ISSA Safety Seminar

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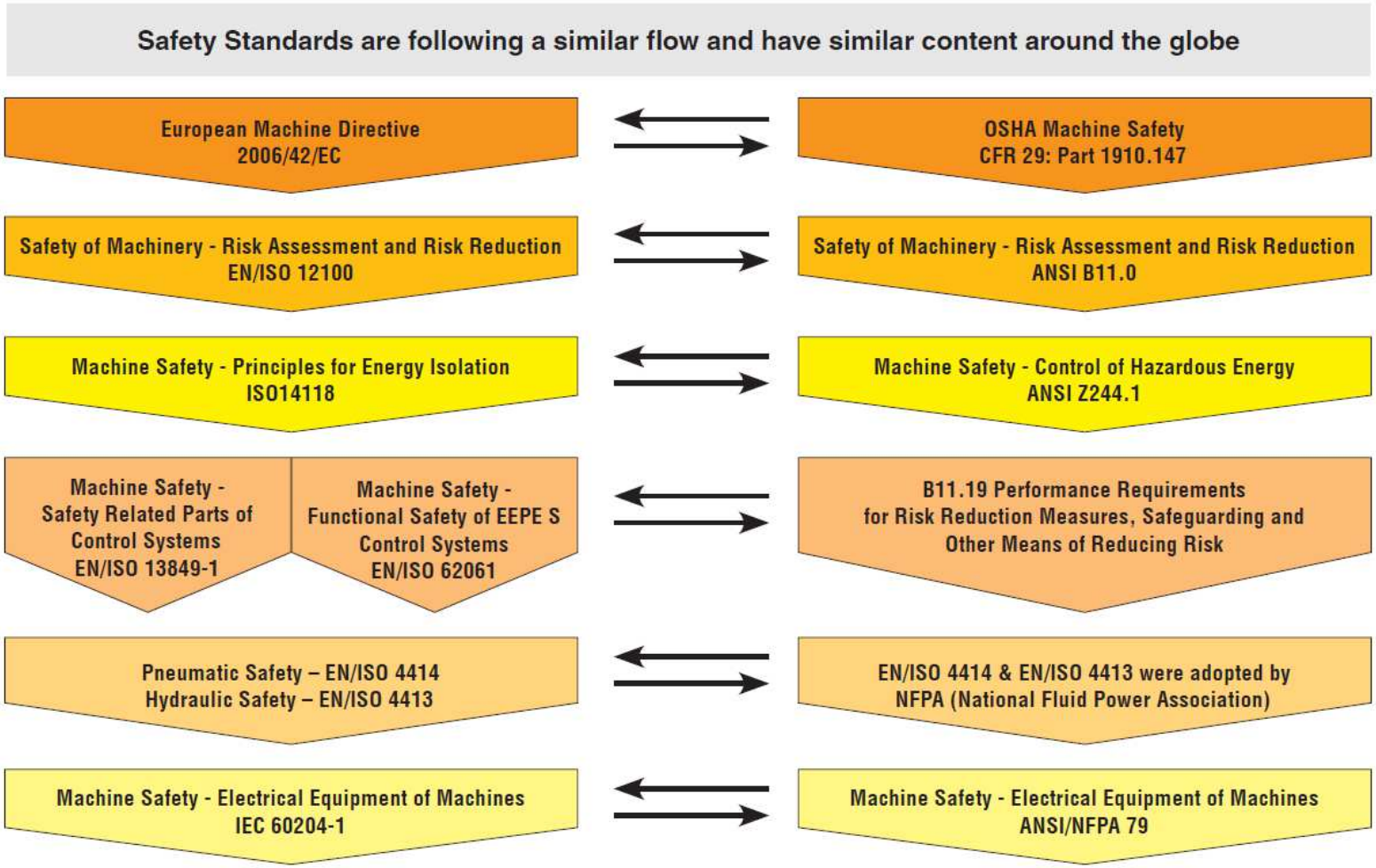
THIS IS WHY

WOMEN LIVE LONGER THAN MEN

Safety Regulations



The PL of the device shall be determined by the estimation of the following:

– $MTTF_D$ mean time to failure dangerous
(lifetime considerations)

– DC – diagnostic coverage
(failure discovery considerations)

– CCF – common cause failures

$MTTF_D$ mean time to failure dangerous (calculation)

Failure is dependent on load and operating frequency - cycles

Denotation of $MTTF_D$ of each channel	Range of $MTTF_D$ of each channel
Low	3 years <= $MTTF_D$ < 10 years
Medium	10 years <= $MTTF_D$ < 30 years
High	30 years <= $MTTF_D$ < 100 years

$$MTTF_D = T_{10D} / 0,1$$

$$T_{10D} = B_{10D} / n_{op}$$

T_{10D} = Mean time until 10% of the components have a dangerous failure
(Component operating time is restricted to T_{10D})

B_{10D} = Number of operations where 10% of the sample has statistically failed to danger.

