

INTRODUCTION

Chemical and processing plants use various gases in their process systems. Many of these gases require special regulator materials to eliminate or reduce corrosion that can contaminate the system and to increase the service life of the regulator. This Application Guide briefly explains the types of regulators and the construction materials available for these regulators.

REGULATOR TYPES

Pressure Reducing Regulators

In some process gas applications, the pipeline pressure may need to be reduced for a process or piece of equipment. Depending upon the accuracy required by the application, a direct-operated or pilot-operated regulator can be used to reduce the gas pressure.

Direct-operated regulators are used for lower flow rates. Pilot-operated regulators are used for high flow rates or where precise pressure control is required.

Differential/Bias Regulators

A differential or bias regulator maintains a pressure difference between two locations in the system.

Relief Valves/Backpressure Regulators

A relief valve or backpressure regulator opens when the upstream controlled pressure increases above the setpoint. Relief valves and backpressure regulators are the same devices. The name is determined by the application. Overpressure protection is provided by relieving pressure when it rises above the setpoint. When upstream pressure rises above the setpoint, the relief/backpressure regulator opens to allow excess upstream pressure to flow downstream, typically into a pressurized system or to atmosphere.

Vacuum Breakers vs. Vacuum Regulators

There is a variety of terminology used to describe vacuum, causing confusion when communicating with someone that uses different terminology. Fisher uses the following vacuum terminology:

First, determine whether the units are in absolute pressure or gauge pressure (0 psig or 0 barg is atmospheric pressure). For example:

- 5 psig (0,34 barg) vacuum is 5 psi (0,34 bar) below atmospheric pressure
- -5 psig (-0,34 barg) is 5 psi (0,34 bar) below atmospheric pressure
- 9.7 psia (0,67 bara) is 9.7 psi (0,67 bar) above absolute zero or 5 psi (0,34 bar) below atmospheric pressure (14.7 psia - 5 psi = 9.7 psia or 1,01 bara - 0,34 bar = 0,67 bara).

Just as there are pressure reducing regulators and pressure relief valves for positive pressure service, there are two basic applications for vacuum service. The terms used for each are sometimes confusing. Therefore, it is sometimes necessary to ask further questions to determine the required function of the regulator. Fisher uses the terms vacuum breaker and vacuum regulator to differentiate between the two types.

Vacuum Breakers

Vacuum breakers limit the increase in vacuum. An increase in vacuum (decrease in pressure) beyond the setpoint is sensed on the diaphragm causing the disk to move away from the seat. This permits a higher pressure to enter the system and restore the controlled vacuum to its original pressure setting.

Vacuum Regulators

Vacuum regulators maintain a constant vacuum at the regulator inlet. A decrease in vacuum (increase in pressure) beyond the setpoint registers on the diaphragm causing the disk to move away from the seat, allowing a higher vacuum source to restore the vacuum to its original setting.

APPLICATIONS

In many cases, piping systems are required to transport the process gas from its storage location outside of the building to the point(s) where it is required within the building. Process gases are supplied from pipelines, cylinders,

or pressurized tanks. Regulators are used to reduce the pressure to a level that is compatible with the supply pressure design parameters of the downstream system. A combination of regulators and relief valves/backpressure regulators may be required to accomplish these objectives.

CONSTRUCTION MATERIALS

Each process gas has its own set of unique characteristics in terms of its chemical composition, corrosive properties, impurities, flammability, hazardous nature, toxic effect, explosive limits, and molecular structure. In some cases special care must be taken to select the proper materials that will come in contact with the process gas.

Material selection for oxygen regulators, for example, must be carefully selected or a fire could result. Oxygen regulators must also be “de-greased or cleaned for oxygen service.”

Typical materials for regulator bodies are cast iron, steel, aluminum, brass, and stainless steel. Monel and Hastelloy C are available in some regulators. Trim materials are typically stainless steels, aluminum, or special alloys as mentioned above. The elastomeric parts (diaphragm, disk, and O-rings) are usually nitrile or neoprene. Other elastomers, such as ethylenepropylene (EPDM), fluoroelastomer (FKM), perfluoroelastomer (FFKM), and teflon (TFE), are also available.

All properties of the process gas should be known and a metals corrosion chart should be consulted to ensure the proper selection of the metal parts that come in contact with the gas. Likewise, an elastomer compatibility chart should be consulted for similar issues. An abbreviated version of these charts follows this Application Guide; the complete versions are in the Technical Reference section of this Application Guide.

It should be noted that a mixture of two or more chemicals may be more or less corrosive than one of the chemicals alone. Rely on past experience when selecting materials for handling a chemical mixture. The charts on the following pages do not address chemical concentrations and mixtures which can affect the corrosion rate.

PROCESS GASES APPLICATIONS

MATERIAL GUIDELINES FOR GASEOUS OXYGEN SERVICE

All organic and inorganic materials will react with gaseous or liquid oxygen at certain pressures and temperatures. The reaction that occurs can cause a fire or an explosion. Because of these inherent dangers, process system design and valve material selection are extremely important.

