Envirovalve Technical Manual

Version A

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TABLE OF CONTENTS

STANDARDS IN THE VALVE AND PRESSURE RELIEF INDUSTRY	1
ABBREVIATIONS USED IN THE VALVE & PRESSURE RELIEF INDUSTRY	2
DEFINITIONS FOR THE PRESSURE RELIEF INDUSTRY	3
PRESSURE RELIEF DEVICE SHELL MATERIAL ASTM SPECIFICATIONS	6
BOLTING MATERIAL ASTM SPECIFICATIONS	9
RELEVANT ASME PRESSURE TEMPERATURE RATINGS	10
FLOW RATE CALCULATION AND TERMS	11
DIMENSIONAL ENVELOPE	12
SEAL OPTIONS AND TEMPERATURE RANGES	13
STANDARD BODY MATERIALS	14
SWITCH OPTIONS	15
ASME CERTIFIED	15
INSTALLATION AND OPERATION	16
SHEAR PIN AND FATIGUE	18
MANUFACTURING	19
RESULTS	20
FATIGUE RESULTS	21

TECHNICAL DATA

STANDARDS IN THE VALVE AND PRESSURE RELIEF INDUSTRY

Material standards are developed by organizations as the American Society for Testing and Materials (ASTM),
the American Iron & Steel Institute (AISI), the Society of Automotive Engineers (SAE), the National Association of Corrosion Engineers (NACE) and the American Society for Metals (ASM).
Some materials are approved by the American Society of Mechanical Engineers (ASME) for their use in Boilers and Pressure Vessels.

The American National Standards Institute, Inc. (ANSI) serves as the national coordinator for the majority of code and product standards related to the Valve and Fittings Industry.

Product standards are also developed and issued by individual user and/or manufacturing agencies such as the American Society of Mechanical Engineers (ASME), American Petroleum Institute (API) and the Manufacturers' Standardization Society (MSS).

Procedural and **safety** standards are issued by ANSI, MSS and ASME.

Following is a partial list of codes and standards that have a direct bearing on the design and production of valves & pressure relief devices. The codes and standards are interrelated as the following descriptions project:

ASME Boiler & Vessel Code
Section I – Power Boilers
Section II – Material Specifications
Section III – Nuclear Power Plant Components
Section V – Nondestructive Examination
Section VIII – Pressure Vessels
Section IX – Welding and Brazing Qualifications

The above Codes (Sections I, III & VIII) cover construction requirements for Boilers, Pressure Vessels, and Nuclear Components that require Authorized Inspection Agency involvement.
Section I and VIII Codes relate to the boiler and pressure vessel proper and not to external piping.
Section III Code includes rules for nuclear components including piping. Section II, V and IX Codes cover material, nondestructive examination and welding requirements, respectively, for ASME construction.

ASME Codes for Pressure Piping
ASME B31.1 – Power Piping
ASME B31.3 – Process Piping
ASME B31.4 – Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum, Gas, Anhydrous Ammonia and Alcohols.
ASME B31.5-92 – Refrigeration Piping
ASME B31.8-95 – Gas Transmission and Distribution Piping Systems
ASME B31.9 – Building Services Piping Systems
ASME B31.11 – Slurry Transportation Piping Systems

The above are piping construction codes that include requirements for design, materials, fabrication, examination, testing, inspection and components.

Valve Standards
ASME B16.34 – Valves - Flanged, Threaded and Welding Ends
API-600 – Steel Gate Valves, Flanged, and Buttwelding Ends
API-602 – Compact Steel Gate Valves
API-603 - Corrosion Resistant Gate Valves
MSS-SP-99 – Instrument Valves
MSS-SP-118 – Compact Steel Globe and Check Valves
ANSI/FCI 70-2 – American National Standard Control Valve Seat Leakage

Flanges, Fittings and Unions
ASME B16.5 – Pipe Flanges and Flanged Fittings
ASME B16.47- Large diameter Pipe Flanges
ASME B16.11 – Forged Steel Fittings, Socket Weld and Threaded

Valve, Fitting, Flange and Union Details
ASME B1.20.1 – Pipe Threads, General Purpose
ASME B16.10 – Face-to-Face and End-to-End Dimensions of Ferrous Valves
ASME B16.20 – Ring Joint Gaskets and Grooves for Steel Pipe Flanges
ASME B16.25 – Buttwelding Ends
MSS-SP-6 – Standard Finishes for Contact Faces of Pipe Flanges and Connecting End Flanges of Valves
MSS-SP-25 – Standard Marking System for Valves, Fittings, Flanges and Unions
MSS-SP-45 – Bypass and Drain Connection Standard

The above standards are detailed dimensional, marking, finish and bypass valve and fittings instructions for use in the manufacture of valves, flanges and fittings. The product standards normally refer to these standards for detailed instructions.

Inspection and Testing
MSS-SP-61 – Pressure Testing of Valves
API-598 – Valve Inspection and Test

NACE Standard
MR-01-75 – Sulfide Stress Cracking Resistant Metallic Material for Oil Field Equipment

Chlorine Institute
PAMPHLET #6 – Piping Systems For Dry Chlorine
This publication is intended to provide useful information concerning the construction of chlorine piping systems including valves.

TECHNICAL DATA

ABBREVIATIONS USED IN THE VALVE & PRESSURE RELIEF INDUSTRY

AARH – Arithmetic Average Roughness Height
AISI – American Iron and Steel Institute
API – American Petroleum Institute
ANSI – American National Standards Institute
ASME – American Society of Mechanical Engineers
ASTM – American Society for Testing and Materials
AWS – American Welding Society
BB – Bolted Bonnet
BHN – Brinell Hardness Number
Btu – British Thermal Unit
BWE – Butt Weld Ends
C or Cel – Celsius degrees
CI – Cast Iron
CI – Chlorine Institute
CR 13 – 13% Chromium Stainless Steel
CRES – Corrosion Resistant Steel
C v – The number of U.S. gallons per minute of water at 70°F which will flow through a valve at a pressure drop of one psi.
CWP – Cold Working Pressure
DN – Diameter Nominal (Metric)
ELL – Elbow
FAS – Free Alongside Steamer
F or Fahr – Fahrenheit degrees
F & D – Faced and Drilled
FF – Flat Face
FHF – Full Hard Faced
FLG – Flanged
FOB – Free on Board
FTTG – Fitting
G – Gas
gpm – Gallon per Minute
HF – Hard Faced
HW – Handwheel
ID – Inside Diameter
INT – Integral
ISRS – Inside Screw Rising Stem
ISNRS – Inside Screw Non. Rising Stem
Kg – Kilograms km – Kilometers
LH – Left Hand
MAV – Motor Actuated Valve
mm – Millimeter
MOV – See MAV
MSS – Manufacturers Standardization Society of the Valve & Fitting Industry
NACE – National Association of Corrosion Engineers (Formerly NACE International)
NPS – Nominal Pipe Size
NPT – National Standard Pipe Thread Taper
NRS – Non Rising Stem
OD – Outside Diameter
One-Piece Stem – An inseparable Stem and Disc made from one piece of metal.
OS&Y – Outside Screw and Yoke
OWG – Oil, Water & Gas (See CWP)
PN – Pressure Nominal (Metric)
Prd – Pressure Relief Device
Prv – Pressure Relief Valve
Psi – Pounds per square inch
Psia – Pounds per square inch absolute
Psig – Pounds per square inch gage
P-T – Pressure-Temperature
Rc – Rockwell "C"
RF – Raised Face
RH – Right Hand
RMS – Root Mean Square Roughness Height
RS – Rising Stem
RTJ – Ring-Type Joint
S – Steam
SAE – Society of Automotive Engineers
SC – Swing Check Valve
Sch. or Sched. – Schedule (Pipe Wall Thickness)
SCFM – Standard Cubic Feet per Minute
Screw Bonnet – Body and Bonnet Threaded Together **SE** – Screwed Ends
Seal Weld – Threaded Joint Back Welded for Seal
SS – Stainless Steel
Stem Nut – Operating Nut
Stuffing Box – Packing Chamber
STD – Standard Wall Thickness
Stop Check – A Check valve in which the closure member can be mechanically closed.
SWE – Socket Weld End
SWP – Steam Working Pressure
T – Tee Valve
Thd. – Threaded
TIR – Total Indicator Reading
UB – Union Bonnet
W – Water
Wedge – Gate
WOG – Water, Oil and Gas (See CWP)
WSP – Working Steam Pressure
WWP – Working Water Pressure
XS – Extra Strong Wall Thickness
XXS – Double Extra Strong Wall Thickness
Y – Wye Valve
Yoke Bushing – Operating Stem Nut
Yoke Nut – Stem Nut

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DEFINITIONS FOR THE PRESSURE RELIEF INDUSTRY

Pressure Relief Device: a device designed to prevent pressure or vacuum from exceeding a predetermined value in a pressure vessel by the transfer of fluid during emergency or abnormal conditions.

TYPES OF DEVICES

***Pressure Relief Valve (PRV)**:* a pressure relief device designed to actuate on inlet static pressure and reclose after normal conditions have been restored. It may be one of the following types and have one or more of the following design features:

(a) low-lift PRV: a pressure relief valve in which the actual discharge area is the curtain area.