B_{10D}=2 x B10

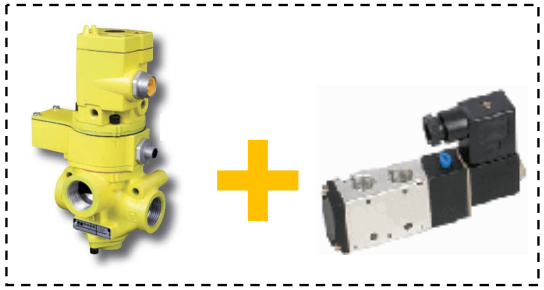
n_{op} = number of operations per year

6.2.5 Category 2: Initiating of a safe state

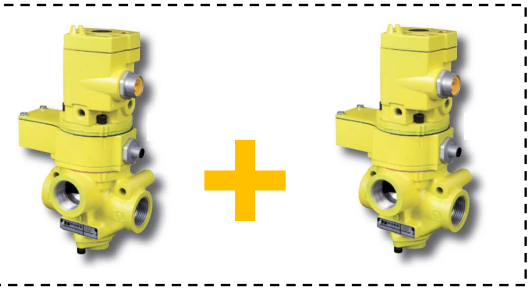
PL a to PL c: whenever practicable,
initiation a safe state,
otherwise a warning will be sufficient

Category 2
PL c

PL d: the Output (OTE) shall initiate a safe state
until the fault is cleared!



Category 2
PL d



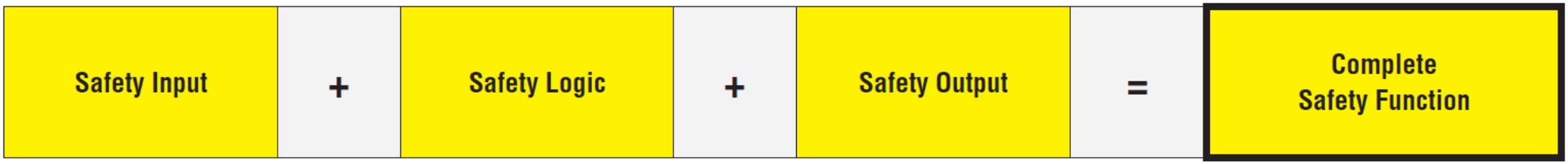
Category 3 / 4
PL d / e

Category 4
PL e

Process control

The Control system does NOT END with the wire!

It includes all components involved in performing the safety function; sensors, manual input, and mode selection elements, interlocking and decision-making circuitry, and output elements that control machine operating devices or mechanisms.

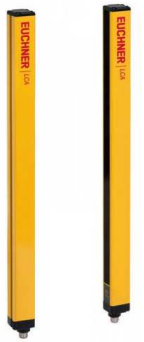


Safety Math

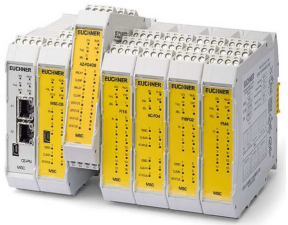
4+4+4 = ?

