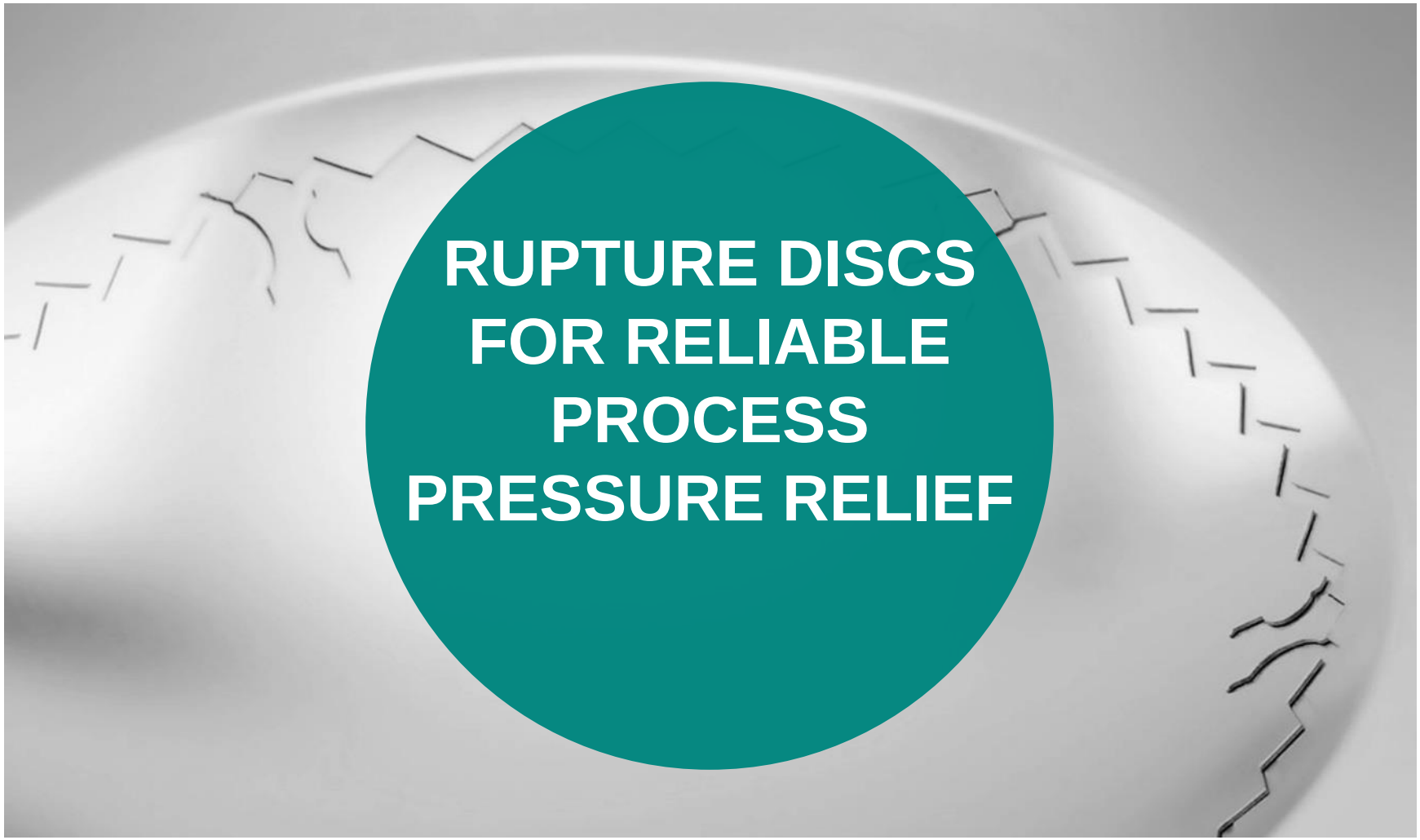
Safety is for life.



Rupture Disks for Reliable Process Pressure Relief

上海兴祥工业设备有限公司
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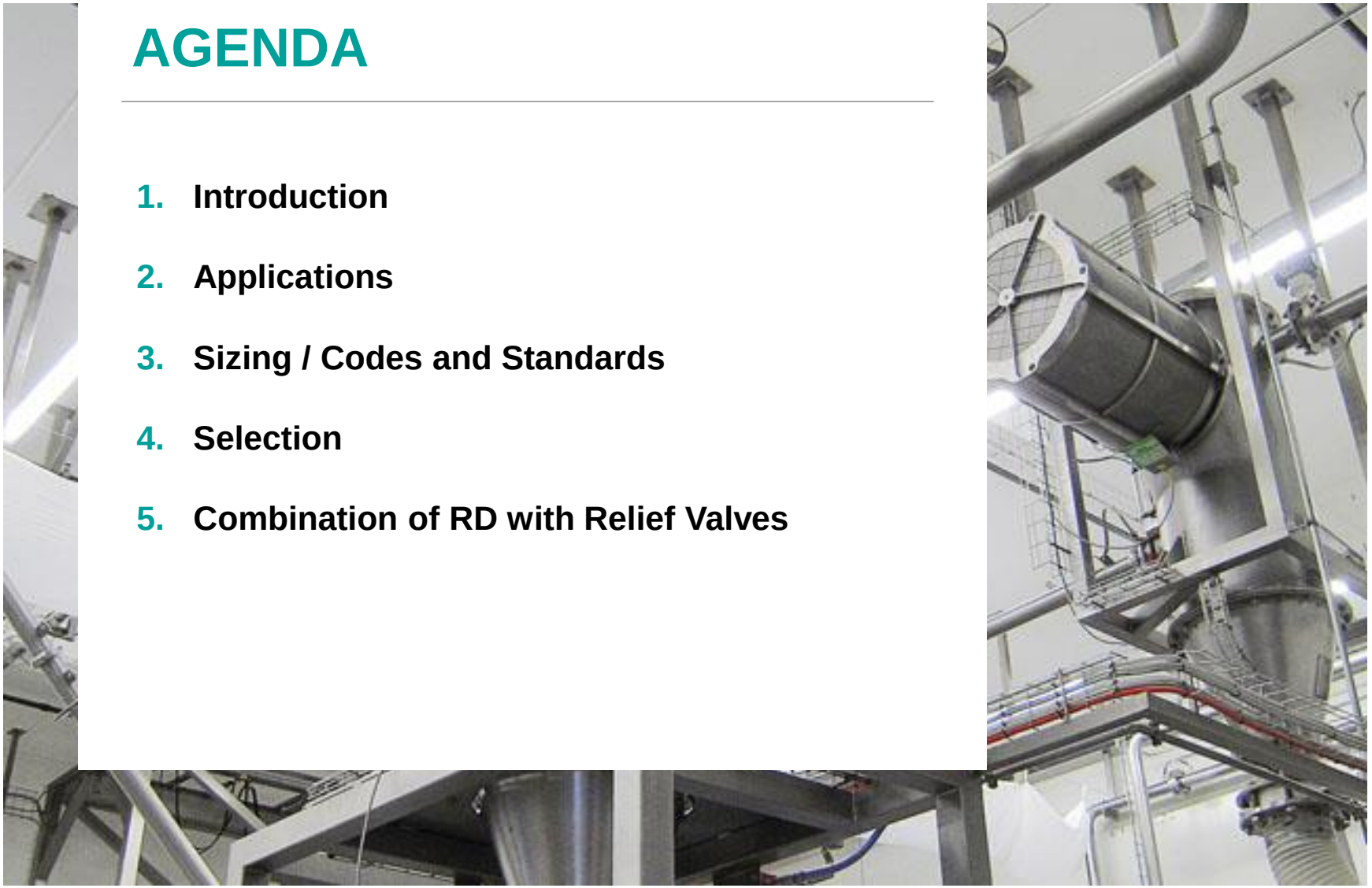
AGENDA

1. **Introduction**
2. **Applications**
3. **Sizing / Codes and Standards**
4. **Selection**
5. **Combination of RD with Relief Valves**



WHAT IS A RUPTURE DISC?

- A non-reclosing vent
- The disc bursts and relieves potentially dangerous overpressure in a pressurised system
- A pressure differential switch - the disc bursts and activates a system

WHAT IS A RUPTURE DISC?

- **API 520:**
  - Rupture disc devices are non-reclosing pressure relief devices
  - used to protect vessels, piping and other pressure containing components from excessive pressure and/or vacuum
  - Rupture discs are used in single and multiple relief device installations. They are also used as redundant pressure relief devices.

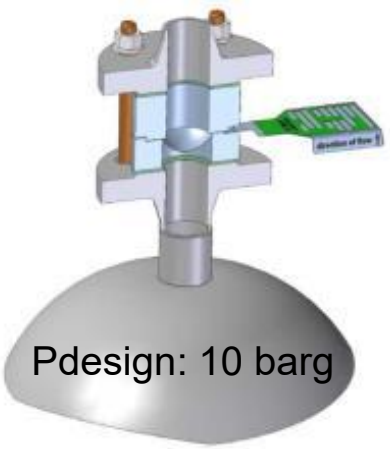
- **EN ISO 4126:**
  - Bursting disc device is a non-reclosing pressure relief device used to protect equipment such as pressure vessels, piping, gas cylinders or other enclosures from excessive pressure and/or excessive vacuum.

WHY USE A RUPTURE DISC?

- **Process Plant Overpressure Protection**
- **Legal Requirements**
  - ✓ Environment protection
  - ✓ Personnel protection
  - ✓ Insurance requirements
- **Low Cost**
  - ✓ Excellent corrosion resistance
  - ✓ No maintenance
- **Negligible Leakage**
- **Rapid full-bore relief**

APPLICATIONS

Rupture Disc as a primary relief device



primary relief device

- Pburst: 10 barg
- to protect the vessel/system against excessive pressure

API 520

Primary relief up to 110% of design
Secondary relief up to 121% on fire case

Rupture Disc as a secondary relief device

- PRV for primary relief, e.g. Pset= 10 barg
- RD as a secondary relief device set at a higher value

- fire case: a higher discharge capacity is required
- secondary back up in case of SRV/PRV malfunctioning due to slow or non-opening by sticking, freezing etc.