(b) full-lift PRV: a pressure relief valve in which the actual discharge area is the bore area.

(c) reduced bore PRV: a pressure relief valve in which the flow path area below the seat is less than the flow area at the inlet to the valve.

(d) full-bore PRV: a pressure relief valve in which the bore area is equal to the flow area at the inlet to the valve, and there are no protrusions in the bore.

(e) direct spring-loaded PRV: a pressure relief valve in which the disk is held closed by a spring.

(f) pilot-operated PRV: a pressure relief valve in which the disk is held closed by system pressure, and the holding pressure is controlled by a pilot valve actuated by system pressure.

(g) conventional direct spring-loaded PRV: a direct spring-loaded pressure relief valve whose operational characteristics are directly affected by changes in the back pressure.

(h) balanced direct spring-loaded PRV: a direct spring loaded pressure relief valve that incorporates means of minimizing the effect of back pressure on the operational characteristics (opening pressure, closing pressure, and relieving capacity).

(i) internal spring PRV: a direct spring-loaded pressure relief valve whose spring and all or part of the operating mechanism is exposed to the system pressure when the valve is in the closed position.

(j) temperature and pressure relief valve: a pressure relief valve that may be actuated by pressure at the valve inlet or by temperature at the valve inlet.

(k) power-actuated PRV: a pressure relief valve actuated by an externally powered control device.

Relief Valve: a pressure relief valve characterized by gradual opening that is generally proportional to the increase in pressure. It is normally used for incompressible fluids.

Safety Relief Valve*:* a pressure relief valve characterized by rapid opening or by gradual opening that is generally proportional to the increase in pressure. It can be used for compressible or incompressible fluids.

Safety Valve: a pressure relief valve characterized by rapid opening and normally used to relieve compressible fluids.

Non-reclosing Pressure Relief Device (PRD)
A pressure relief device designed to actuate and remain open after operation. A manual resetting means may be provided.

Design Features: nonreclosing pressure relief devices may include one or more of the following design features:

(a) low-lift device: a device in which the actual discharge area is dependent on the lift of the disk.

(b) full-lift device: a device in which the actual discharge area is independent of the lift of the disk.

(c) reduced bore device: a device in which the flow path area below the seat is less than the flow path area of the inlet to the device.

(d) full-bore device: a device in which the flow path area below the seat is equal to the flow path area of the inlet to the device.

Design Types:
(a) rupture disk device: a device containing a disk that ruptures when the static differential pressure between the upstream and downstream side of the disk reaches a predetermined value. A rupture disk device includes a rupture disk and may include a rupture disk holder.

(b) pin device: a device actuated by static differential pressure or static inlet pressure and designed to function by the activation of a load-bearing section of a pin that supports a pressure-containing member. A pin is the load-bearing element of a pin device. A pin device housing is the structure that encloses the pressure-containing members. Examples of these devices include the following:

> *(1) breaking pin device:* a device designed to function by the breakage of a load-carrying section of a pin that supports a pressure-containing member.
>
> *(2) buckling pin device:* a device designed to function by the buckling of an axially loaded compressive pin that supports a pressure-containing member.
>
> *(3) shear pin device:* a device designed to function by the shearing of a load-carrying member that supports a pressure-containing member.

DEFINITIONS FOR THE PRESSURE RELIEF INDUSTRY

(c) fusible plug device: a device designed to function by the yielding or melting of a plug, at a predetermined temperature, that supports a pressure-containing member or contains pressure by itself.

(d) direct spring-loaded device: a device actuated by static differential pressure or static inlet pressure in which the disk is held closed by a spring. Upon actuation, the disk is held open by a latching mechanism.

(g) pilot-operated device: a device in which the disk is held closed by system pressure and the holding pressure is controlled by a pilot actuated by system pressure. The pilot may consist of one of the devices listed above.

DIMENSIONAL CHARACTERISTICS — NONRECLOSING PRESSURE RELIEF DEVICES

Flow Path*:* the three-dimensional and geometric characteristics of a device that affects the measured relieving capacity. It is defined from the cross section of the inlet to the cross section of the outlet, including all streamlines in the flow.

Inlet Area: the cross-sectional flow area at the inlet opening of a pressure relief device.

Inlet Size: the nominal pipe size of the inlet of a pressure relief device, unless otherwise designated.

Net Flow Area*:* the area that determines the flow after a nonreclosing pressure relief device has operated. The (minimum) net flow area of a rupture disk is the calculated net area after a complete burst of the disk, with appropriate allowance for any structural members that may reduce the net flow area through the rupture disk device.

Outlet Size: the nominal pipe size of the outlet passage from a pressure relief device, unless otherwise designated.

OPERATIONAL CHARACTERISTICS OF PRESSURE RELIEF DEVICES

Back Pressure*:* the static pressure existing at the outlet of a pressure relief device due to pressure in the discharge system.

Breaking Pressure*:* the value of inlet static pressure at which a breaking pin or shear pin device functions.

Burst Pressure: the value of inlet static pressure at which a rupture disk device functions.

Chatter: abnormal rapid reciprocating motion of the movable parts of a pressure relief valve in which the disk contacts the seat.

Coefficient of Discharge: the ratio of the measured relieving capacity to the theoretical relieving capacity.

Cold Differential Test Pressure: the inlet static pressure at which a pressure relief valve/device is adjusted to open on the test stand. This test pressure includes corrections for service conditions of superimposed back pressure and/or temperature.

Constant Back Pressure: a superimposed back pressure that is constant with time.

Flow-Rating Pressure: the inlet stagnation pressure at which the relieving capacity of a pressure relief device is measured.

Flow Resistance: a dimensionless term that expresses the number of velocity heads lost due to flow through a rupture disk device (where velocity head is one-half the velocity squared divided by the acceleration of gravity).

Flutter*:* abnormal, rapid reciprocating motion of the movable parts of a pressure relief valve/device in which the disk does not contact the seat.

Leak Test Pressure*:* the specified inlet static pressure at which a quantitative seat leakage test is performed in accordance with a standard procedure.

Marked Breaking Pressure: the value of pressure marked on a breaking pin or a shear pin device or its nameplate.

Marked Burst Pressure*:* the value of pressure marked on the rupture disk device or its nameplate or on the tag of the rupture disk, indicating the burst pressure at the coincident disk temperature.

Marked Set Pressure: the value or values of pressure marked on a pressure relief device.

Measured Relieving Capacity: the relieving capacity of a pressure relief device measured at the flow-rating pressure, expressed in gravimetric or volumetric units.

Opening Pressure: the value of increasing inlet static pressure of a pressure relief valve/device at which there is a measurable lift or at which the discharge becomes continuous as determined by seeing, feeling, or hearing.

Overpressure: a pressure increase over the set pressure of a pressure relief valve/device, usually expressed as a percentage of set pressure.

Popping Pressure: the value of increasing inlet static pressure at which the disk moves in the opening direction at a faster rate as compared with corresponding movement at higher or lower pressures.

Primary Pressure: the pressure at the inlet in a pressure relief device.

DEFINITIONS FOR THE PRESSURE RELIEF INDUSTRY

Rated Relieving Capacity: that portion of the measured relieving capacity permitted by the applicable code or regulation to be used as a basis for the application of a pressure relief device.

Reference Conditions: those conditions of a test medium that are specified by either an applicable standard or an agreement between the parties to the test, which may be used for uniform reporting of measured flow test results.

Relieving Conditions: the inlet pressure and temperature on a pressure relief device during an overpressure condition. The relieving pressure is equal to the valve/device set pressure or burst (or the rupture disk burst pressure) plus the overpressure. (The temperature of the flowing fluid at relieving conditions may be higher or lower than the operating temperature.)

Relieving Pressure: set pressure plus overpressure.

Set Pressure: the value of increasing inlet static pressure at which a pressure relief device displays one of the operational characteristics as defined under opening pressure, popping pressure, start-to-leak pressure, burst pressure, or breaking pressure

Simmer: the audible or visible escape of fluid between the seat and disk at an inlet static pressure below the popping pressure and at no measurable capacity. It applies to safety or safety relief valves on compressible fluid service.

Start-to-leak Pressure: the value of increasing inlet static pressure at which the first bubble occurs when a pressure relief valve/device is tested by means of air under a specified water seal on the outlet.

Static Blowdown: the difference between the set pressure and the closing pressure of a prd/prv when it is not overpressured to the flow-rating pressure.

Superimposed Back Pressure: the static pressure existing at the outlet of a pressure relief device at the time the device is required to operate. It is the result of pressure in the discharge system from other sources.

Theoretical Relieving Capacity: the computed capacity expressed in gravimetric or volumetric units of a theoretically perfect nozzle having a minimum cross sectional flow area equal to the actual discharge area of a pressure relief valve or net flow area of a nonreclosing pressure relief device.

Variable Back Pressure: a superimposed back pressure that will vary with time.

TECHNICAL DATA

PRESSURE RELIEF DEVICE SHELL MATERIAL ASTM SPECIFICATIONS

When material permits the usage above 1000ºF the flanged PRDs are limited to 1000ºF..

