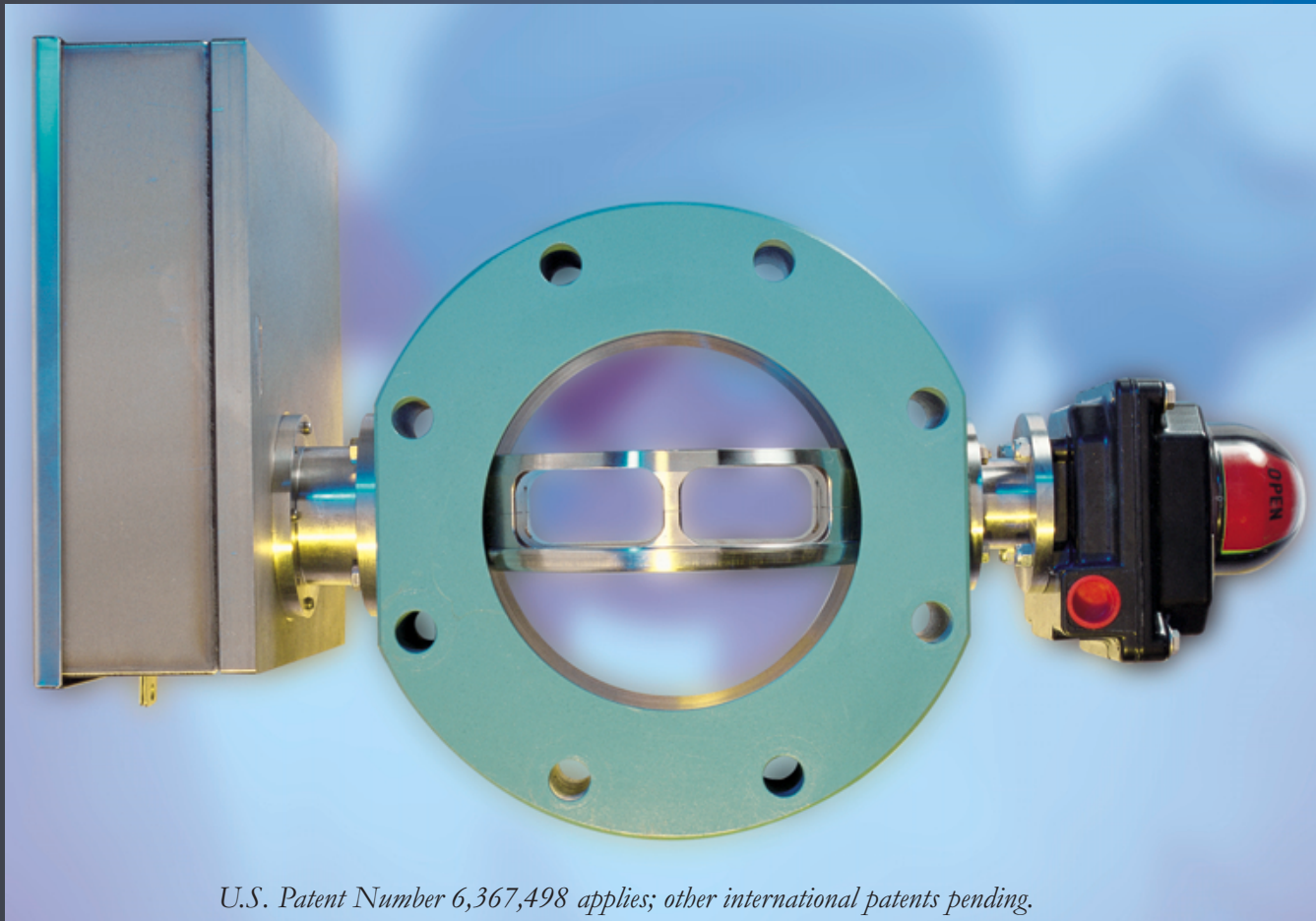




BS&B SAFETY SYSTEMS, L.L.C.
BS&B SAFETY SYSTEMS LTD.

Buckling Pin Pressure Relief Technology



U.S. Patent Number 6,367,498 applies; other international patents pending.