4

Light Curtain
Safety Input



Safety PLC
Logic



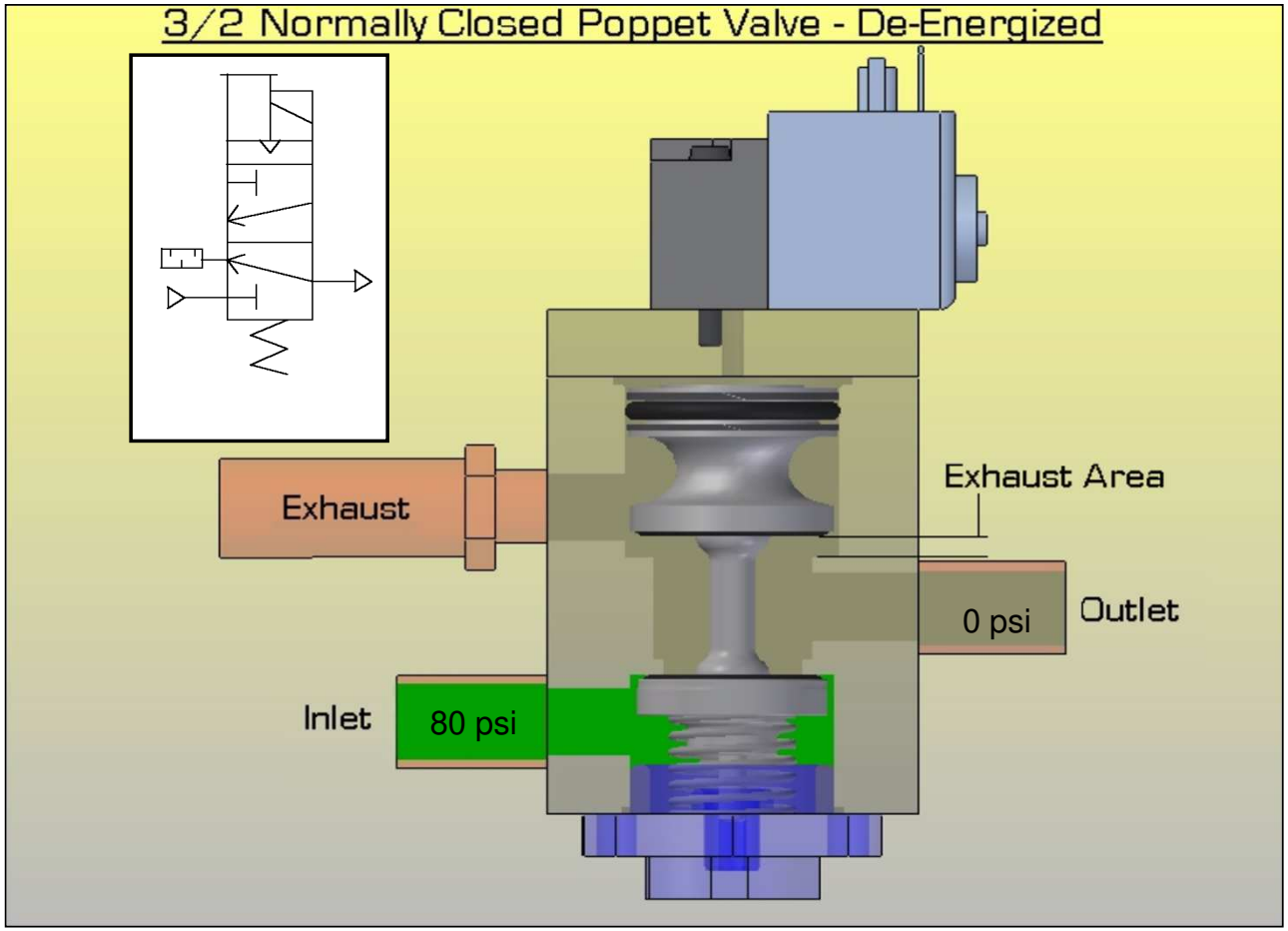
Safety Valve

PNEUMATIC 3/2- and 5/2-SAFETY VALVE:
BASICALLY A *PNEUMATIC SAFETY RELAY!*

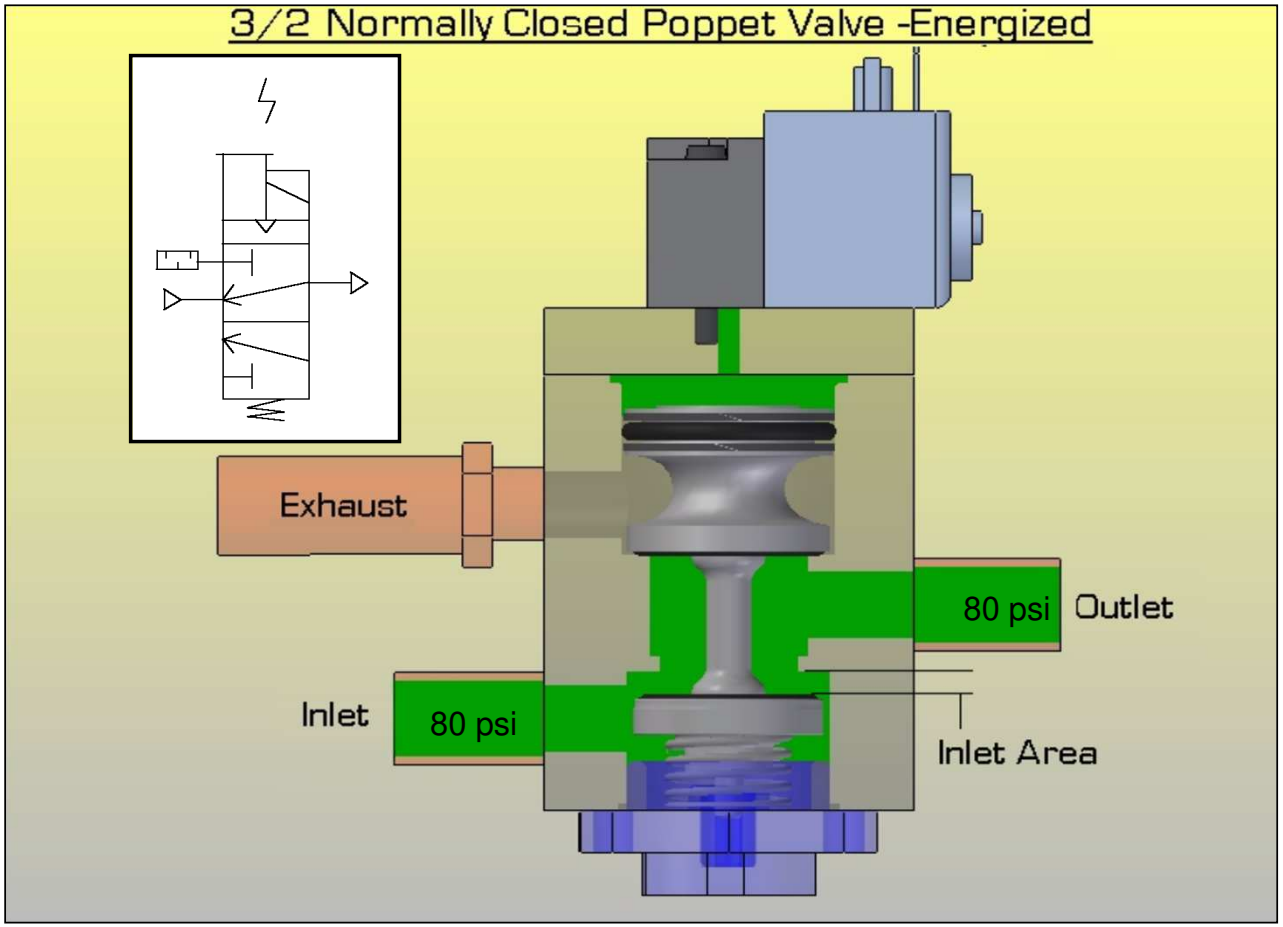
Intended for:

- main air supply for whole machine or zone
- safety control ofpower units
- Many systems utilize a downstream pressure switch to verify that pressure is exhausted if the volume and risk assessment warrants it

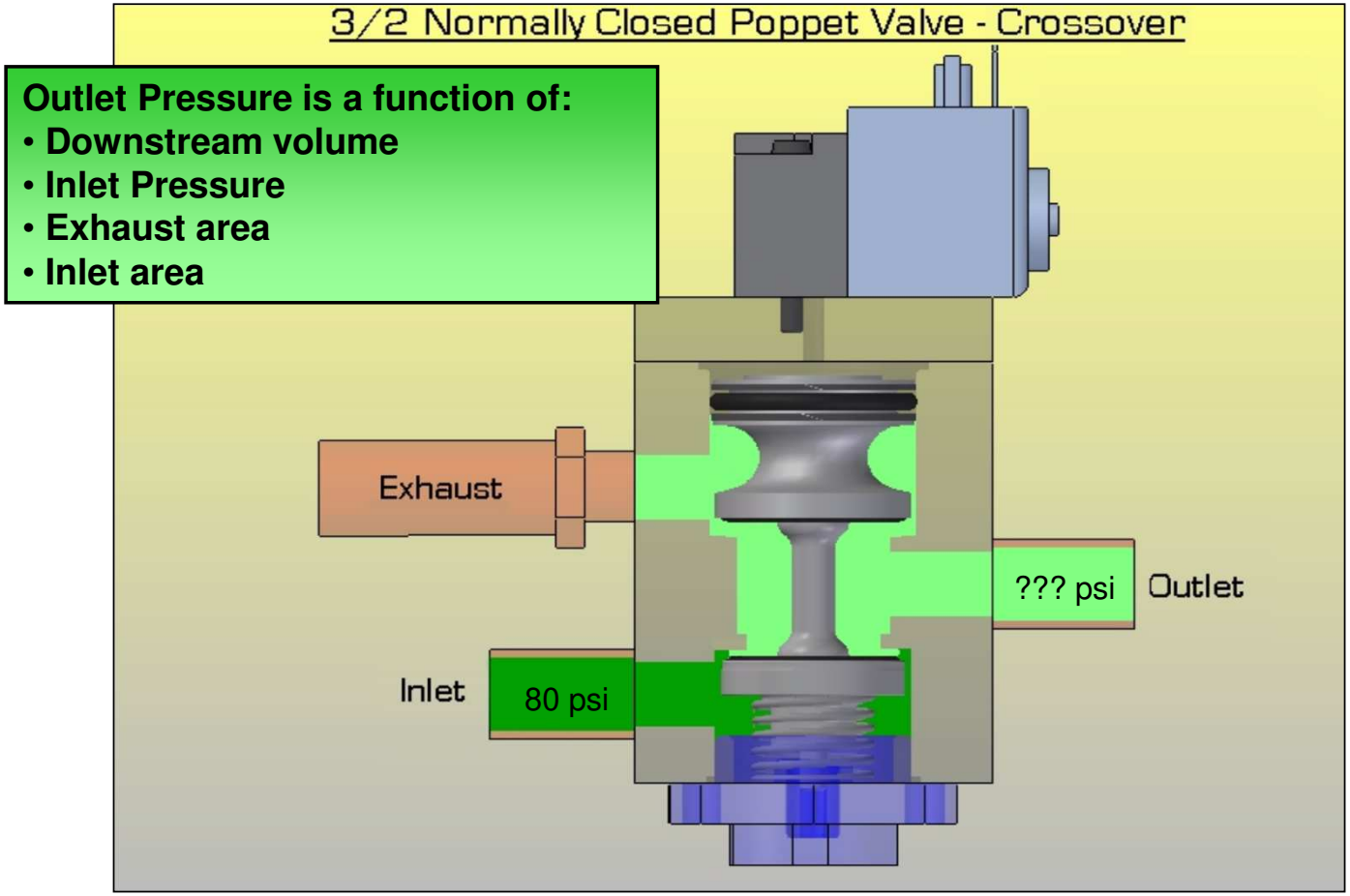
Hazards & Failures



Hazards & Failures



Hazards & Failures

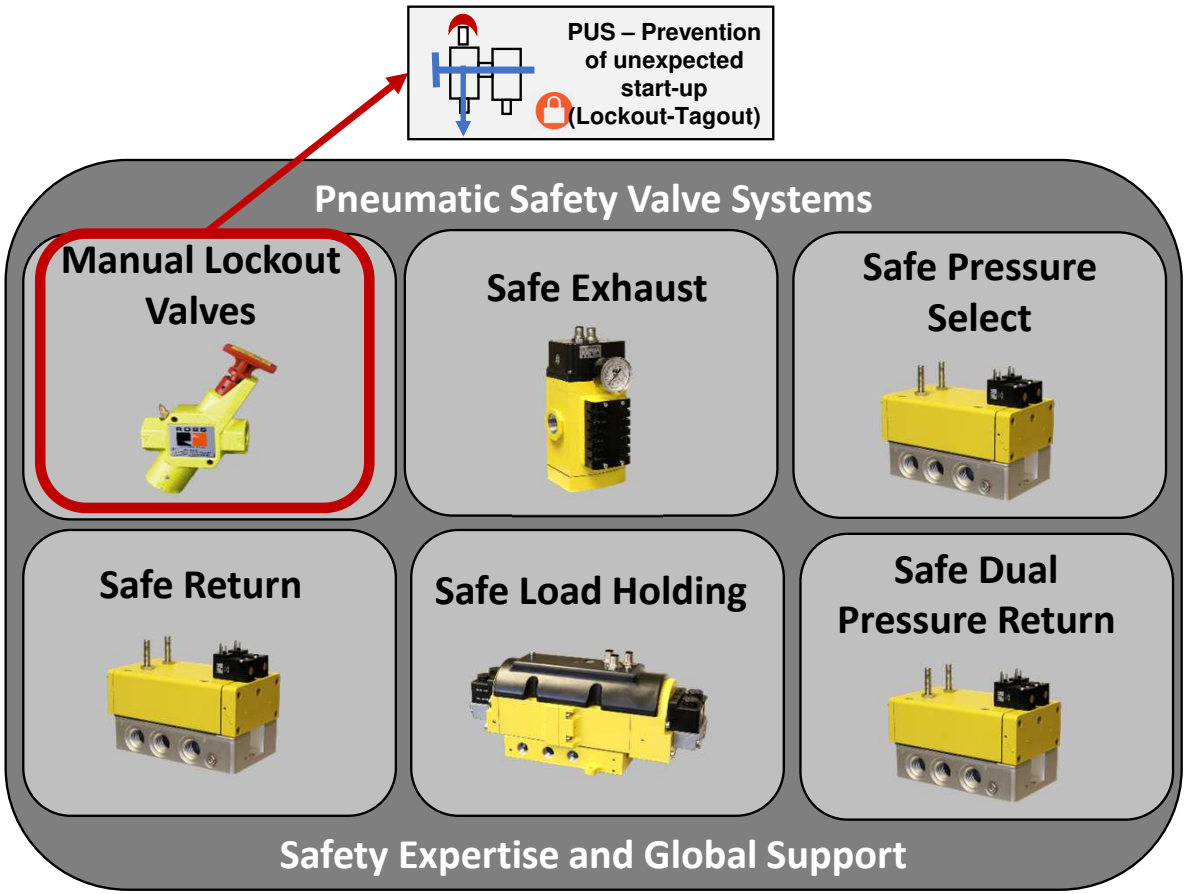


Hazards & Failures

Hazards & Failures

This will never happen?

Pneumatic Lock-out Valve Solutions



Superior Value in Pneumatic Safety

- Broadest safety valve portfolio
- Superior pneumatic safety technology
- Longest lasting valves in the market

Pneumatic Lock-out

- **ISO 14118** Safety of machinery - Prevention of unexpected start-up
- **OSHA 1910.147** The control of Hazardous energy
- **ANSI Z244** Lockout/Tagout
- **CSA Z460** Control of hazardous energy - Lockout and other methods

  - Lockout whenever a body part is put into a point of operation

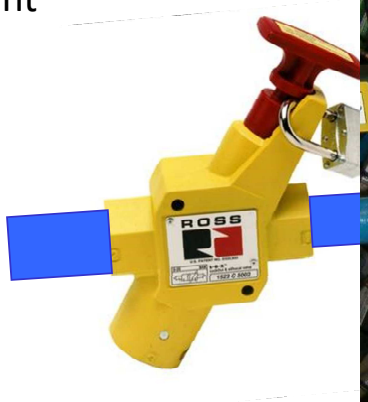
Pneumatic Lock-out

„Napo in … Safe maintenance!“ Episode „Lock out“

Courtesy of Via Storia, France

Pneumatic Lock-out

- Requirements (ISO 14118)
  - A manually operated valve
  - Not be used for any other function
  - Located outside of hazardous areas
  - Should only be able to be locked in off position
  - Easily identified and operated
  - Tamper resistant

