completing Module 1, you will be able to:

- Categorize similarities and differences of gases and liquids under pressure
- Recognize the significance of stored energy when working with pressure.
- Identify the relationship between pressure, volume, and temperature for a confined gas.

Fluids: Gas versus Liquid

Liquid

- Obeys Pascal's Law
- Seeks own level
- Relatively incompressible

Gas

- Obeys Pascal's Law
- Fills any container, regardless of shape
- Compressible

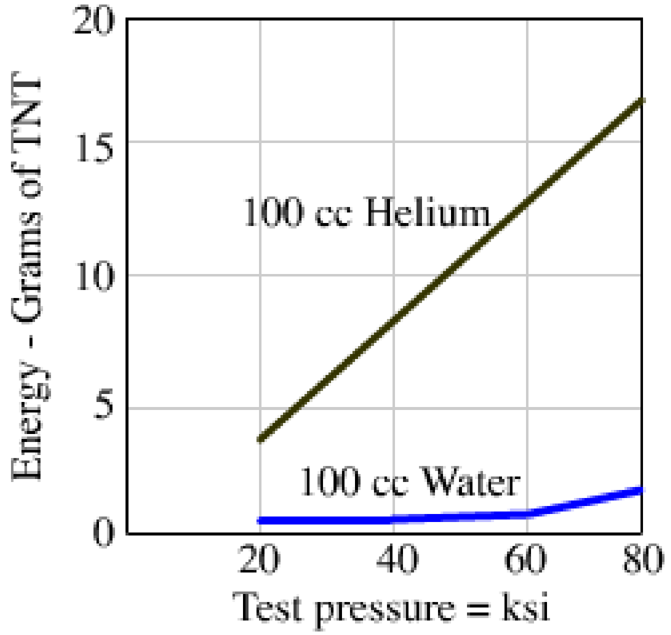
Fluids: Gas versus Liquid

Compressibility is important for stored energy considerations. The potential for stored energy is much higher when working with gas than liquid. For water, volume reduction is ~ 1/3% for every 1000 psi. For helium, volume reduction depends on pressure range, i.e., 30% from 2 ksi to 3 ksi, 10% from 7 ksi to 8 ksi.

Stored Energy as a Function of Test Pressure

Potential stored energy is much higher for a gas than liquid. For example, as shown here, the stored energy potential for helium is much higher than that of water.

Think about it; *1 gram* of TNT has equivalent energy to catching a 40 pound suitcase tossed from the 8th floor of a hotel.



The Significance of Stored Energy

Compressed fluids store energy. The more compressible the fluid, the more stored energy. The following formulas are used to calculate stored energy:

Liquid: PdV mechanical work

$$E = \frac{P_1^2 V}{2B}$$

Gas: Isentropic expansion of a confined gas

$$E = \frac{P_1 V_1}{k-1}\left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}\right]$$

Where: E = stored energy
P_1 = MAWP
P_2 = atmospheric pressure
k = ratio of specific heats
V = volume
B = liquid bulk modulus

Stored-Energy Conversions

A table of TNT Stored Energy Equivalents is provided in the HS5050-W Reference Guide (page 2) to help you make stored-energy conversions on the job.

Gas Laws*

Gas Laws define relationships between pressure (P), volume (V), and temperature (T).

Boyle's Law:	$PV = C$	Pressure x Volume = Constant (C) (*when T=C*)
Gay-Lussac's Law:	$\frac{V}{T} = C$	Volume depends on Temperature (*when P=C*)
Ideal Gas Law combines both:	$\frac{PV}{T} = C$	Officially written as: $\boxed{PV = RT}$ Where the constant R depends on the type of gas

*For more on these formulas see: Warren C. Young, *Roark's Formulas for Stress & Strain*, Sixth Edition, McGraw-Hill Inc., New York: 1989.

A Closer Look at the Ideal Gas Law

According to the Ideal Gas Law ($PV/T = C$), if a fixed quantity of gas is taken through any sort of process, then:

$$\frac{PV}{T} \text{ at the initial condition} = \frac{PV}{T} \text{ at the final condition}$$

OR

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Note: Absolute pressure (14.7 psia = 1 atmosphere) and absolute temperature (Celsius + 273 = Kelvin and Fahrenheit + 460 = Rankine) must be used for P and T.

Applying the Concepts

Let's look at an example of how to apply this concept.

A cylinder of helium is received by the vendor. The temperature of the helium is 70°F and the pressure inside the cylinder is 2,250 psig. An employee inadvertently stores the cylinder near a heat source, and several hours later, the helium is heated to 180°F. What is the new pressure inside the cylinder (in psia)? Let's break it down.

The following information is given:

P_1 = 2,250 psig P_2 = ?
T_1 = 70°F T_2 = 180°F
V_1 = constant $V_2 = V_1$ = constant

First, we must do some conversions. Since we are looking for psia we must add 15 to P_1. We also need to convert °F to Rankin by adding 460.

After we have completed the conversions, we simply plug the new values into the formula as shown below.

$P_1 = 2{,}250 + 15 = 2{,}265 \text{ psia} \qquad P_2 = ?$

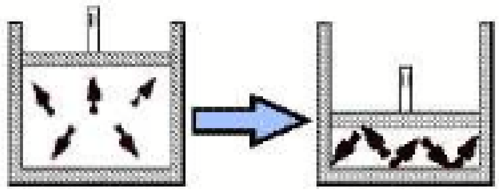
$T_1 = 70 + 460 = 530 \text{ R} \qquad T_2 = 180 + 460 = 640 \text{ R}$

$$\left(\frac{PV}{T}\right)_1 = \left(\frac{PV}{T}\right)_2 \longrightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

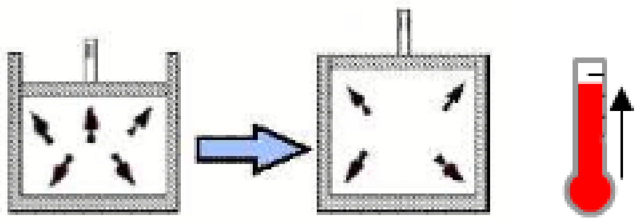
$$P_2 = \left(\frac{P_1}{T_1}\right) T_2 = \left(\frac{2{,}265 \text{ psia}}{530 \text{ R}}\right) 640 \text{ R} = 2{,}735 \text{ psia}$$

P-V-T Relationships for a Confined Gas

With confined gas, when you add energy (i.e., heat) the parameters will change. For instance, in the following example if temperature were constant and we increased pressure inside the cylinder, volume would decrease.

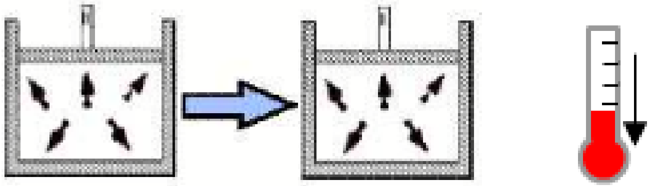


However, if pressure were constant and we increased the temperature, volume would increase.



P-V-T Relationships for a Confined Gas

Finally, keeping *volume* constant, if we decrease pressure, temperature also would decrease.



Module 1 Review - Question 1 of 3

How many standard cubic feet (SCF) are contained in the helium cylinder pictured here? Please type your answer in the blank below and click the Check Answer button to see how you did.

Given:

$P_1 = 2265$ psia $\quad P_2 = 14.7$psia

$T_1 = 70°F$ $\quad T_2 = 70°F$

$V_1 = 1.5$ ft.3 $\quad V_2 =$ ____ SCF

Check Answer

Standard Cylinder:
9" diameter, 52" tall

Note: one cubic foot of gas at "standard conditions" of temperature and pressure, i.e., average sea level conditions is 70°F and one atmosphere (14.7 psia).

Actually, the answer is 231 SCF. Here is how to find the solution.

Given:

$P_1 = 2265$ psia $\quad P_2 = 14.7$psia

$T_1 = 70°F \quad T_2 = 70°F$

$V_1 = 1.5$ ft.$^3 \quad V_2 = ?$ SCF

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$P_1V_1 = P_2V_2$ (since temperature is constant)

$$V_2 = \frac{P_1V_1}{P_2} = \frac{2{,}265 \times 1.5}{14.7} = 231 \text{ SCF}$$

Module 1 Review - Question 2 of 3

A cylinder of helium is received by the vendor. The temperature of the helium is 65°F and pressure inside the cylinder is 1,800 psig. An employee inadvertently stores the cylinder near a heat source, and several hours later, the helium is heated to 195°F. What is the new pressure inside the cylinder in psia? Use the formula explained earlier in this section to find the solution. Type your answer in the blank box below. (Use a whole number for your answer.)

[ ] psia

Check Answer

Actually, the answer is 2,264 psia. Here's how to find the solution.

Given:

P_1 = 1,800 psig $\quad$ P_2 = ?

T_1 = 65°F $\quad$ T_2 = 195°F

V_1 = constant $\quad$ $V_2 = V_1$ = constant

We must first do some conversions. Since we are looking for psia we must add 15 to P_1. We also need to convert °F to Rankin by adding 460. Therefore we now have:

P_1 = 1,815 psia $\quad$ P_2 = ?

T_1 = 525 R $\quad$ T_2 = 655 R

$$\left(\frac{PV}{T}\right)_1 = \left(\frac{PV}{T}\right)_2 \longrightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$P_2 = \left(\frac{P_1}{T_1}\right) T_2 = \left(\frac{1{,}815 \text{ psia}}{525 \text{ R}}\right) 655 \text{ R} = 2{,}264 \text{ psia}$$

Module 1 Review - Question 3 of 3

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

Actually, as you can see, the potential for stored energy is much higher when working with gas!

Gas - failed at 8,500 psig. the energy equivalent of 17.72 grams of TNT.

Liquid - failed at 9,200 psig. the energy equivalent of 0.170 grams of TNT.

Module 2 – High-Pressure Fittings/Equipment

Learning Objectives

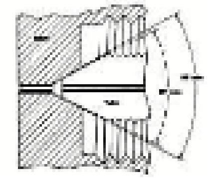
After completing Module 2, you will be able to:

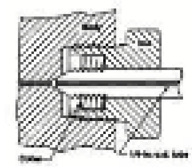
- Recall the proper use of coned-and-threaded connections.
- Identify uses of different stem assemblies.
- Assess considerations when selecting high-pressure hardware including valves, relief devices, piping, tubing, hoses, and gauges.
- Identify markings on Autoclave Engineers valves.

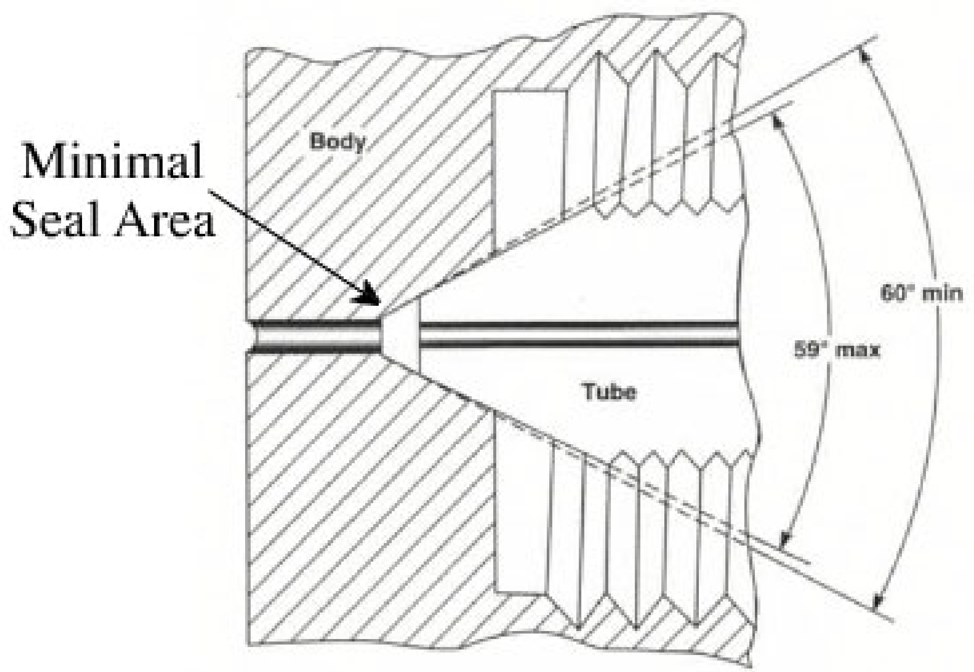
Coned-and-Threaded Connections

This type of connection provides line-contact sealing, resulting in minimal seal area. you want to use the smallest seal to mimimize force.

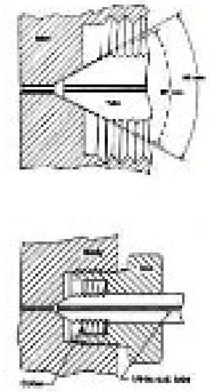
Remember, pressure = force/area. The smallest area needed to make the proper seal will have the lowest force trying to push the tube out. As a pressure seal deteriorates, the force on the end of the tube will increase because the area of the seal will increase. This could then cause a leak.

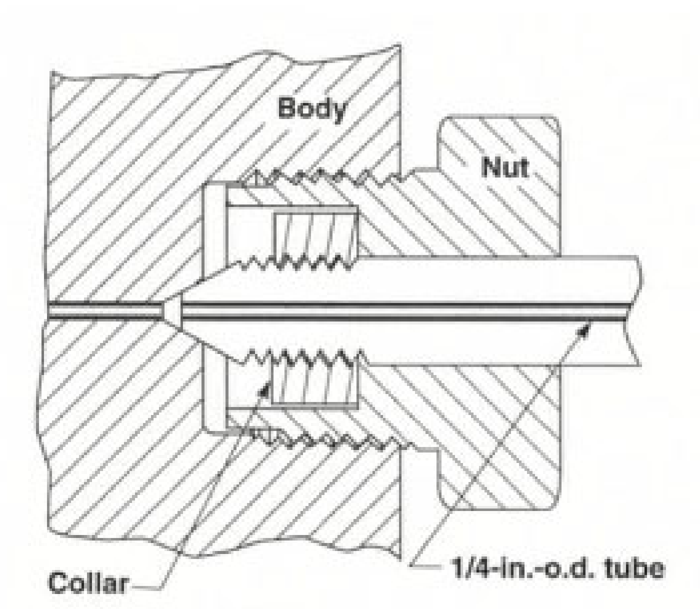


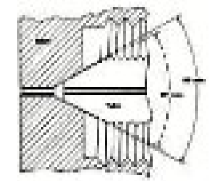


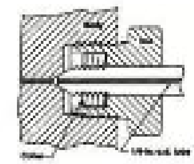


Minimal
Seal Area
Body
Tube
59° max
60° min




Body
Nut
Collar
1/4-in.-o.d. tube





Coned-and-Threaded Connections

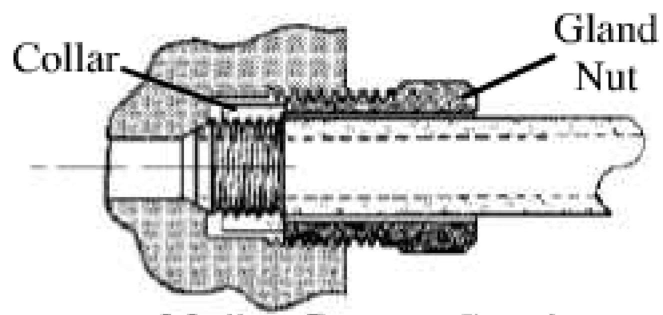
This type of connection has the following benefits:

- Excellent choice for re-makes.
- Very reliable in thermal cycling.
- Easy to service.