**The Buckling Pin Relief Valve (BPRV™)
offers quick and simple
field reset without removal
from the piping system.**

The Buckling Pin Relief Valve (BPRV™) can improve productivity within a facility by dramatically reducing the down time that can be caused with other non-reclosing pressure relief devices.

The BPRV is an in-line pressure relief device which offers quick and simple field reset without removal from the piping system. This non-reclosing pressure relief device provides practical technology for the protection of applications containing one or more of the following conditions:

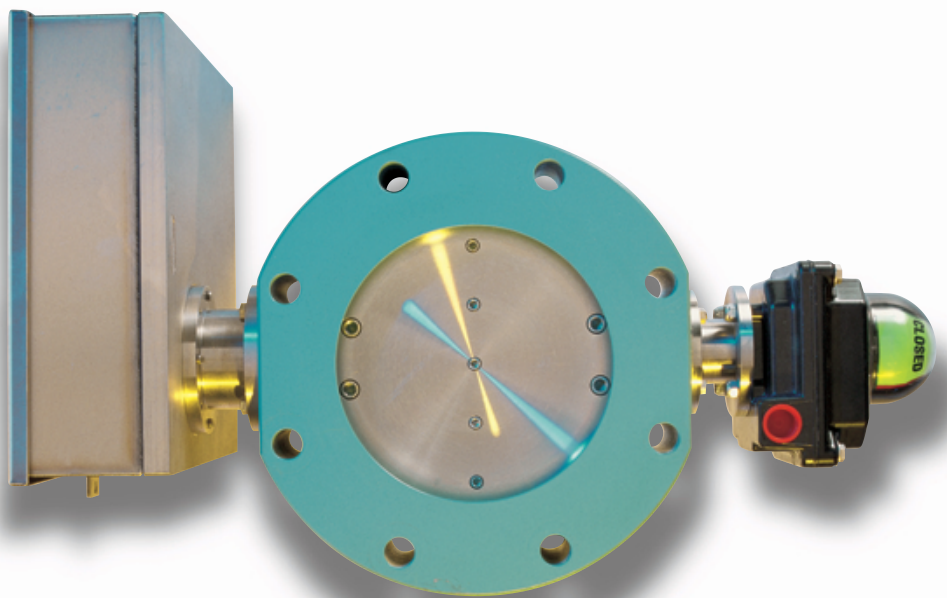
- ◆ Continuous Processing
(fast reset in the line)
- ◆ Hazardous Service
(limits operator exposure)
- ◆ Large Line Size
(convenient reset in the Line)
- ◆ Inaccessible Location
(external reset in the line)
- ◆ Frequent Operation
(fast reset in the line)

Buckling Pin Pressure

Design (U.S. Patent #6,367,498 applies; Worldwide Patents Pending)

The design of the BPRV™ is based upon the offset shaft butterfly valve concept. The offset of the shaft results in a turning moment being generated about the valve shaft when a pressure differential is applied across the device. A Buckling Pin mounted externally to the process normally resists this turning moment. By calibrating the Buckling Pin to collapse at a load coincident with that resulting from the shaft torque at a predetermined differential pressure, the BPRV provides accurate pressure relief.

Buckling Pin technology provides an accurate and reliable means of calibrating a pressure relief device. When an axial load is applied to a straight cylindrical pin, it will buckle at a specific load according to Euler's Law. Buckling Pins that are manufactured from the same material and have the same configuration will buckle at predictable and repeatable loads.



Three Primary BPRV Components

1-Rotating Disc. A rotating disc normally closes the flow path and turns through 90 degrees in response to an overpressure/underpressure condition. The rotating disc is constructed from metal and has a hollow design. This maximizes the flow path through the BPRV and ensures the stability of the disc during normal service and at the time of opening. (See catalog cover photo).

2-Flanged Body. A flanged body contains the rotating disc, holding it in place using shaft connections that are sealed within the body and pass through bearings to permit free rotation of the disc within the body. The body is a 1-piece design with no constructional welds or other potential external leak paths.

3-External Enclosure and Mechanism. The external enclosure and mechanism provides the set pressure control for the BPRV. The mechanism is designed to resist the turning moment of the disc shaft during normal service pressure conditions. When the desired set pressure is reached, the mechanism releases the disc due to the function of a Buckling Pin which has been built with sufficient strength to resist disc rotation until that point. The mechanism is contained within a stainless steel enclosure. The enclosure door includes a seal to permit service under severe environmental conditions.

