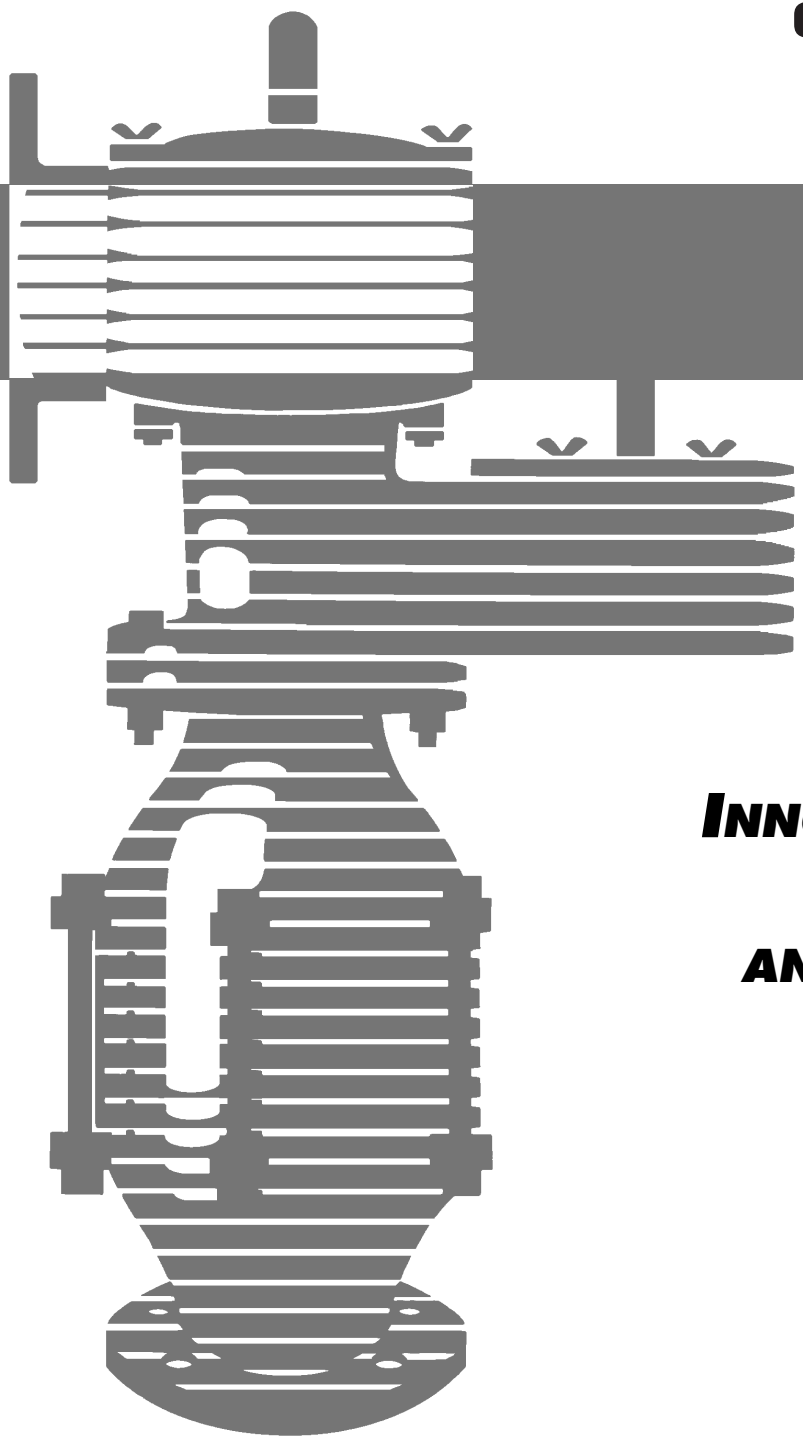
GROTH®
CORPORATION



Innovative Solutions for Process and Liquid Storage Tank Protection

Groth Products Group

Overview

GROTH CORPORATION

Established in Houston, Texas in 1960, Groth has grown to employ more than 200 associates with three plants in Houston, Texas, Geismar, Louisiana and Lake Charles, Louisiana. The Houston plant is 81,000 square feet. In 1971 Groth started the "Vent Valve" division and is now the leading pressure/vacuum relief valve manufacturer in the United States.

The three divisions of the Company are as follows:

- Groth Products Group (GPG) Manufacturing Division
- Representation Division
- Valve Repair Division

PRESSURE/VACUUM RELIEF VALVE

The pressure/vacuum valve is a protection device mounted on a nozzle opening on the top of a fixed roof atmospheric storage tank. Its primary purpose is to protect the tank against rupturing or imploding. Without an opening or a controlled opening, a fixed roof atmospheric tank would rupture under increasing pressure caused by pumping liquid into the tank or as a result of vapor pressure changes caused by severe thermal changes. Imploding, or the collapsing of a tank, occurs during the pumping out procedure or thermal changes. As the liquid level lowers, the vapor space pressure is reduced to below atmospheric pressure. This vacuum condition must be alleviated through a controlled opening on the tank. In short, the tank needs to breathe in order to eliminate the possibility of rupturing or imploding. Because of its primary function, a pressure/vacuum valve is commonly referred to as a "breather valve".