There are three applications for this type of connection. One for medium-pressure and two for high-pressure situations.

Coned-and-Threaded Connections

Medium pressure (Slimline) connections are used for pressure up to 20,000 psi. Note the position of the collar; it is in front of the gland nut.



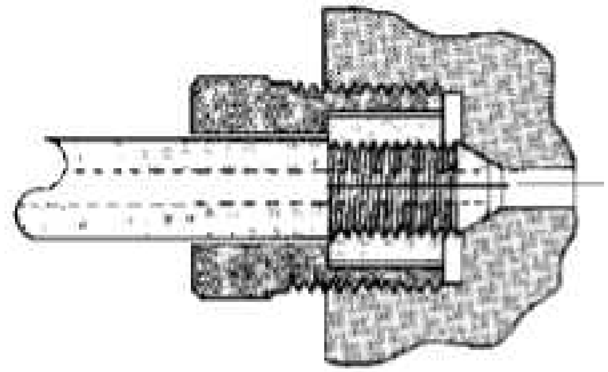
Medium Pressure Coned-and-Threaded Connection

Some example tube sizes of medium-pressure connections (stainless steel) are:

- 1/4" o.d. (outside diameter) x 0.125 i.d. (inside diameter): 20,000 psig @ room temperature
- 3/8" o.d. x 0.219 i.d.: 20,000 psig @ room temperature
- 9/16" o.d. x 0.359 i.d.: 20,000 psig @ room temperature

Coned-and-Threaded Connections

High-pressure connections employ two different connections depending on the pressure range. Note the position of the collar; it is within the gland nut.



High Pressure Coned
and Threaded Connection
(30,000 psi - 60,000 psi)

Some example tube sizes of high-pressure connections (stainless steel) are:

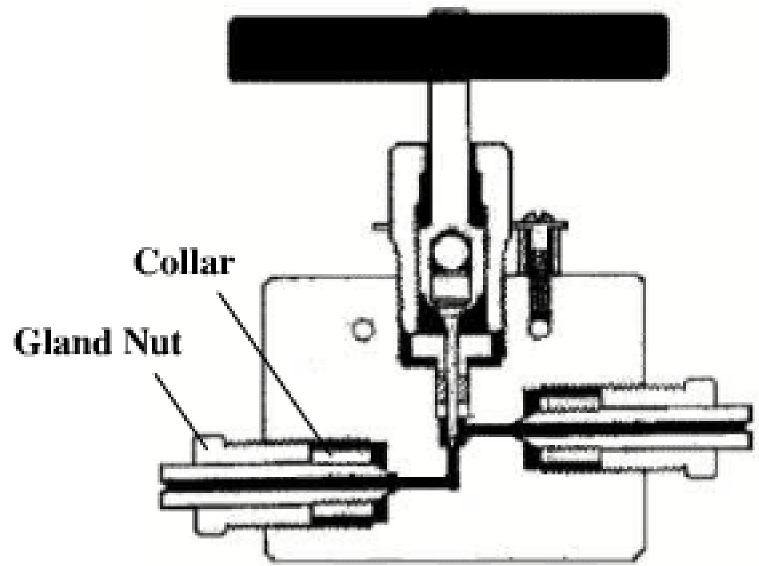
- 1/4" o.d. x 0.094 i.d.: 30,000 psi @ room temperature
- 1/4" o.d. x 0.062 i.d.: 60,000 psi @ room temperature

Coned-and-Threaded Connections

The other high pressure connection is for 100,000 to 150,000 psi. Note the position of the collar; it is again in front of the gland nut.

An example tube size at this level is:

5/16" o.d. x 0.062 i.d.: 150,000 psig @ -325 to 100 °F

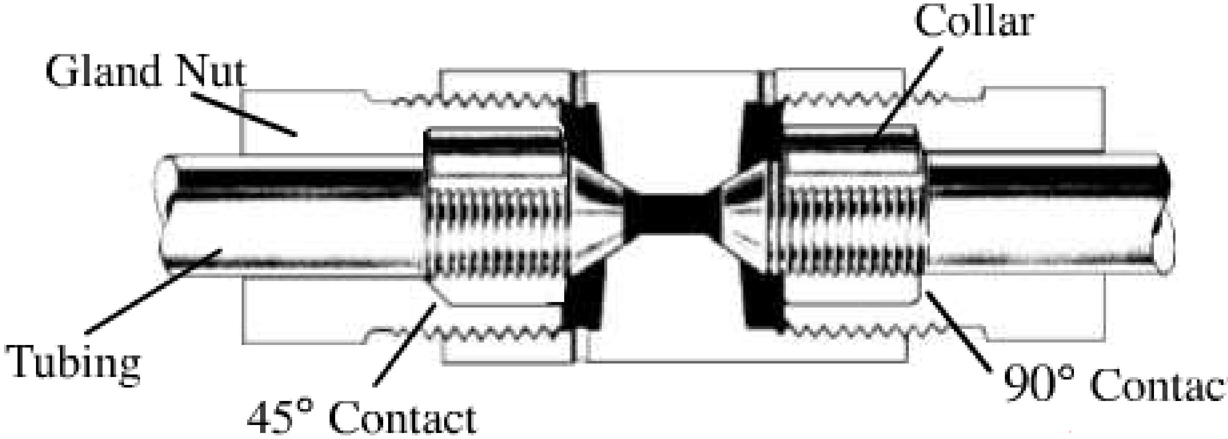


High Pressure Coned and Threaded Connection (100 ksi - 150 ksi)

A Few Cautions with This Type of Connection

- Tubing, collars and gland nuts ar NOT interchangeable for medium- and high-pressure connections.

- Old connections have 90° angle contact, while newer designs have 45° angle contact. Therefore, be certain that you inspect components and do not interchange them with each other.



High-Pressure Fittings/Valves

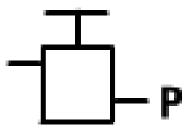
Some important information to remember about high-pressure fittings and valves:

- The threads carry the load.
- Provide pressure relief (weep holes). These holes provide leak detection.
- Pressure rating must be *equal to or greater than* system MAWP.
- Assure seat/stem/seal material compatibility.

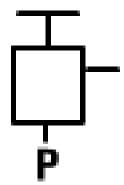
Common Valve Types

Below are typical high-pressure valves. There are four types. The arrows indicate normal flow through the valve. "P" indicates the pressure ports. Mouse over any of the pictures to see a detailed drawing of each valve.

Two-port valves

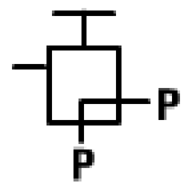


Type 1:
Straight Through
Valve

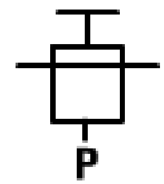


Type 2:
Angle Valve

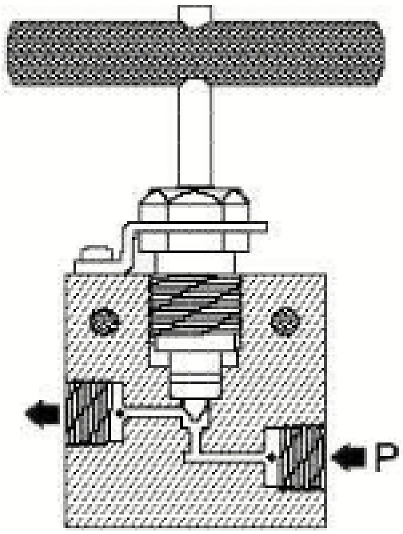
Three-port valves

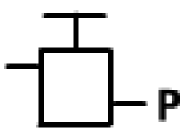


Type 3:
Two Pressure
Ports

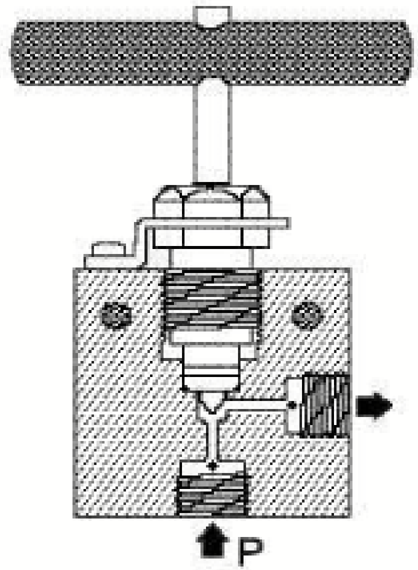


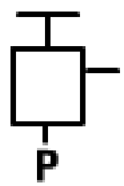
Type 4:
One Pressure
Port



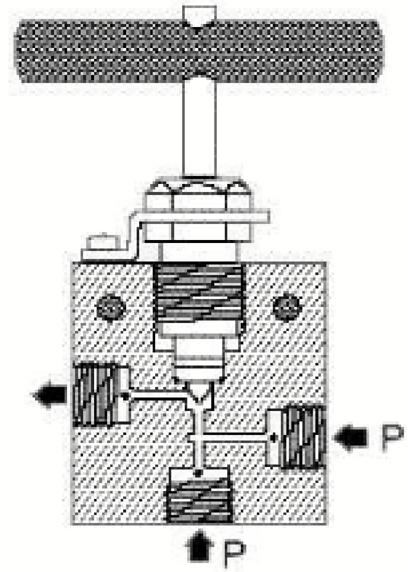


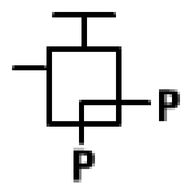
Type 1:
Straight Through
Valve



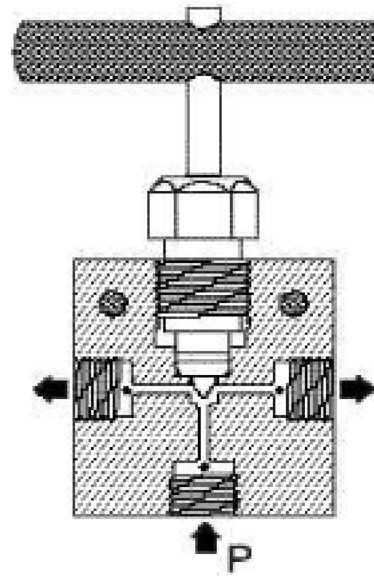


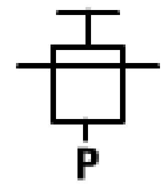
Type 2:
Angle Valve





Type 3:
Two Pressure
Ports



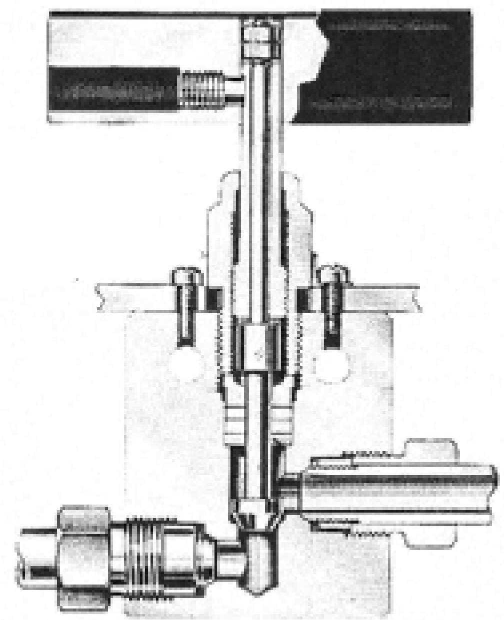


Type 4:
One Pressure
Port

High Pressure Valves

Most high-pressure valves employ non-rotating systems because:

- It avoids leakage by minimizing galling and scoring.
- Similar materials can be used for stem and seat, providing better corrosion resistance.
- Remachinable bodies provide long service life.



STEM SLEEVE threads into BONNET rotating against BEARING WASHER which pushes downward against FLOATING INNER STEM to seat positively without galling or scoring.

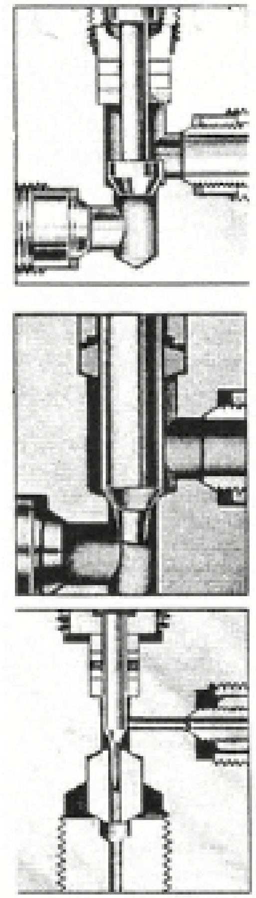
High Pressure Valves (continued)

Also consider the following three stem types when selecting valves.

1) Vee Stem
   - On/Off service. No throttling effect.

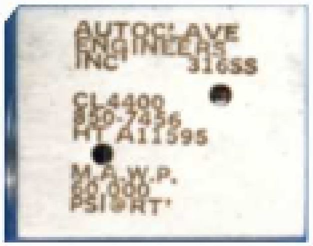
2) Regulating Stem
   - More accurate flow control than Vee Stem.
   - Good general purpose for throttling and shut-off.

3) Micro Metering Stem
   - Precise control of small flows. Requires a shut-off valve upstream.



Markings on High-Pressure Components

High pressure fittings and valves normally will have pressure and temperature ratings stamped on them. Notice the markings on the components below.



Markings on High-Pressure Components

The valve pictured below has been pressure-rated at different temperatures.

MAWP (IF TEMP OF VALVE BODY HAS NEVER EXCEEDED 800°F)

@RT	@800°F	@1200°F
30,000 PSI	25,200 PSI	N/A

MAWP (IF TEMP OF VALVE BODY HAS EVER EXCEEDED 800°F)

@RT	@800°F	@1200°F
12,000 PSI	10,500 PSI	4500 PSI

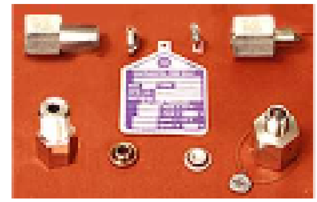
Autoclave Engineers Valves - Identifying Markings

To the right is an example of an Autoclave Engineers (AE) valve. There are many markings on these valves. The part number is very important, especially when ordering components. Mouse over the part number below the valve to see a breakdown.

Do's and Don'ts for Relief Devices

- Do not place a valve between a relief device and protected component.
- Relief-device settings may NOT exceed *lowest-rated* component MAWP.
- Do not point relief at people.
- The relief must not restrict gas flow.
- Reliefs are to be set by authorized people only (i.e., by LLNL Pressure Inspectors, normally every three years).

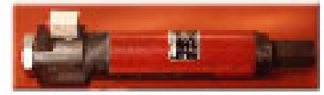
Spring-Loaded Relief Device



Rupture Disk Assembly

Note: at higher pressure, the use of rupture disks is more common than spring-loaded relief devices. Mouse over the above photos for examples.

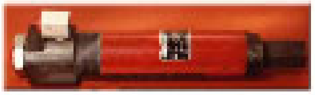
Spring-Loaded Relief Device



Spring-Loaded Relief Device

Rupture Disk Assembly

Rupture Disk Assembly



Spring-Loaded Relief Device

Rupture Disk Assembly

High-Pressure-System Components

Pipe Tubing

- Pressure rating must be *equal to or greater than* system MAWP.
- For pipe fittings, assume MAWP equals 150 psi, unless specified by either:
  - stamped rating
  - manufacturer's reference (catalog)

Note: Use *National Standards* whenever possible (e.g. ASME, DOT, ANSI B31.1).