PED

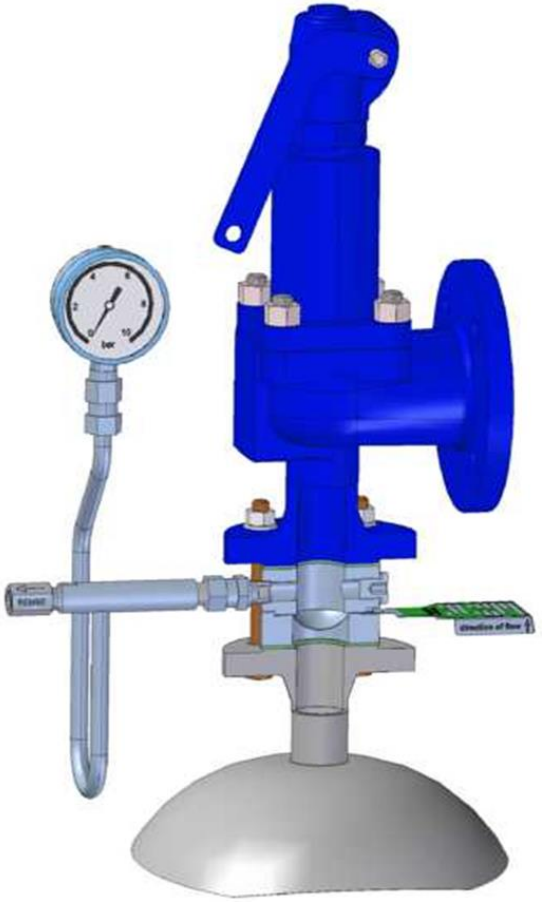
Max. overpressure 110% of PS

RD COMBINATION WITH PRV

Rupture discs are used upstream of PRV to:

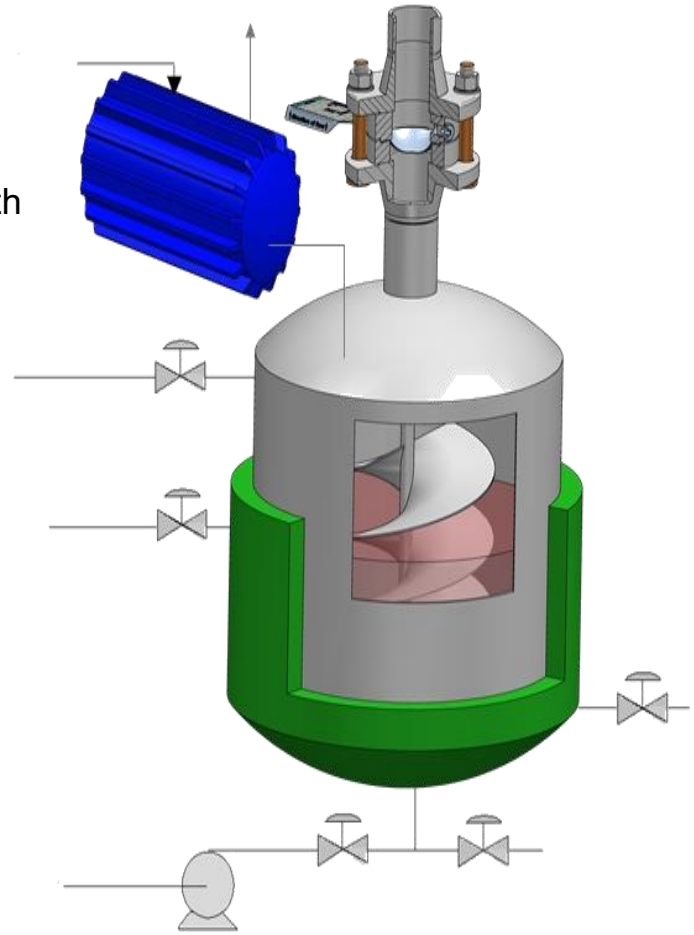
- isolate the valve from the system
- reduce valve maintenance
- provide corrosion protection to avoid the cost of high alloy PRV
- prevent leakage and product loss

➢ Burst pressure = PRV set pressure



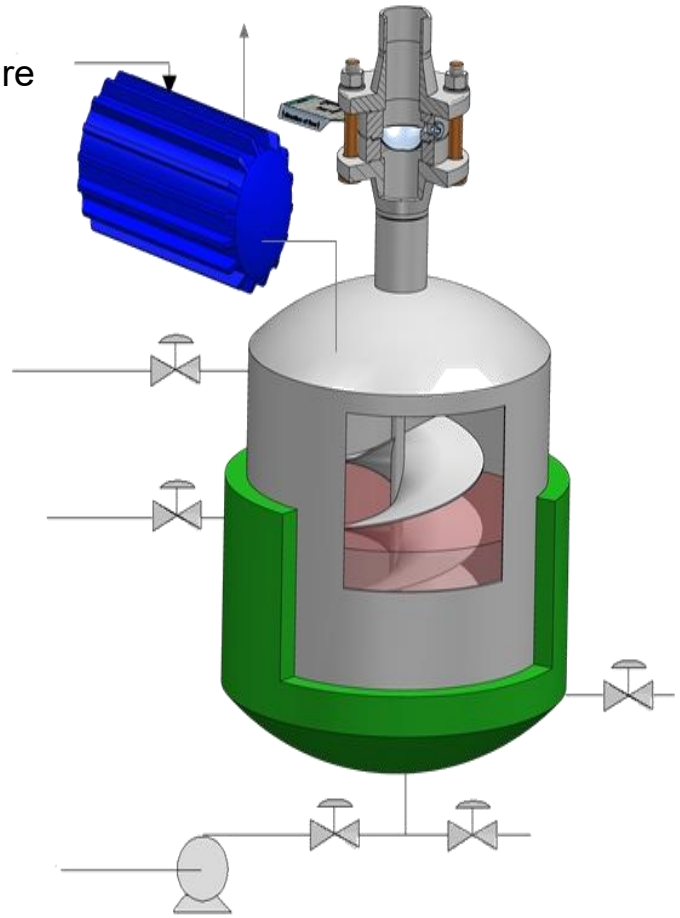
RD SELECTION → NO SIZING REQUIRED

- **Size (The size of the disc)**
- **Pressure → Burst pressure**
  - ✓ working (operating) pressure
  - ✓ design pressure / vessel strength
  - ✓ pressure and/or vacuum cycling
  - ✓ back pressure, if any
- **Temperature**
  - ✓ Coincident (burst) temperature
  - ✓ Max. operating temperature
- **Application**
  - ✓ liquid
  - ✓ gas / vapor
  - ✓ polymerisation
  - ✓ Combined with safety valve
- **Special requirements**
  - ✓ sterile / aseptic
  - ✓ Corrosion
  - ✓ ...
- **Required Material**
- **Flange class**



RD SELECTION → SIZING REQUIRED

- **Temperature**
  - ✓ Design and relieving temperature
- **Application**
  - ✓ Liquid → Density, viscosity
  - ✓ gas / vapor →
  - Mol. Weight
  - Specific heat ratio (Cp/Cv)
  - Compessibility factor



To calculate the suitable disc size
→ Required discharge capacity (lb/hr)

To calculate the discharge capacity
→ specified size
If combined with a Safety Valve
→ valve inlet size

Independent of all others: PLS INDICATE
„Required quantity“

API 520: ACCUMULATION LIMITS FOR SIZING

Table 1—Set Pressure and Accumulation Limits for Pressure Relief Devices

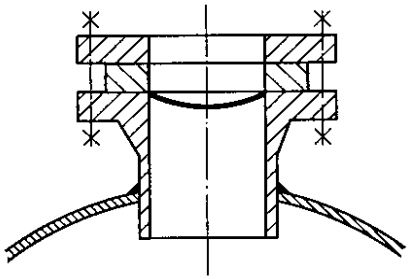
Contingency	Single Device Installations		Multiple Device Installations	
	Maximum Set Pressure %	Maximum Accumulated Pressure %	Maximum Set Pressure %	Maximum Accumulated Pressure %
Non-fire Case				
First relief device	100	110	100	116
Additional device(s)	—	—	105	116
Fire Case				
First relief device	100	121	100	121
Additional device(s)	—	—	105	121
Supplemental device	—	—	110	121
NOTE All values are percentages of the maximum allowable working pressure.				

SIZING METHOD COEFFICIENT OF DISCHARGE

For calculations acc. to ASME Sec. VIII, Div. 1

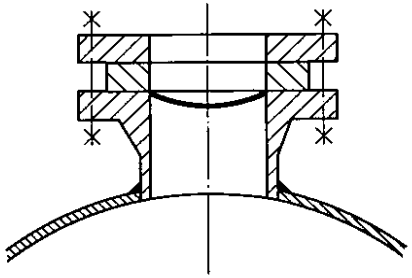
and API 520 coefficent of Discharge K_d = 0.62

Variations for calculations acc. to EN ISO 4126-2 and AD2000-A1 Merkblatt



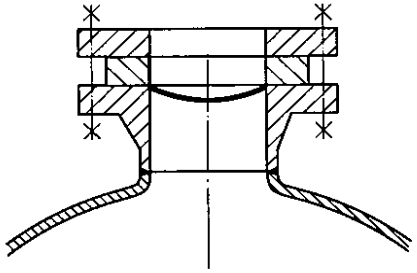
$\alpha_{D/G}$ = 0,68

α_F = 0,50



$\alpha_{D/G}$ = 0,73

α_F = 0,62



$\alpha_{D/G}$ = 0,80

α_F = 0,80

SIZING USING COEFFICIENT OF DISCHARGE

Sizing acc. to ASME Sec. VIII Div.1 / API 520 Part 1

example:

- medium: Flare gas
- capacity: 240,000 kg/h
- mol. weight: 31.9 kg/kmol
- isentropic exponent (Cp/Cv): 1.29
- compressibility: 0.96
- bursting pressure 1 bar g @ 80° C

required size? demo-calc.xls

SIZING: FLOW RESISTANCE METHOD

API 520 Part 1, Section 5.11.1.3

The calculated size of a pressure relief system containing a RD may also be determined by analyzing the total system resistance to flow.

The calculation shall be made by using accepted engineering practices for determining fluid flow through piping systems. The calculated relieving capacity shall be *derated* by 0.90.

The RD is considered as a just another piping component of the relief system.Flow resistance is defined as (Kr) value.

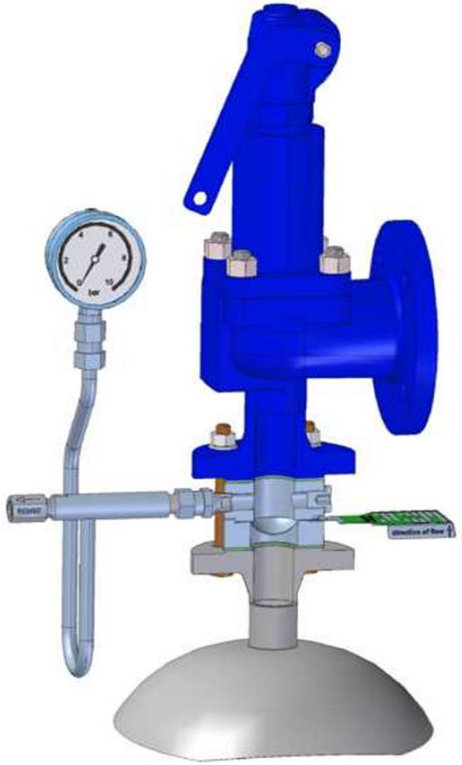
ASME certified values should be used *where available.*

SIZING REQUIREMENTS FOR COMBINATION

The combination capacity method

- Size the PRV for stand alone, using normal sizing procedures
- then de-rate the capacity of the valve is by the default combination capacity factor of 0.90 (as per API/ASME and EN ISO 4126-3)

Essential requirement: The rupture disc size must be equal to or greater than the nominal pipe size of the PRV inlet.