FLAME/DETONATION ARRESTERS

Flame arresters are fire safety devices. They prevent flames from entering a tank and also provide protection from flashes within a tank. They can also be used as an in-line flashback prevention device.

EMERGENCY VALVE

The primary function of the emergency relief valve is to provide a controlled opening on a tank that will be large enough to prevent rupturing of the tank under severe pressure increases caused by close proximity to intense fire.

Each of these safety devices are used on the atmospheric, fixed roof, non-refrigerated, storage tank.

Pressure Vacuum Relief Valves

Flame and Detonation Arresters

Blanket Gas Regulator & Pilot Operated Relief Valve

Advantages of Pressure/Vacuum Relief Valves

WHY PRESSURE/VACUUM RELIEF VALVES ARE REQUIRED

1. Saves money by saving product.
2. Protects tank from over or under pressure when sized properly.
3. Protection against fire hazard when conforming to API standards.
4. Minimizes evaporation loss.
5. Reduces atmospheric corrosion of tank.
6. Generally in all cases required by OSHA, EPA, etc.

PRESSURE/VACUUM VALVES SAVE MONEY

Actually, any properly sized opening in the tank's upper structure protects the tank from damage, but utilizing a pressure and vacuum valve also serves to accomplish other advantages. Two of the more important are: economic savings and fire hazard protection. In 1952, American Petroleum Institute developed a formula to determine tank evaporative losses. The API equation was formulated after the results of a total of 256 individual tests were compiled. Of the 256 tanks tested (1/2 with open vents and 1/2 with pressure/vacuum valves), only 178 were considered valid. The remainder were eliminated because of inadequate data, obviously incorrect test methods, poor tank conditions, or leaky fittings.
The API has a formula for calculating tank breathing loss. The principle factors are: turnovers per year, true vapor pressure of the product, diameter of the tank in feet, the average outage in feet, the average daily ambient temperature change, and the paint factor. The test was conducted on tanks containing gasoline with pressure and vacuum valves set at 1/2 oz. pressure and 1/2 oz. vacuum. API 2521 states that 1/2 oz. is the usual setting.

CALCULATING TANK PRODUCT LOSS

A multiple correlation for tanks 20 feet in diameter or larger, based on model equation, derived from the tests on the tanks, yielded in the case of gasoline:

$$L_y = \frac{TPY}{1{,}000}\left(\frac{P}{14.7\text{-}P}\right)^{.68} D^{1.73} H^{.51} T^{.50} F_P$$

Where:

- L_y = the breathing loss in barrels per year.
- TPY = turn overs per year
- P = the true vapor pressure at bulk liquid temperature in pounds per square inch absolute
- D = tank diameter in feet
- H = the average outage in feet
- T = average daily ambient temperature change
- F_p = the paint factor

A modification of the above equation was then required which would accommodate small-diameter tanks.

$$L_y = \frac{TPY}{1{,}000}\left(\frac{P}{14.7\text{-}P}\right)^{.68} D^{1.73} H^{.51} T^{.50} F_P C$$

IN MOST CASES A PRESSURE/VACUUM RELIEF VALVE WILL PAY FOR ITSELF BEFORE YOU PAY THE INVOICE

The results of these tests indicate that the evaporation loss on a tank with a 55,000 barrel capacity would be 2,000 barrels per year if an open vent was installed, and only 1,382 barrels per year if a pressure/vacuum valve was utilized, thereby saving 618 barrels per year, every year. This study also coined a new catchword, "Conservation Vent". So if you hear the term conservation vent, you know that the valve referred to is a pressure/vacuum valve or breather valve.
If the product in the tank cost $40 per barrel, this would be a savings in one year of $24,720 per tank. Pressure/vacuum relief valves provide savings of millions of dollars and millions of barrels of product in a facility with as many tanks as are picture on page 2. The cost of these valves is so minimal that the valve will have paid for itself in probably less than thirty days.

API's Estimated Breathing Loss Table

Tank Diameter in Feet	Nominal Tank Capacity	Breathing loss		BBLS/Year Saved Using Pressure Relief Valve
		Estimated Losses With Pressure Relief Valve	Estimated Losses With Open Vent	
30	5,000	154	235	81
42.5	10,000	297	441	144
60	20,000	570	825	255
100	55,000	1,382	2,000	618

Advantages of Pressure/Vacuum Relief Valves

BASIC FIRE PROTECTION

An advantage of using a pressure/vacuum valve is that the valve provides fire protection for your tank. A pressure/vacuum valve is normally closed except when venting to pressure or vacuum conditions; and an open vent always has a free passageway between the vapor in the tank and atmosphere. Therefore, a pressure/vacuum valve is usually closed allowing the tank vapor to reach true vapor pressure.
Under true vapor pressure, the vapor in the tank is too rich to burn. The tank is also closed off eliminating a free passageway for fire or sparks to ignite the potentially combustible vapor in the tank. If the valve has been activated by excessive tank pressure, the now open valve is causing a condition where any vapors escaping are under positive pressure and the fire hazard will be kept away from the vapor content of the tank. If flames are in the area and the tank is in an emptying mode, the vapors are not escaping and combustion is not likely even though the tank has a combustible mixture.