Group No. ASME B16.34	Material			Product Form									
				Forgings		Castings		Plates		Bars		Tubular	
	Commercial Name	Designation	Temp. Service (ºF)	Spec.	Grade	Spec.	Grade	Spec.	Grade	Spec.	Grade	Spec.	Grade
1.1	Carbon Steel	C-Si	-20º to 800º	A105	(2)	A216	WCB (2)	A515	70 (2)	A105	(2)	A672	B70 (2)
	Cold Temp. Service	C-Mn-Si	-50º to 800º	A350	LF2 (2)			A516	70 (2)	A350	LF2 (2)	A672	C70 (2)
	Carbon Steel	C-Mn-Si	-20º to 800º							A696	C (2)		
	Low Temp. Service	31/2Ni	-150º to 650º	A350	LF3					A350	LF3		
	Fusion welded steel	C-Mn-Si	-20º to 700º					A537	CL. 1				
	Low Temp. Service	C-Mn-Si-V	-60º to 650º	A350	LF6 Cl.1					A350	LF6 Cl.1		
1.2	Carbon Steel	C-Si	-20º to 800º									A106	C
	Carbon Steel	C-Mn-Si	-20º to 800º			A216	WCC (2)						
	Low Temp. Service	C-Mn-Si-V	-60º to 650º	A350	LF6 Cl.2					A350	LF6 Cl.2		
	Low Temp. Service	21/2Ni	-100º to 650º			A352	LC2	A203	B				
	Low Temp. Service	31/2Ni	-150º to 650º			A352	LC3	A203	E				
	Cold Temp. Service	C-Mn-Si	-150º to 650º			A352	LCC						
	Carbon Steel	C	-20º to 800º							A675	70 (1)		
1.3	Low Carbon Steel	C-Mn-Si	-20º to 800º					A516	65			A672	C 65
	Cold Temp. Service	C-Si	-50º to 650º			A352	LCB	A515	65			A672	B 65
	Low Temp. Service	21/2Ni	-100º to 800º					A203	A				
	Low Temp. Service	31/2Ni	-150º to 800º					A203	D				
	High Temp. 1/2 Moly	C-1/2Mo	-20º to 875º			A217	WC1 (3)						
	Cold Temp. 1/2 Moly	C-1/2Mo	-75º to 650º			A352	LC1						
	Carbon Steel	C	-20º to 800º							A675	60 (1)(2)(4)		
1.4	Carbon Steel	C	-20º to 800º							A675	65 (1)(2)(4)		
	Low Carbon Steel	C-Si	-20º to 800º					A515	60 (2) (4)			A106	B (2)
		C-Si	-20º to 800º									A672	B 60 (2)
		C-Mn-Si	-20º to 800º	A350	LF1 (2)			A516	60 (2) (4)	A350	LF1 (2)	A672	C 60 (2)
		C-Mn-Si	-20º to 1000º							A696	B		
	High Temp. 1/2 Moly	C-1/2Mo	-20º to 875º	A182	F1 (3)			A204	A (3)	A182	F1 (3)	A691	CM-70 (3)
1.5			-20º to 875º					A204	B (3)				
	1/2Chrome 1/2 Moly	1/2Cr-1/2Mo	-20º to 875º					A387	2 CL.1 (3B)				1/2Cr (3b)
		1/2Cr-1/2Mo	-20º to 1000º					A387	2 CL. 2				
1.6	Carbon 1/2 Moly	C-1/2Mo	-20º to 875º									A691	CM-75
	1/2Chrome 1/2 Moly	1/2Cr-1/2Mo	-20º to 1000º	A182	F2					A182	F2		
1.7	1/2Cr 1/2Mo 1Ni	Ni-1/2Cr-1/2Mo	-20º to 1000º			A217	WC4						
	3/4Cr 1Mo 3/4Ni	3/4Ni-Mo-3/4Cr	-20º to 1050º			A217	WC5						

(1) Leaded grades shall not be used for service above 850ºF only killed steels with not less than 0.10% residual silicon be used.
(2) Permissible, but not recommended for prolonged use above 800ºF, max temperature service of 1000ºF for short periods of time.
(3) Permissible, but not recommended for prolonged use above 875ºF, max temperature service of 1000ºF for short periods of time.
(3b) Permissible, but not recommended for prolonged use above 875ºF, max temperature service of 1200ºF for short periods of time.
(4) Not to be used over 850ºF
(5) Permissible, but not recommended for prolonged use above 1100ºF, max temperature service of 1200ºF for short periods of time.

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TECHNICAL DATA

PRESSURE RELIEF DEVICE SHELL MATERIAL ASTM SPECIFICATIONS

When material permits the usage above 1000ºF the flanged PRDs are limited to 1000ºF..

Group No. ASME B16.34	Material			Product Form									
				Forgings		Castings		Plates		Bars		Tubular	
	Commercial Name	Designation	Temp. Service (ºF)	Spec.	Grade	Spec.	Grade	Spec.	Grade	Spec.	Grade	Spec.	Grade
1.8	1 Chrome 1/2 Moly	1Cr-1/2Mo	-20º to 1100º					A387	12 Cl.2 (4)			A691	1CR (4)
	11/4 Chrome 1/2 Moly	11/4Cr-1/2Mo-Si	-20º to 1100º					A387	11 Cl.1(4)			A691	11/4 CR (4)
	21/4 Chrome Moly	21/4Cr-Mo	-20º to 1100º					A387	22 Cl.1(4)			A691	21/4 CR (4)
		2 1/4Cr-1Mo	-20º to 1100º									A335	P22 (4)
		2 1/4Cr-1M	-20º to 1100º									A335	FP22 (4)
1.9	1 1/4 Chrome 1/2 Moly	1 1/4Cr-1/2Mo	-20º to 1100º	A182	F11 Cl.2 (4)			A387	11 Cl.2 (4)	A182	F11 Cl.2 (4)		
	1 1/4 Chrome 1/2 Moly	1 1/4Cr-1/2Mo	-20º to 1100º			A217	WC6			A739	B11 (4)		
1.10	2 1/4 Chrome Moly	21/4Cr-1Mo	-20º to 1100º	A182	F22 Cl.3 (4)	A217	WC9	A387	22 Cl.2 (4)	A182	F22 Cl.3 (4)		
		21/4Cr-1Mo	-20º to 1100º							A739	B22 (4)		
1.11	3 Chrome 1 Moly	3Cr-1Mo	-20º to 1000º	A182	F21 (3			A387	21 Cl.2 (3	A182	F21 (5)		
	Manganese 1/2 Moly	Mn-1/2Mo	-20º to 875º					A302	A & B (1)				
	Mn-Si-1/2Mo-1/2Ni	Mn-s1/2Mo-1/2Ni	-20º to 875º					A302	C (1)				
	Mn-1/2Mo-3/4Ni	Mn-1/2Mo-3/4Ni	-20º to 875º					A302	D (1)				
	Carbon Manganese	C-Mn-Si	-20º to 700º					A537	CL2)				
		C-1/2Mo	-20º to 700º					A204	C				
1.12	5 Chrome 1/2 Moly	5Cr-1/2Mo	-20º to 1200º					A387	5 Cl.1			A691	5CR
		5Cr-1/2Mo	-20º to 1200º					A387	5 Cl.2			A335	P5
		5Cr-1/2Mo	-20º to 1200º									A369	FP5
		5Cr-1/2Mo-Si	-20º to 1200º									A335	P5b
1.13	5 Chrome 1/2 Moly	5Cr-1/2Mo	-20º to 1200º	A182	F5a	A217	C5 (4)			A182	F5a		
1.14	9 Chrome 1 Moly	9Cr-1Mo	-20º to 1200º	A182	F9	A217	C12 (4)			A182	F9		
1.15		9Cr-1Mo-V	-20º to 1000º	A182	F91	A217	C12A	A387	91 Cl.2				
1.16		C-1/2Mo	-20º to 850º									A335	P1
		C-1/2Mo	-20º to 850º									A369	FP1
		1Cr-1/2Mo	-20º to 850º					A387	12 Cl.1			A691	1CR (4)
		11/4Cr-1/2Mo-Si	-20º to 850º									A335	P11
		11/4Cr-1/2Mo-Si	-20º to 850º									A369	FP11
		1Cr-1/2Mo	-20º to 850º									A335	P12
		1Cr-1/2Mo	-20º to 850º									A369	FP12
1.17		5Cr-1/2Mo	-20º to 1100º	A182	F5					A182	F5		
	1Chrome 1/2 Moly	1Cr-1/2Mo	-20º to 1100º	A182	F12 Cl.2 (4)					A182	F12 Cl.2 (4)		
1.18		9Cr-2W-V	-20º to 1200º	A182	F92					A182	F92	A335	P92
		9Cr-2W-V	20º to 1100º									A369	FP92
NA (5)	Low Temp. Service		-150º to 700º									A333	Gr. 3

(1) Permissible, but not recommended for prolonged use above 875ºF. max temp. service of 1010ºF for short periods of time.
(2) Permissible, but not recommended for prolonged use above 1100ºF. max temp. service of 1200ºF for short periods of time.
(3) Permissible, but not recommended for prolonged use above 1000ºF. max temp. service of 1200ºF for short periods of time.
(4) Use normalized and tempered material only.
(5) Not included in ASTM 16.34 but can conservatively be grouped with 1.4 within its specified temperature range

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When material permits the usage above 1000ºF the flanged PRDs are limited to 1000ºF..