- higher Capacity Factors than 0.90 can be used, if the combination is certified,e.g. KUB with LESER Safety Valve has a certified factor of 1.0

(-) too much less data available on other combinations,
mostly based on one size method

SELECTION: BURSTING PRESSURE

ASME Code performance requirements:

burst tolerance

- for burst pressures above 40 psig: +/- 5%
- for burst pressures up to and including 40 psi: +/- 2 psi

Manuf. Design Range (MDR)

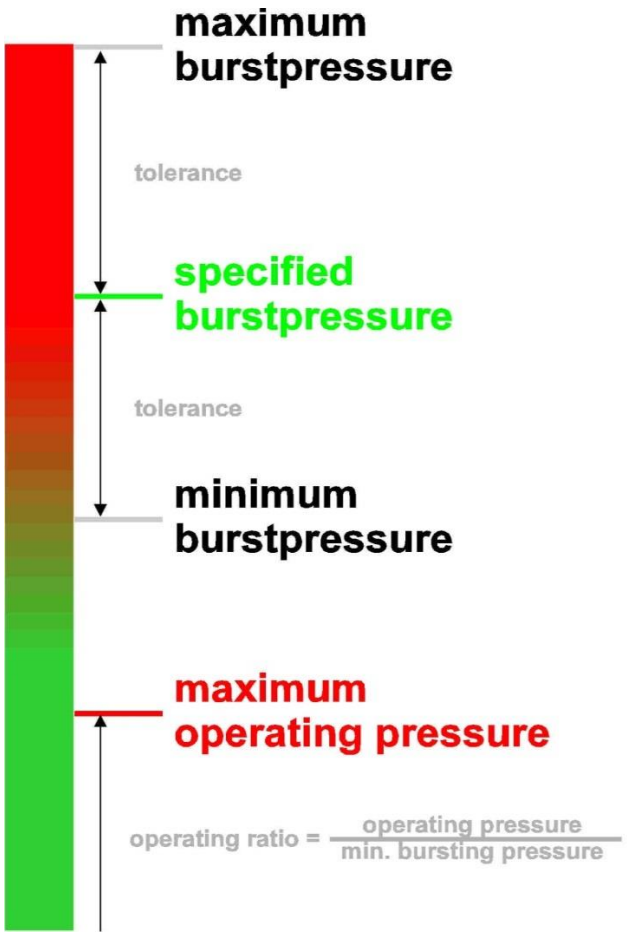
Depends on the manufacturer, typically -10%, -5% or 0%

Acceptance

2 burst tests at coincident temperature

Note: EN ISO 4126-2 requires higher no. of tests for batches of 10 pcs. and above

RUPTURE DISC SELECTION



P_{design}: 100 psi(g)

example:

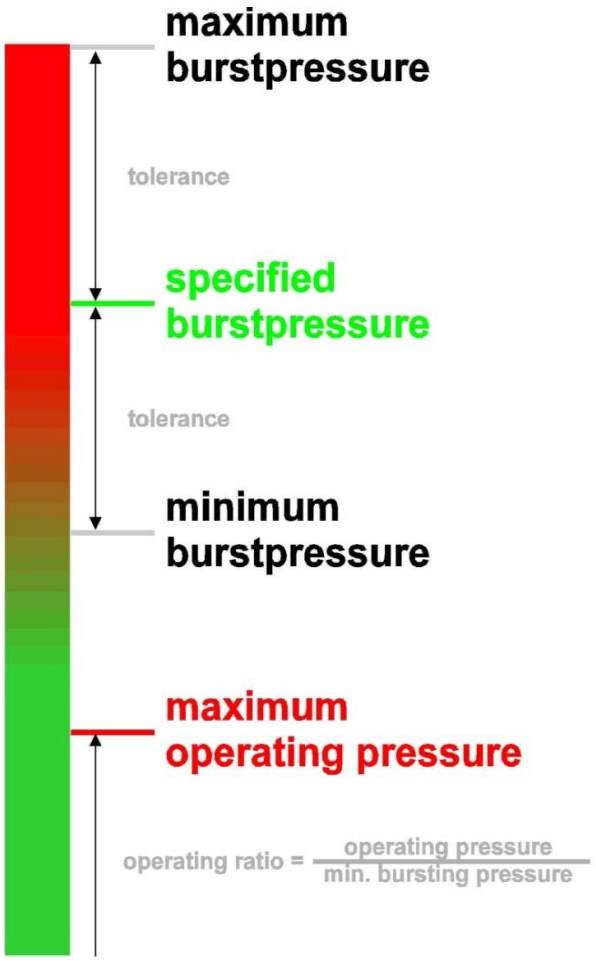
- bursting pressure : 100 psig
- burst tolerance : +/-5%
- Manuf. Design Range (MDR) : 0%

- nom. bursting pressure : 100 psig
- max. bursting pressure : 105 psig
- min. bursting pressure : 95 psig

- *Max. safe operating pressure for extended service life of RD depends on the type*

→ Operating ratio

SELECTION: OPERATING RATIO



Operating ratio (OR):

(operating pressure / min. bursting pressure)

Bursting pressure: 100 psig

Burst tolerances: +/- 5%

Manuf. Design Range (MDR): 0%

Max. bursting p: 105 psig

Min. bursting p: 95 psig

Normal operating: 85 psig

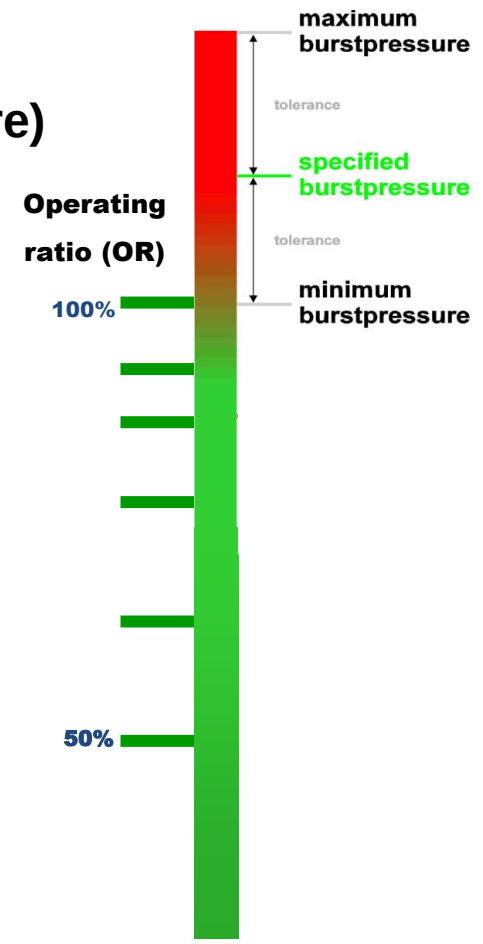
Operating ratio: ?

Operating ratio: 0.895 (89.5%)

SELECTION: OPERATING RATIO (OR)

OR Operating ratio =

(max. operating pressure / min. bursting pressure)



- 98% for **KUB®** -rupture discs (KUB, TCR-KUB)
- 90% for reverse acting – ***industrial standard*** (IKB)
- 80% for Triple section type (ODV, STAR)
- 70% for conventional forward acting (BT)
- 50% for flat and graphite bursting discs

TEMPERATURE INFLUENCE

- Rupture discs are temperature sensitive devices.
- Bursting pressures can vary significantly with the temperature of the rupture disc device.

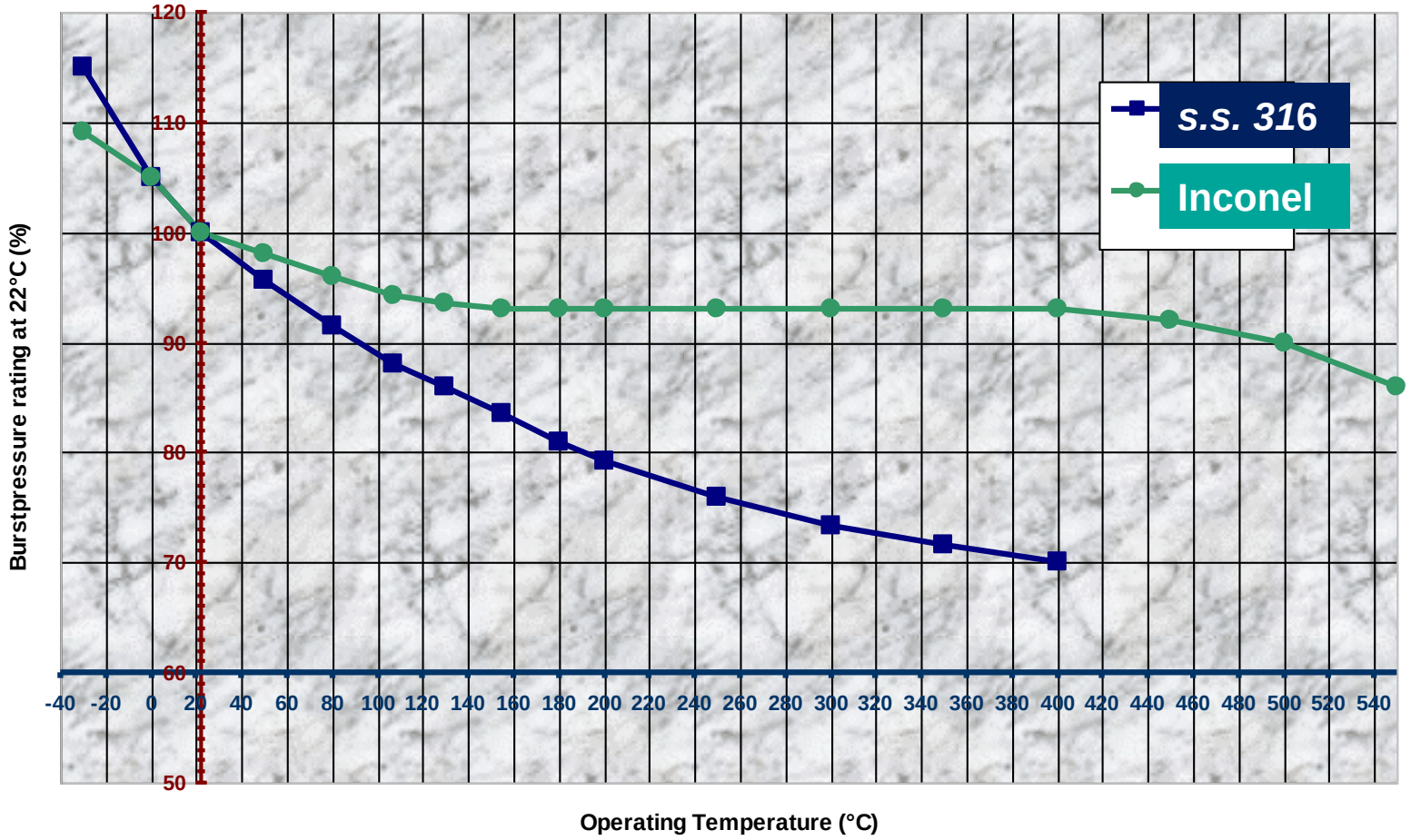
- The burst temperature may be different from the normal fluid operating temperature.
- As the temperature at the disc increases, the bursting pressure usually decreases.

➢ For these reasons, the rupture disc must be specified at the pressure and temperature the disc is expected to burst.

TEMPERATURE INFLUENCE

BT-KUB

- temperature and burstpressure relationships



CORROSION BASICS

Corrosion risk is highly important in material selection for RD since these are made from thin materials.