1. Closed tank principle. When a pressure/vacuum valve is closed, fumes are not escaping to allow combustion.

2. Pressure when open principle. When the valve is open, the velocity of the relieving vapor is greater than the flame speeds.

3. Over rich principle due to equilibrium being reached in a closed tank and therefore the fumes are too rich to burn. When emptying or pumping out of the tank, oxygen vapors are susceptible to burning and flame arresting should be used.

4. The vacuum created during dispensing of product will prevent fumes from escaping and consequently is generally protected.

REDUCED CORROSION

An additional reason for using pressure/vacuum valves, they help reduce overall corrosion in the plant. Plant corrosion is reduced due to less product escaping from the tank and therefore less corrosion is produced by escaping vapors. This means overall plant maintenance is reduced thereby saving labor and dollars.

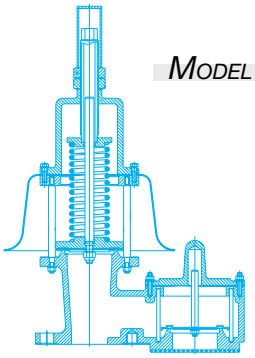
RECOMMENDED AND REQUIRED

Pressure/vacuum valves are recommended by API 2000 for use on atmospheric storage tanks in which oil with a flash point below 100° F is stored. OSHA states that tanks storing Class 1 liquids shall be equipped with venting devices which shall be normally closed except under pressure or vacuum condition.
Generally speaking, the majority of the regulatory bodies dealing with tank safety, API, OSHA, NFPA, Insurance Companies etc. require installation of these devices on flammable liquid storage tanks.

Pressure/Vacuum Valve Operation

HOW PRESSURE/VACUUM RELIEF VALVES OPERATE

How does a pressure/vacuum valve operate? Most atmospheric tanks require a venting device that will allow large volumes of vapor to escape under relatively low pressures. Usually the allowable set pressure is in inches of water column pressure, both for positive and vacuum conditions. This is because most large storage tanks have a relatively low maximum allowable working pressure. These tanks are generally large volume welded vessels that are built to API 650 standard. In order to accommodate large volumes at low set pressures, these valves have ports that are greater in area than the inlet or nozzle connection. The low setting required necessitates weight loading the valve as opposed to spring loading. Because of the above, a pressure/vacuum valve requires approximately 100% over set pressure in order to reach full opening of the valve. However, when deciding on a set pressure, the weight-loaded valve operation MAWP should be at least twice the required set pressure to obtain optimum flow. If the MAWP is less than 100% above the required set, the valve could be larger in size than normally required. The possibility of valve chatter and accelerated seat and diaphragm wear will exist if less than 20% over pressure is allowed. Simply stated, a pressure/vacuum valve is not exactly like a high pressure safety relief valve and should not be sized at 10% or 20% over pressure. When sizing a pressure/vacuum valve, consult the manufacturer flow curves and allow sufficient overset pressure.

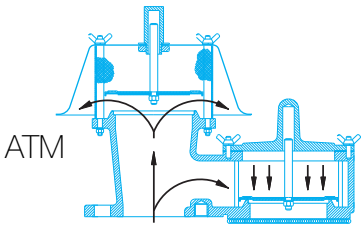


Model 1201B

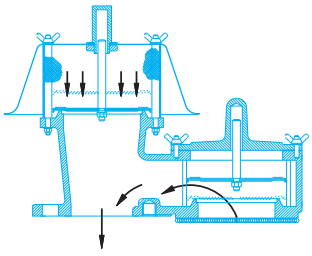
SPRING LOADED VALVES

The spring loaded valve is used on higher pressure tanks (generally over 1 PSIG). They will protect from over pressure and excessive vacuum while reducing tank breathing, thereby saving product.