High-Pressure-System Components

Hose

- Use only where required.
- Use shortest lengths possible, with minimum bends.
- Tie down the ends and secure every seven feet.
- Do NOT use with toxins or radioactive materials.

High-Pressure-System Components

When working with pressure gauges, make sure that:

- Full scale = 2 times MAWP (1.2 minimum).
- Materials are compatible.
- The gauge has a blow-out back (safety-type component).
- There is surge protection (e.g. with dampers, snubbers).
- There is no contamination by calibrating oil.
- Relief protection is provided.

Note: in high-pressure systems, you will see more pressure transducers than pressure gauges.

High-Pressure-System Components

The HS5050-W Reference Guide has more information on the disassembly, inspection, cleaning, and assembly of Autoclave Engineers 30VM valves. If you haven't already done so, please download a copy of the reference guide.

Module 2 Review - Question 1 of 3

Which of the following is FALSE concerning a coned-and-threaded connection?

A) Coning provides line contact sealing, resulting is a minimal seal area.

B) Medium pressure connections are used for pressure up to 20,000 psi.

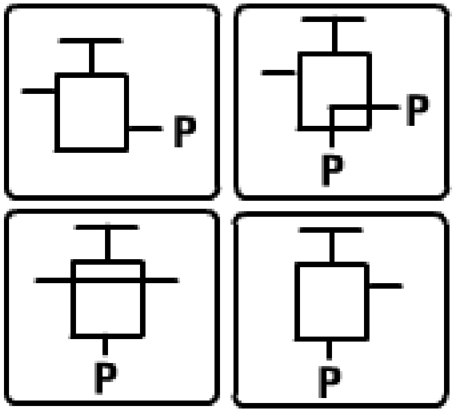
C) Threading positively locks tube to the fitting using a collar.

D) Tubing, collars and gland nuts are interchangeable for medium and high pressure connections.

That's right! Tubing, collars, and gland nuts are NOT interchangeable for medium- and high-pressure connections.

Module 2 Review - Question 2 of 3

Match each diagram on the left to the corresponding valve type on the right. With your mouse, drag the diagram into the corresponding yellow area. If you don't place the diagram on the correct area, it will snap back to its original position.



Type 1: Straight Through Valve

Type 2: Angle Valve

Type 3: (Two Ports to Pressure)

Type 4: (One Port to Pressure)

Module 2 Review - Question 3 of 3

Steve is working on a high-pressure system involving nitrogen. He sets the relief device below the lowest component MAWP and assumes the MAWP of the tubing and fittings are 3000 psi. Steve then verifies that the hose ends are tied down and makes sure the gauges being used are 2 times the MAWP of the system. What, if anything, did Steve do wrong?

A) The relief device should have been set above the highest component MAWP.

B) The gauges being used should be less than or equal to the MAWP of the system, thereby providing relief protection.

C) Steve should have verified the tubing and fitting's MAWP by checking for a stamped rating and/or referencing the manufacturer's catalog.

D) Steve followed all system requirements and the system should be ready for use.

Module 3 - Pressure System Design

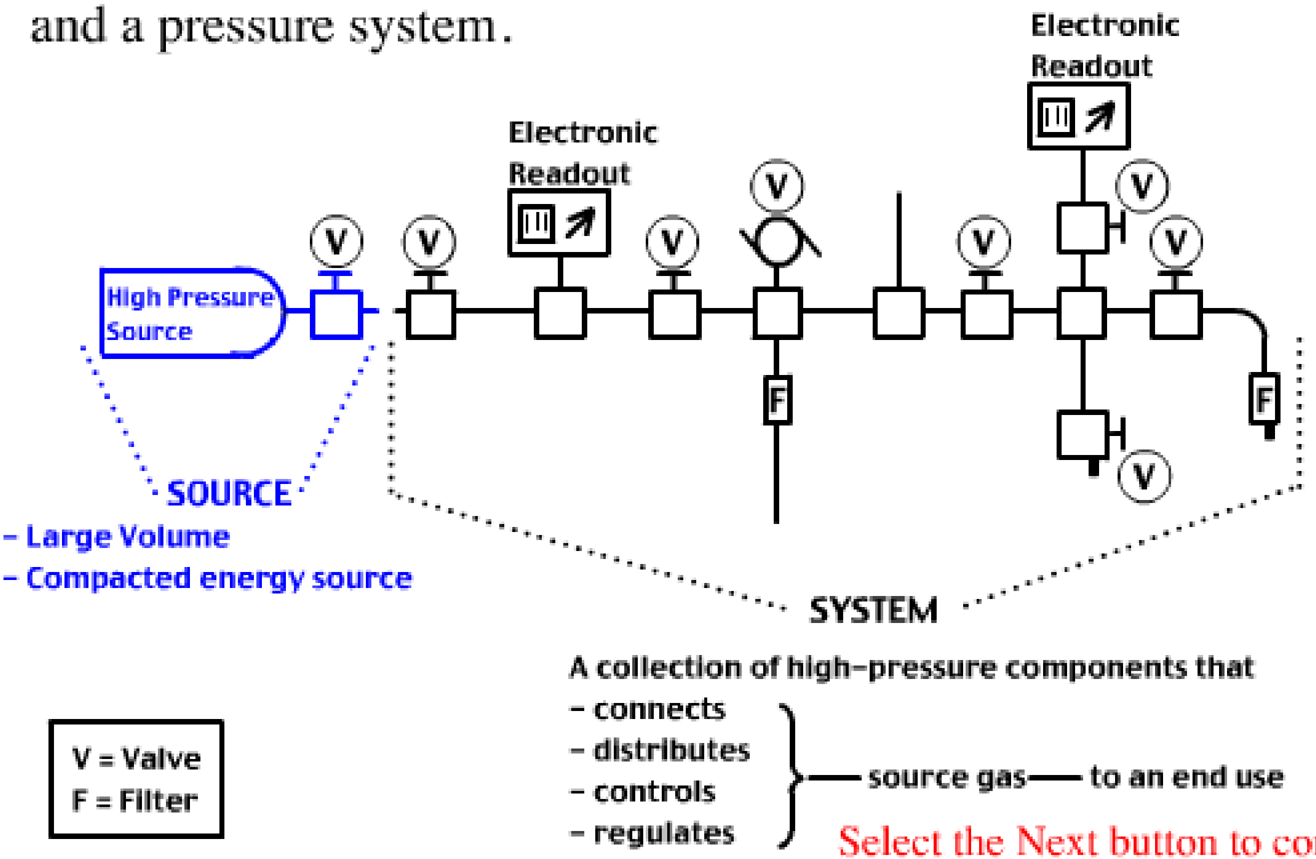
Learning Objectives

After completing Module 3, you will be able to:

- Identify the difference between a pressure source and a pressure system.
- Recognize the fundamentals of pressure system design.
- Locate pressure system resources.

Pressure Systems versus Pressure Sources

This diagram illustrates the difference between a pressure source and a pressure system.



Select the Next button to continue.

Pressure System Ground Rules

- The MAWP of a system is determined by the *lowest-rated* component of the system.
- Pressure tests for systems are different than for sources.
- Sources are not allowed to over-pressurize systems:
  - Limit source to the rating of the weakest system component.
  - Use a pressure-relief device if the source cannot be limited.
  - Pressure regulators are NOT adequate as limiters. (Regulators only *reduce* pressure, they do not limit pressure.)

More Pressure System Ground Rules

Foreign particles must be kept out of a high-pressure system.

- Cap all unused lines:
    - Uncap to use.
    - Recap after use.
- Use particulate filters.
- Inspect all components before use.
- Air flush, degrease, and deburr as required.

Drawing Sketches/Schematics

It is always good to have systems documented in the Safety Note. Provide sketches or schematics so they are available to others.

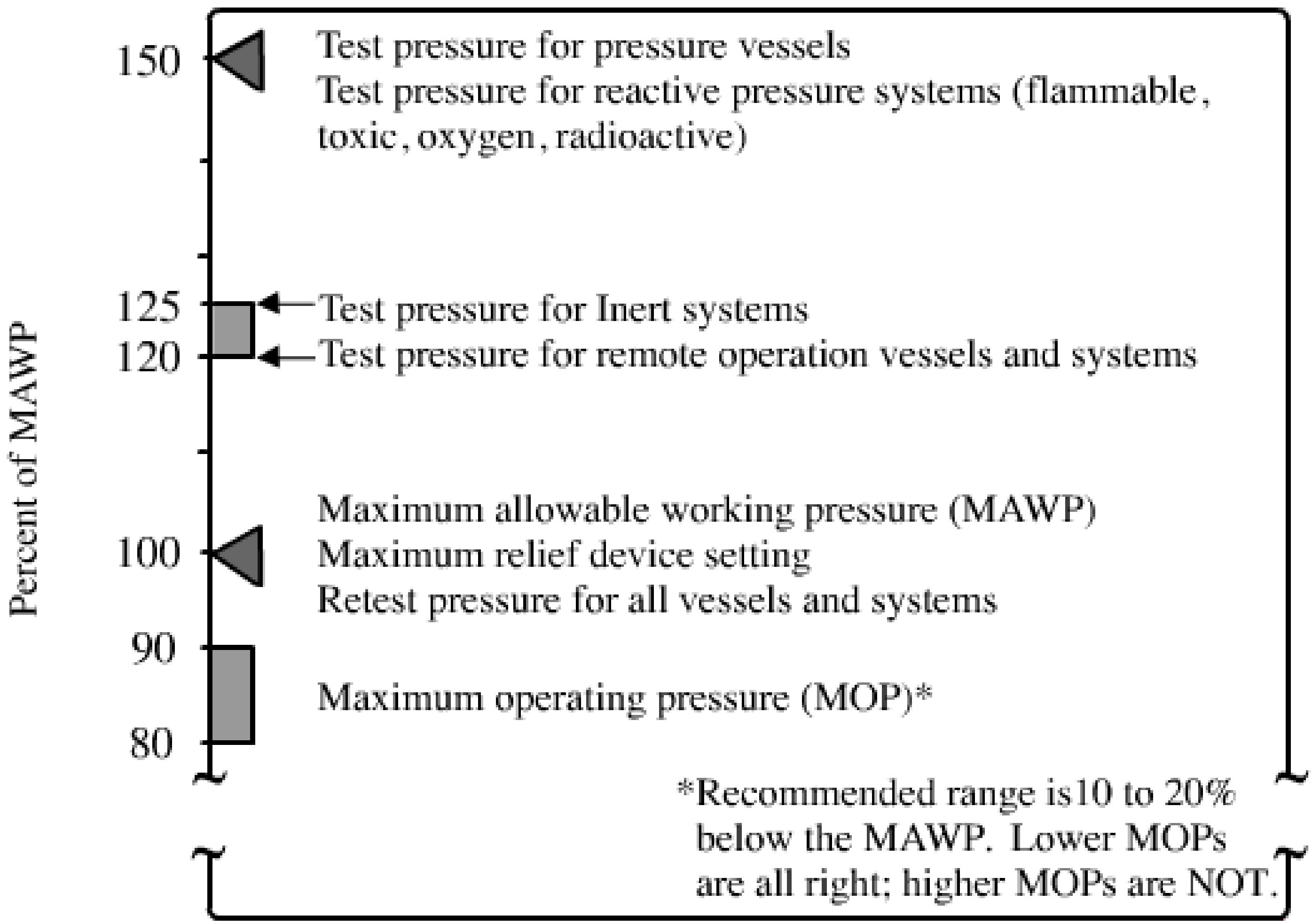
Functional Schematics

- No (or few) crossed lines.
- Best way to understand how systems works.

Locational Schematics

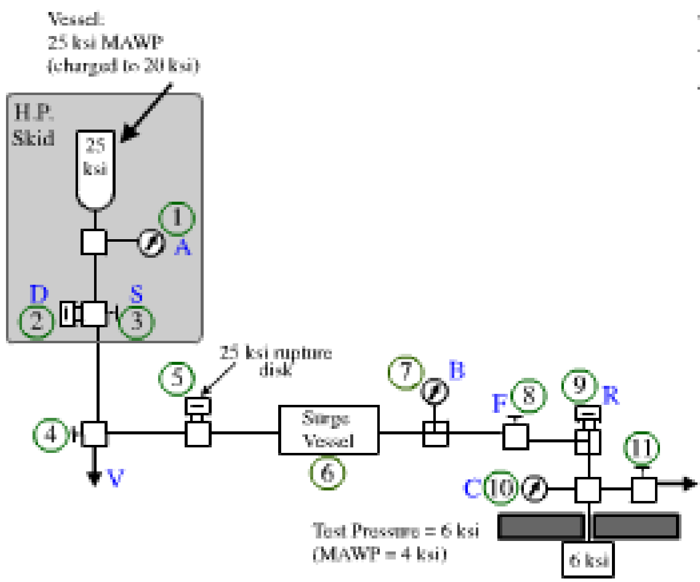
- Describes component location (sometimes).
- Often difficult to understand.

Note: Assembly drawings should contain the MAWP.

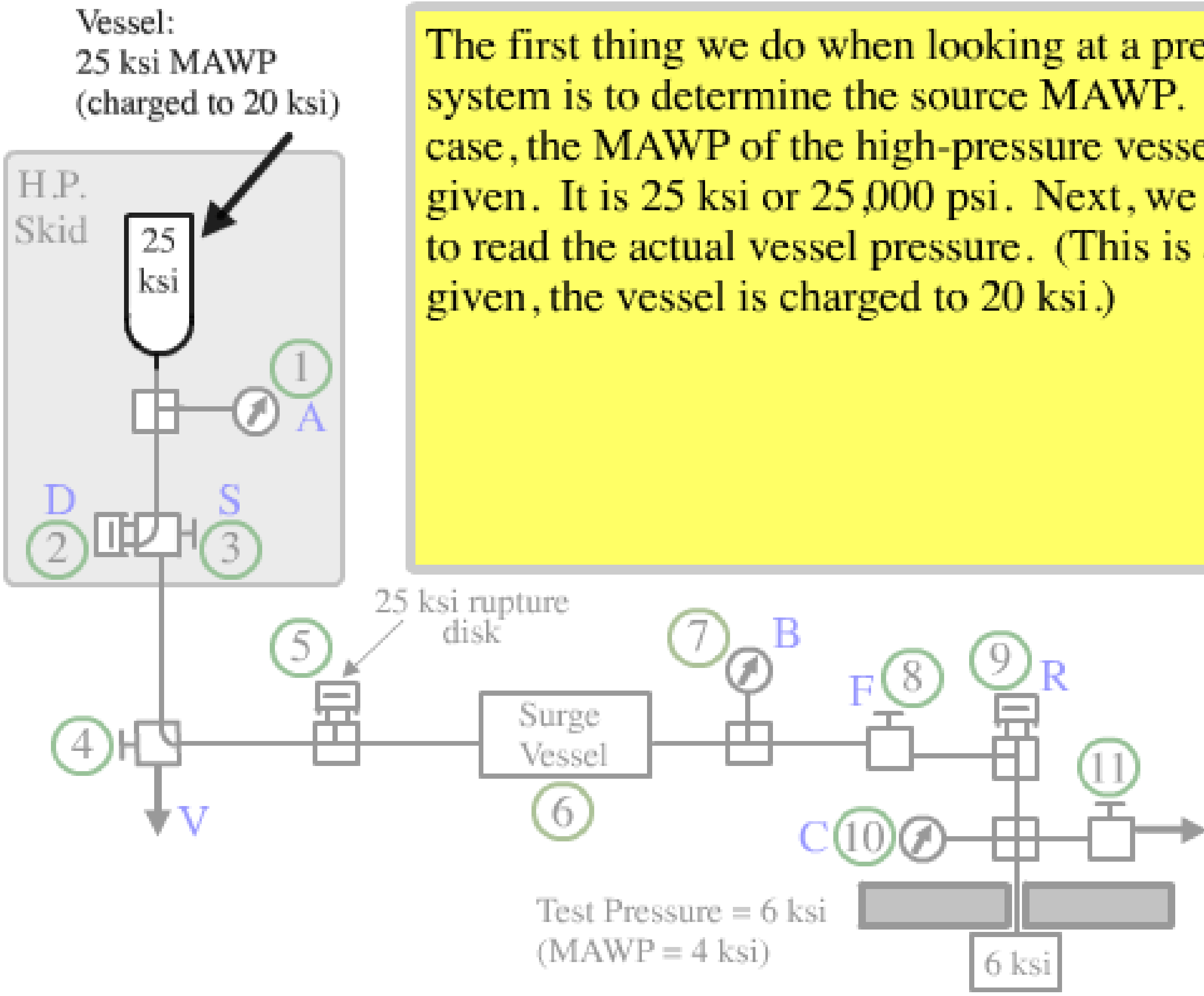

Percent of MAWP
150
Test pressure for pressure vessels
Test pressure for reactive pressure systems (flammable, toxic, oxygen, radioactive)
125
120
Test pressure for Inert systems
Test pressure for remote operation vessels and systems
100
Maximum allowable working pressure (MAWP)
Maximum relief device setting
Retest pressure for all vessels and systems
90
80
Maximum operating pressure (MOP)*
*Recommended range is10 to 20% below the MAWP. Lower MOPs are all right; higher MOPs are NOT.