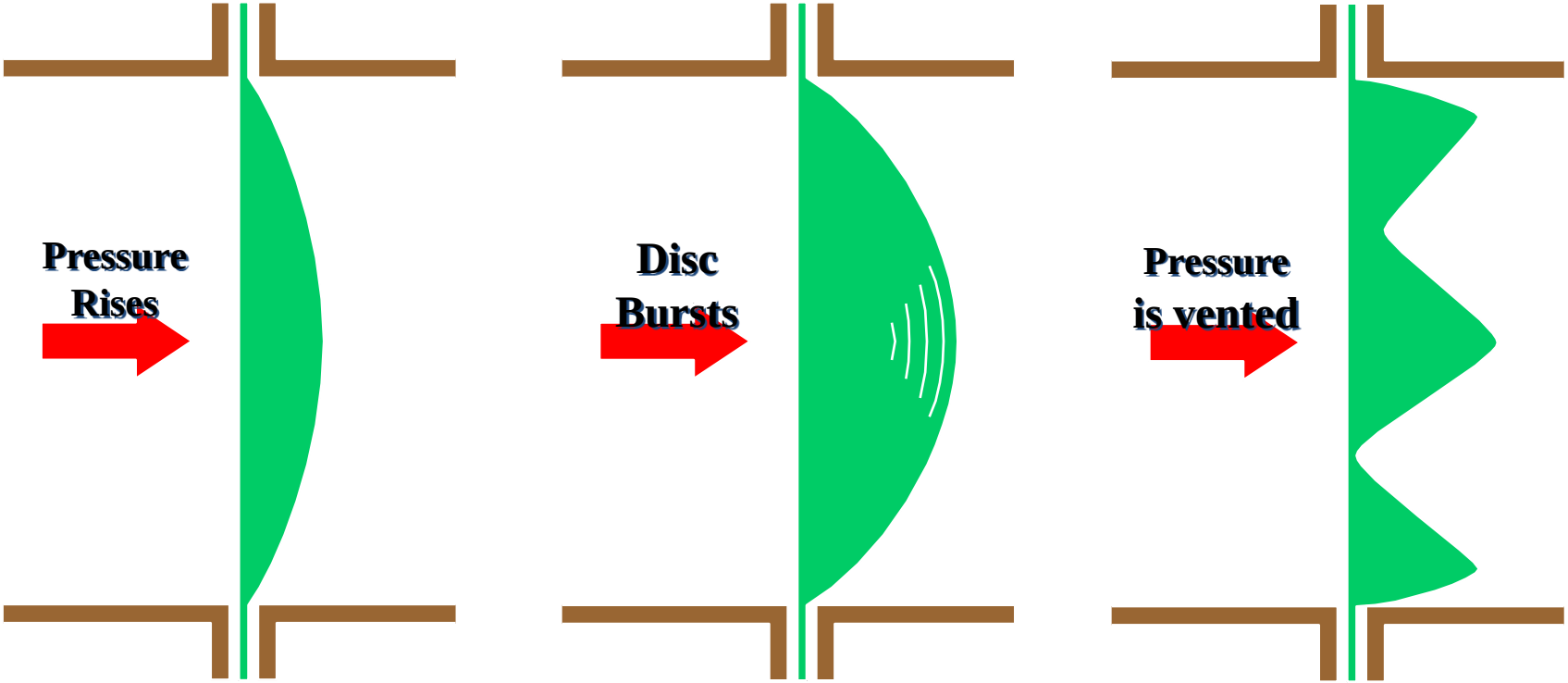
EN ISO 4126 Bursting Disc Safety Devices:

Materials: “The materials for bursting disc safety devices shall be determined by the user and the manufacturer.”

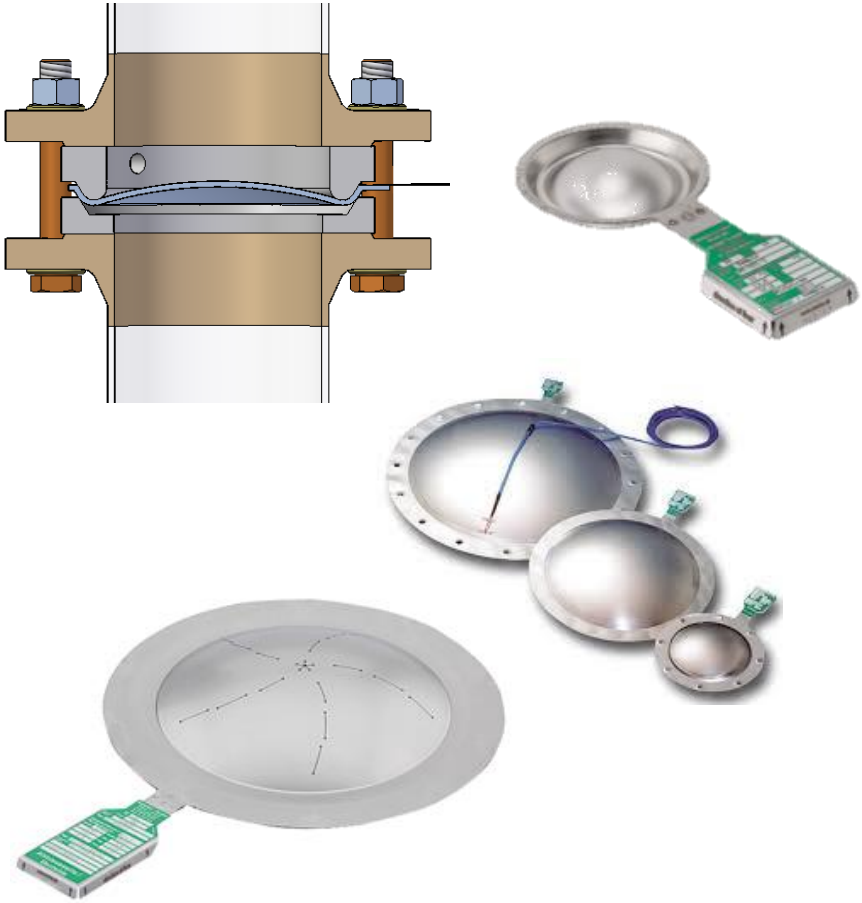
NACE MR0175/ISO 15156

Petroleum and natural gas industries - Materials for use in H_2S-containing environments in oil and gas production

FORWARD ACTING (TENSION LOADED) RUPTURE DISCS



REMBE® FORWARD ACTING DISCS (TENSION LOADED)



BT, BT-ODV

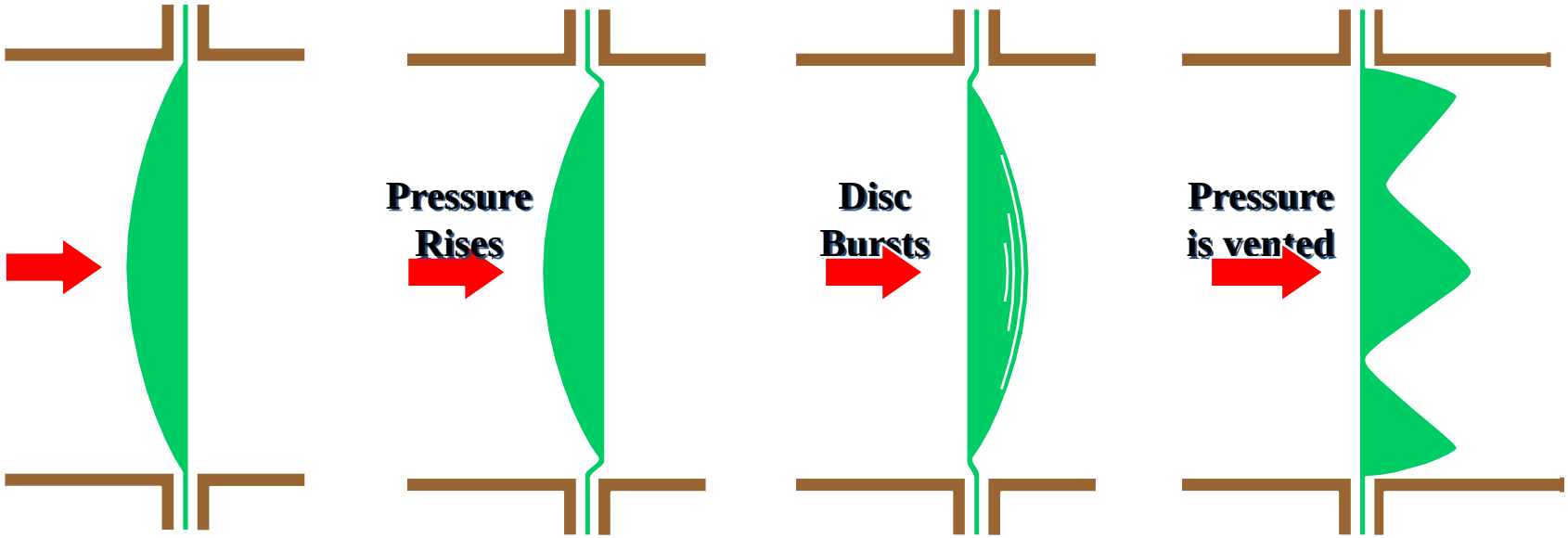
- ✓ 30 degree seat
- ✓ BT – risk of fragmentation

BT-STAR

- ✓ Flat Seat holder
- ✓ Triple section disc
- ✓ Non-Fragmenting design

- Liquid & Gas service
- Stainless Steel, Aluminium, Inconel, Monel, Hastelloy, Nickel, Tantalum, Titanium, PTFE, FEP, PFA