1. They are required as weight limit is reached.
2. Will virtually eliminate "Top Hat" lock.



Tank Pressure

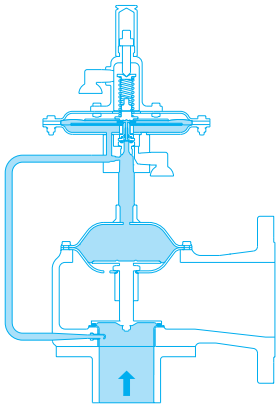


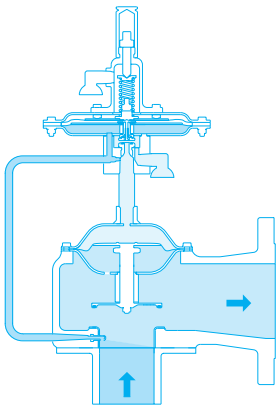
Tank Vacuum ATM

PILOT OPERATED RELIEF VALVE

The Pilot Operated Relief Valve is designed to provide safe, dependable, and accurate low pressure and/or vacuum protection. Full flow is attained at no more than 10% overpressure. This reduces the need for high over pressure which saves product and prevents fugitive emissions. Blowdown may be adjusted to requirements between 0% and 20% of set pressure. Properly adjusted the Pilot Operated Relief Valve is bubble tight up to 95% of set pressure. The Pilot Operated Relief Valve provides the Maximum available control technology as specified in the Clean Air Act of 1990.

Model 1660





API Standard 2000 for Venting Atmospheric and Low Pressure storage Tanks

SIZING A PRESSURE/VACUUM RELIEF VALVE

API Standards are provided as an engineering aid for specification and selection of "normal" and "emergency" pressure and vacuum relief valves for aboveground liquid petroleum storage tanks. Normal venting capacity is obtained without exceeding pressure or vacuum that would cause physical damage or permanent deformation to the tank. The following will help in sizing a pressure/vacuum valve:

1. Normal Relief: The sum of vapor replacement resulting from emptying or filling and thermal in-breathing or out-breathing.
2. Emergency Relief: Thermal out-breathing from fire exposure.
3. All Tanks: Generally require the sizing of a normal pressure and vacuum relief valve to be sized and an independent emergency relief valve to be sized separately.
4. Flow Curves: These curves provide pressure and vacuum capacity which is required for sizing.

OSHA AND API REQUIREMENTS

The OSHA requirement for tank protection published by the Department of Labor and part 1910.106 revised as of July 1, 1985 addresses sizing requirements. OSHA suggest sizing should be in accordance with API 2000. All requirements are clearly defined in this publication.

PRESSURE/VACUUM RELIEF VALVE SETTING

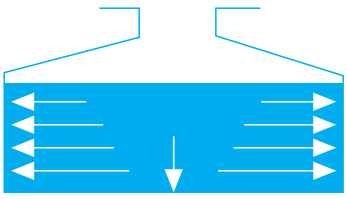
API 2521

"Pressure/vacuum valves on atmospheric pressure fixed-roof tanks are usually set at ½ oz. per square inch pressure or vacuum. Test data indicate that an increase of 1 oz. per square inch in the pressure set point over the usual ½ oz. per square inch reduces breathing losses by approximately 7 percent. However, the test data indicate that each additional increase of 1 oz. per square inch in pressure set point reduces the breathing losses in progressively smaller increments."

API 2513

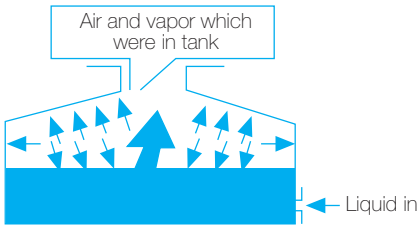
"The pressure and vacuum setting of a breather valve are dictated by the structural characteristics of the tank and should be within safe operating limits. A certain amount of pressure and vacuum beyond this setting is necessary to overcome pressure drop in order to obtain required flow. Proper size and settings can best be determined by reference to API Std 2000: Venting Atmospheric and Low-Pressure Storage Tanks (1992) and to the manufacturers tank data determined in accordance with this publication. The pressure setting for pressure/vacuum valves to be installed on large tanks constructed in accordance with API 12: Specification for Large Welded Production Tanks (1957) usually is limited to ½ oz. because roof plates will start to shift when the pressure rises much above 1 oz."

STORAGE TANK DESIGN
(National Fire Protection Agency)



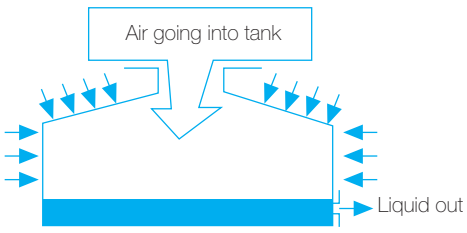
1. TO HOLD LIQUID

Liquid exerts pressure on the sides and base of the tank. Pressure=height of liquid.



2. TO BE FILLED

For liquid to get in, air and vapor must get out. If they can't, the tank will be pressurized. For air and vapor to be pushed out, the pressure in the tank must be slightly above atmospheric pressure.
The tank is designed for an internal pressure of 8 in. water gage (WG).