High-Pressure System Design

Following is an interactive presentation analyzing a pressure system design . You will be asked to apply concepts that were presented earlier in this course. Simply use the forward ⏩ and back ⏪ buttons to navigate through the presentation.



Press this button to begin. ⏩



The first thing we do when looking at a pressure system is to determine the source MAWP. In this case, the MAWP of the high-pressure vessel is given. It is 25 ksi or 25,000 psi. Next, we need to read the actual vessel pressure. (This is also given, the vessel is charged to 20 ksi.)

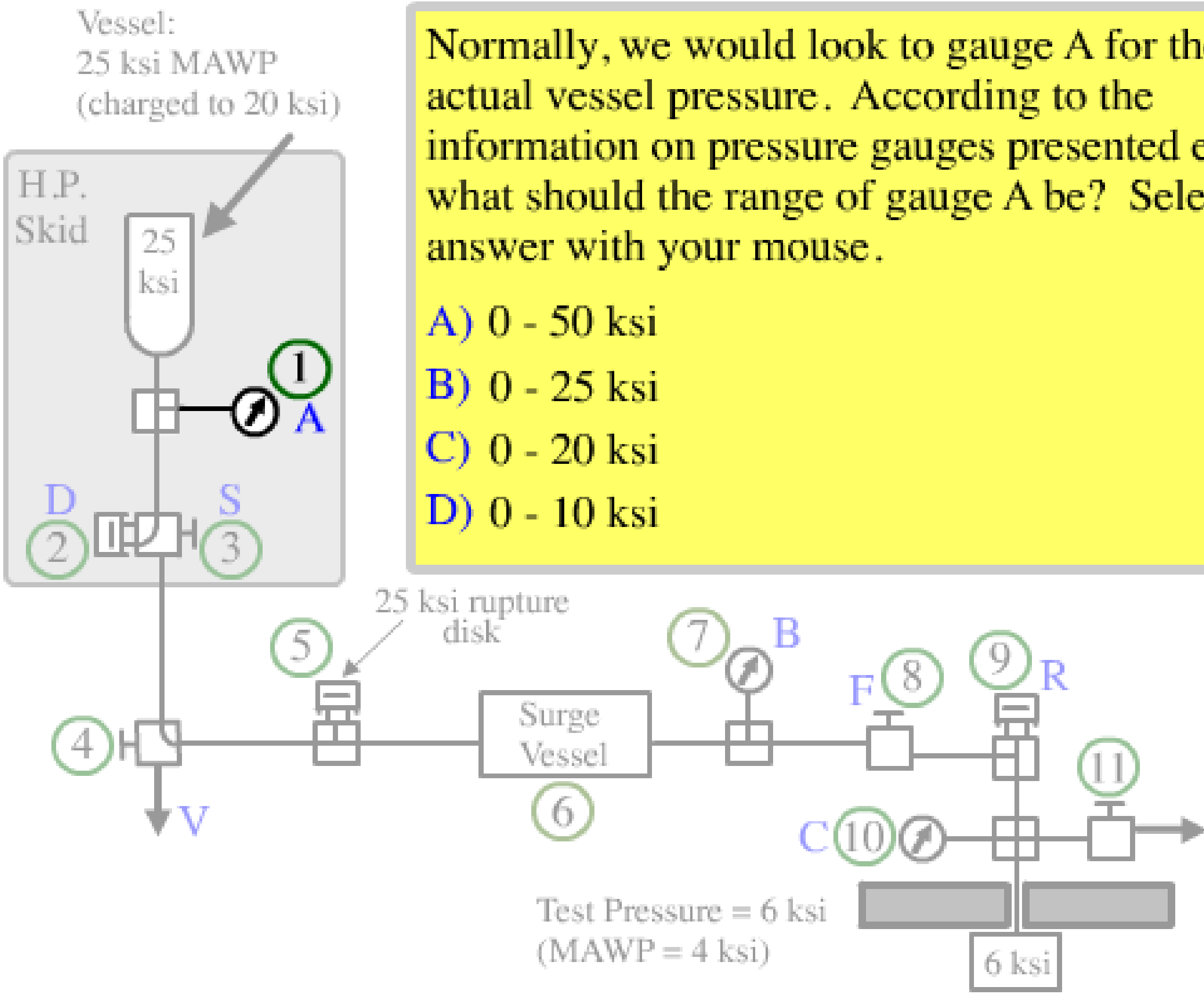
Normally, we would look to gauge A for the actual vessel pressure. According to the information on pressure gauges presented earlier, what should the range of gauge A be? Select an answer with your mouse.

A) 0 - 50 ksi

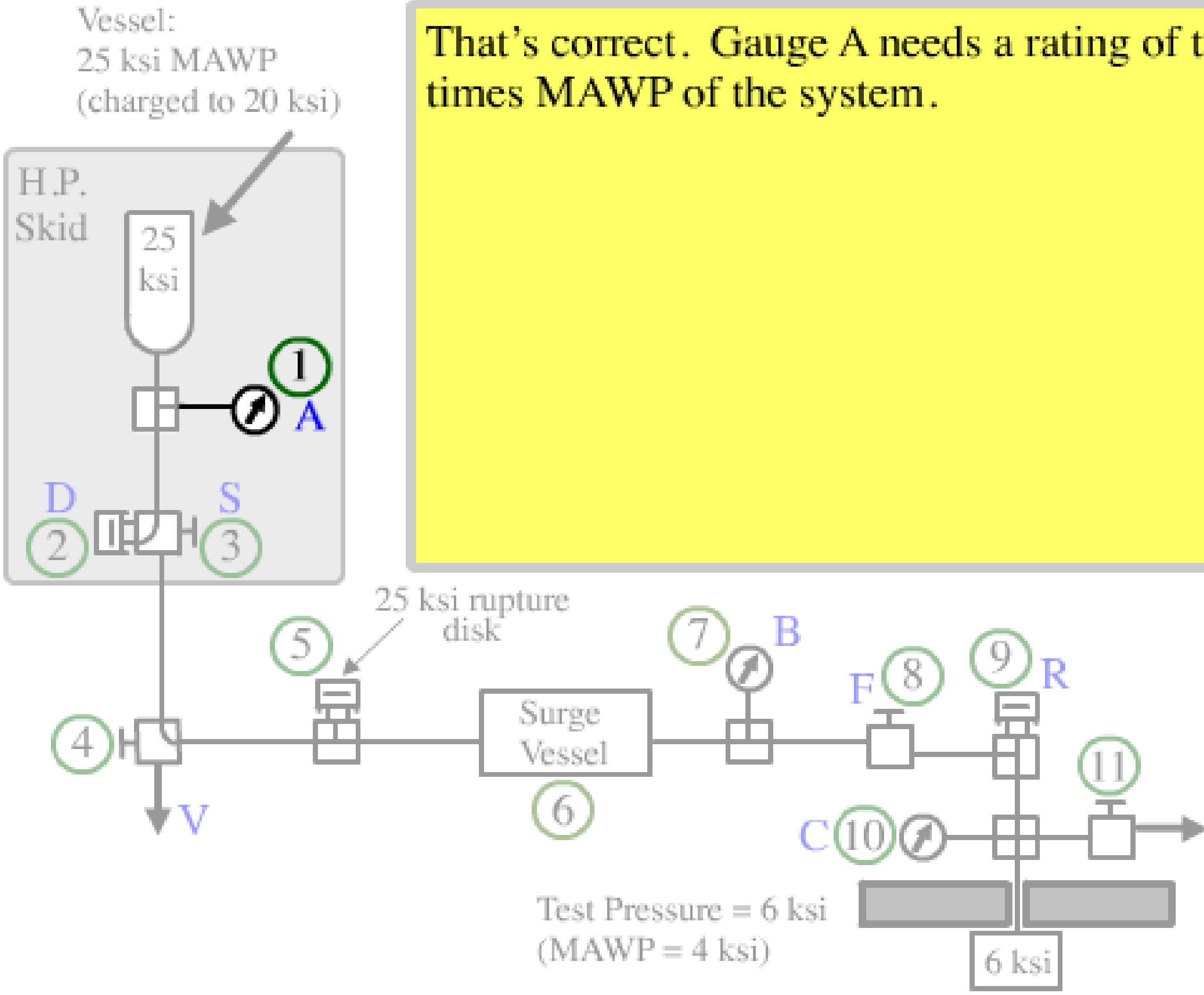
B) 0 - 25 ksi

C) 0 - 20 ksi

D) 0 - 10 ksi



That's correct. Gauge A needs a rating of two times MAWP of the system.



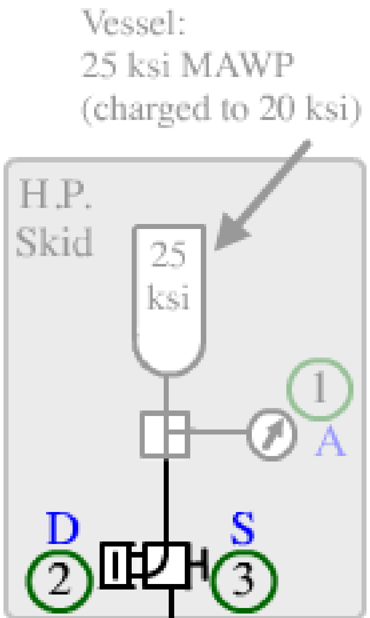
Continuing through the system, we arrive at rupture disk D and valve S. What should this rupture disk be rated at? Please select an answer.