REVERSE ACTING (COMPRESSION LOADED) RUPTURE DISCS



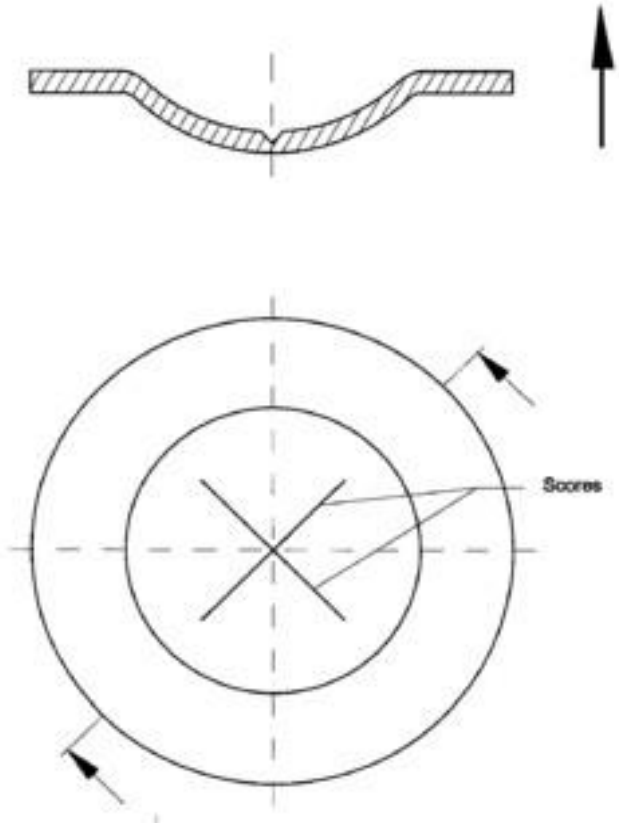
Higher Operating Ratio

Cycle Life: Resists Fatigue

Better Valve Protection

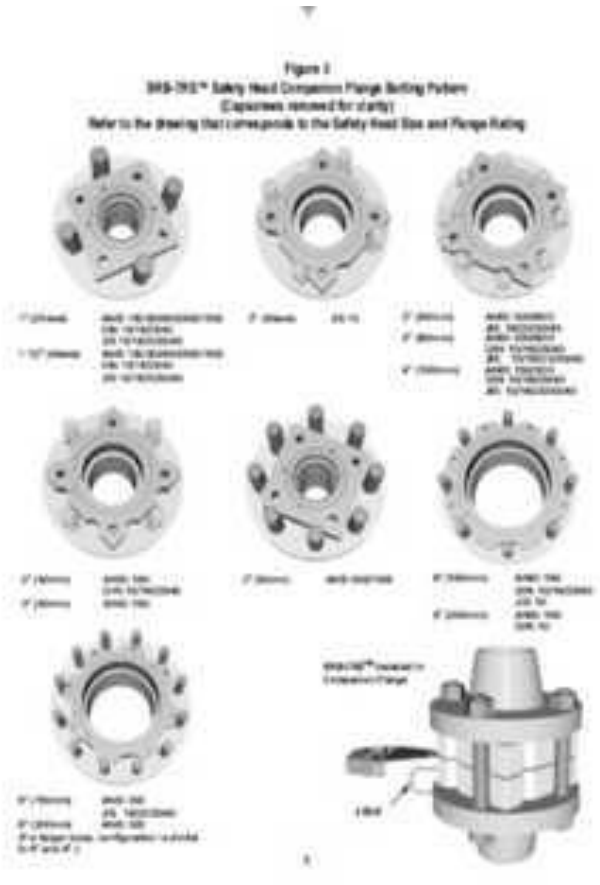
SCORED REVERSE ACTING DISCS

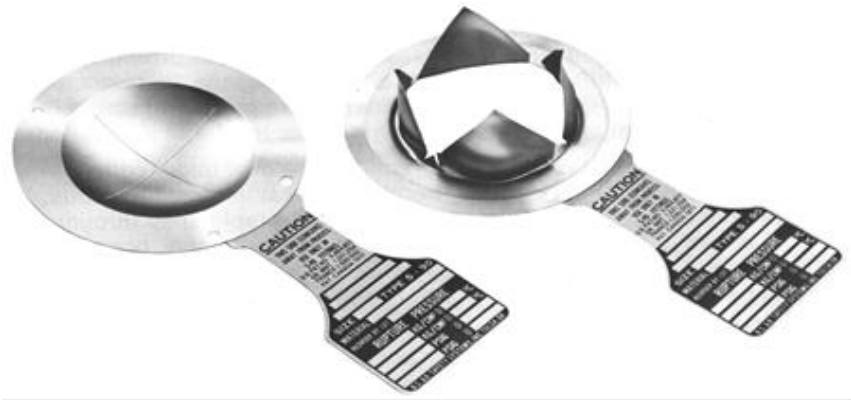
The Industry‘s Standard



- Cross scoring is typical but also peripherally scored designs available
- Scoring is pre-weakening of the material
- Scoring process causes work hardening around the score lines
- Weakened material is at risk of corrosion: PREMATURE FAILURE
- Design require controlled torque & supervised installation

SCORED REVERSE ACTING DISCS REQUIRES CONTROLLED TORQUE PROCEDURES





Installation of Safety Head SRB-7FS™ Assembly in Pressure System

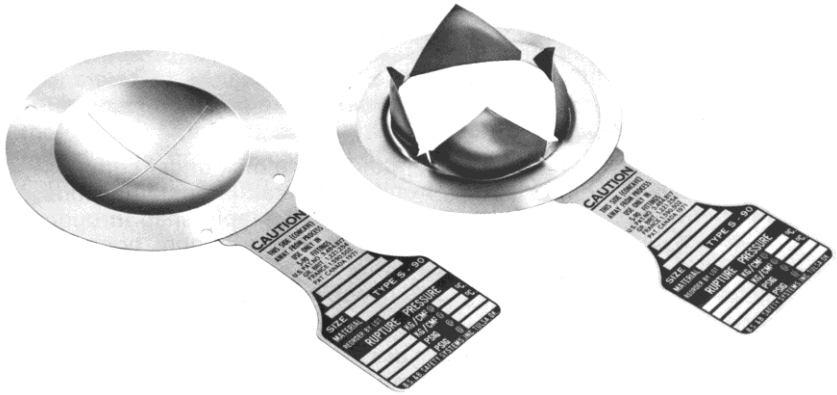
(Refer to Figure 6)

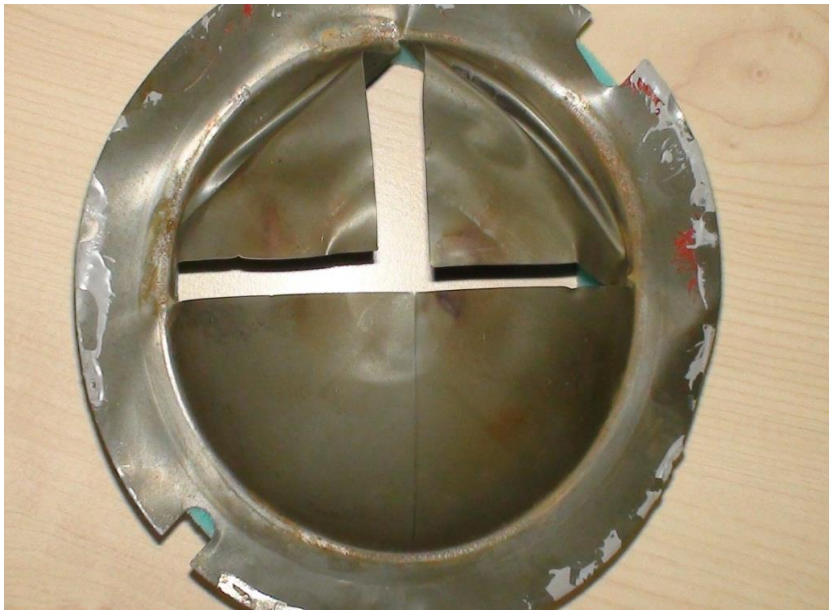
1. Insert the preassembled SRB-7FS™ safety head in the pressure system. **Ensure flow arrows on the disk tag and on the safety head point in the same direction.** Concave side of disk, must be away from process.
2. Install gaskets between the safety head and the companion flanges. We recommend a compressed fiber gasket 1/16" (1.5 mm) or 1/8" (3 mm) thick. The user is cautioned to select gasket materials adequate for the service conditions including the ability of the gasket to resist "cold flow." Gaskets that cold flow will allow torque relaxation affecting their sealing performance. (The burst pressure of disks installed in pre-torqueable safety heads SRB-7RS™ is unaffected.) **Contact BS&B Safety Systems, L.L.C. or BS&B Safety Systems Ltd. if an alternative gasket type is used, or for advice on the use of spiral wound gaskets.**
3. Install studs with nuts. Tighten all nuts finger tight before torquing. Evenly torque the studs to the values in Table C. Torque evenly in a diagonal pattern by applying 1/4 of the recommended torque to each stud. Repeat pattern by torquing to 1/2 then 3/4 of the recommended torque value. Then using same pattern, torque to full torque value. Do not exceed the specified torque value.

4

SCORED REVERSE ACTING DISCS

The Industry‘s Standard





REMBE® REVERSE ACTING DISCS

- **KUB®** and **IKB®** are manufactured using Laser technology and computer controlled processes, conserves material structure
- 100% guaranteed relief area
- Non-Fragmenting designs
- Unique REMBE designed innovations
- Interchangeable designs
- Non-Torque sensitive
- Precise production results

IKB® : SUBLIMATED DESIGN

- May look similar to some of the “peripherally scored” discs on the market *but* the IKB is different
- ***Sublimation:*** of an element is the transition from solid to gas phase with no liquid phase in between. Sublimation is an ***endothermic phase transition*** that occurs at temperatures and pressure below the ***triple point***

✓ Conserves the material structure: reduced risk of corrosion

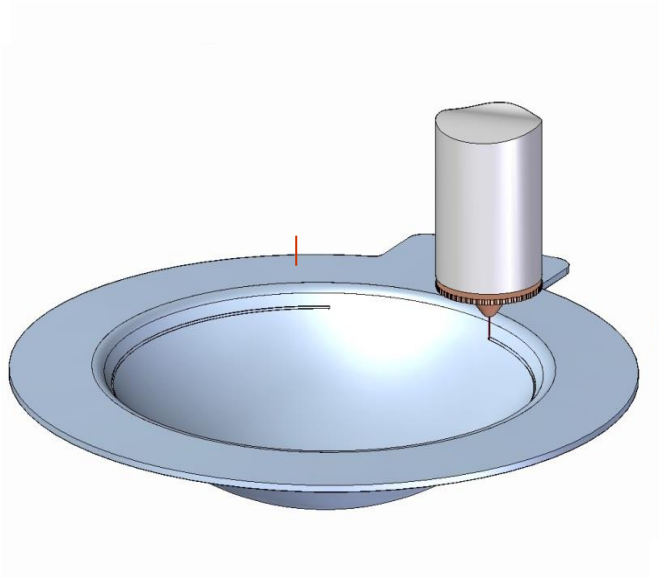
✓ Precise production results

✓ Excellent pre-defined full bore opening

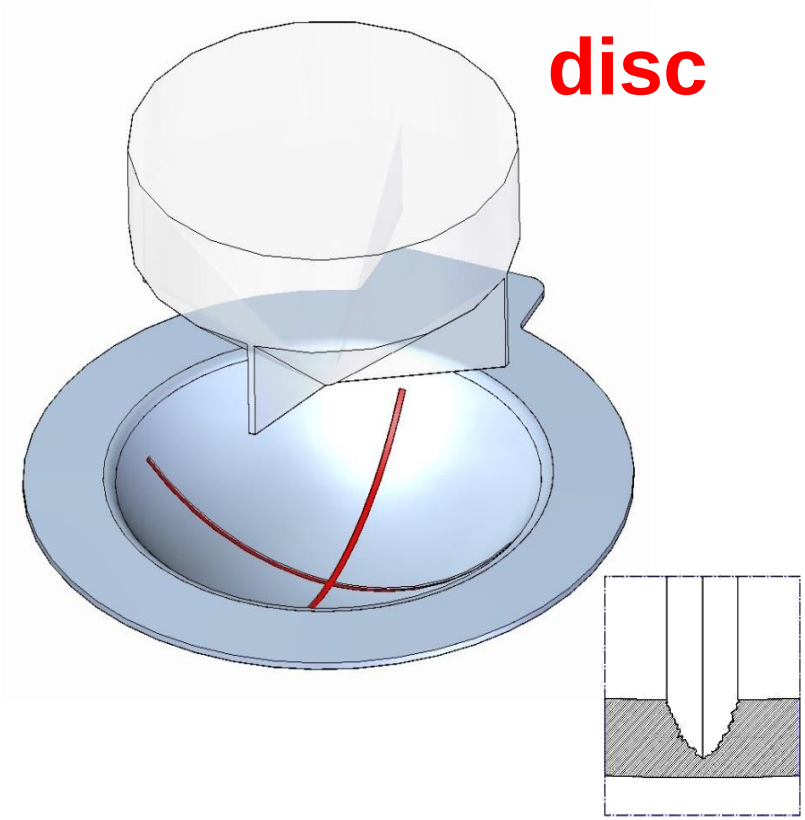
IKB® VS. SCORED DISC

Manufacturing Technique

IKB®



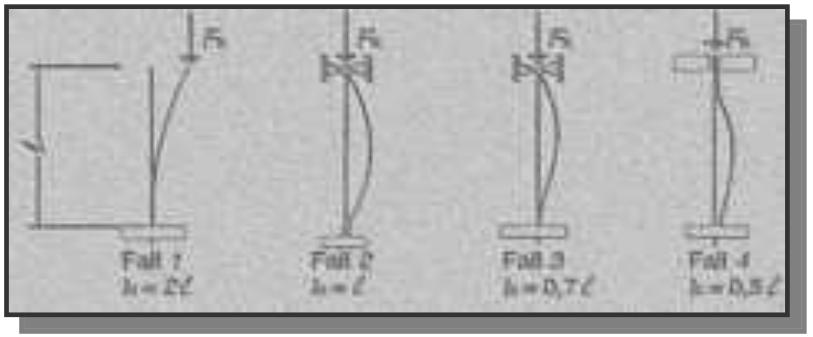
scored disc



KUB®

Euler‘s Law & Buckling Pin Rupture Discs

Leonard Euler (1707-1783)