Group No. ASME B16.34	Material			Product Form									
				Forgings		Castings		Plates		Bars		Tubular	
	Commercial Name	Designation	Temp. Service (ºF)	Spec.	Grade	Spec.	Grade	Spec.	Grade	Spec.	Grade	Spec.	Grade
2.1	Type 304 Standard	18Cr-8Ni	-425º(2) to 800º			A351	CF3						
	Type 304 Standard	18Cr-8Ni	-425º(2) to 1000º (1)	A182	F304	A351	CF8	A240	304	A182	304	A312	TP304
	Type 304 High Temp.	18Cr-8Ni	-20º to 1500º	A182	F304H	A351	CF10	A240	304H	A182	304H	A312	TP304H
	Type 304 Standard	18Cr-8Ni	-425º(2) to 1000º (1)							A479	304	A358	304
	Type 304 Standard	18Cr-8Ni	-425º(2) to 1000º (1)							A479	304H	A376	TP304
	Type 304 High Temp.	18Cr-8Ni	-20º to 1500º									A376	TP304H
	Type 304 Standard	18Cr-8Ni	-425º(2) to 1000º (1)									A430	TP304
	Type 304 High Temp.	18Cr-8Ni	-20º to 1500º									A430	TP304H
2.2	Type 316 Standard	16Cr-12Ni-2Mo	-425º(7) to 850º			A351	CF3M						
	Type 316 Standard	16Cr-12Ni-2Mo	-425º(2) to 1000º (1)	A182	F316	A351	CF8M	A240	316	A182	316	A312	TP316
	Type 316 High Temp.	16Cr-12Ni-2Mo	-20º to 1500º	A182	F316H	A351	CF10M	A240	316H	A182	316H	A312	TP316H
	Type 316 Standard	16Cr-12Ni-2Mo	-425º(6) to 1000º (1)							A479	316	A358	316
	Type 316 Standard	16Cr-12Ni-2Mo	-425º(2) to 1000º (1)							A479	316H	A376	TP316
	Type 316 High Temp.	16Cr-12Ni-2Mo	-20º to 1500º									A376	TP316H
	Type 316 Standard	16Cr-12Ni-2Mo	-425º(2) to 1000º (1)									A430	TP316
	Type 316 High Temp.	16Cr-12Ni-2Mo	-20º to 1500º									A430	TP316H
		18Cr-8Ni	-20º to 800º			A351	CF3A						
	Type 317 Standard	18Cr-13Ni-3Mo	-20º to 1000º	A182	F317			A240	317			A312	TP317
	Type 317 High Temp.	18Cr-13Ni-3Mo	-20º to 800º	A182	F317H	A351	CF8A	A240	317H			A312	TP317H
	Type 317 Standard	19Cr-10Ni-3Mo	-20º to 1500º			A351	CG8M						
2.3	304 Low Carbon	18Cr-8Ni	-425º(2) to 800º	A182	F304L			A240	304L	A182	F304L	A312	TP304L
	304 Low Carbon	18Cr-8Ni	-425º(2) to 800º										
	316 Low Carbon	16Cr-12Ni-2Mo	-425º(7) to 850º	A182	316L			A240	316L	A182	F316L	A312	TP316L
	316 Low Carbon	16Cr-12Ni-2Mo	-425º(7) to 850º							A479	F316L		
	317 Low Carbon	18Cr-12Ni-2Mo	-425º(7) to 850º	A182	F317L					A182	F317L		

(1) At temperatures over 1000F, use only when carbon content is 0.04% or higher. Maximum temperature service 1500F.
(2) For cryogenic application
(3) For cryogenic application. 316 & 316L shall meet requirements of low temp in ASME B31.3, paragraph 323.2 for LH2 service

Enviro-Valve Inc.
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BOLTING MATERIAL ASTM SPECIFICATIONS

Bolting Material Specifications (1)

Common Designation	Spec. No.	Grade	Notes	Common Designation	Spec. No.	Grade	Notes
Alloy & S.S. Bolting	A193	-	(2)(3)	High Temp. Bolting (13)	A449		(7)(8)
Carbon Steel Bolting	A307B	-	(4)(5)	Alloy Steel Bolting	A453	651 & 660	(9)
Low Temp Bolting	A320	-	(2)(3)(6)	Alloy Steel Bolting Sp.	A540		
Q&T Alloy Bolting	A354			17-4 PH Bolting	A564	630	(7)
Monel 400 Bolting	B164		(10)-(12)	Ni-Cr-Fe Alloy Bolting	A408		(10)-(12)
Monel 400 Bolting (16)	B165		(11)(12)	Alloy 20 Bolting (14)	B473		(10)
Hastelloy B-2 Bolting (17)	B335	N10665	(10)	Hastelloy C-276 Bolting 15)	B574	N10276	(10)
Inconel 600 Bolting (18)	B166	N06600	(10)(11)	Hastelloy C-22 Bolting (15)	B574	N06022	(10)
				High Temp. PH Ni Alloy	B637	N07718	(10)
				High Temp PH Ni Alloy	A1014	N07718	(10)

GENERAL NOTES:

(a) The user is responsible for assuring that bolting material is not used beyond limits specified in governing codes or regulations.
(b) ASME Boiler and Pressure Vessel Code Section II materials that also meet the requirements of the listed ASTM specification may also be used.
(c) Material limitations, restrictions, and special requirements are shown on the pressure–temperature tables.

NOTES:

(1) Repair welding of bolting material is not permitted.
(2) Where austenitic bolting materials have been carbide solution treated but not strain hardened, they are designated Class 1 or Class 1A in ASTM A193. ASTM A194 nuts of corresponding material are recommended.
(3) Where austenitic bolting materials have been carbide solution treated and strain hardened, they are designated Class 2, 2B, or 2C in ASTM A193. ASTM A194 nuts of corresponding material are recommended.
(4) For limitations of usage and strength level, see para. 5.1.2.
(5) Bolts with drilled or undersize heads shall not be used.
(6) For ferritic bolting materials intended for service at low temperature, ASTM A194 Grade 7 nuts are recommended.
(7) Acceptable nuts for use with quenched and tempered steel bolts are ASTM A194 Grade 2 and 2H.
(8) Mechanical property requirements for studs shall be the same as for bolts.
(9) Bolting materials suitable for high-temperature service with austenitic stainless steel valve materials.
(10) Nuts may be of the same material or may be of compatible grade of ASTM A194.
(11) Forging quality not permitted unless the producer last heating or working these parts tests them as required for other permitted conditions in the same specification and certifies their final tensile, yield, and elongation properties to equal or exceed the requirements for one of the other permitted conditions.
(12) Maximum operating temperature is arbitrarily set at 260°C (500°F), unless material has been annealed, solution annealed, or hot finished, because hard temper adversely affects design stress in the creep-rupture temper range.
(13) With expansion coefficients comparable to Austenitic Stainless Steels
(14) For temperature service up to 800F
(15) For temperature service up to 1250F
(16) For temperature service up to 900F
(17) For temperature service up to 800F
(18) For temperature service up to 1600F

Bolt Material		Nut Material		Temperature Range (ºF)
Specification	***Grade***	***Specification***	***Grade***	
ASTM A193	B7	ASTM A194H	2H	-20º to 1000º
ASTM A320	L7	ASTM A194	4	-150º to 1000º
ASTM A193	B16	ASTM A194	2H	-20º to 1100º
ASTM A193	B8	ASTM A194	8F	-450º to 1500º
ASTM A 193	B8 CL2	ASTM A194	8F	-450º to 1000º

TECHNICAL DATA

RELEVANT ASME PRESSURE TEMPERATURE RATINGS

Pressure Rating for Various Group Materials at Standard ANSI 150 Class versus Temperature - ASME B16.34

Material Group	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8 (1)	1.9 &1.10	1.11	1.12
Hydrostatic Shell Test	430	430	410	360	410	340	430	360	430	430	360
Temp. °F)											
-20 to 100	284.2	287.1	266.8	236.4	266.8	226.2	287.1	236.4	287.1	290.0	236.4
122	278.4	282.8	263.9	232.0	266.8	226.2	282.8	233.5	282.8	282.8	232.0
212	256.7	256.7	252.3	216.1	256.7	226.2	256.7	220.4	256.7	256.7	213.2
302	229.1	229.1	229.1	208.8	229.1	226.2	229.1	214.6	229.1	229.1	205.9
392	200.1	200.1	200.1	200.1	200.1	200.1	200.1	200.1	200.1	200.1	200.1
482	175.5	175.5	175.5	175.5	175.5	175.5	175.5	175.5	175.5	175.5	175.5
572	147.9	147.9	147.9	147.9	147.9	147.9	147.9	147.9	147.9	147.9	147.9
617	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9
662	121.8	121.8	121.8	121.8	121.8	121.8	121.8	121.8	121.8	121.8	121.8
707	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3
752	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3
797	79.8	79.8	79.8	79.8	79.8	79.8	79.8	79.8	79.8	79.8	79.8
842	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
887	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7
932	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6
1000	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3

Pressure Rating for Various Group Materials at Standard ANSI 150 Class versus Temperature - ASME B16.34

Material Group	1.13	1.14	1.15	1.16	1.17	1.1.8	2.1	2.2	2.3
Hydrostatic Shell Test	430	430	430	340	430	430	420	420	350
Temp. (°F)									
-20 to 100	290.0	290.0	290.0	226.2	287.1	290.0	275.5	275.5	230.6
122	282.8	282.8	282.8	224.8	282.8	282.8	265.4	266.8	221.9
212	256.7	256.7	256.7	217.5	256.7	256.7	227.7	234.9	192.9
302	229.1	229.1	229.1	207.4	229.1	229.1	205.9	214.6	174.0
392	200.1	200.1	200.1	200.1	200.1	200.1	191.4	198.7	162.4
482	175.5	175.5	175.5	175.5	175.5	175.5	175.5	175.5	152.3
572	147.9	147.9	147.9	147.9	147.9	147.9	147.9	147.9	145.0
617	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9
662	121.8	121.8	121.8	121.8	121.8	121.8	121.8	121.8	121.8
707	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3
752	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3
797	79.8	79.8	79.8	79.8	79.8	79.8	79.8	79.8	79.8
842	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
887	53.7	53.7	53.7	53.7	53.7	53.7	53.7	53.7	
932	40.6	40.6	40.6	40.6	40.6	40.6	40.6	40.6	
1000	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	

Notes:
(1) Application above 620°C is limited to tubing of maximum outside diameter of 88.9 mm.