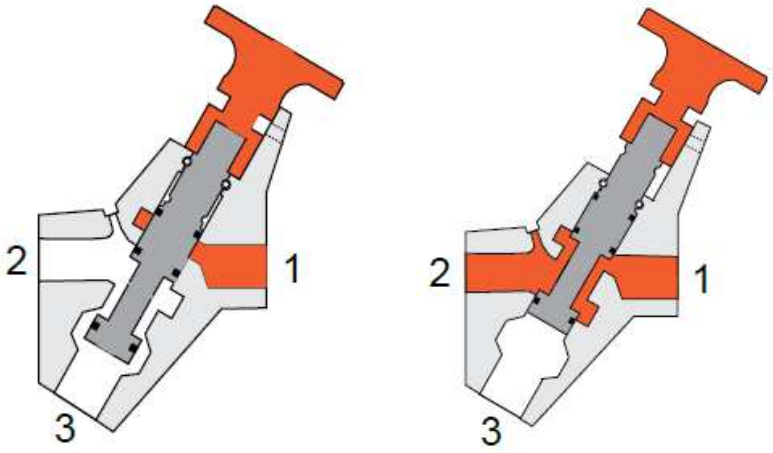


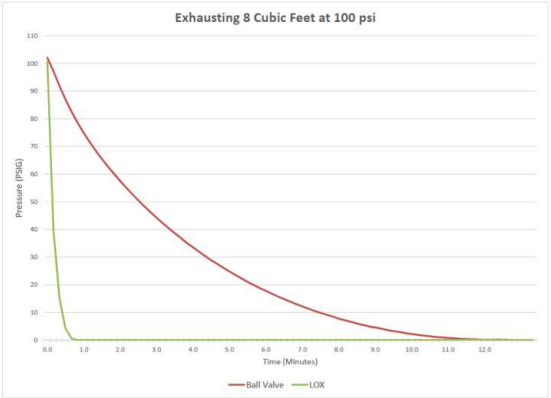
Pneumatic Lock-out

- Best Practice (ANSI B11.0 & B155.1)
  - “Positive action” which would indicate only two positions (ON and OFF)
  - A method for the employee to verify that the energy has dissipated after
  - Full diameter exhaust (rapid release of <u>stored</u> energy)

Example: 230l at 7 bar (valve G ½”)

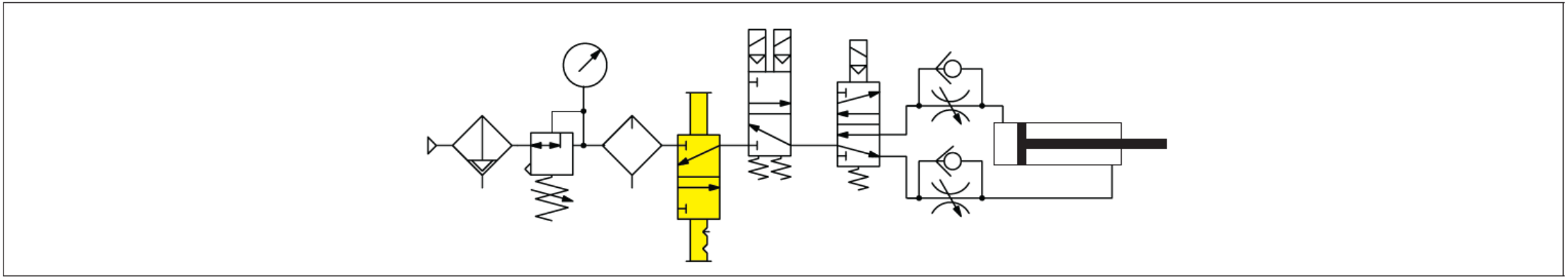
- L-O-X® - Valve = 35 seconds
- Bleed port > 11 minutes