Oxygen service has many inherent hazards and requires careful and knowledgeable design of the process system. The information and guidelines presented here are intended to help the user; however, other factors, such as service conditions and process system design, must be considered to properly select materials that will handle this gas in a safe manner.

Many of the materials commonly used in valves have ignition temperatures above the normal flowing temperatures of gaseous oxygen. Ignition of these materials by normal flowing temperatures is generally not the danger. The danger is in the ignition of these materials by abnormal, localized high temperature. This list has been compiled from the best information available, but does not necessarily contain all the hazardous conditions that might be encountered in oxygen service applications.

Flow Velocity

All valve materials should be suitable for oxygen service, and material selection should meet the velocity criteria, such as set by the Compressed Gas Association Pamphlet G-4.4 (copies can be obtained from Compressed Gas Association, Inc., 500 Fifth Avenue, New York, NY 10036). In general, if the velocity through the port of the valve can exceed 200 feet per second (61 meters per second), only copper-base alloy material should be used for valve body and trim parts in contact with the flow stream.

Foreign Particle Impingement

A foreign particle, such as weld spatter, that is being carried in the flow stream and that strikes the valve trim or the valve body wall might have its kinetic energy transformed into sufficient heat to raise the impinging particle or the material it strikes to its respective ignition temperature.

Ignition by Already-Burning Material

An organic valve disk, for example, that has already been ignited by foreign particle impingement will release sufficient heat to ignite surrounding metallic materials, thus initiating a serious fire.

Vibration

A part that is caused to vibrate, usually by the flowing velocity, might generate enough heat from internal friction to raise its temperature to its ignition point.

Rapid Compression of Gas

Opening a valve to pressure the downstream system will result in the compression of the gas in the downstream system. If this is done rapidly, it can result in abnormally high gas temperatures, which might ignite material in the valve and piping system.

Static Electricity Discharge

The flow of gas across the trim of a ball, butterfly, or eccentric disk valve might generate a static charge on the trim. Because these valves inherently do not have a good grounding path from the trim to the valve body or from the valve body to the pipeline, use proper provisions and care for their grounding. Failure to do this might allow a discharge spark between the trim and valve body or between the valve body and adjacent piping, igniting the surrounding material.

Conclusion

The list shows that many of the hazards arise from the velocity of the flowing gas. For this reason, it is imperative that the system be designed such that flowing velocities will be low.

Organic Materials

Organic materials have ignition temperatures below those of metals. Use of organic materials in contact with oxygen should be avoided, particularly when the material is directly in the flow stream. When an organic material must be used for parts, such as valve seats, diaphragms, or packing, it is preferable to select a material with the highest ignition temperature, the lowest specific heat, and the necessary mechanical properties.

Lubricants and sealing compounds should be used only if they are suitable for oxygen service

and then used sparingly. Ordinary petroleum lubricants are not satisfactory and are particularly hazardous because of their high heat of combustion and high rate of reaction.

The approximate ignition temperatures in 2000 psig (138 bar) oxygen for a few organic materials are shown in the following table.

MATERIAL	Typical Ignition Temperature in 2000 psig (138 Bar) Oxygen	
	°F	°C
PTFE and Kel-F	875	468
70% Bronze-filled PTFE	875	468
Fluoroelastomer	600	316
Nylon	410	210
Polyethelene	360	182
Neoprene and Nitrile	300	149

Metals

The selection of metals should be based on their resistance to ignition and rate of reaction. Following is a comparison of these two properties for some commonly used valve materials.

Resistance to Ignition in Oxygen

Materials are listed in order from hardest to ignite to easiest to ignite.

- Copper, copper alloys, and nickel-copper alloys (such as Monels)—most resistant
- Stainless steel (300 Series)
- Carbon steel
- Aluminum—least resistant

Rate of Reaction

Materials are listed in order from slowest rate of combustion to most rapid rate of combustion.

- Copper, copper alloys, and nickel-copper alloys (such as Monels)—do not normally propagate combustion
- Carbon steel
- Stainless steel (300 series)
- Aluminum—burns very rapidly

Note that stainless steel, once ignited, burns more rapidly than carbon steel. Nevertheless, the austenitic grades (300 series) of stainless steel are considered to be much better than carbon steel because of their high resistance to ignition.