FLOW RATE CALCULATION AND TERMS

WHAT IS MNFA (MINIMUM NET FLOW AREA) AND WHEN IS IT USED

The MNFA is only used to rate the capacity of the device when the *"Coefficient of Discharge"* method is employed to rate flow. This method may only be used in unique circumstances when the following conditions are met:

i. The pipe discharges directly to the atmosphere
ii. The Accu-Shear device is installed within 8 pipe diameters of the beginning of the piping from the pressure vessel
iii. The Accu-Shear device is installed within 5 diameters of the end of the discharging pipe

The specifics of this method are outlined in the ASME Pressure Vessel Code Section VIII.

WHAT ABOUT THE Cv FACTOR?

The Cv factor is typically used for fluid control valves rather than pressure relief devices however a conversion exists in the crane 410 technical paper (A-31), the equation used is below (where d is the diameter in inches of the line) a graphical figure is found in the Crane 410 paper:

$$C_V = \frac{29.9d^2}{\sqrt{K_r}}$$

Using the above formula, and the data from the National Board flow tests on the 3D 1/8 scale printed Accu-Shear models used for flow certification, estimates for Cv values can be found and are shown in the table below:
:

Approximate **Cv Values** from Crane Manual Conversion

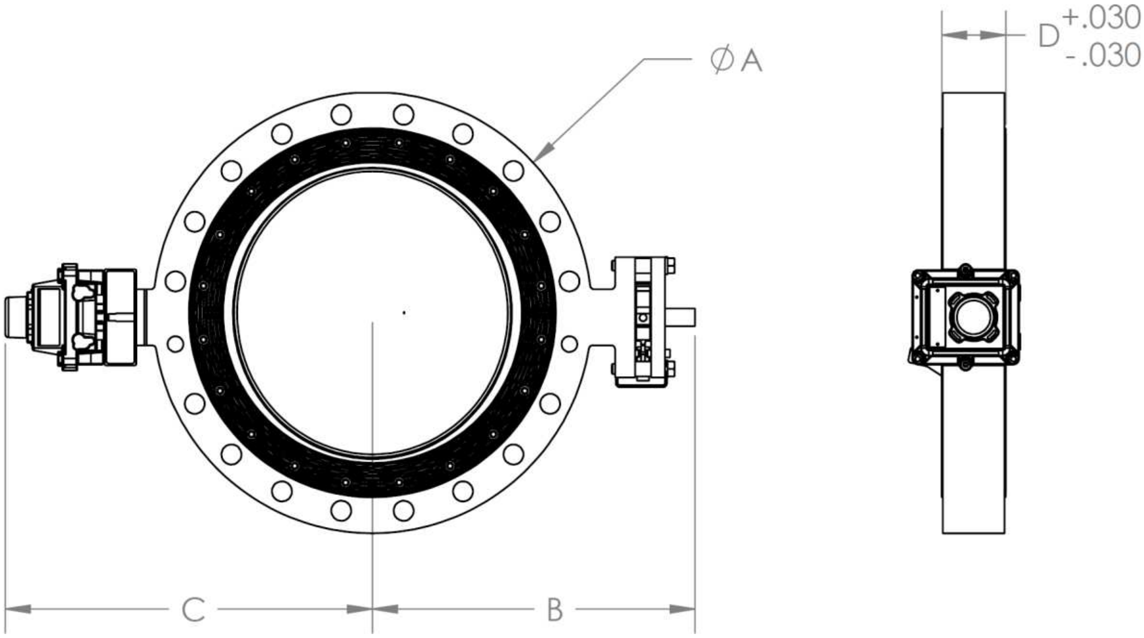
Size	Model	Coefficient of Resistance (Kr) = 3.71*	Coefficient of Resistance (Kr) = 1.91**
8	LP	993	1,385
8	HP	993	1,385
10	LP	1,552	2,163
10	HP	1,552	2,163
12	LP	2,235	3,115
12	LL	2,235	3,115
12	HP	2,235	3,115
14	LP	3,043	4,240
14	HP	3,043	4,240
16	LP	3,974	5,539
16	HP	3,974	5,539
18	LP	5,030	7,010
18	HP	5,030	7,010
20	LP	6,209	8,654
20	HP	6,209	8,654
24	LP	8,941	12,462
24	HP	8,941	12,462

** **Certified** Coefficient of Resistance for Entire Accu-Shear Line, actual flow capacity will fall above that predicted by this coefficient*

*** **Average** Coefficient of Resistance, actual flow capacity will fall above or below that predicted by using this coefficient*

TECHNICAL DATA

DIMENSIONAL ENVELOPE (NO SWITCH INSTALLED)



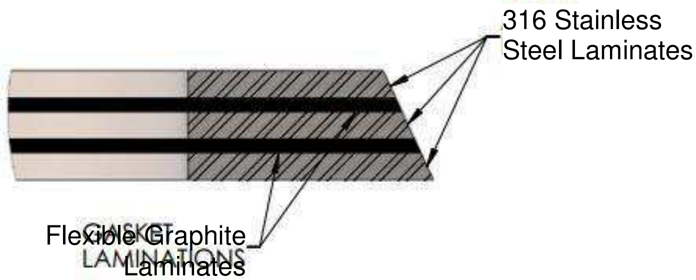
DEVICE SIZE	A (in)	B (in)	C (in)	D (in)	WEIGHT (lbs)
6LP	11.0	13.6	15.0	16.000	110
6HP	11.0	13.6	15.0	16.000	110
8LP	13.5	14.5	16.2	4.000	160
8HP	13.5	14.5	16.2	4.000	160
10LP	16.0	15.5	17.3	4.375	210
10HP	16.0	15.5	17.3	4.000	210
12LP	19.0	16.5	18.8	4.875	275
12HP	19.0	16.5	18.8	4.000	275
14LP	21.0	17.4	19.9	5.000	330
14HP	21.0	17.4	19.9	4.000	330
16LP	23.5	18.3	20.0	5.000	375
16HP	23.5	18.3	20.0	4.000	375
18LP	25.0	19.3	22.0	5.000	400
18HP	25.0	19.3	22.0	4.000	400
20LP	27.5	20.2	23.0	5.000	550
20HP	27.5	20.2	23.0	4.000	550
24LP	32.0	22.7	26.0	5.000	600
24HP	32.0	22.7	26.0	5.000	600
30LP	38.8	27.0	30.0	6.000	800

**THE 'HP' AND 'LP' DENOTE HIGH PRESSURE (15-45psi) AND LOW PRESSURE (5-15psi) DEVICE SIZES*
***6 INCH LINE SOLUTION UTILIZING STANDARD 8 INCH PRD WITH 6X8 ADAPTERS BOLTED ON*

SEAL OPTIONS AND TEMPERATURE RANGES

Metal Seal

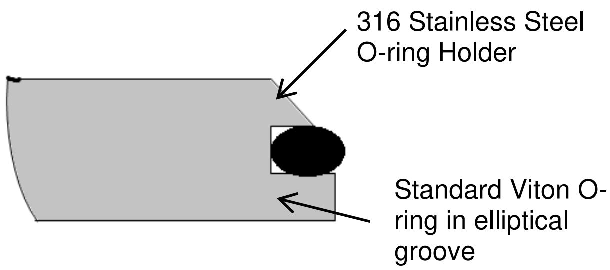
The Accu Shear PRD utilizes a triple offset butterfly valve design allowing for use of a laminated 316 stainless steel and flexible graphite seal as shown in the image.