Relief Technology

Three Set Pressure Calibration Controls

1-The Offset of the BPRV Disc Shaft from the Center Line.

A large offset will generate a higher shaft load; a small offset will generate a lower shaft load. For BPRV devices supplied for applications within the ANSI 150/DIN PN10 flange pressure range, a standard offset is used that does not exceed 1"/25mm, even for the largest installation.

2-The Buckling Strength of the Buckling Pin.

This is a function of the 4th power of the pin diameter, the Modulus of Elasticity of the Pin material, and the inverse of the Pin length. Buckling Pin diameter is used for significant set pressure tuning, length adjustment is used for fine tuning.

3-The Enclosure Mechanism Uses a Lever Principal.

This enables a wide range of BPRV set pressures to be obtained with modest Buckling Pin lengths and diameters while using a standard disc shaft offset. This enables the mechanism to be compact and results in a simple Pin installation procedure that can be completed by a single operator without special tools. Note: The BPRV is calibrated before shipment to meet the users required set pressure and tolerance.

Size and Set Pressure Capability

The BPRV is available with a standard range of sizes and set pressures designed to suit applications that are compatible with ANSI 150, DIN PN 10 or similar flange specifications as shown in Table 1.

In addition to these standard specifications, the BPRV is capable of meeting a wide range of dedicated customer requirements that have already included:

High Set Pressures: Over 2000 psi/138 Bar in a 6"/150mm nominal size installed between ANSI 900 flanges

Low Set Pressure: 20" Water Column/50 mBar in a 24"/600mm nominal size

Please consult BS&B Safety Systems with your special applications.

Table 1-Set Pressure Capability:Standard

Size		Set Pressure			
		Minimum		Maximum	
in	mm	psi	bar	psi	bar
1"	25	40	2.76	275	18.96
1 1/2"	40	10	0.69	275	18.96
2"	50	5	0.34	720	49.64
3"-6"	80-150	5	0.34	275	18.96
8" - 16"	200-400	3	0.21	275	18.96
18" - 24"	450-600	1	0.07	150	10.34
26" - 36"	650-900	1	0.07	125	8.62
38" - 60"	950-1500	1	0.07	100	6.89

Set Pressure Certification and Tolerance

In line with International Standards, the BPRV is certified at the customer requested set pressure. This certification is a result of Buckling Pin tests conducted in the BPRV to confirm compliance with set pressure and tolerance expectations. The BPRV is certified with a single set pressure tolerance, as indicated in Table #2. For set pressures between 20 psi/1.38 Bar and 40 psi/2.76 Bar, the BPRV provides a superior set pressure tolerance option of +/-5% compared to other non-reclosing pressure relief devices.

When certified according to ASME/North American standards, the BPRV is marked with the customer requested set pressure (Table #1). When certified according to European (PED) standards, the BPRV is marked with the customer requested set pressure and the tolerance based upon Table 2. Alternatively, European certification allows for marking the BPRV with a minimum/maximum set pressure (which will also be calculated from Table 2).

Table 2-Set Pressure Tolerances

Pressure	Tolerance
Over 40psi/2.76 Bar	+/-5% Standard
From 1-40 psi/0.07-2.76 Bar	+/-0.14 Bar/2 psi Standard
Over 20 psi/1.38 Bar	+/-5% Upon Request

Note: For BPRV units supplied according to the PED, the performance tolerance can be negotiated between BS&B and the user.

Operating Pressure Ratio

Buckling Pin technology provides outstanding resistance to operating pressure conditions. The BPRV can be operated up to 95% of minimum set pressure. This is called the 'Operating Pressure Ratio'. Subject to special testing, there is the ability to increase this ratio further.

Note: Remember to subtract the negative set pressure tolerance in the case of a BPRV marked with 'set pressure' rather than a defined min/max.

Pressure Cycling Service

Buckling Pin devices are well suited to cyclic service pressure conditions. Operating under compression, the Buckling Pin is not subject to tensile fatigue failure. The BPRV can be cycled to its maximum operating pressure ratio thousands of times.