$$F_K = \pi^2 \cdot \frac{EI}{l_K^2}$$

$$\sigma_K = \pi^2 \cdot \frac{E}{\lambda^2}$$

Berstdruck nur abhängig von E-Modul und Schlankheit

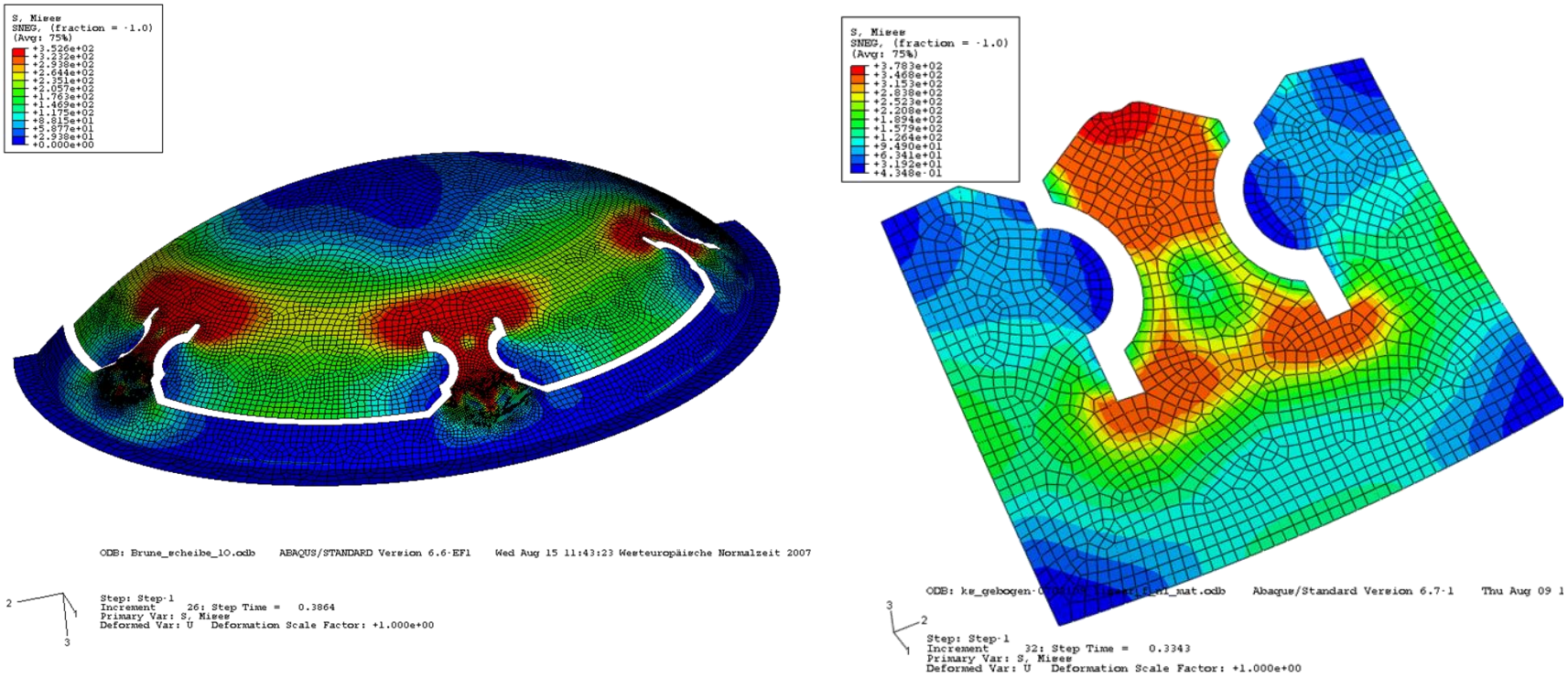
KUB®

Euler‘s Law & Buckling Pin Rupture Discs

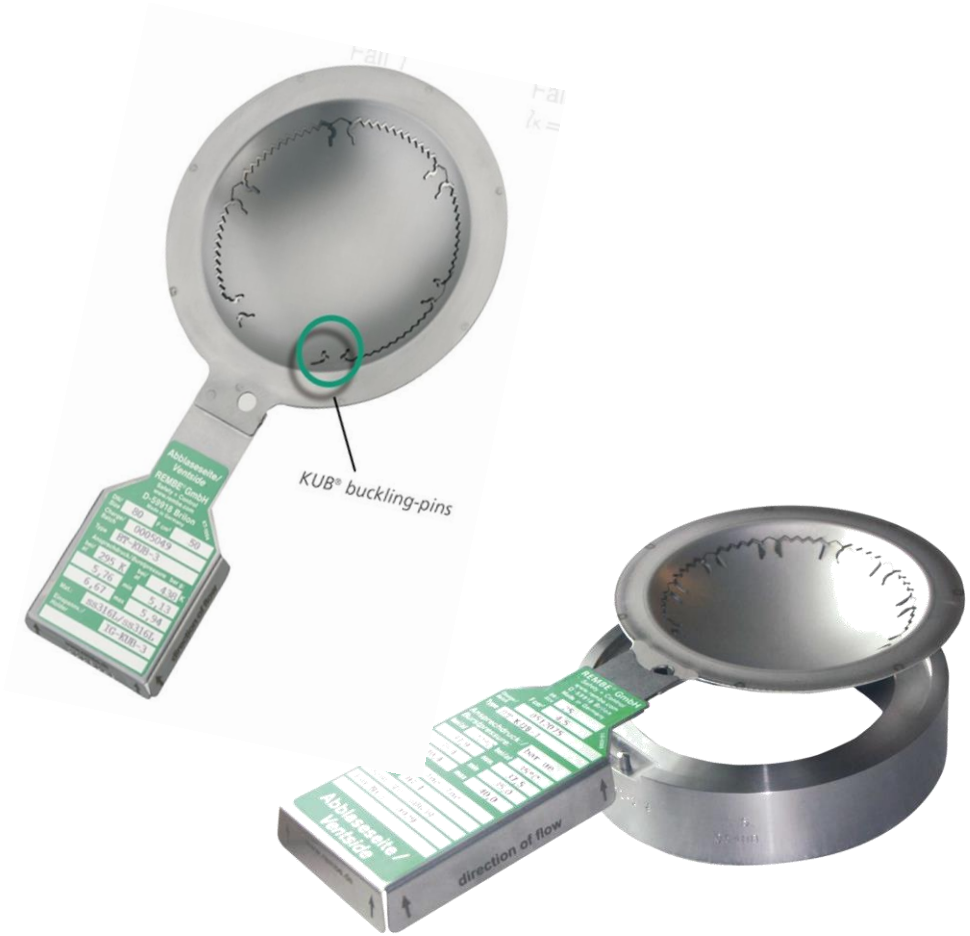
- Euler’s law defines the axial compression force which will cause a column to fail in buckling.
- Laser cut buckling pin element
- No pre-weakening of material or structural changes.
- Smooth process side: No risk of corrosion and premature failure.
- 98% operating ratio. Lowest manufacturing tolerances due to numeric controlled laser cutting.
- Robust, even at low pressures.

KUB®

FEM Analysis

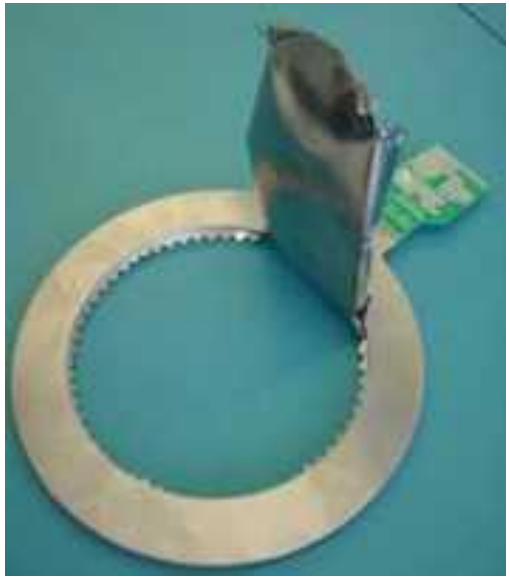


KUB® UNDER WORKING CONDITIONS



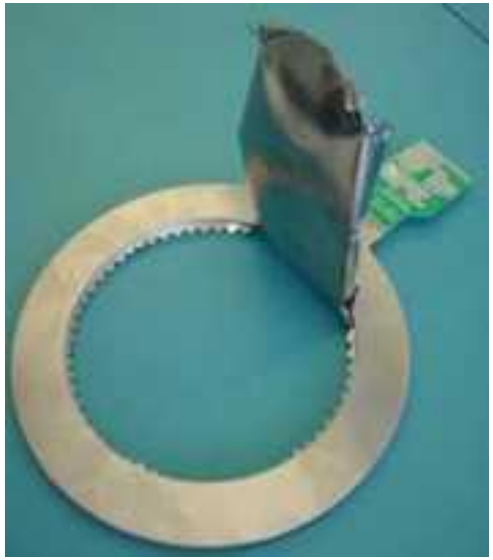
KUB® AFTER RESPONSE

- Full relief area
- Non-fragmenting
- Full discharge capacity in combination with PRV



KUB® BENEFITS

- Can not be damaged during installation, not torque sensitive
- Corrosion safe design
- Highest operating ratio up to 98%
- Re-useable after inspection