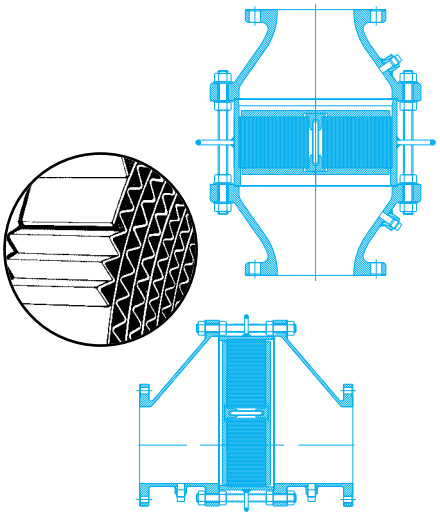
3. TO BE EMPTIED

For liquid to get out, air must get in. If it can't, the tank will be underpressured. For air to be sucked in, the pressure in the tank must be slightly below atmospheric pressure.
The tank is designed for an external pressure (or vacuum in the tank) of 2 ½ in. WG.

Flame and Detonation Arresters

FLAME ARRESTER

A flame arrester is a safety device installed on a nozzle on top of a tank when the flash point of the stored product is lower than the possible tank temperature. A majority of the time, a "vent to atmosphere" pressure/vacuum valve is installed on top of the flame arrester. A flame arrester is also used as in-line safety device



where combustible gases are transported through low pressure pipe lines to actual combustion, as in an incinerator or flare or where combustion fumes are vented through piping to atmosphere where lightning can cause a flame. Flame arresters should be designed to stop tank farm fires caused by lightning, sparking, or actual flame in the immediate tank area, and to prevent flashbacks in lines. In order to accomplish the above, a flame arrester must act as a barrier (stop a flame), a flame holder (contain the flame at the barrier), and dissipate heat in order to prevent auto ignition on the down side of the flame arrester.

In order to be an effective flame prevention device, a flame arrester must have a quenching or hydraulic diameter small enough to stop the flame created by the combustible gas. Each combustible gas has a different required hydraulic diameter to be able to stop the flame. The hydraulic diameter of Groth Flame Arresters is .048" (1.23 mm).

In addition to stopping the flame, an arrester must be able to dissipate heat. Flame element mass ensures that hot gases above the auto ignition temperature never reach the downstream side of the flame arrester.

With an in-line installation, structural integrity is important to insure safety if a detonation should occur. Proper gasketing to insure an oxygen free environment in the event of a detonation is also important. Unless a flame arrester meets or exceeds the above mentioned design criteria, it is not a true flame arrester.

DETONATION ARRESTER

A detonation arrester is another safety device installed in a piping system. A detonation is defined as a flame front propagating through a flammable gas or vapor at a velocity equal to or greater than the speed of sound. A detonation arrester should be installed when the source of a flash back is greater than ten pipe diameters from the installation of the arrester or when there is a possible restriction in the line. Groth Detonation Flame Arresters are Bi-Directional and can be installed in a vertical or horizontal piping installation. The model 7658A has been successfully tested and USCG approved as a Type II Detonation Flame Arrester suitable for applications where stationary flames may rest on the element.

MODEL 7658A

AIR OPERATED RELIEF VALVE

Air operated relief valves are used to replace weight loaded and pilot operated valves in severe applications where polymerization and crystalization may take place and plug as well as corrode the pilot valve. The pressure switch coupled with a solenoid valve and using plant instrument air instead of corrosive product vapor provides a bubble tight seal in the valve.

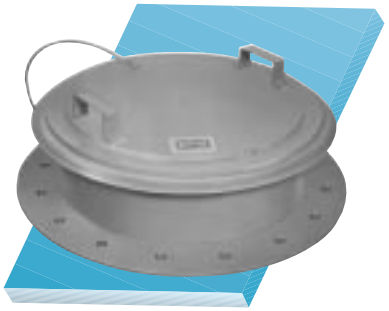
MODEL 1520

EMERGENCY VALVES

Emergency valves are required by API on storage tanks in order to protect the tank against excessive pressure caused by external fire exposure or flashes within the tank.The excessive pressure caused by an external fire is generally because an adjacent tank is on fire or some other structure in close proximity is on fire. Flashes are generally caused by a chemical reaction in the tank. Regardless of the cause of the excessive pressure, an opening larger than the normal pressure/vacuum valve is necessary in order to carry off the additional volume resulting from the fire exposure the tank is experiencing. API 2000 states emergency venting my be accomplished by the use of:

1. Larger or additional open vents.
2. Larger or additional pressure/vacuum valves or pressure relief valves.
3. A gage hatch which permits the cover to lift under abnormal internal pressure.
4. A manhole cover which permits the cover to lift under abnormal internal pressure. (ERV Model 2000/2400)
5. A connection between the roof and shell which is weaker than the weakest vertical joint in the shell or shell to bottom connection (weak roof to shell weld).