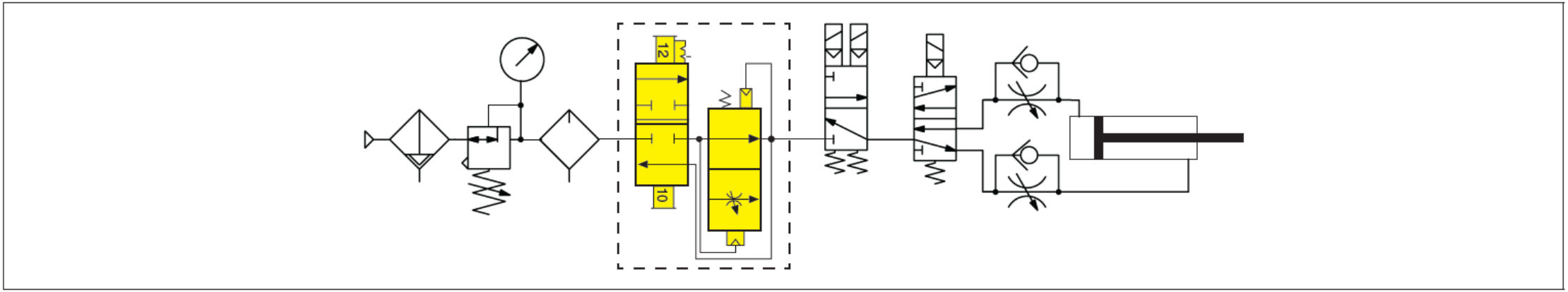


Pneumatic Lock-out

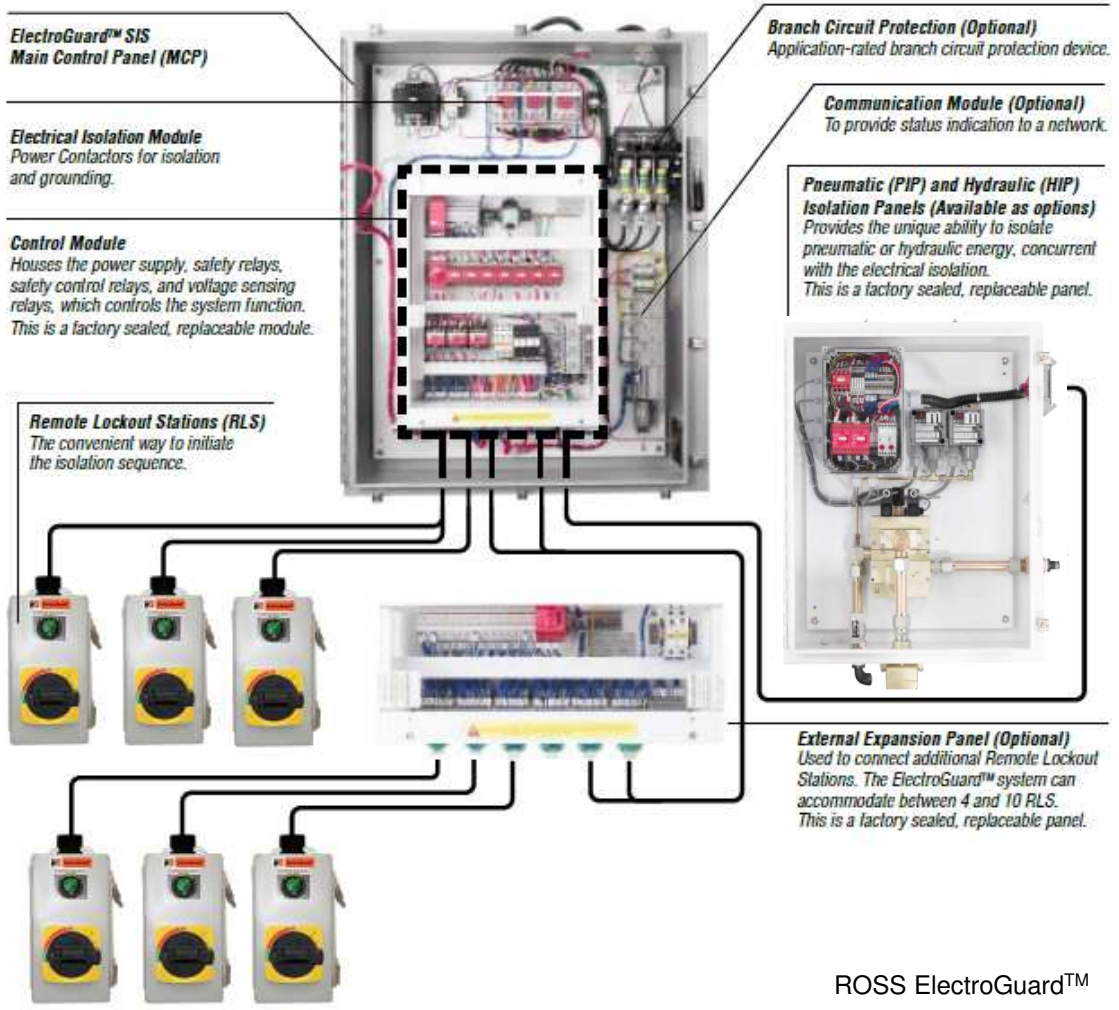
Pneumatic Energy Isolation Example 1 – With standard Lockout valve without Soft-Start



Pneumatic Energy Isolation Example 2 – With standard Lockout valve with Soft-Start

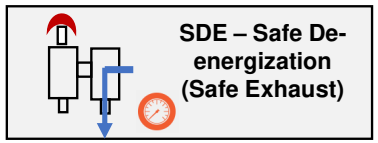


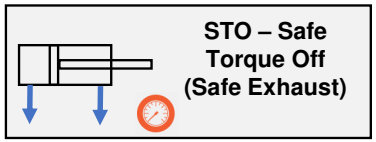
Safety Isolation systems for LOTO (OSHA conform)