Materials of Construction

The user may specify the material of construction for each of the three major BPRV components: Standard materials are as follows:

Valve Body. The standard materials are carbon steel and stainless steel. Alternate materials include Hastelloy[®]* C-276, Monel[®]*, Alloy 20, and metals that can be obtained in the form of cut plate or a forging (depending upon the size of the device to be fabricated).

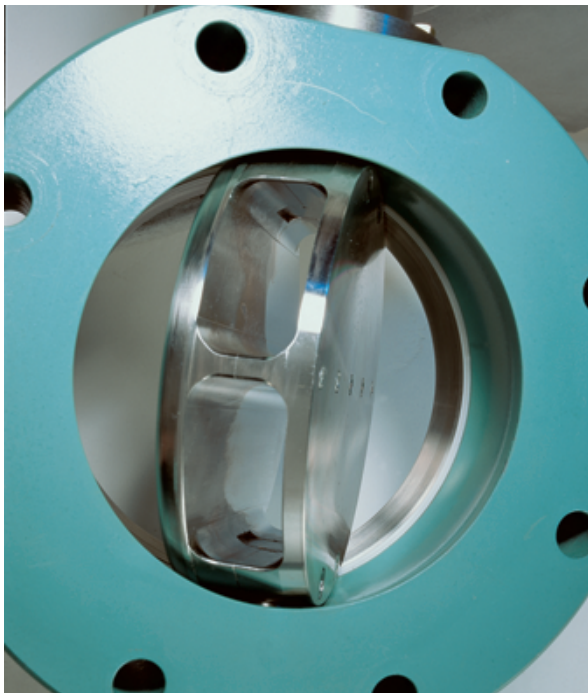
Valve Disc. The minimum material is stainless steel. The disc provides the valve sealing surface, therefore a resistant surface must be ensured. Alternate materials are the same as for the valve body.

Enclosure. The standard material is stainless steel with Viton door seals. Alternates may be requested.

Seals

The primary seal in the BPRV is mounted in the 1-piece body, held in place by a sealing ring. This seal engages a curved surface on the leading edge of the disc and has a profile that provides a tight shut-off from both the inlet and outlet sides of the device. The standard seal material is Teflon[®] (alternates are available upon request).

On the outlet side of the disc, there are two shaft connections that hold the disc freely within the body. These are also fitted with standard Teflon seals. Free rotation of the disc about the shaft is assured by the use of either bushings or bearings (depending upon size and set pressure) installed with a Teflon seal on either side. The shaft seals are not in process contact from the inlet side when the BPRV is in the closed position. (Alternate shaft seals are available upon request).



Installation

The BPRV is designed for “in-line” installation between pipe flanges. Each device is a 'full face' design with the pipe flange bolting typically passing through the perimeter of the body. Some flange specifications have a compact bolting pattern that would interfere with the bushings or bearings if through bolt holes were used; in these cases, a threaded blind bolt hole is provided on both sides of the BPRV so a full set of flange bolts is installed.



The piping may run horizontally, vertically, or at an oblique angle. The BPRV can be supplied set-pressure certified for any of these orientations. The user must identify the installation configuration at time of order to ensure appropriate calibration testing of the BPRV. The BPRV body can be fitted with lifting lugs to ease maneuver of the device into place between pipe flanges.

Field Reset

When a Buckling Pin has functioned and the BPRV is to be reset, this can typically be accomplished while the device remains installed in the piping system. The enclosure is opened, the used Buckling Pin removed, the disc rotated back into the closed position, a replacement Buckling Pin installed and the mechanism reset. This takes only a few minutes and can be completed by a single operator, even with the largest size BPRV.

Temperature

The materials of construction for the BPRV permit a wide range of service temperatures. Each device has two different temperature considerations:

1. Compatibility of service temperature with seal materials.
2. Buckling Pin coincident temperature at time of function.

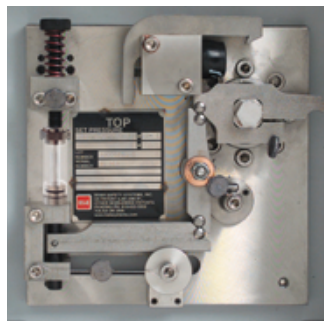
The standard Teflon seals can be operated between $-40^{\circ}\text{F}/-40^{\circ}\text{C}$ and $+400^{\circ}\text{F}/260^{\circ}\text{C}$. While flowing, temperatures down to cryogenic conditions can be handled. Seal performance is regained once the Teflon seal has returned to the recommended operating range.