Features	***Benefits***
316 Stainless Steel Seal Laminates	Inherently Fire Safe
Flexible Graphite Seal Laminates	-400 °F to 1,500 °F
Nitronic 60 Seat	No Seating torque impairing opening
Conical Seat at Angular Offset	Consistent Opening Torque

O-ring Seal

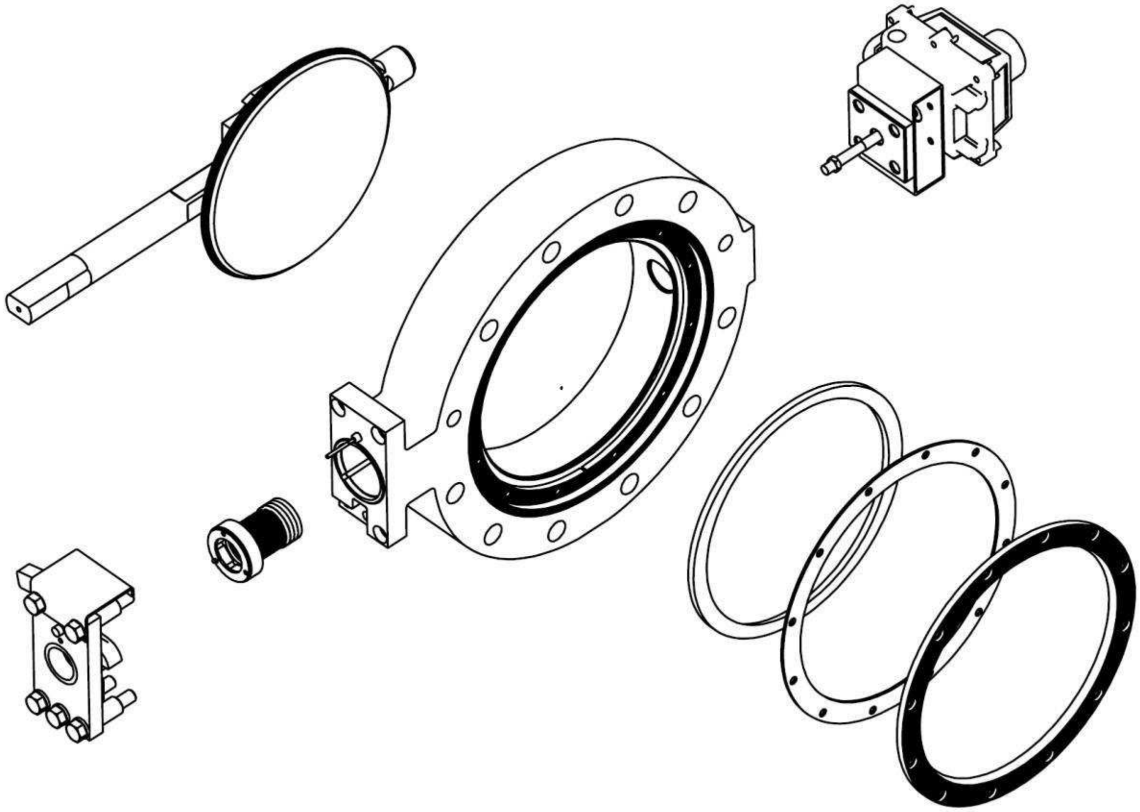
The triple offset butterfly valve design implemented in our Accu-Shear PRD can be used in combination with a Viton O-ring allowing for ease of sealing at minimal costs.



Features	***Benefits***
Viton O-ring	-15 °F to 400 °F
Standard O-ring Groove cross section	Easily Replicable
Standard 316 Stainless Steel Seat	Economical Choice with Optimal Sealing Performance
Conical Seat at Angular Offset & elliptical O-ring Groove	Consistent Opening Torque

TECHNICAL DATA

STANDARD BODY MATERIALS



DESCRIPTION	STANDARD MATERIALS*		
	LOW TEMP CARBON ***(-125°F to 650°F)***	**STAINLESS TRIM** ***(-425°F to 1000°F)***	**CARBON TRIM** ***(0°F to 800°F)***
PRESSURE VESSEL	ASTM A333 Gr. 3	ASTM A312 Gr. TP316	ASTM 106 Gr B/C
FLANGE	ASTM A350 LF3	ASTM A182 Gr. 316	ASTM A105
DEVICE SEAT	SEE SEALS SEC.	SEE SEALS SEC.	SEE SEALS SEC.
SHAFT BUSHING	NITRONIC 60	NITRONIC 60	NITRONIC 60
SHAFT (>572°F)	A564 S17400 H1150	A564 S17400 H1150	A564 S17400 H1150
SHAFT (< 572°F)	NA	INCONEL 625	INCONEL 625
MISC BAR PARTS	ASTM A350 LF3	ASTM A479 Gr. 304	ASTM A105
MISC PLATE PARTS	ASTM 516 Gr. 65	ASTM A240 Gr. 304	ASTM A36
SEAL ASSEMBLY	PALLET BODY	ASTM A240 Gr. 316	ASTM A36
SEAL	SEE SEALS SEC.	SEE SEALS SEC.	SEE SEALS SEC.
PALLET SEAL	BRAIDED GRAPHITE	BRAIDED GRAPHITE	BRAIDED GRAPHITE
SHEAR PIN BUSHING	SHEAR PIN BUSHING	NITRONIC 60	NITRONIC 60

*CUSTOM MATERIALS BEYOND OUR STANDARD TRIMS CAN BE QUOTED ON A PER PROJECT BASIS

TECHNICAL DATA

SWITCH OPTIONS

The Accu-Shear Pin PRD can be equipped with a wide range of valve/device top switches however our standard options are the DXP series of valve top switches from TopWorx©.

We are of course happy to accommodate any switch requirements that our customer may desire.

ASME CERTIFIED

In October 2013, EnviroValve completed the requirements to stamp each of our Accu-Shear Pin PRDs (8" to 24", 15 to 45 PSI) with a 'UD' and 'NB' stamp. The line has been qualified with a Kr factor equal to 3.71.

Accu Shear Pin PRD	Face to Face Length	Pipe Internal Ø	Shaft Ø	Inlet Sizes	Outlet Sizes	Flow Area (in^2)	Eq. Ø	Approx. Orifice Ø (orfice is eliptical in shape)	β	α	Set Pres. (psi)	Media
8LP	10.00	7.99	1.25	8NPS	8NPS	25.23	5.67	7.31	0.709	0.914	5 - 15	Air
8HP	10.00	7.99	1.25	8NPS	8NPS	24.57	5.59	7.30	0.700	0.913	15 - 45	Air
10LP	10.00	10.05	1.50	10NPS	10NPS	45.69	7.63	9.33	0.759	0.928	5 - 15	Air
10HP	10.00	10.05	1.50	10NPS	10NPS	44.39	7.52	9.31	0.748	0.926	15 - 45	Air
12LP	10.00	11.99	1.50	12NPS	12NPS	72.01	9.58	11.23	0.799	0.937	5 - 15	Air
12HP	10.00	11.99	1.50	12NPS	12NPS	70.65	9.48	11.20	0.791	0.934	15 - 45	Air
14LP	10.75	13.17	1.75	14NPS	14NPS	87.86	10.58	12.41	0.803	0.942	5 - 15	Air
14HP	10.75	13.17	1.75	14NPS	14NPS	86.65	10.50	12.38	0.797	0.940	15 - 45	Air
16LP	10.75	15.11	1.75	16NPS	16NPS	122.71	12.50	14.30	0.827	0.947	5 - 15	Air
16HP	10.75	15.11	1.75	16NPS	16NPS	122.00	12.46	14.28	0.825	0.945	15 - 45	Air
18LP	11.25	17.04	1.75	18NPS	18NPS	162.28	14.37	16.21	0.843	0.951	5 - 15	Air
18HP	11.25	17.04	1.75	18NPS	18NPS	162.22	14.37	16.21	0.843	0.951	15 - 45	Air
20LP	11.75	18.98	1.75	20NPS	20NPS	208.93	16.31	18.12	0.859	0.955	5 - 15	Air
20HP	11.75	18.98	1.75	20NPS	20NPS	208.93	16.31	18.12	0.859	0.955	15 - 45	Air
24LP	13.00	22.85	2.00	24NPS	24NPS	316.59	20.08	21.95	0.879	0.961	5 - 15	Air
24HP	13.00	22.85	2.00	24NPS	24NPS	316.61	20.08	21.95	0.879	0.961	15 - 45	Air
8HP (1/8 SCALE)	1.25	1.00	0.16	1NPS	1NPS	0.38	0.70	0.91	0.700	0.913	NA	Air
16HP (1/8 SCALE)	1.34	1.89	0.22	2NPS	2NPS	1.91	1.56	1.79	0.825	0.945	NA	Air
24HP (1/8 SCALE)	1.63	2.86	0.25	3NPS	3NPS	4.95	2.51	2.74	0.879	0.961	NA	Air

INSTALLATION AND OPERATION

Install Device Horizontal

Though the pressure relief devices must be installed horizontally a locking mechanism is optional to allow for mounting right side up (as shown) or rotated 180 degrees for and upside down installation.