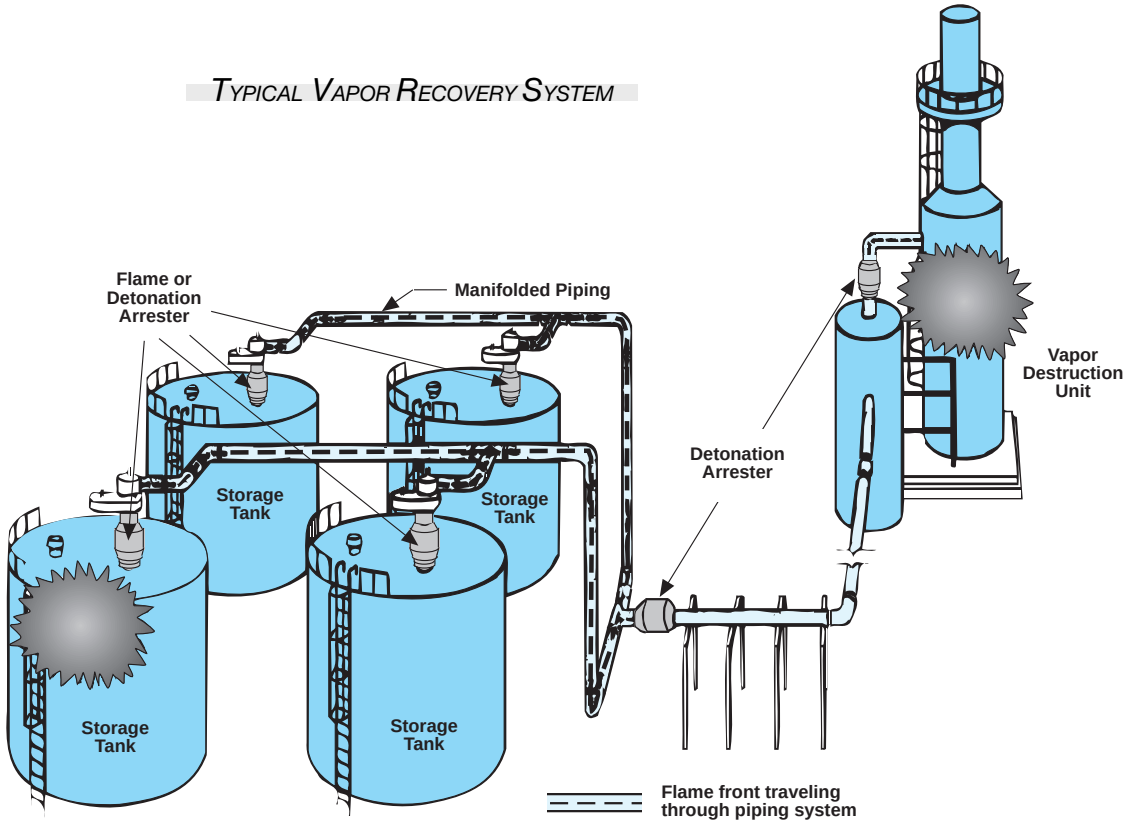
Model 2000



VAPOR RECOVERY SYSTEM

With the implementation of the Clean Air Act of 1990, most Liquid Product Storage terminals and hydrocarbon processing plants must control evaporative hydrocarbon emissions from loading and storage operations. Two types of recognized technologies are vapor recovery using carbon absorption or vapor combustion. Both systems require pressure/vacuum valves and flame or detonation arresters to minimize emissions and maximize safety.