With the Buckling Pin installed in the enclosure, the process temperature does not reach the pin. In general, the Buckling Pin will be at ambient temperature making certification of the Pin lot at $72^{\circ}\text{F}/22^{\circ}\text{C}$ appropriate.

Variation of ambient temperature causes minimal change in Buckling Pin performance - as little as 1% over the range $-40^{\circ}\text{F}/-40^{\circ}\text{C}$ to $200^{\circ}\text{F}/93^{\circ}\text{C}$. Ambient temperature conditions for each application should be reviewed with BS&B Safety Systems, L.L.C.

Enclosure and Mechanism Construction

Three standard mechanisms are employed to meet the torque requirements of the BPRV nominal sizes 1”- 60” (25 mm-150 mm). In all cases, the mechanism is fitted to a solid stainless steel baseplate to ensure rigidity. The mechanism is either installed inside a stainless steel enclosure or has an enclosure bolted to the baseplate (see M4200 photo). The M16000 mechanism handles low torque applications typical of BPRV sizes 1”-6” (25 mm-150 mm). The more substantial M4200 mechanism handles the torque range typical for higher pressure 4” (100 mm) BPRV devices through low pressure 24” (600 mm) size. The M1600 mechanism is designed to handle the very high torque requirements of BPRV devices sized 24”-60,” nominal size. (The light duty M600 mechanism for small size BPRV devices is offered with an economic, light-weight glass fiber enclosure as an option).



M600 for sizes 6” and smaller



M4200 for sizes 6” and larger

The mechanism front cover is provided with a latch tongue that aligns with another on the side to allow the user to add a preferred locking mechanism. Turn latches mounted on the front of the enclosure energize the door elastomer seal.

All mechanisms comprise of stainless steel and protective coated high tensile steel components. This combination avoids seizing of moving parts through the use of similar metals, and provides excellent corrosion resistance. The mechanism is fully sealed within the enclosure when the door is latched shut.

Mechanism Function

The BPRV mechanisms use a lever principal to balance input load from the rotating disc against output load applied to the Buckling Pin. When the (input load) x (distance from lever load input to the fulcrum) > the (Buckling Pin collapse load) x (distance from fulcrum to the lever load output), the BPRV will open.

The input load is provided by the pressure generated torque on the disc shaft. This loads the input side of the lever arm. When the Buckling Pin operates, the lever is free to move, allowing the shaft to rotate through 90 degrees into the full open position. At most set pressures, the BPRV will latch in the full open position to ensure the greatest flow rate through the device. The location of the fulcrum is tailored by BS&B Safety Systems, L.L.C. during the calibration of each BPRV. This set pressure control feature of the BPRV design is used for fine tuning. The fulcrum location is factory set and wire sealed for tamper evidence.

Customized BPRV Units/Command Activation

The BPRV can be user command activated in two different configurations:

BPRV-CAE

If it is known that the BPRV will always sense a positive differential pressure, an actuator (e.g. solenoid or pneumatic piston) installed adjacent to the buckling pin can be used to buckle the pin on demand. This will release the BPRV mechanism and allow the disc to rotate freely under pressure.

This is known as a “command activated enclosure,” or CAE, and allows the valve to be used as both a pressure relief device and a command actuated quick opening valve.

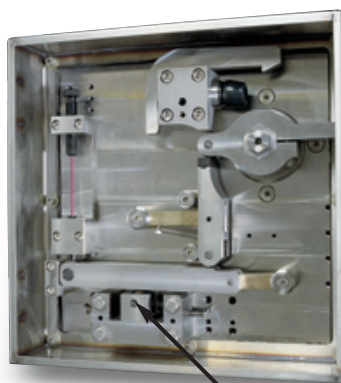
BPRV-CAS

If command actuation is desired in an application where positive differential pressure cannot be guaranteed, a powered actuator can be installed on the free shaft of the BPRV. When the operating conditions require the valve open, the actuator is powered to overcome both the buckling pin and any back pressure induced torque on the BPRV shaft to open the device.

This is known as a “command activated shaft,” or CAS, and allows the BPRV to be used as both a pressure relief device and a command actuated quick opening valve.