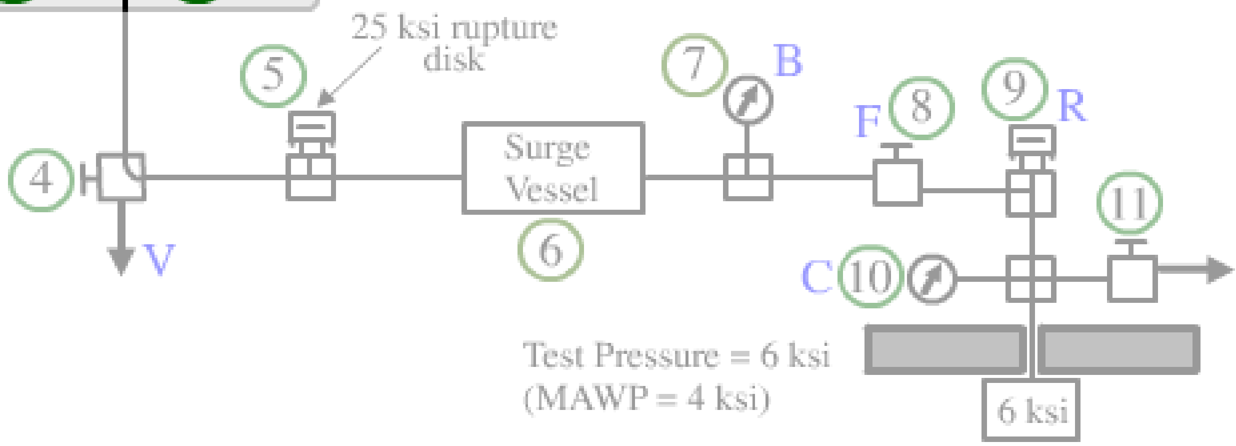
A) 30 ksi

B) 27.5 ksi

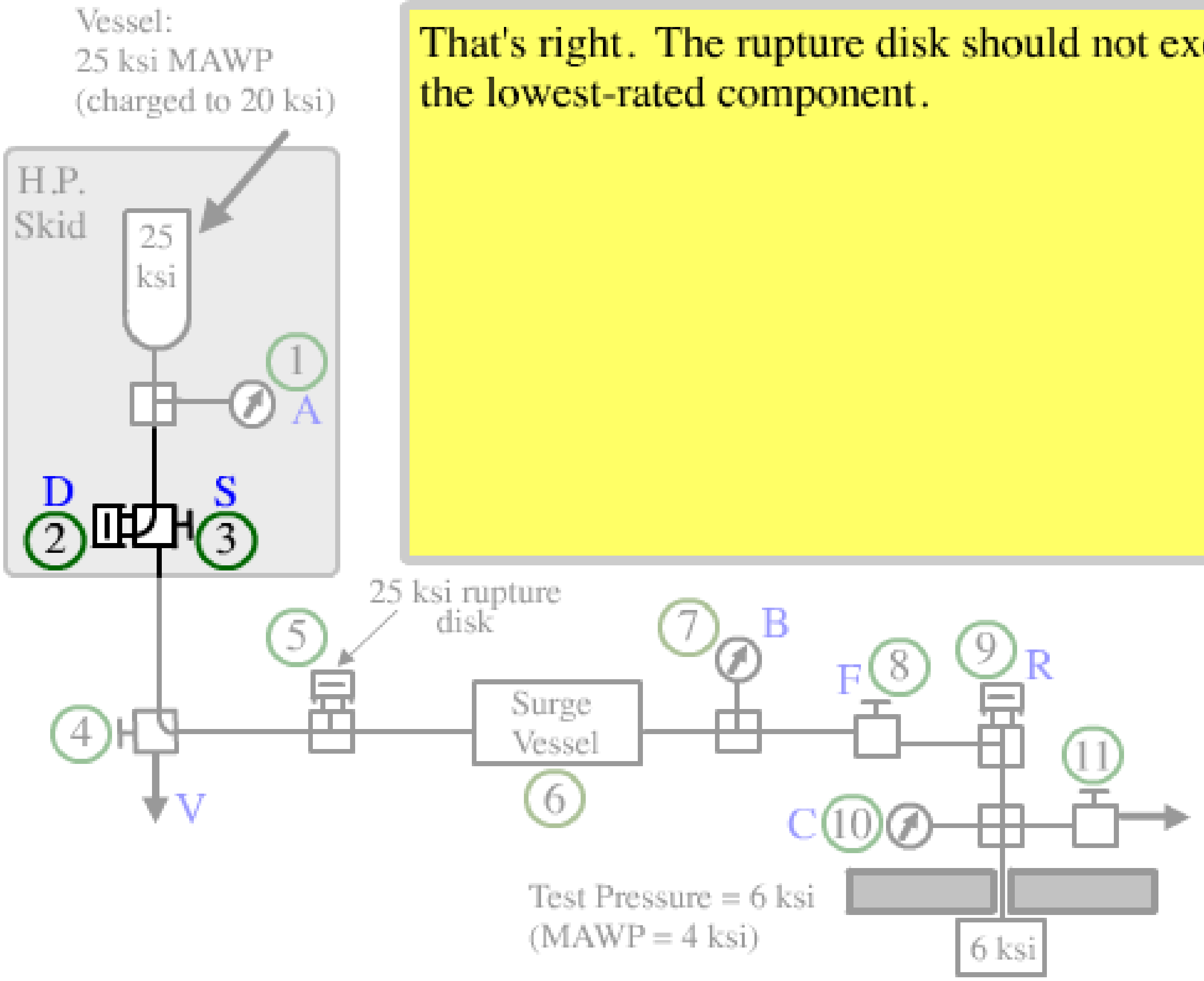
C) 25 ksi

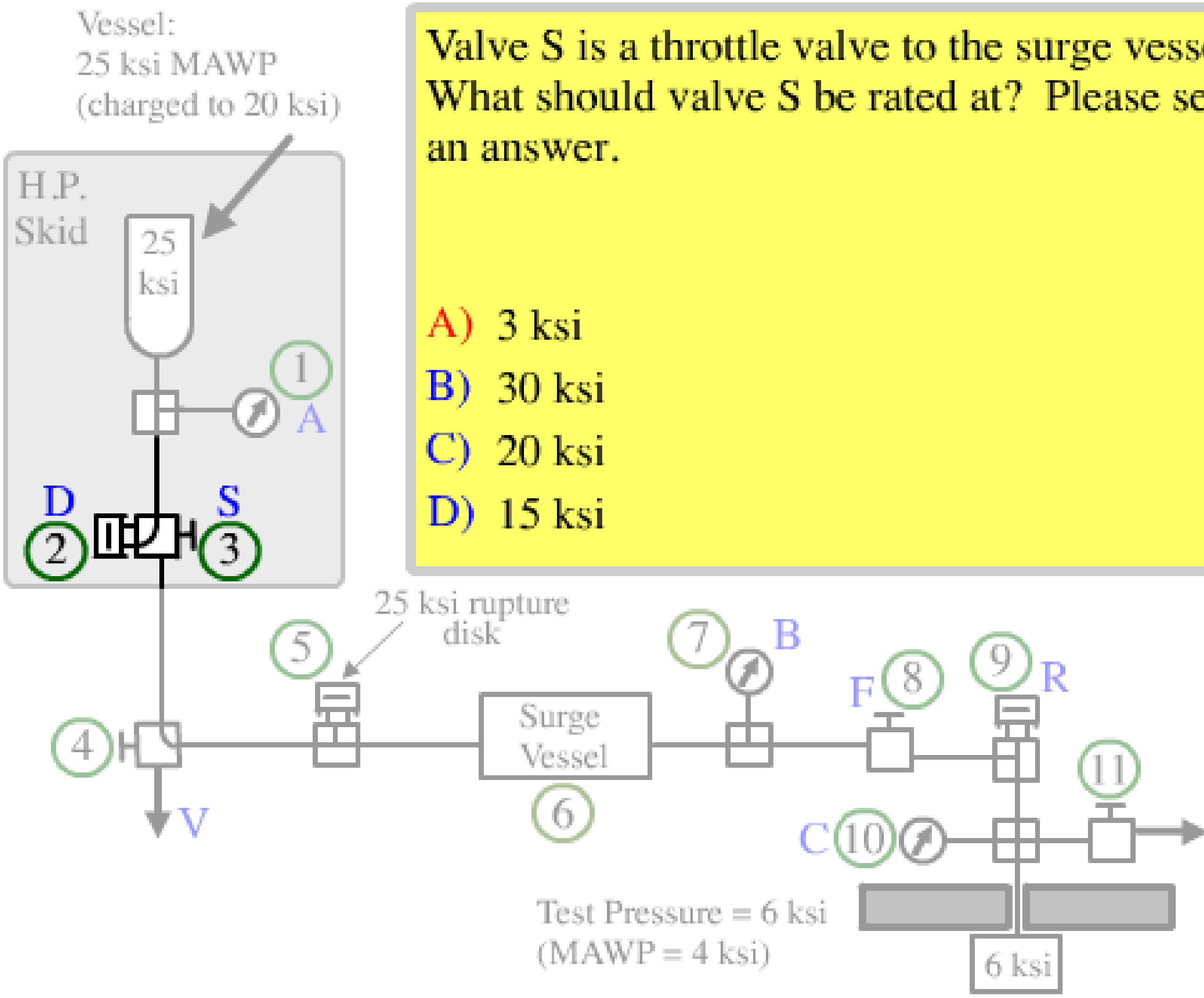
D) 6.6 ksi





That's right. The rupture disk should not exceed the lowest-rated component.





Valve S is a throttle valve to the surge vessel. What should valve S be rated at? Please select an answer.

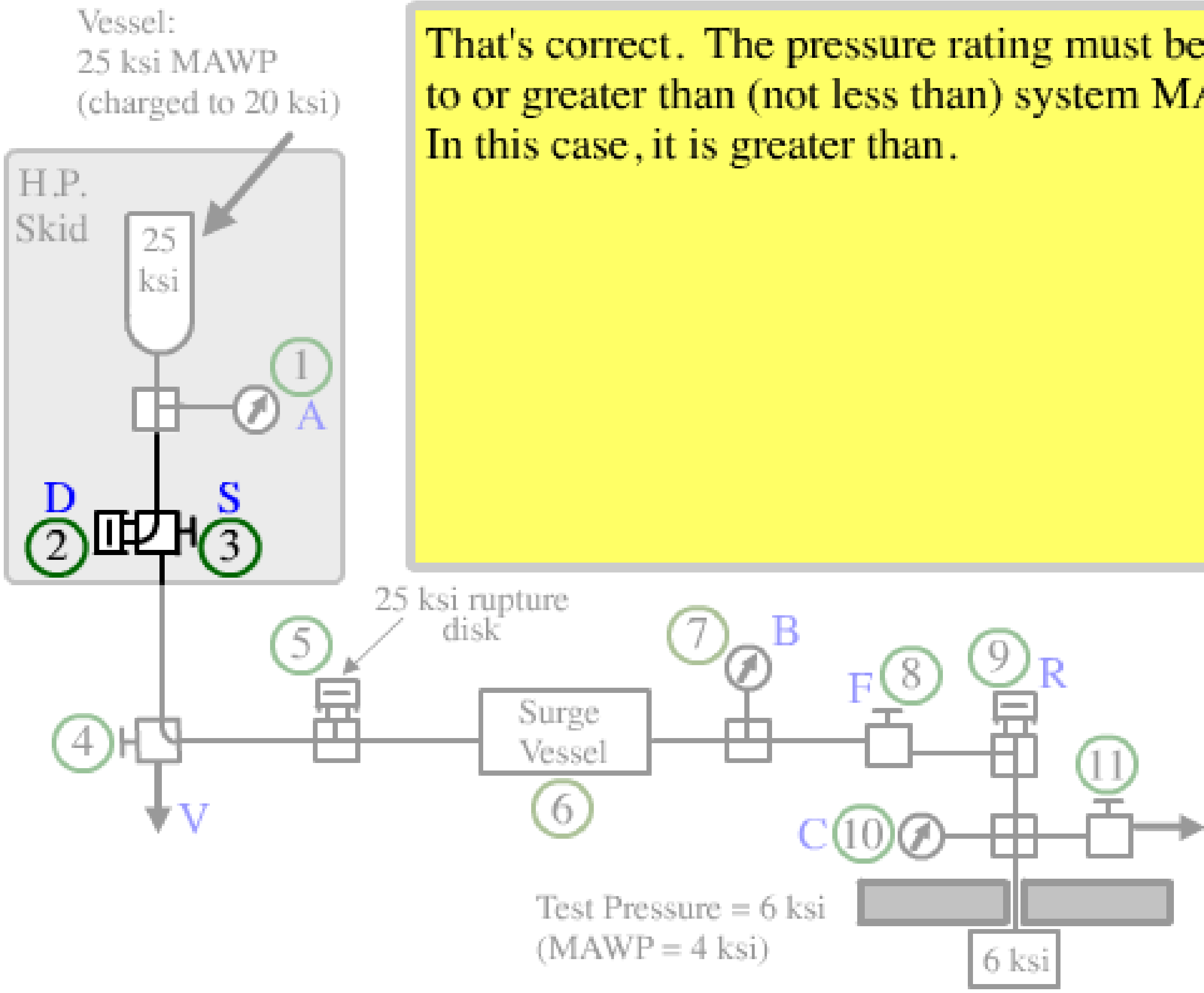
A) 3 ksi

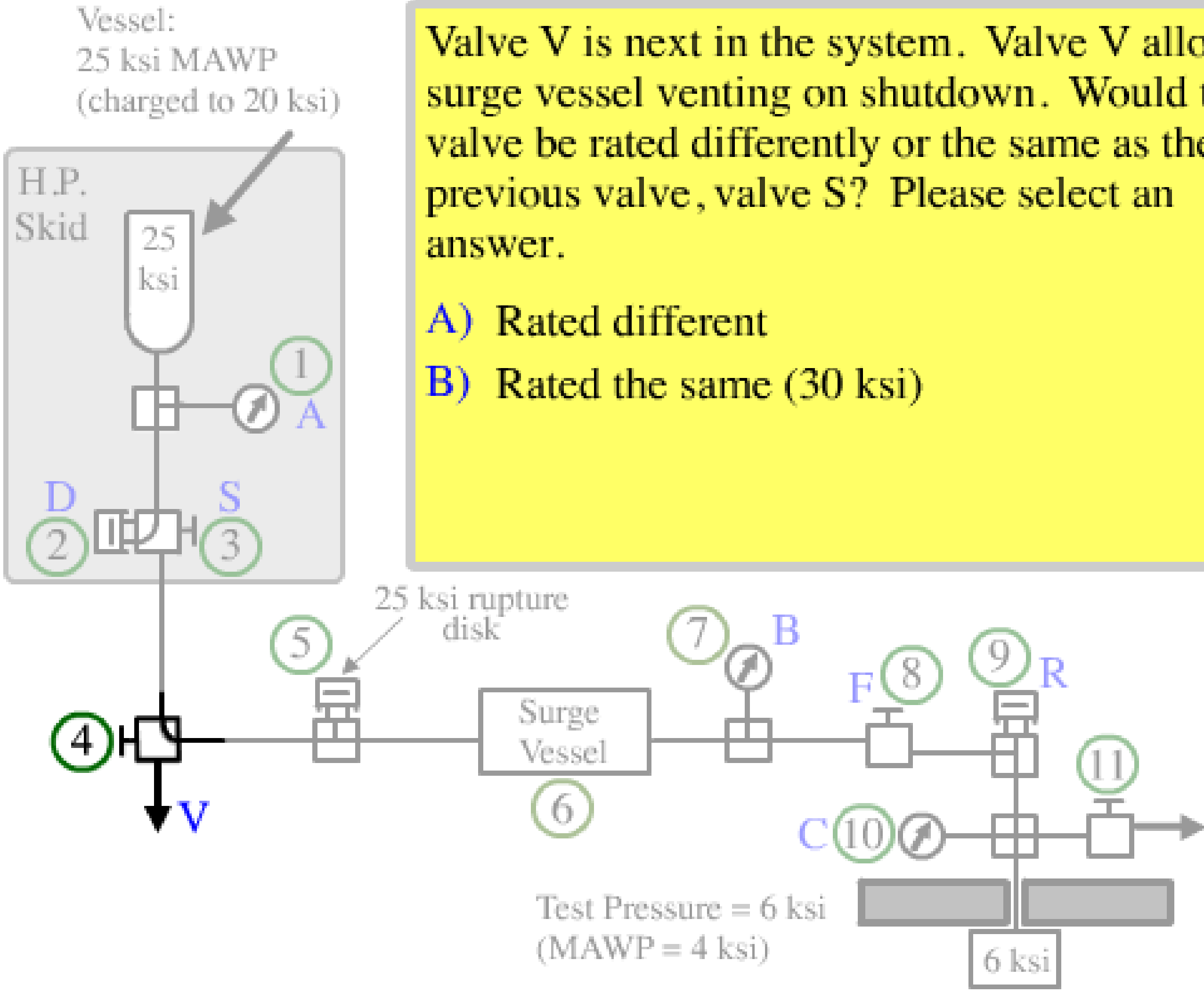
B) 30 ksi

C) 20 ksi

D) 15 ksi

That's correct. The pressure rating must be equal to or greater than (not less than) system MAWP. In this case, it is greater than.



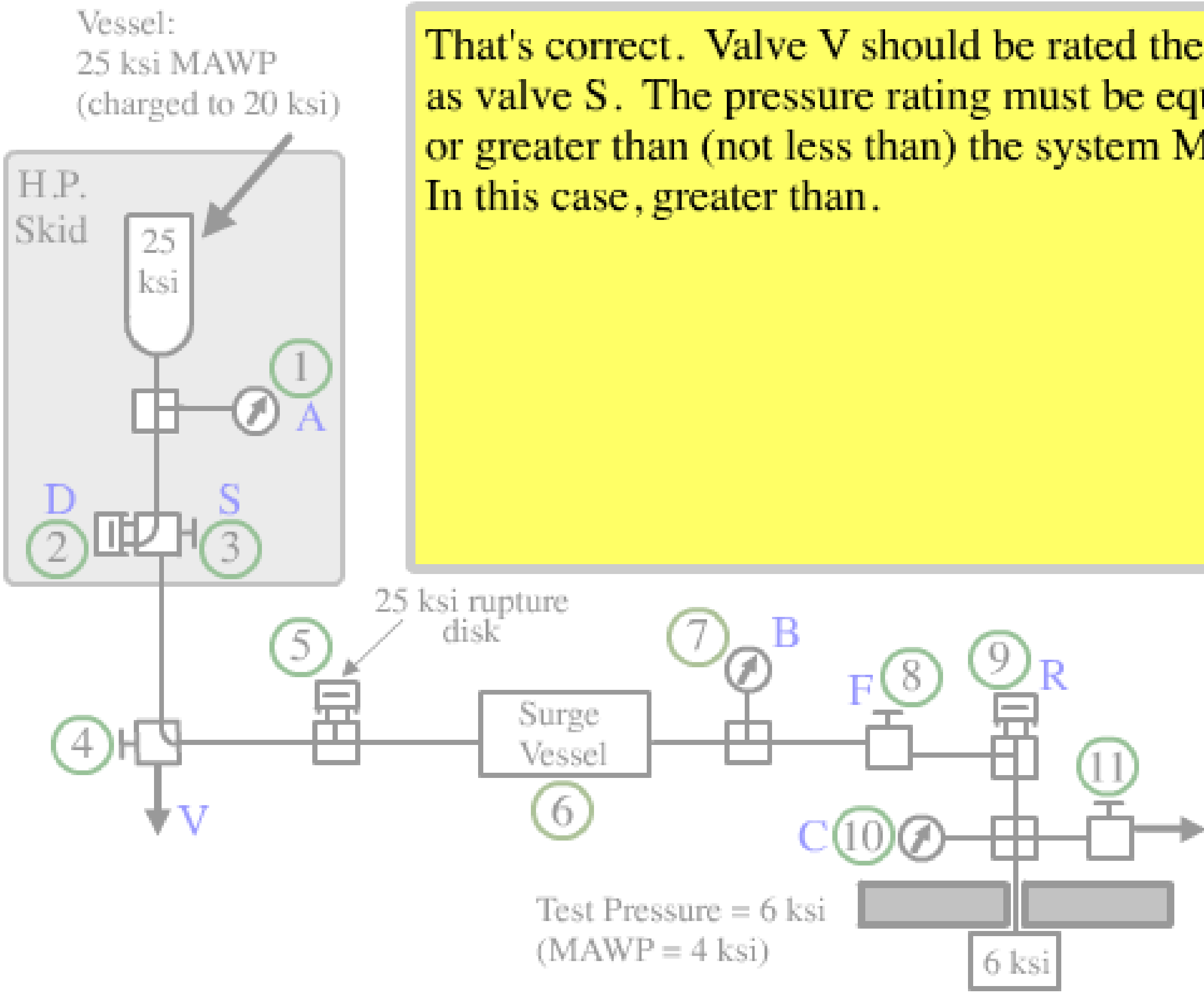


Valve V is next in the system. Valve V allows surge vessel venting on shutdown. Would this valve be rated differently or the same as the previous valve, valve S? Please select an answer.