PROCESS GASES APPLICATIONS

CORROSION INFORMATION							
FLUID	MATERIAL						
	WCB Steel	Cast Iron or Ductile Iron	302 or 304 Stainless Steel	CF8M or 316 Stainless Steel	416 Stainless Steel	Monel	Hastelloy C
Acetic Acid Vapors (<150°F (65°C))(2/3)	C	C	A (304 only)	A	C	A	A
Acetone	A	A	A	A	A	A	A
Acetylene	A	A	A	A	A	A	A
Ammonia	A	A	A	A	A	A	A
Benzene (Benzol)	A	A	A	A	A	A	A
Butane	A	A	A	A	A	A	A
Carbon Dioxide (Dry)	A	A	A	A	A	A	A
Carbon Dioxide (Wet)	C	C	A	A	C	A	A
Carbon Disulfide	A	A	A	A	B	B	A
Carbon Tetrachloride	B	B	B	B	C	A	A
Chlorine Gas (Dry)	A	A	A	B	B	A	A
Chlorine (Wet)	C	C	C	C	C	C	A
Coke Oven Gas	A	A	A	A	A	B	A
Ether	B	B	A	A	A	A	A
Ethyl Chloride	C	C	B	B	C	A	A
Ethylene	A	A	A	A	A	A	A
Formaldehyde	B	B	A	A	A	A	A
Freon (Wet)	B	B	B	A	C	A	A
Freon (Dry)	B	B	A	A	A	A	A
Helium	A	A	A	A	A	A	A
Hydrogen	A	A	A	A	A	A	A
Methane	A	A	A	A	A	A	A
Natural Gas	A	A	A	A	A	A	A
Nitrogen	A	A	A	A	A	A	A
Phosphoric Acid Vapors	C	C	B	A	C	B	A
Propane	A	A	A	A	A	A	A
Sulfur Dioxide (Dry)	C	C	C	B	C	C	A
Sulfur Trioxide (Dry)	C	C	C	B	C	B	A

A- Recommended
 B- Minor to moderate effect. Proceed with caution.
 C- Unsatisfactory
 N/A- Information Not Available

ELASTOMER INFORMATION						
FLUID	MATERIAL					
	Neoprene (CR)	Nitrile (NBR)	Fluoroelastomer (FKM)	Ethylenepropylene (EPDM)	Perfluoroelastomer (FFKM)	Teflon (TFE)
Ammonia (Anhydrous) (<140°F (60°C))	A	A	C	A	A	A
Ammonia (Gas, Hot)	B	C	C	B	A	A
Benzene	C	C	B	C	A	A
Butadiene Gas	C	C	B	C	A	A
Butane Gas	B	A	A	C	A	A
Carbon Tetrachloride	C	C	A	C	A	A
Chlorine (Dry)	C	C	A	C	A	A
Chlorine (Wet)	C	C	B	C	A	A
Coke Oven Gas	C	C	A	C	A	A
Ethyl Acetate	C	C	C	B	A	A
Hydrogen Gas	A	A	A	A	A	A
Hydrogen Sulfide (Dry)	A	A ⁽¹⁾	C	A	A	A
Hydrogen Sulfide (Wet)	B	C	C	A	A	A
Nitrogen	A	A	A	A	A	A
Propane	A	A	A	C	A	A
Sulfur Dioxide	C	C	C	A	A	A

1- Performance worsens with hot temperature
 A- Recommended
 B- Minor to moderate effect. Proceed with caution.
 C- Unsatisfactory

PROCESS GASES APPLICATIONS

AVAILABLE CONSTRUCTION MATERIALS																													
TYPE	BODY						INTERNAL METAL PARTS						DIAPHRAGMS						O-RINGS & OTHER ELASTOMER PARTS										
	Aluminum	Brass/Bronze	Hastelloy C	Iron (Cast or Ductile)	Monel	Stainless Steel	Steel	Alloy 20	Aluminum	Brass/Bronze	Hastelloy C	Monel	Stainless Steel	Steel	Ethylenepropylene (EPDM)	Fluoroelastomer (FKM)	Hastelloy C	Monel	Neoprene (CR)	Nitrile (NBR)	Stainless Steel	TFE Protector	Ethylenepropylene (EPDM)	Fluoroelastomer (FKM)	Neoprene (CR)	Nitrile (NBR)	Nylon (PA)	Perfluoroelastomer (FFKM)	Teflon (TFE)
63EG-98HM			•	•	•	•	•				•	•	•	•	•	•	•				•	•	•	•		•		•	
66 Series				•		•	•						•			•					•		•	•			•		
66R Series				•		•	•						•			•					•		•	•			•		
67C Series	•					•							•			•					•		•	•			•		
95 Series			•	•	•	•	•				•	•	•		•	•	•	•	•			•	•	•		•		•	•
95B Series	•	•							•	•			•			•		•	•			•		•	•			•	
98 Series			•	•	•	•	•				•	•	•		•	•	•	•	•			•	•	•		•		•	•
99				•			•		•	•			•			•					•			•	•		•		
627 Series				•		•	•						•		•	•					•		•	•		•	•	•	•
1098-EGR				•		•	•						•		•	•					•		•	•		•	•	•	•
1301		•				•							•								•			•	•		•		•
Y690A			•	•		•						•	•			•					•		•	•		•	•	•	•
Y690VB			•	•		•						•	•			•					•		•	•		•	•	•	•
Y692			•	•		•	•					•	•			•					•		•	•		•	•	•	•
Y692VB			•	•		•						•	•			•					•		•	•		•	•	•	•
Y695A			•	•		•						•	•			•					•		•	•		•	•	•	•
Y695VR			•	•		•	•					•	•			•					•		•	•		•	•	•	•
Y696			•	•		•	•					•	•			•					•		•	•		•	•	•	•
Y696VR			•	•		•	•					•	•			•					•		•	•		•	•	•	•

TIPS

- Direct-operated regulators generally have faster response to quick flow changes than pilot-operated regulators.