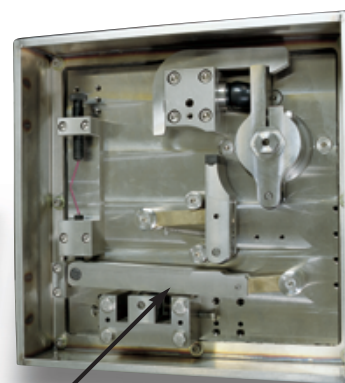
The BPRV-CAE and BPRV-CAS are examples of customized design options that can be satisfied with this versatile pressure relief technology. BS&B Safety Systems welcomes the opportunity to develop solutions to unique applications.

Closed Valve



Fulcrum

Open Valve



Lever Arm

Quality Assurance

Every BPRV is thoroughly tested before shipment. Pre-delivery inspection can be divided into:

- ◆ Dimensional Inspection
- ◆ Leak Tightness Verification
- ◆ Buckling Pin Calibration and Set Pressure Testing

Before the BPRV is assembled from component parts, each component is dimensionally verified for its critical features. After assembly, the performance of the seals is checked. ANSI standard B16.104 is typically followed with a minimum test standard of Class IV established. Many BPRV devices are supplied to the stricter Class V and Class VI limits which require a 'bubble tight' construction.

All Buckling Pins that are supplied as a lot are manufactured from a single batch of raw material at the same time. The BPRV set pressure is established through Buckling Pin destructive testing. Once the appropriate Pin configuration has been achieved for the required set pressure, the lot of Pins is completed with in very tight dimensional tolerances. BS&B Quality Assurance personnel witness set pressure tests for certification purposes. All Buckling Pins are supplied tagged with a traceable lot number, set pressure and the serial number of the BPRV unit for which they have been calibrated. SAF-T-PIN™ Buckling Pin Cartridges are recommended for optimum control and traceability.

When fully calibrated and certified, wire seals are installed at the following key locations:

- ◆ Junction of the Body and the Enclosure
- ◆ Fulcrum Connection to the Enclosure Baseplate
- ◆ Junction of the Sensor to the Shaft (where fitted)

Codes and Standards

Several International standards recognize Buckling Pin devices and provide guidelines for their certification. These include ASME, in the form of code case 2091, and TUV AD Merkblatt A1 and the European Pressure Equipment Directive (PED). The BPRV can be supplied to all established standards.

Maintenance

If desired, the Buckling Pin can be removed and the BPRV tested by rotating the disc into the open position triggering the mechanism. There must be no pressure on the device. The Buckling Pin can then be reinstalled.

Occasionally it will be necessary to replace the disc seal. This can be accomplished quickly and easily. The disc seal is held in place by a seal ring that inserts into the inlet of the one-piece body. This seal ring is simply removed using simple tools and the used seal pulled out from the BPRV body. After inspecting the seating area and clearing away any debris, the BS&B replacement seal is installed and the seal ring put back in place. Seal replacement does not require disassembly of the BPRV body or mechanism. It is recommended a spare disc seal is purchased for each BPRV.

Testing In Place

Since the BPRV might be interpreted as a relief valve, many users wish to perform scheduled maintenance to ensure the set pressure has not been compromised while the valve is in service. The normal procedure for testing of many types of relief valves is to remove the valve from service and send to a valve repair shop for a pop test and re-certification. The advantage of the BPRV is that the valve can be re-tested in-situ. The offset shaft is designed with a hexagon drive in the enclosure. The user can leave the valve in service between the flanges and attach a torque wrench to the hex. All the user needs to do is load the shaft with a torque wrench until the valve opens. BS&B Safety Systems, L.L.C. can supply a torque value range which, when applied to the hex drive of the offset shaft, will buckle the pin and activate (open) the valve. Once the value recorded on the torque wrench lies within this torque range supplied by BS&B, the user knows that the valve set pressure has not been compromised and the product is now re-tested. This allows users to re-check the valve within 10-15 minutes, without having to remove it from service.

Testing in place greatly reduces the maintenance expenses compared with relief valves by dramatically reducing the time and labor involved with the re-validation process.