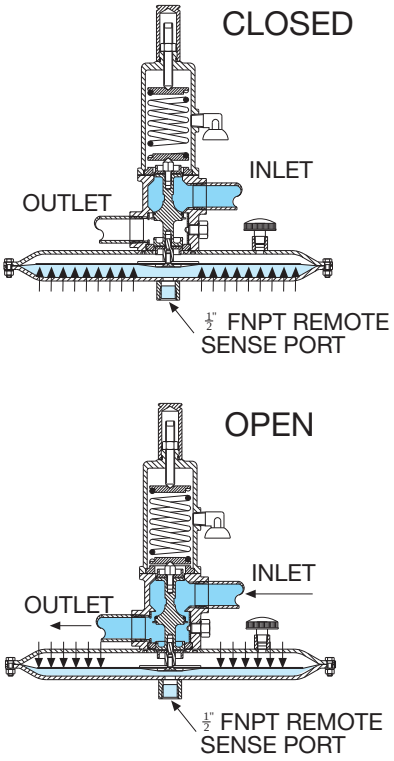
Typical Vapor Recovery System



Vapor Emission Reduction

GAS BLANKETING

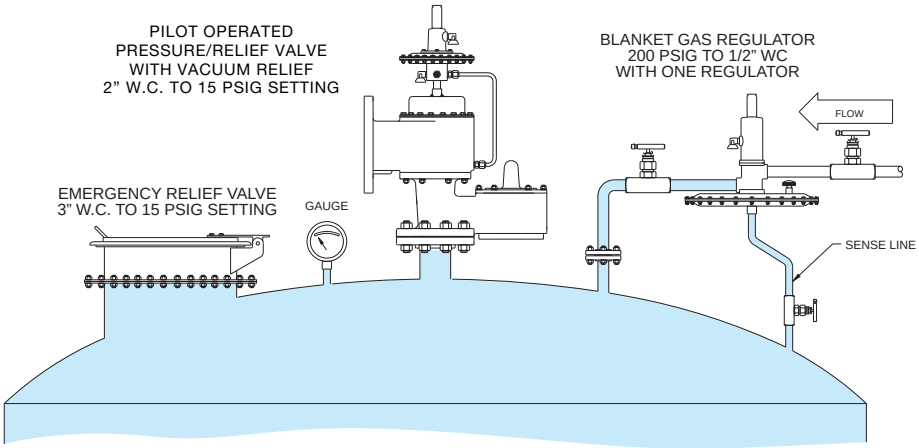
The Groth Blanket Gas Regulator ensures that a constant gas pressure is maintained in the vapor space of a storage tank. When liquid is removed from a tank or the temperature is



reduced, a vacuum would be developed. With the Groth Blanket Gas Regulator, a blanket gas is supplied to prevent any vacuum from developing and to maintain the desired blanket pressure. In addition to preventing outside air and moisture from entering the storage vessel, a blanket gas pressure, as low as ½"W.C., reduces the evaporation of the stored product to a negligible amount. The result would not only conserve product but would also greatly reduce emissions. The advantages are in addition to the fire protection that is provided.

CLEAN AIR ACT OF 1990 METHOD 21 LEAK TEST

The 1990 ammendment to the 1998 Clean Air Act, requires the emissions of any of the identified volatile organic compunds (VOC) be kept to under 500 parts per million (PPM). Method 21 is the leak test procedure required to be utilized in order to detect rate of leakage. Using Groth Corporation pilot operated devices with the film seat option, and the Groth blanket gas regulator provides overpressure or underpressure protection for liquid storage tanks while assuring your compliance to the Clean Air Act.



CONCLUSION

Tank protection equipment is specialized. Understanding this equipment and how it should be applied will ensure that your storage tank is protected properly from any number of potential hazards. Protection from rupturing or imploding, and protection from fire hazards are the major considerations. Just as important should be the environmental and conservation features this equipment affords your company.

Electronic Catalog
PC-compatible electronic catalog and technical data. Makes valve selection and specification simple. Includes sizing program for P/V valves per API 2000.

Cal-Q-Size 2000
Sizing System Software.
IBM Compatible
Calculates in accordance with API Standard 2000.

Pressure/Vacuum Relief Valves

Model 1200 A
Pressure/Vacuum Relief Valve
Modular design
Sizes: 2" through 12"
Pressure settings: 1/2 OZ./in.^{2} to 15 PSIG
Vacuum settings: 1/2 OZ./in.^{2} to 12 PSIG
Page 100

Model 1220 A
Pressure/Vacuum Relief Valve
Pipe-away feature
Modular design
Sizes: 2" through 12"
Pressure settings: 1/2 OZ./in.^{2} to 15 PSIG
Vacuum settings: 1/2 OZ./in.^{2} to 12 PSIG
Page 120

Model 1000 Series
Pressure/Vacuum Relief Valve
Common pipe-in/out feature
Pressure settings: 1/2 OZ./in.^{2} to 15 PSIG
Vacuum settings: 1/2 OZ./in.^{2} to 12 PSIG
Page 150

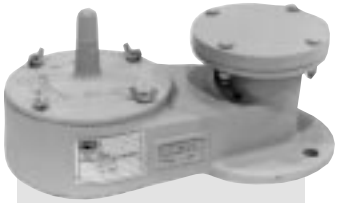
Fiberglass Valves
Most Groth valves can be constructed of fiberglass.
Page 160

Pressure Relief Valves

Model 1260 A
Pressure Relief Valve
Modular design
Pipe-away feature
Sizes: 2" through 12"
Pressure settings: 1/2 OZ./in.^{2} to 15 PSIG
Page 300

Model 2300 Series
Pressure Relief Valve
Modular design
Sizes: 2" through 12"
Pressure settings: 1/2 OZ./in.^{2} to 15 PSIG
Page 310

Vacuum Relief Valves



Model 1300 A
Vacuum breaker
Modular design
Sizes: 2" through 12"
Vacuum settings: 1/2 OZ./in.^{2} to 12 PSIG
Page 320

Model 1360 A
Vacuum breaker
Modular design
Side mount
Modular design
Sizes: 3" through 14"
Vacuum settings: 1/2 OZ./in.^{2} to 12 PSIG
Page 330

Pilot Operated Relief Valves

Model 1660
Pressure Relief Valve
High flow capacity
Sizes: 2" through 12"
Pressure settings: 2" W.C. through 15 PSIG
Page 600

Model 1420
Pressure/Vacuum Relief Valve
Modular design
Pressure & vacuum relief
High flow capacity
Sizes: 2" through 12"
Pressure settings: 3 OZ./in.^{2} through 15 PSIG
Vacuum settings: 1/2 OZ./in.^{2} to 12 PSIG
Page 650