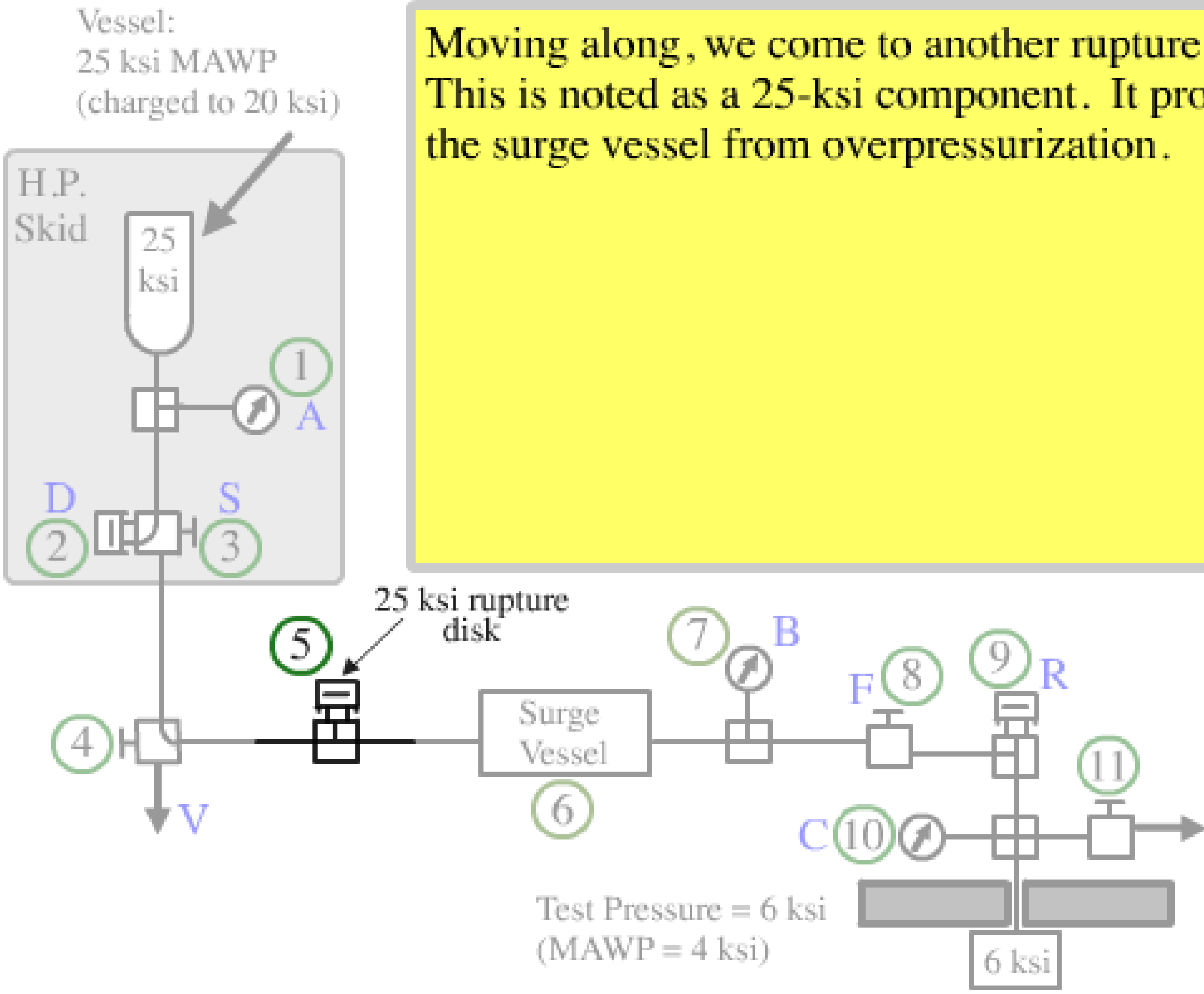
A) Rated different

B) Rated the same (30 ksi)

That's correct. Valve V should be rated the same as valve S. The pressure rating must be equal to or greater than (not less than) the system MAWP. In this case, greater than.



Moving along, we come to another rupture disk. This is noted as a 25-ksi component. It protects the surge vessel from overpressurization.



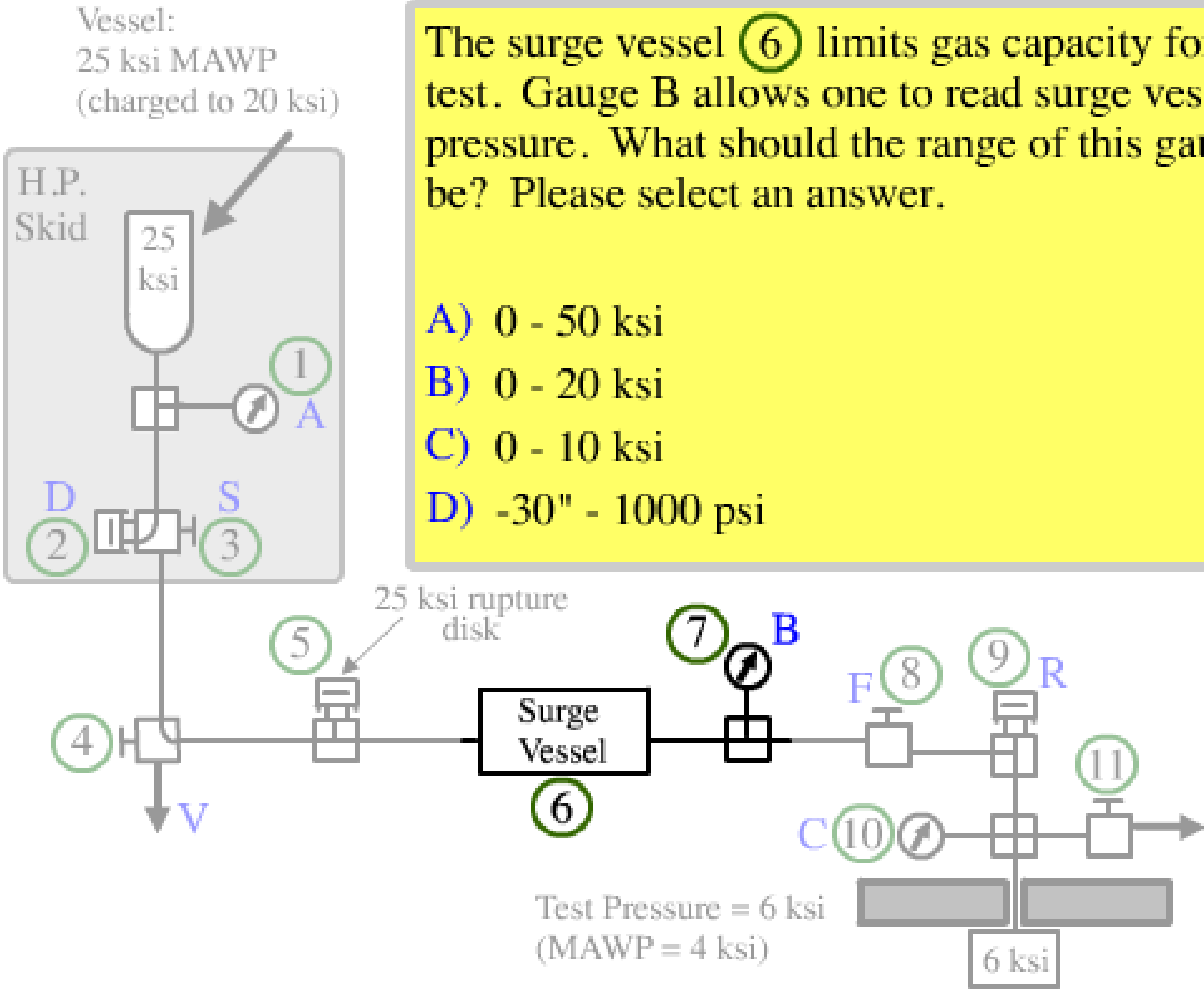
The surge vessel (6) limits gas capacity for the test. Gauge B allows one to read surge vessel pressure. What should the range of this gauge be? Please select an answer.

A) 0 - 50 ksi

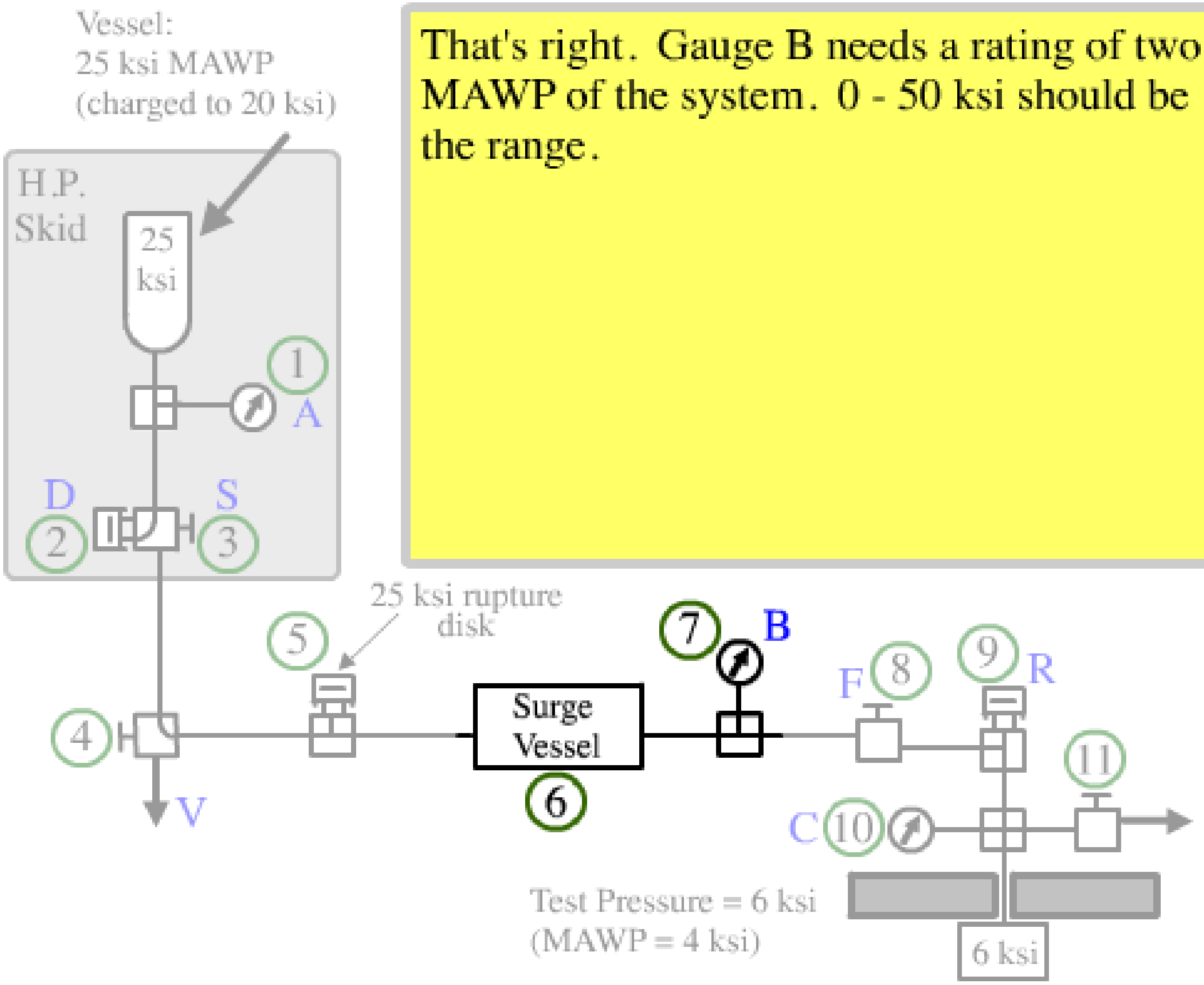
B) 0 - 20 ksi

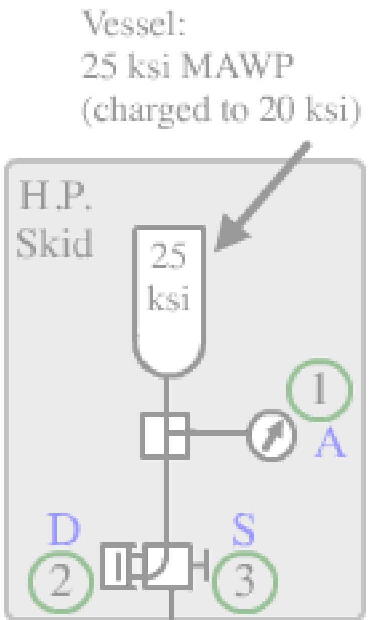
C) 0 - 10 ksi

D) -30" - 1000 psi



That's right. Gauge B needs a rating of two times MAWP of the system. 0 - 50 ksi should be the range.





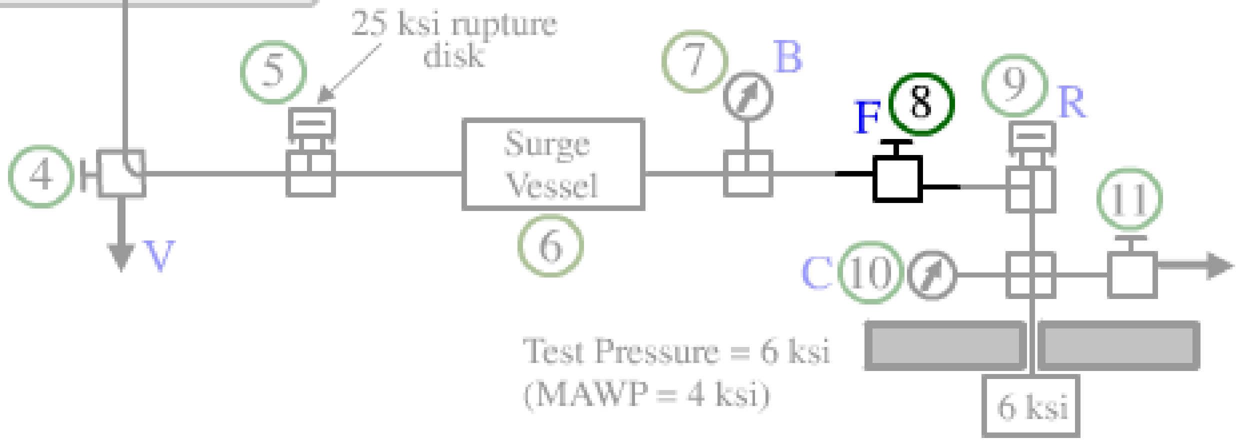
Valve F is a throttle valve to test. If the test pressure of this system is 6 ksi (MAWP = 4 ksi), what should the rating of this valve be? Please select an answer.