Optional SAF-T-PIN™ Buckling Pin Cartridge

The BPRV can be provided with Buckling Pin Cartridges that are installed like an electrical fuse. The SAF-T-PIN™ Buckling Pin Cartridge allows a "Quick-Change" option of Buckling Pins with a simple push-in/pull-out design for installation within the enclosure. Each SAF-T-PIN™ Cartridge contains a calibrated Buckling Pin that is perfectly mounted for optimum performance.

The SAF-T-PIN cartridge locates into the BPRV mechanism in one direction only ensuring fail-safe installation.

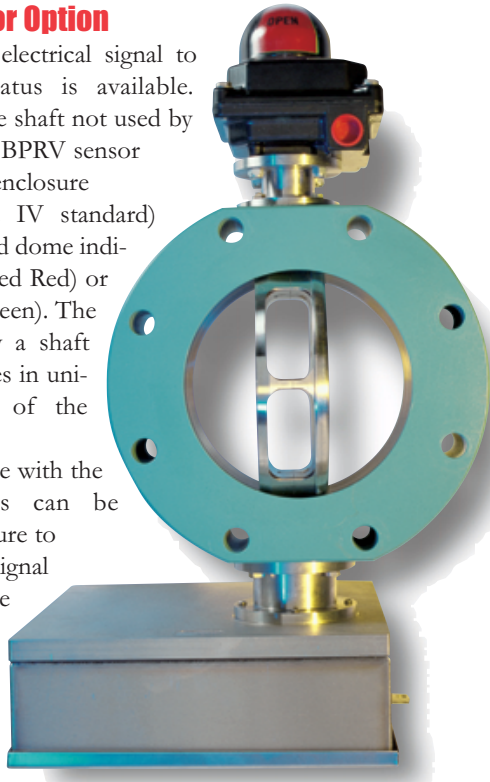
The transparent cartridge permits visual inspection of the Buckling Pin, and the stainless steel ends of the cartridge are marked with full set pressure and traceability information including the serial number of the BPRV device. The SAF-T-PIN™ cartridge avoids the need

for special installation procedures and any concern of handling bare Buckling Pins. Worldwide patents pending.



Sensor/Indicator Option

Both a visual and electrical signal to confirm BPRV status is available. Mounted on the free shaft not used by the mechanism, the BPRV sensor comprises a sealed enclosure (typically to Nema IV standard) that houses a colored dome indicating 'Open' (colored Red) or 'Closed' (colored Green). The dome is rotated by a shaft extension that moves in unison with the disc of the BPRV. Electrical switching compatible with the users requirements can be added to the enclosure to provide a remote signal or alarm when the BPRV operates. This can be provided to meet intrinsically safe requirements.



SmartDisk™ Compatible

The BPRV can be supplied with SmartDisk™ wireless sensor technology that allows an electrical signal to be generated at a monitoring station located up to several thousand feet away from the BPRV without the cost of hard wiring. Please refer to catalog 77-1016 for more information.

Information Required to Order the BPRV

General

- ◆ Tag Number
- ◆ Line Size
- ◆ Flange Specification

Operating Conditions

- ◆ Set Pressure and Tolerance Requested
- ◆ Set Temperature (Pin Conditions)

Service Conditions

- ◆ Fluid
- ◆ Vapor/Gas: Molecular Weight
- ◆ Liquid: Specific Gravity
- ◆ Required Flow Capacity (if known)
- ◆ Normal Service Pressure
- ◆ Vacuum Conditions
- ◆ Back Pressure Conditions
- ◆ Normal Service Temperature (Process)
- ◆ Flowing Temperature (Process)
- ◆ Static or Pulsing Service Pressure

Materials

- ◆ Valve Disc
- ◆ Valve Body
- ◆ Disc Seal
- ◆ Enclosure

Installation/Flow Path

- ◆ Vertical, Horizontal, Oblique (specify angle to Horizontal)

Accessories

- ◆ Sensor — Visual/Electrical
- ◆ Sensor Electrical Requirements
- ◆ Buckling Pin or Buckling Pin Cartridge
- ◆ Quantity of Pins/Cartridges

Note: When the BPRV opens, the disc may project beyond the body cavity within which it is retained when closed. When installing or removing the BPRV from service it is essential the disc is in the closed position to avoid damage to the disc and mechanism. Please seek advice from BS&B Safety Systems when the BPRV is to be installed close to a "T-piece" or other piping path that may present an unusual flow pattern to the device.



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