Model 1560
Extreme service valve
Modular design
Pressure relief
High flow capacity
Sizes: 2" through 12"
Pressure settings: 3 OZ./in.^{2} through 15 PSIG
Page 670

Model 2500
Emergency Relief Valve
Sizes: 18", 20" and 24"
Pressure settings: 8 OZ./in.^{2} to 15 PSIG

Available in aluminum (type 356), carbon steel, stainles

Emergency Relief Valves

Model 2301A
Pressure Relief Valve
Sizes: 2" through 12"
Pressure settings: 1/2 OZ./in.^{2} to 15 PSIG

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Model 2000
Emergency relief manhole cover
Sizes: 16", 20" and 24"
Pressure settings: 1-1/2 OZ./in.^{2} to 16 OZ./in.^{2}
Also available with vacuum breaker.

Page 400

Model 2450
Emergency relief manhole cover with hinged cover with vacuum breaker
Sizes: 20" through 24"
Vacuum settings: 1/2 OZ./in.^{2} to 4 OZ./in.^{2}
Pressure settings: 2 OZ./in.^{2} to 8 OZ./in.^{2}
Also available pressure only.

Page 420

Model 2100
High pressure emergency relief valve
Sizes: 16", 20" and 24"
Pressure settings: 1 PSIG to 15 PSIG

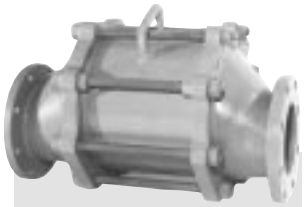
Page 410

Flame and Detonation Arresters

Model 7618
Flame arrester (vertical design)
FM approved
Sizes: 2" through 60"

Available with weather hood.

Page 200



Model 7628
Flame arrester (horizontal design)
FM approved
Sizes: 2" through 30"

Page 200

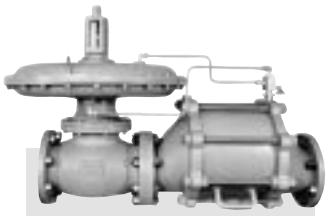
Model 7658 A
Detonation arrester (horizontal design)
Coast Guard approved
Sizes: 2" through 24"

Page 230

Model 7622
Flame check
Sizes: 1/2" through 1-1/2"

Page 210

Flame Trap Assemblies



Model 8400A
Back Pressure Regulator and Flame Trap Assembly
Sizes: 2" through 12"

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Model 8500A
Flame Trap Assembly
Sizes: 2" through 12"

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Blanket Gas Regulator

Model 3000 Series
Blanket Gas Regulator.
Regulates and controls inert gas blanket in storage tanks.
Setting from 1/2" W.C. to 10 PSIG.

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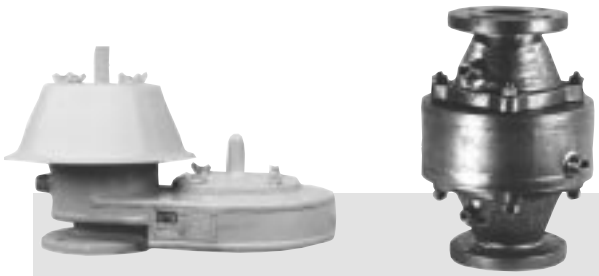
s steel, fiberglass, and other materials, in most models.

Steam Jacketed Products



Most Groth valves and flame arresters can be steam jacketed.

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Additional Products

Model 6000 Series
Gauge hatch.
Sizes: 4" through 10".

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Model 8110
Back Pressure Check Valve
Sizes 2" through 12"

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Additional Products

Model 8330
Sediment Traps
Sizes 2" to 12"
Available in carbon steel, stainless steel and other materials.
Capacity 12 gallons minimum.

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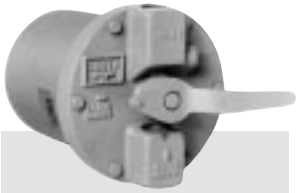

Model 8460
Manual Drip Trap

Model 8450
Automatic Drip Trap

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Model 4000 Series
Vacuum breaker
High working pressure
Sizes: 1/2" through 12"
Vacuum settings: 2 OZ./in.^{2} to 12 PSIG

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Model 8600
Foam Separator

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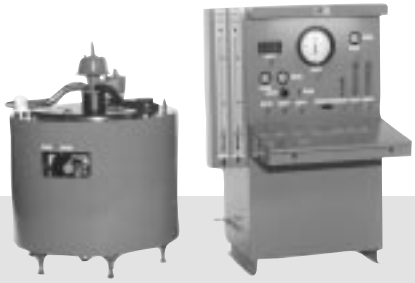
Test Stands



Pressure/Vacuum Relief Valve Test Stand
Provides convenient, accurate testing and setting of P/V valves or high pressure relief valves.
Includes leak testing.

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GROTH IS COMMITTED TO THE TOTAL QUALITY IMPROVEMENT PROCESS

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