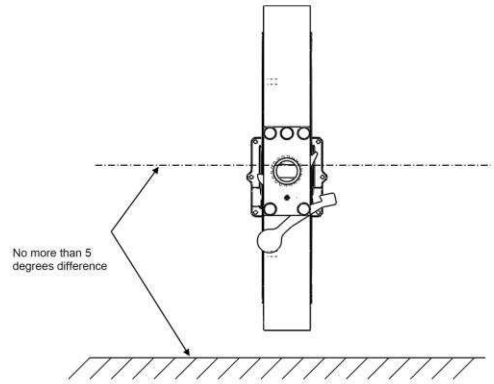
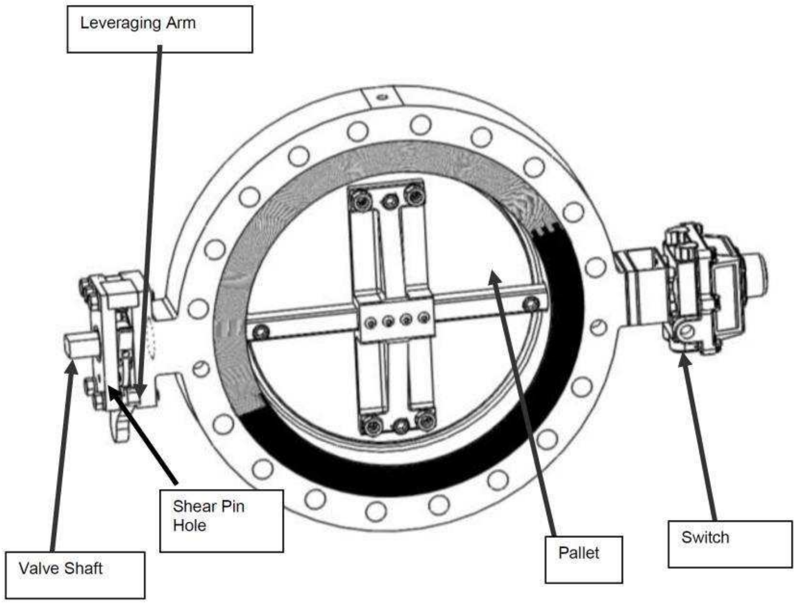


Figure IV-1: Illustration of Properly Oriented Valve

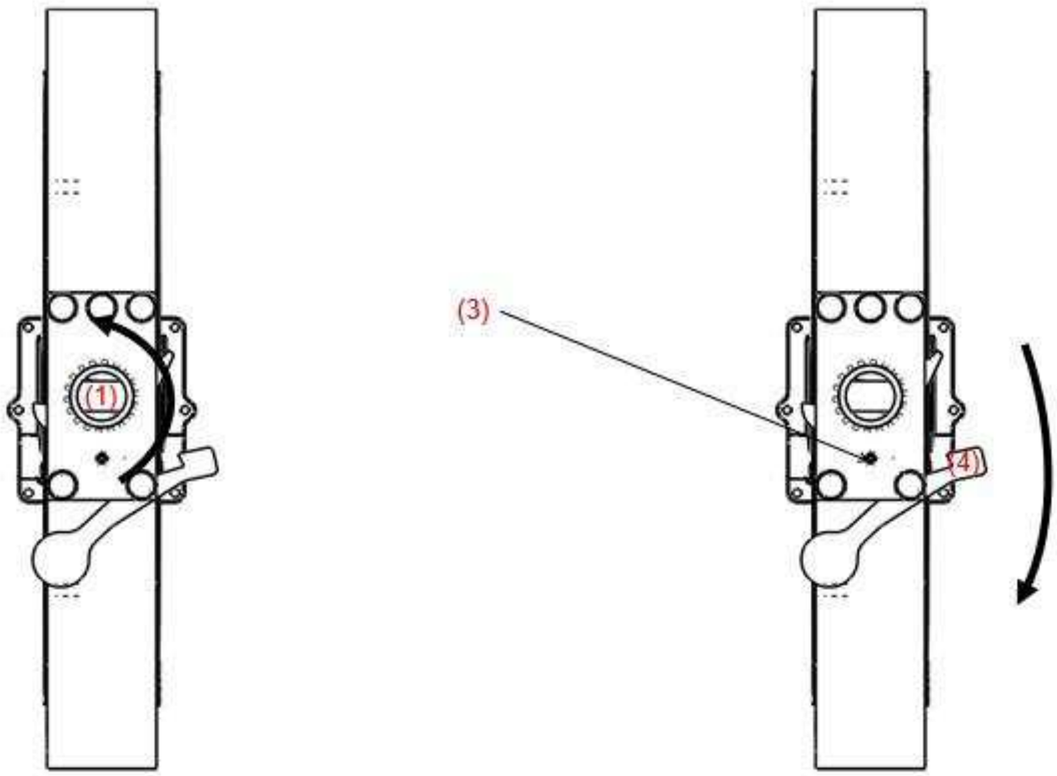
Operation

In the factory the device is assembled and then the pallet is positioned to ensure a proper seal and preload on the pin through a series of adjustment bolts. Once a seal is achieved the pallet is locked in place (relative to the shaft) via retaining bolts.



When installed on site the device is closed manually with a wrench and a calibrated shear pin is inserted to hold the device in the closed position.

A leveraging bar is used to give the installer a mechanical advantage in closing the device. The diagrams below show the steps taken to replace the shear pin.



I. *Close Valve by using a large handled adjustable wrench at location (1) (24" long handled wrench recommended) and rotate the valve shaft fully counter-clockwise.*

II. *Move the adjustable wrench from shaft (1) to the leveraging bar at position (4). Rotate the bar clockwise.*

III. *Apply enough force clockwise to the wrench at position (4) so that upon visual inspection of the hole at position (3) it appears that everything is lined up.*

Closing the Valve & Inserting New Pin

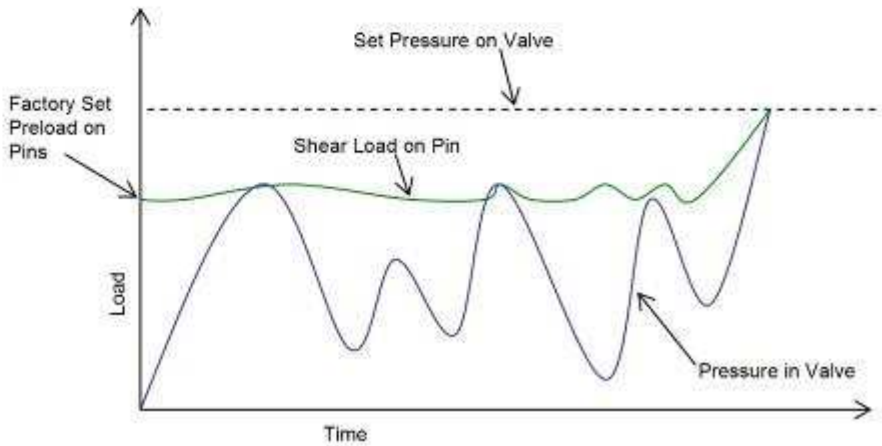
I. *Use the punch to clean out any remnants of the last pin in the hole at position (3).*

II. *Insert the pin into the hole in position (3) while simultaneously applying the needed clockwise force to the wrench at position 4 to keep the holes lined up. Be careful not to bend pin on install or it may result in device opening at lower pressure.*

SHEAR PIN AND FATIGUE

Load Cycling:

The illustrative chart to the right shows how the preload insulates the 'shear load on pin' from the 'pressure in the device'.

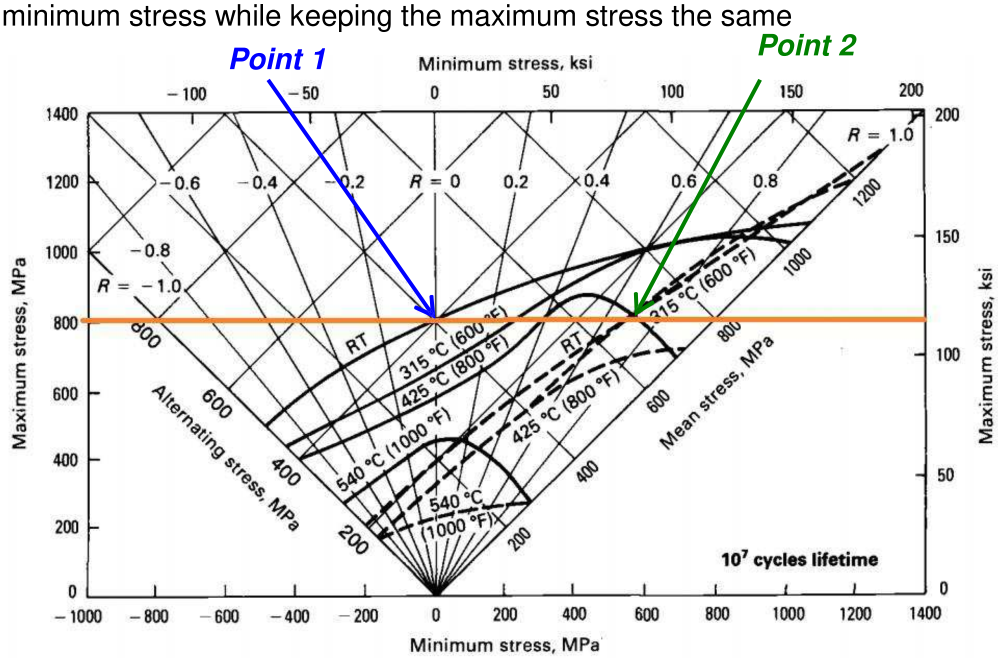


Without the preload mechanism the pin would cycle between a minimum stress of close to 0 and a maximum stress of something higher (blue line).

With the Accu-Shear preload, the minimum stress the pin experiences is a value much closer to the maximum stress. In low maximum stress cycles, the pin is completely insulated from the fatigue cycle (green line).