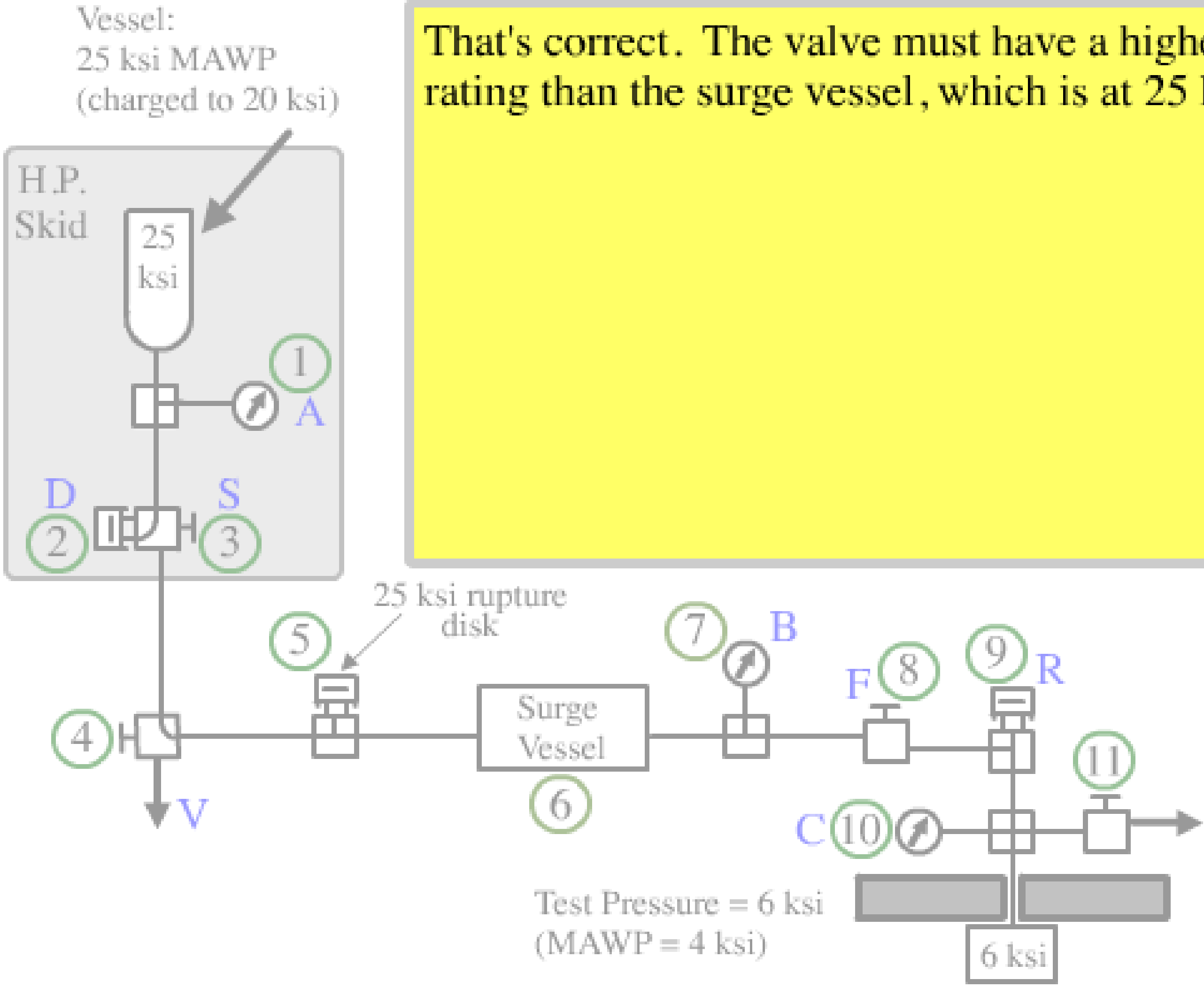
A) 4 ksi

B) 6 ksi

C) 15 ksi

D) 30 ksi





That's correct. The valve must have a higher rating than the surge vessel, which is at 25 ksi.

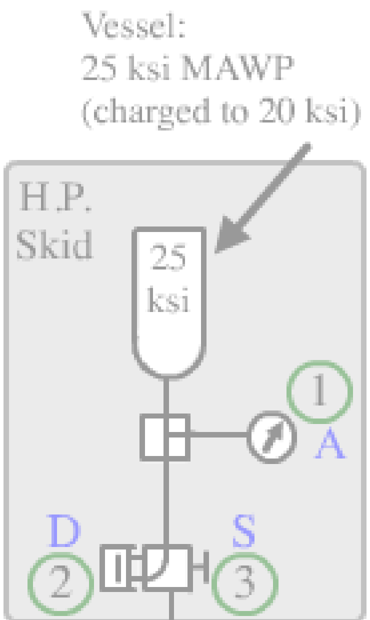
Next in line is another relief device, relief device R. It protects the test from overpressure. What should the setting of relief device R be if only valves with the following ratings are available? Hint: the pressure relief valve will be set at 120% of test pressure to protect the test.

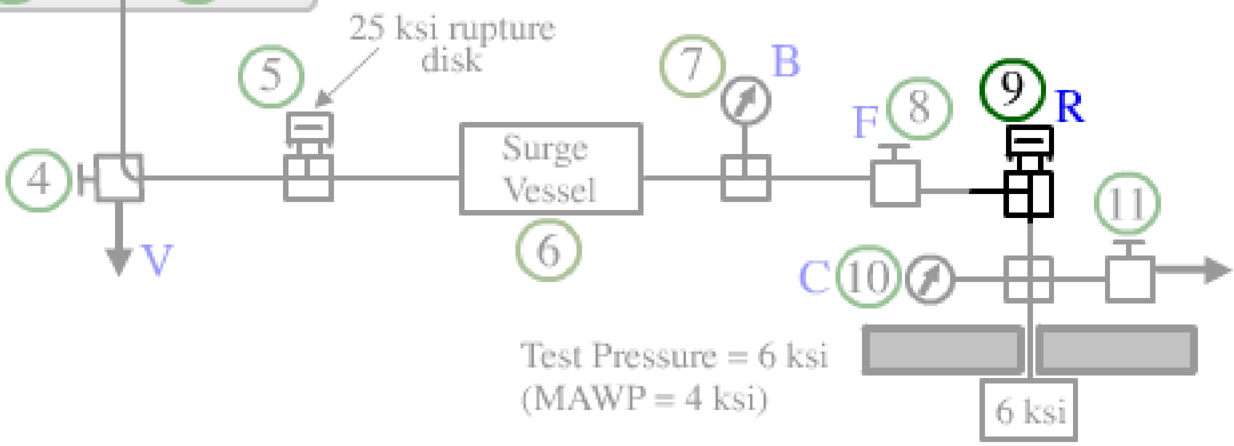
A) 7.5 ksi

B) 9.0 ksi

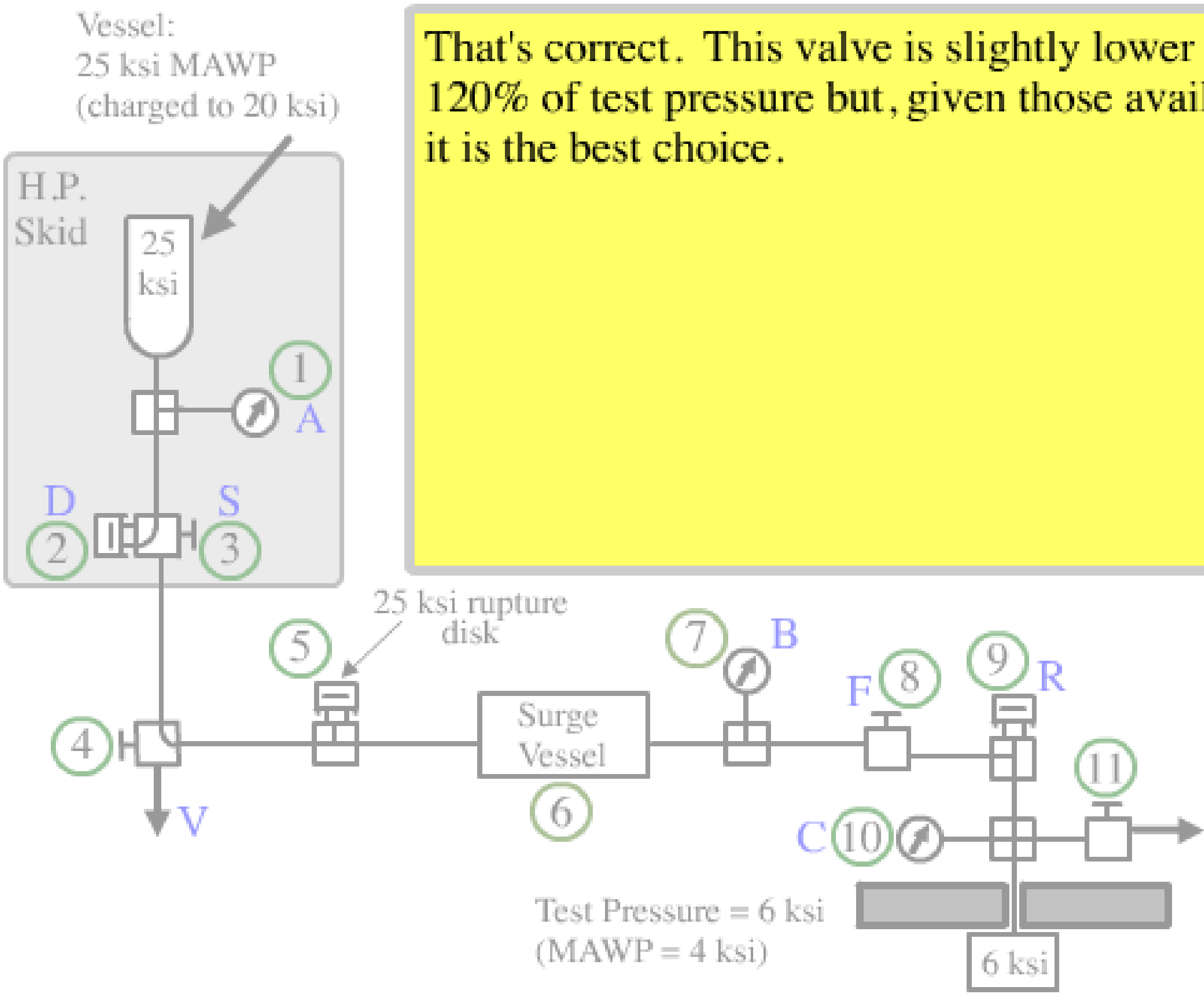
C) 7.0 ksi

D) 4.8 ksi





That's correct. This valve is slightly lower than 120% of test pressure but, given those available, it is the best choice.



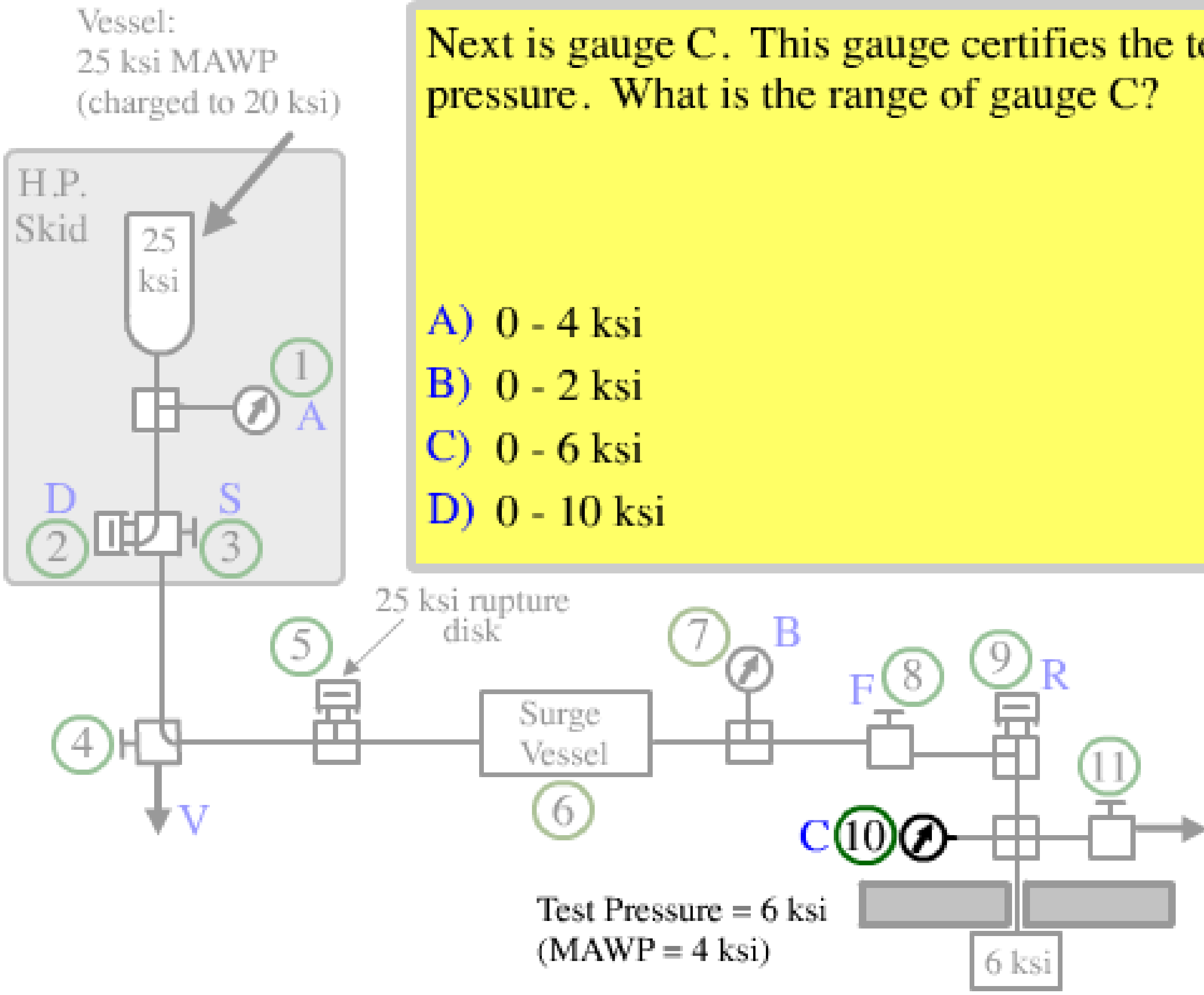
Next is gauge C. This gauge certifies the test pressure. What is the range of gauge C?