COMPARISON OF A RUPTURE DISC + PRV

Rupture Disc

- ✓ Absolutely Leak Tight
- ✓ Competitive
- ✓ Full Bore Opening

- × Non-reclosing device
- × Single Use

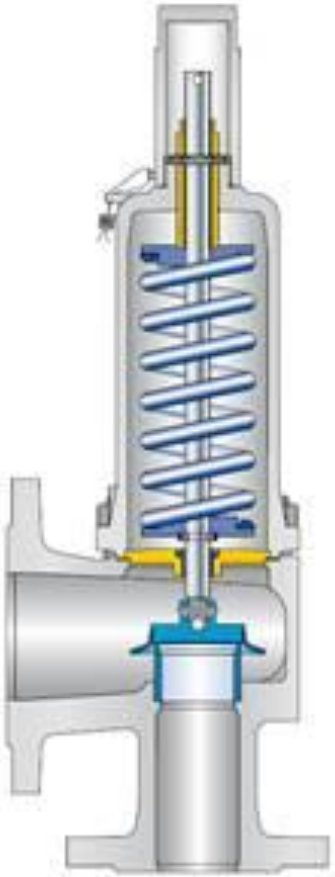
Pressure Relief Valve

- ✓ Reclosing Device
- ✓ Reuseable

- × Requires maintenance
- × Not leak tight – risk of product loss

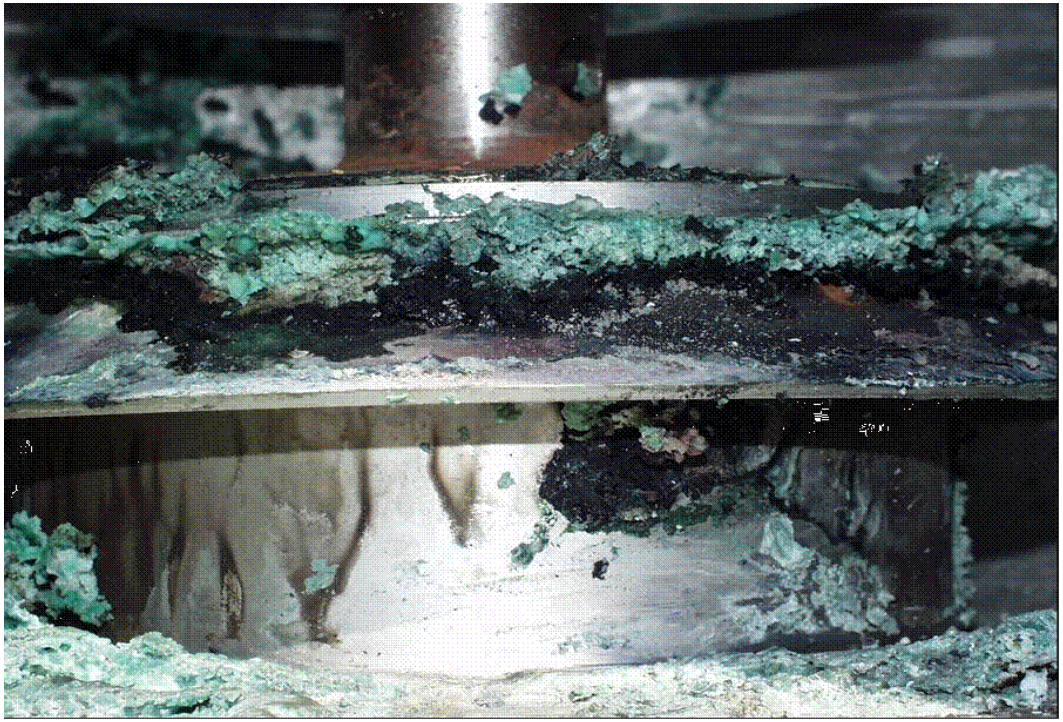
The advantages are consolidated with the combination of a rupture disc and a pressure relief valve!

PRV STAND ALONE

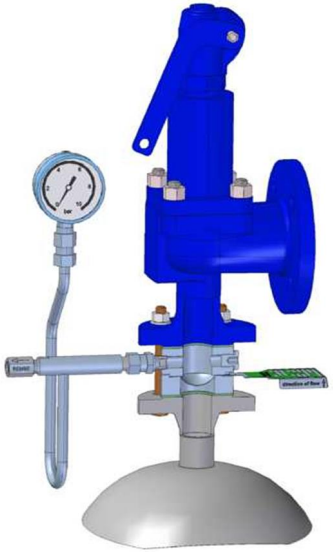


PRV applied for polymerizing media

- **high risk of overpressurizing of equipment**



KUB® IN COMBINATION WITH A PRV



ASME Code, Section VIII, Div. 1 on the use of rupture discs in combination with PRV:

- Isolate the valve from the system: corrosion protection, avoid the cost of a high alloy PRV
- Protect PRV against polymerisation
- prevent leakage and product loss
- Helps to reduce maintenance costs

REDUCING CAPEX AND IMPROVING PERFORMANCE

Standard PRV with 4" 150 # x 6" 150 # (with M Orifice)			
	PRV	Material	Material
		316SS (CF8M)	Hastelloy (C-22 Body & C-4 wetted parts)
	Standard Price PRV	4,694	21,511

		Standard S.s. PRV & Hastelloy disc+holder	Hastelloy PRV
Quantity 1		9,120	21,511
Quantity 10		79,310	215,110

KUB®-*V-SERIES*

In situ testing of your PRV

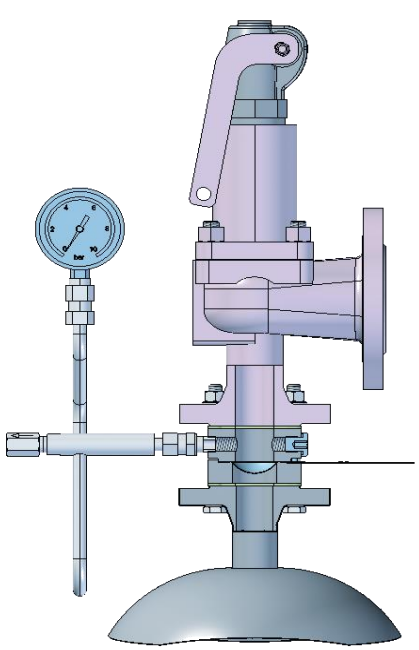
KUB®-*V-Series* is designed for use in combination with PRV in order to

- ✓ Lift-Test and maintain PRV in place
- ✓ extend maintenance intervals of PRV: Cost saving
- ✓ maximize Lifetime of PRV

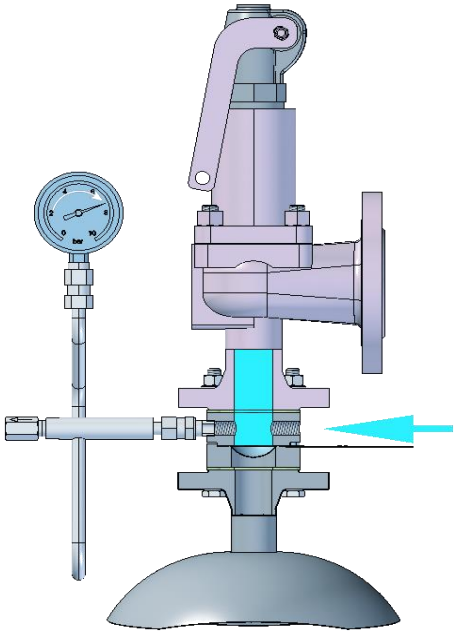
Disc is designed and certified for back pressure resistance = burst pressure + 30%