To illustrate the benefits of raising the minimum stress, the chart below shows different load cycling combinations on 4340 steel bar that resulted in fatigue lives of 10^7 cycles. The curved lines show different test temperatures with the solid lines being an unnotched bar and the dashed lines being a weaker notched bar with a stress concentration of Kt=1.33 and 'RT' denoting a room temperature test.

To see the effects of raising the minimum stress while keeping the maximum stress the same (adding a preload) an orange line has been placed on the graph at a constant maximum stress of 120ksi. **Point 1** represents a case similar to a pin with no preload - minimum stress 0. **Point 2** represents a case similar to a pin with a preload - minimum stress equal to 90ksi. To reach 10^7 cycles requires an unnotched bar of 4340 at room temperature (solid 'RT' line @ point 1), but when a preload is added 10^7 cycles can be reached with a much weaker notched bar of 4340 (dashed 'RT' line @ point 2).



Constant-lifetime fatigue diagram for AISI-SAE 4340

steel bars

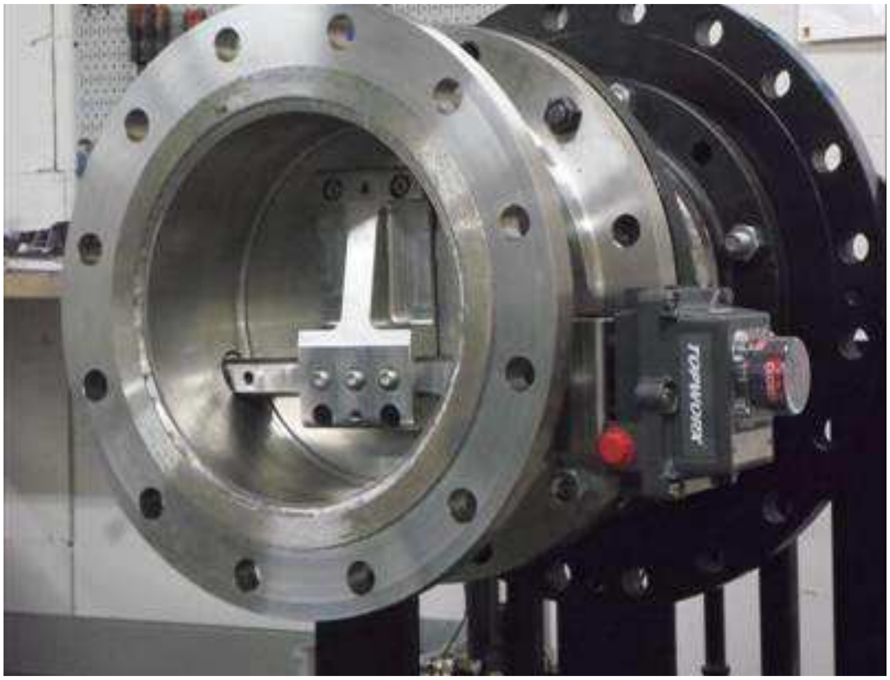
MANUFACTURING

Enviro-Valve Inc. is dedicated to quality products delivered in reasonable time. With facilities in Broken Arrow, OK (pictured below) and a strong network of partnered machine shops and vendors we are centrally located and structured to provide very responsive customer care.

We machine all critical components (calibrated shear pins for example) within our own facility in Broken Arrow and have the utmost in quality control - testing each fully assembled device a minimum of 3 times, and providing a computerized test report with shipment, before it is deemed ready to ship.

The picture below shows part of an order of Accu-Shear pressure relief devices getting ready for final packaging.

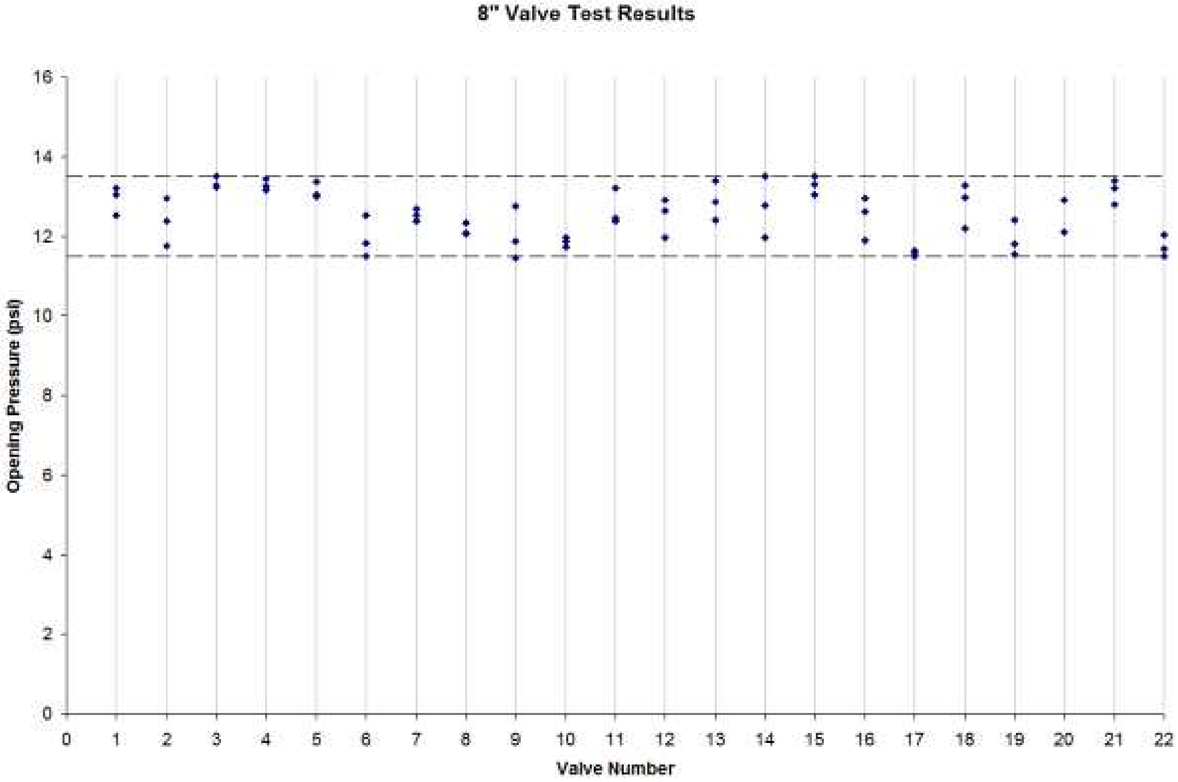
RESULTS (RESULTS ACROSS 22 DIFFERENT DEVICES)



As stated, each device that leaves our warehouse is tested a minimum of three times with production shear pins to ensure they meet performance specifications. The picture to the right shows part of our test stand.

Each test is recorded in real time via a pressure transducer and DAQ unit. This allows the customer the ability to review our tests in detail, to ensure that the pressure rate increase and other items match the installed conditions as closely as possible.

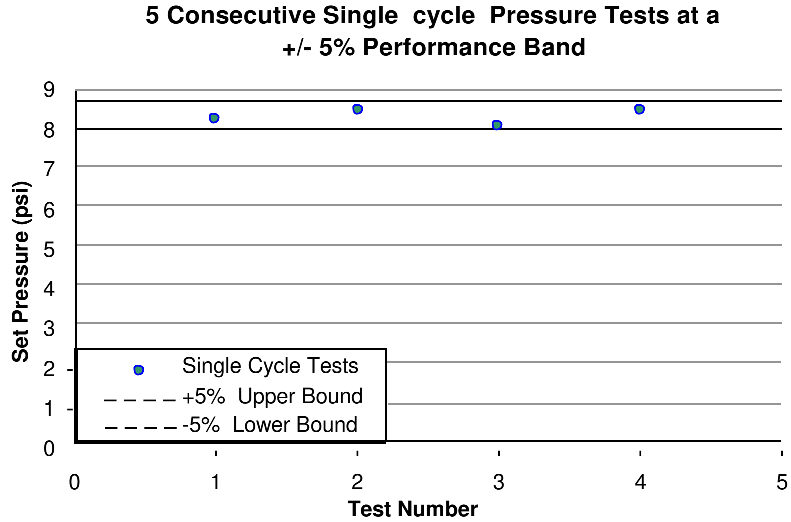
Below is a summarized view of 22 eight inch devices tested before delivery. As can be seen all devices - 66 tests - performed within the performance range specified by the customer using the same part numbered pin.



TECHNICAL DATA

FATIGUE RESULTS (ALL TESTS ON SAME DEVICE)

Along with amazing repeatability across multiple devices (shown on previous page) our device has yielded very consistent fatigue results. To the right are the set pressure results of a 10 inch device set to 8.25 psi in a series of 5 consecutive single cycle tests - similar to what each device leaving our facility must undergo. A video of this test can be found on our website under the videos tab.



This same device was then subjected to a series of 25, 50 and 100 cycle tests between 7 psi and 3 psi, 89% and 38% of the minimum acceptable set pressure, respectively. After the completion of the cycle test the device was then pressured down to zero and a single cycle pressure test was performed. For all three cases the set pressure fell within the 8.25 psi +/- 5% performance band. Illustrative graphs of the three trials are found below.