A) 0 - 4 ksi

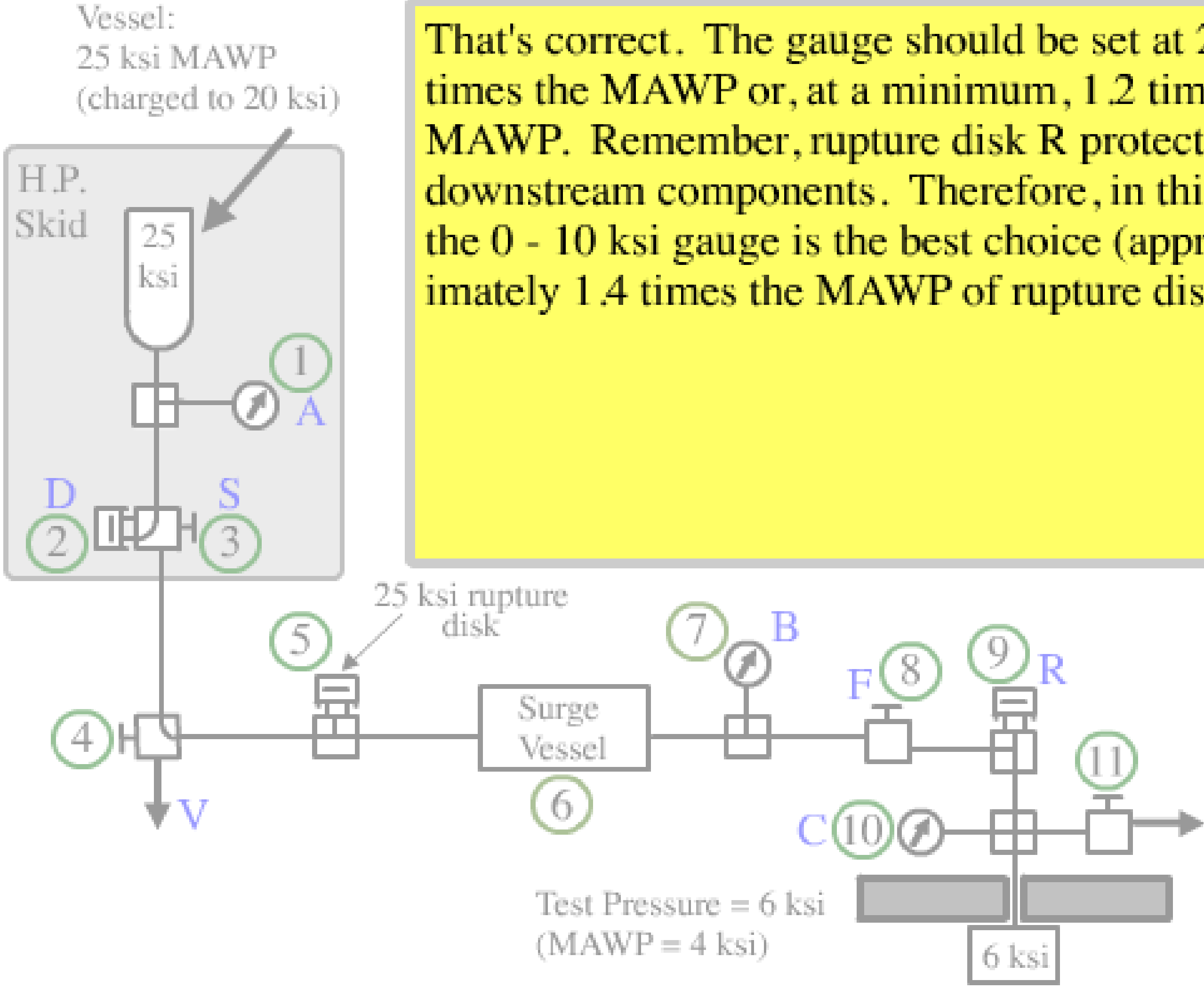
B) 0 - 2 ksi

C) 0 - 6 ksi

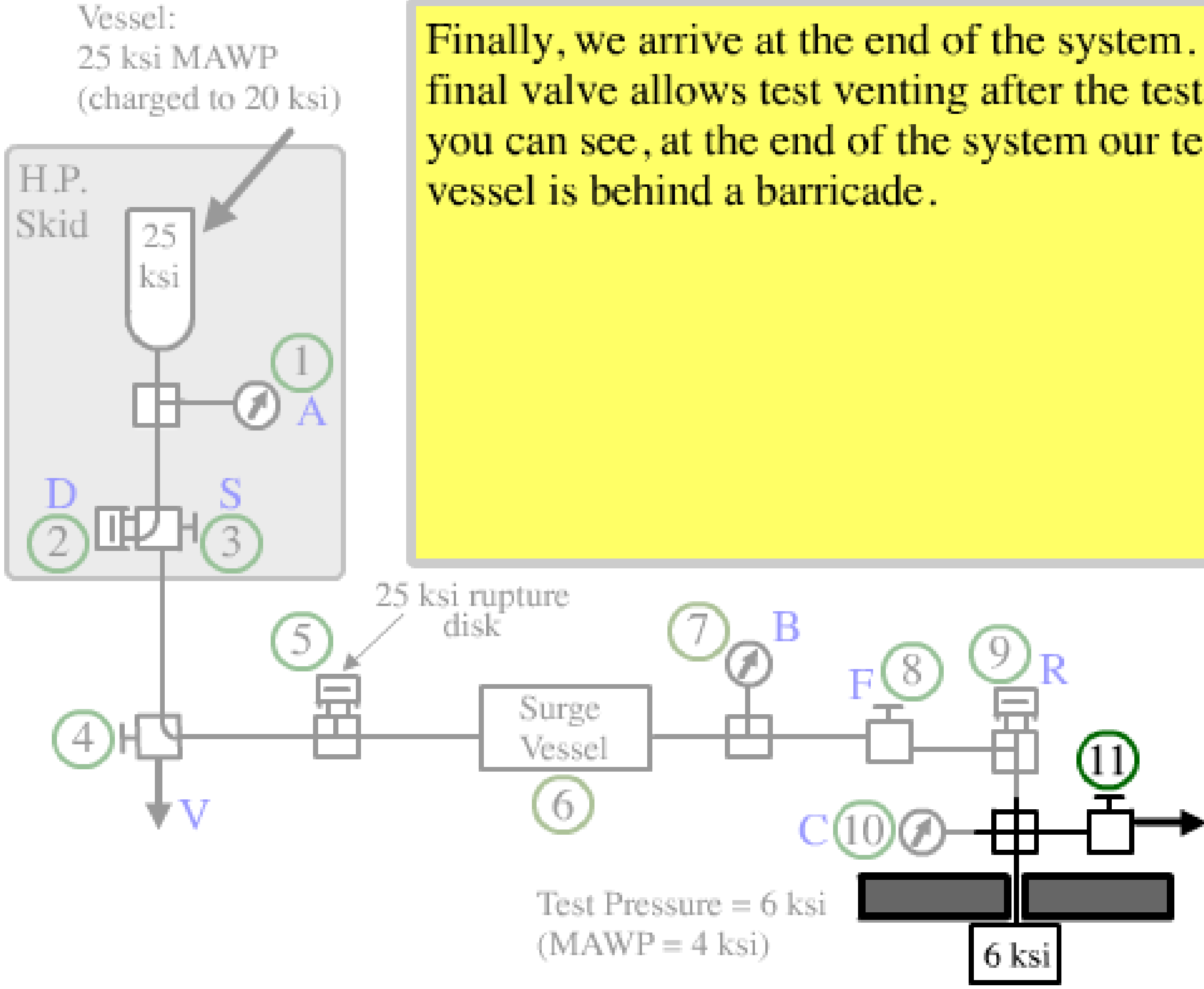
D) 0 - 10 ksi

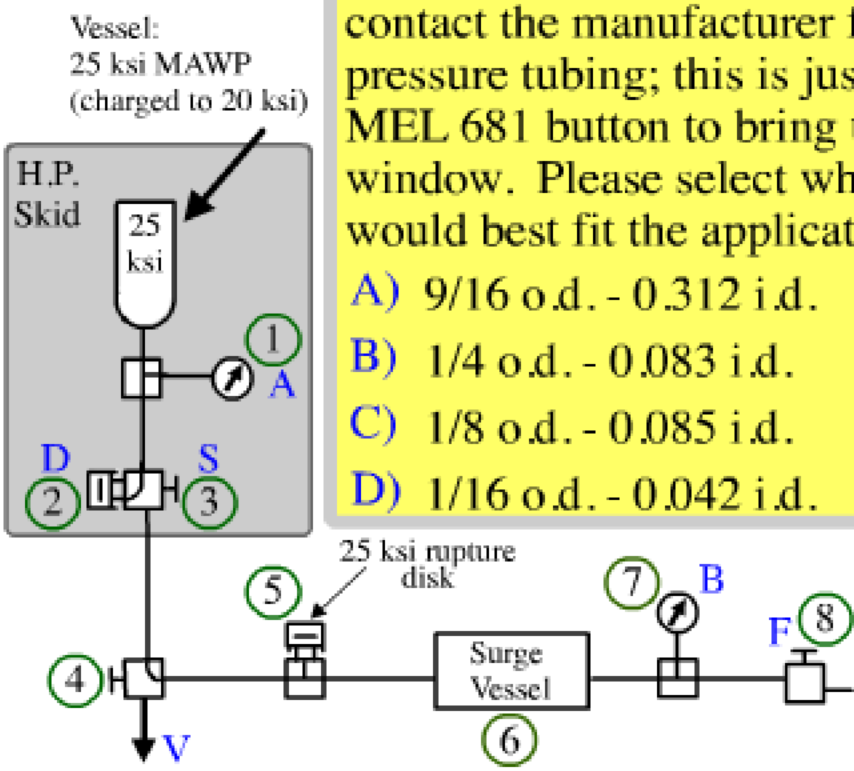


That's correct. The gauge should be set at 2 times the MAWP or, at a minimum, 1.2 times the MAWP. Remember, rupture disk R protects the downstream components. Therefore, in this case, the 0 - 10 ksi gauge is the best choice (approximately 1.4 times the MAWP of rupture disk R).



Finally, we arrive at the end of the system. This final valve allows test venting after the test. As you can see, at the end of the system our test vessel is behind a barricade.





One final question. What should the tubing size be between the skid and valve F in our system? For this question, you can use an example tubing chart based on Mechanical Engineering Livermore or MEL standard. Note, however, that in the field you should contact the manufacturer for the rating of high-pressure tubing; this is just an example. Click the MEL 681 button to bring the chart up in a separate window. Please select which tubing size listed below would best fit the application.

A) 9/16 o.d. - 0.312 i.d.

B) 1/4 o.d. - 0.083 i.d.

C) 1/8 o.d. - 0.085 i.d.

D) 1/16 o.d. - 0.042 i.d.

MEL 681

Example Tubing Chart (MEL 681)

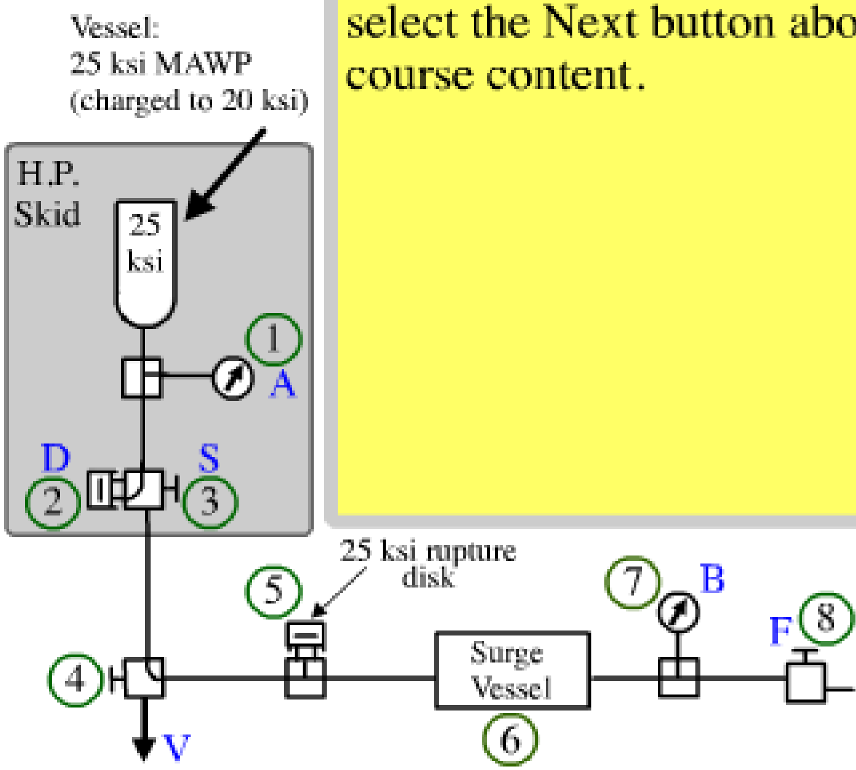
Note: MAWP values shown to be applied to example problem only.

O.d. (in.)		I.d. (in.)		Nominal wall thickness (in.)	MAWP (psig)
Nominal	Tolerance	Nominal	Tolerance		
1/16	0.0645/0.0625	0.005	0.006/0.004	0.028	60,000
|	|	|	|	|	|
1/16	0.0645/0.0625	0.042	0.044/0.040	0.010	20,000
1/8	0.128/0.125	0.085	0.087/0.083	0.020	20,000
|	|	|	|	|	|
1/8	0.128/0.125	0.093	0.095/0.091	0.016	15,000
1/4	0.249/0.243	0.083	0.083/0.078	0.084	55,000
|	|	|	|	|	|
1/4	0.254/0.250	0.210	0.212/0.208	0.020	3,000
5/16	0.311/0.305	0.062	0.062/0.057	0.125	100,000
3/8	0.374/0.368	0.125	0.125/0.120	0.125	60,000
3/8	0.379/0.375	0.305	0.308/0.302	0.035	3,500
1/2	0.504/0.500	0.402	0.405/0.399	0.049	59,804
9/16	0.561/0.555	0.187	0.187/0.182	0.189	60,000
|	|	|	|	|	|
9/16	0.561/0.555	0.312	0.323/0.317	0.125	20,000
3/4	0.749/0.743	0.437	0.437/0.432	0.157	25,000
|	|	|	|	|	|
3/4	0.754/0.750	0.620	0.623/0.617	0.065	3,500
1	0.999/0.993	0.562	0.562/0.558	0.219	20,000
1	0.999/0.993	0.687	0.687/0.682	0.157	10,000

* *Based on a theoretical burst pressure safety factor of 2 or higher.*

That's right. We need tubing with a pressure rating equal or greater than system MAWP. The 1/4" tubing is the best choice.

This is the end of the interactive presentation. Please select the Next button above to continue with the course content.



Pressure System Guidance

As mentioned earlier, the HS5050-W Reference Guide is available for your convenience. This document describes, in detail, how to disassemble, inspect, clean, and assemble Autoclave Engineers 30VM valves. The guide also contains a table of TNT Stored Energy Equivalents, temperature conversions, and the diagram of pressure relationships. If you haven't already done so, please download a copy or bookmark the link in your browser for quick reference.

Pressure System Guidance

The *ES&H Manual* is also valuable resource for more specific information on high-pressure systems. Please use the links below to access the information.

Document 18.2 (Pressure System Design)

Document 18.3 (Pressure Testing)

Document 18.4 (Hydrogen)

Document 18.5 (Cryogens)

High-Pressure-System Resources

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.

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 3 Review - Question 1 of 2

Which is true about pressure systems?

A) Pressure systems usually store more energy than vessels.

B) Pressure systems and sources are tested using the same processes.

C) Pressure systems are limited by their weakest component.

That's right! Pressure systems are limited by their weakest component.

Module 3 Review - Question 2 of 2

How can you keep foreign particles out of a high-pressure system?

A) Cap all unused lines.

B) Use particulate filters.

C) Air flush, degrease, and deburr as required.

D) All of the above.

That's right! You could do all of the above to keep foreign particles out of high-pressure systems.

This concludes High-Pressure Safety (HS5050-W). To get credit for the course, you must take the test and pass with a score of 80% or better. Select the Next button to take the test.