KUB®-*V-SERIES*

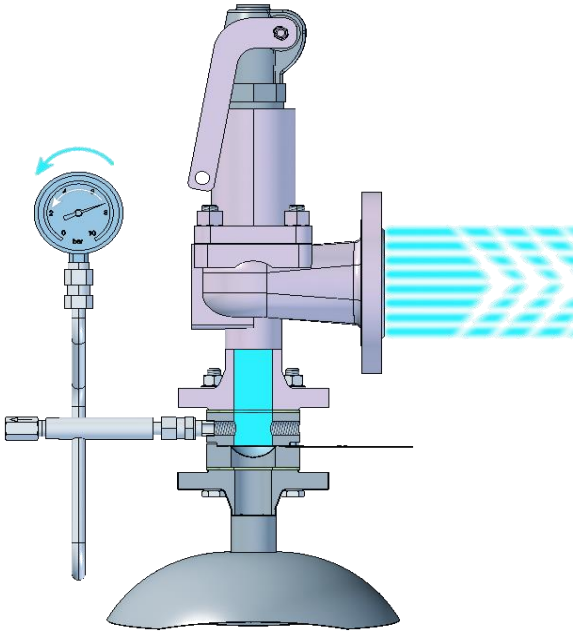
Just 3 steps to lift-test your PRV



Step 1: safe condition



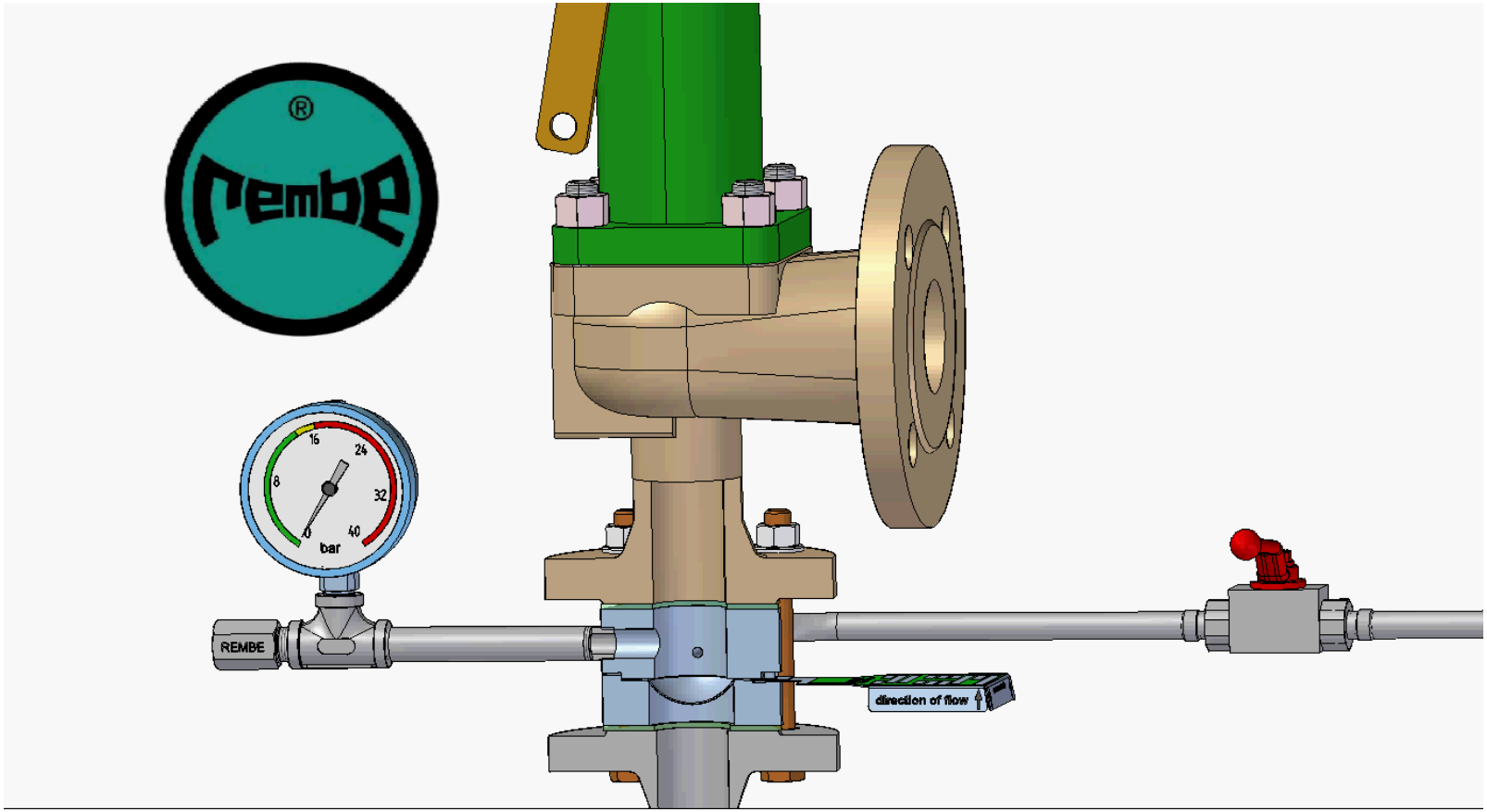
Step 2: pressurize chamber



Step 3: Lift test of valve

KUB®-*V-SERIES*

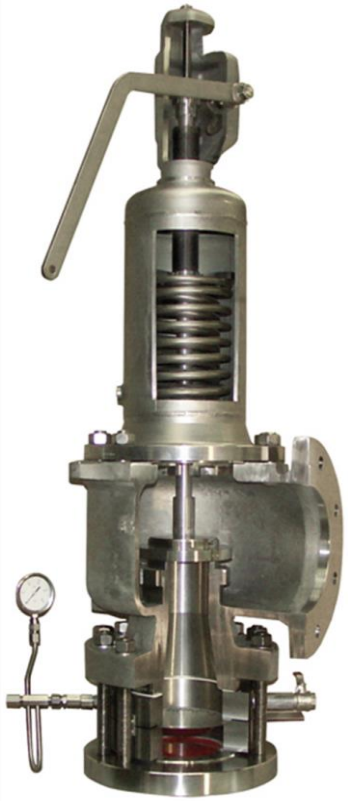
In-Situ testing of your PRV



KUB®-*V-SERIES*

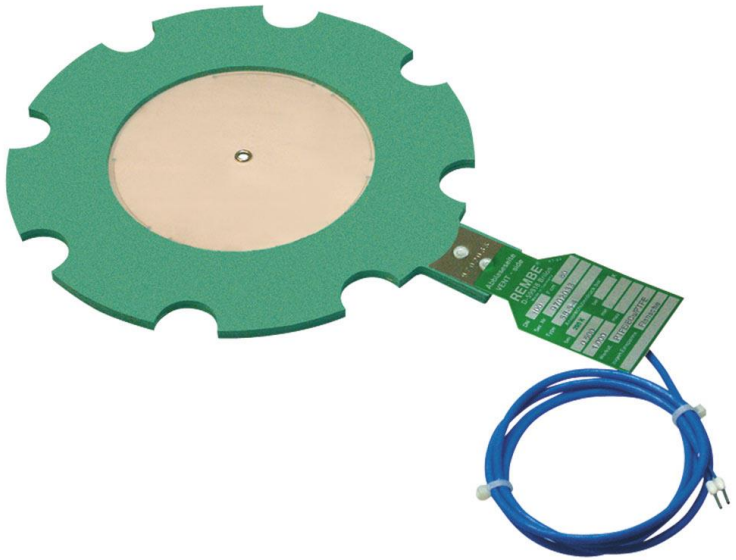
Long term benefit

Unprotected Pressure Relief Valve



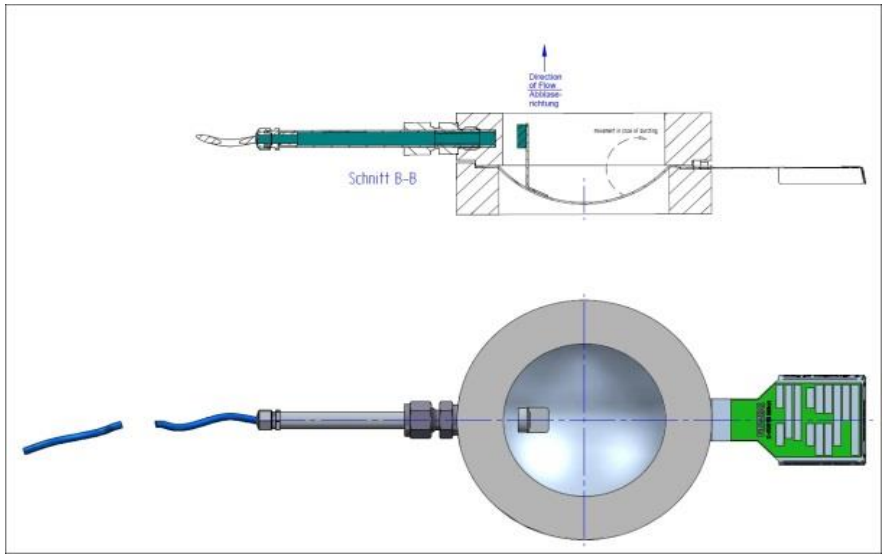
Protected Pressure Relief Valve
with KUB®

SIGNALLING AND MONITORING DEVICES

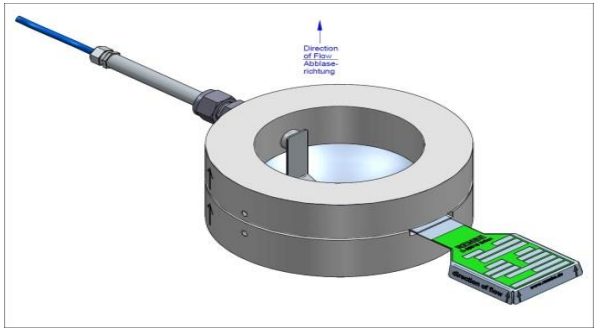


- Type: SB/SB-S
- SB – without relief bore
- SB-S – with relief bore
- Signalling of response of discs or leakage detection
- Maintenance free
- In case of response, an electrical signal is produced, which can be used for remote alarm purposes

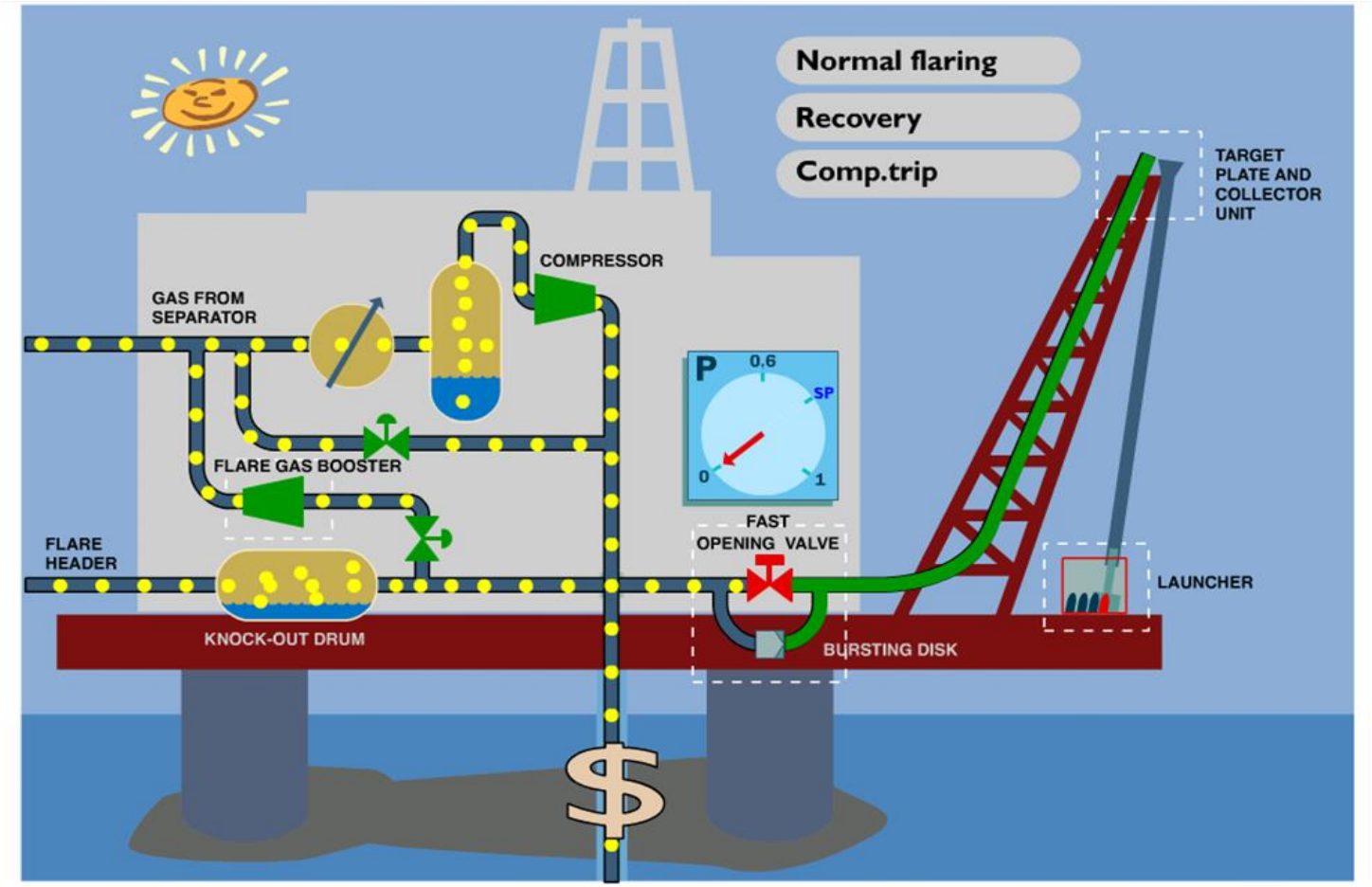
NIMU® NON-INVASIVE MONITORING UNIT



- non-invasive alarm unit
- simple but effective
- isolated from the process medium
- senses the disc position and immediately when the disc opens a corresponding signal is available to the control and monitoring PLC circuits alerting the operator which disc has opened.



OFFSHORE AND FPSO-FLARE APPLICATION



OIL&GAS AND FLARE APPLICATIONS PROTECTED BY REMBE® RD (CUSTOMER LIST EXTRACT)

- SBM – Shell STONES FPSO
- ENI Norge GOLIAT FPSO
- GASCO Ruwais Abu Dhabi
- Petronas Ethylene, Malaysia
- SKARV and Veslefrikk (VFR) Aibel/Statoil, Norway
- MODEC – various FPSO‘s for PETROBRAS
- AKER Solutions, Norway

O&G AND PETROCHEMICAL APPLICATIONS PROTECTED BY REMBE® RD (CUSTOMER LIST EXTRACT)

- SAMCO / SABIC Acrylic Acid Complex in Al Jubail, KSA, 77 installations, EPC: Samsung/Linde
- RRE (Ruwais Refinery Expansion) Abu Dhabi, EPC GS E&C
- QAPCO LDPE 3, Qatar: EPC: UHDE, Bad Soden
- LANXESS BTR, Singapore EPC: Foster Wheeler
- EVONIK ME-5, Singapore EPC: Jacobs Engineering
- UHV, Thailand, EPC: SK Engineering
- Mary, Turkmenistan, EPC: KHI-Japan
- BAGFAS, Turkey, EPC: UHDE

REGISTRATIONS (EXTRACT)

Endusers

GASCO

Kuwait Oil Company

KNPC

Saudi Aramco

sabic

Contractors

eni

saipem

SBM OFFSHORE

AkerSolutions

FOSTER WHEELER

Maire Tecnimont

Technip

REMBE® GmbH Safety+Control

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