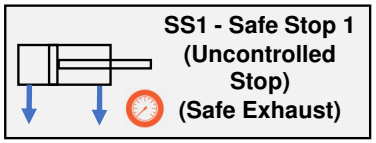


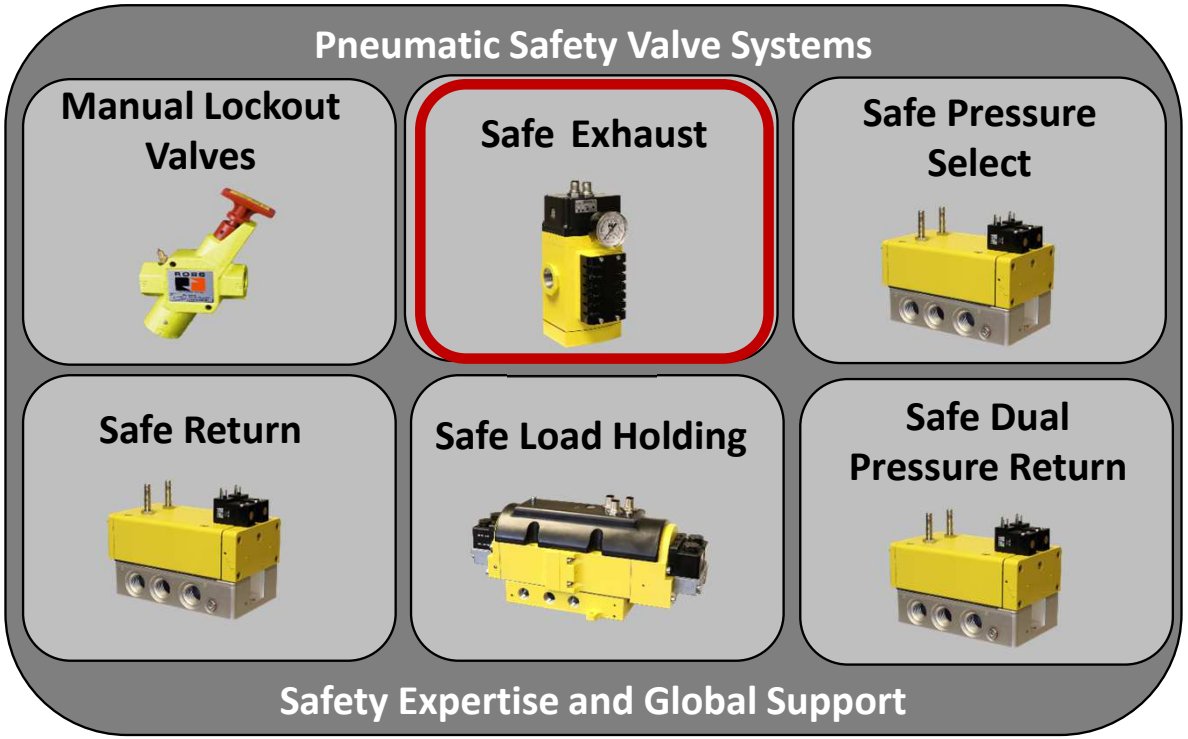
ROSS ElectroGuard™

Pneumatic safe-exhaust







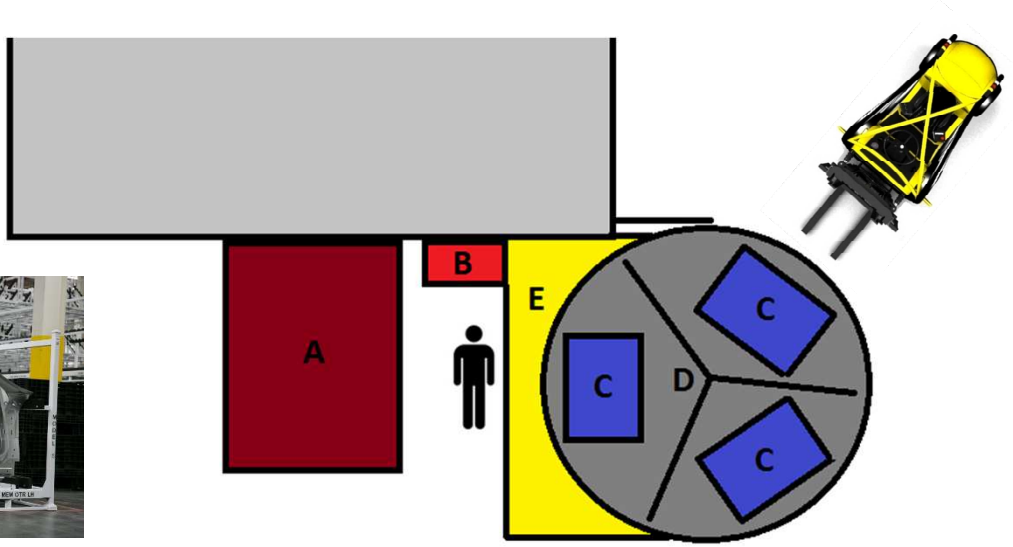


Superior Value in Pneumatic Safety

- Broadest safety valve portfolio
- Superior pneumatic safety technology
- Internally or externally Monitored
- Soft-start options
- Longest lasting valves in the market

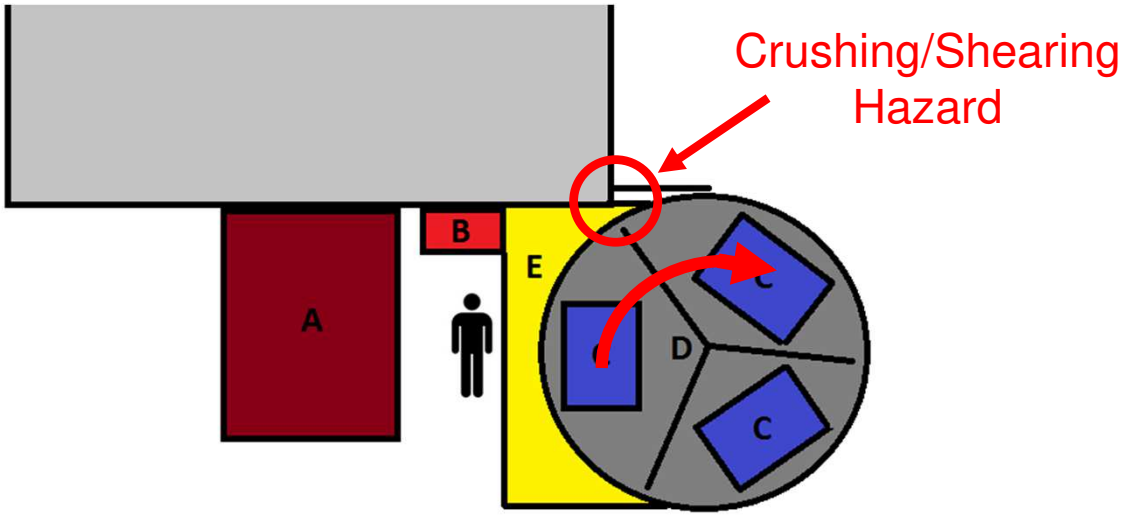
Pneumatic safe-exhaust - Example

- Transfer press line part removal
  - Operator removes part from conveyor A
  - Part is placed on rack C
  - Fork trucks remove full racks, load empty racks



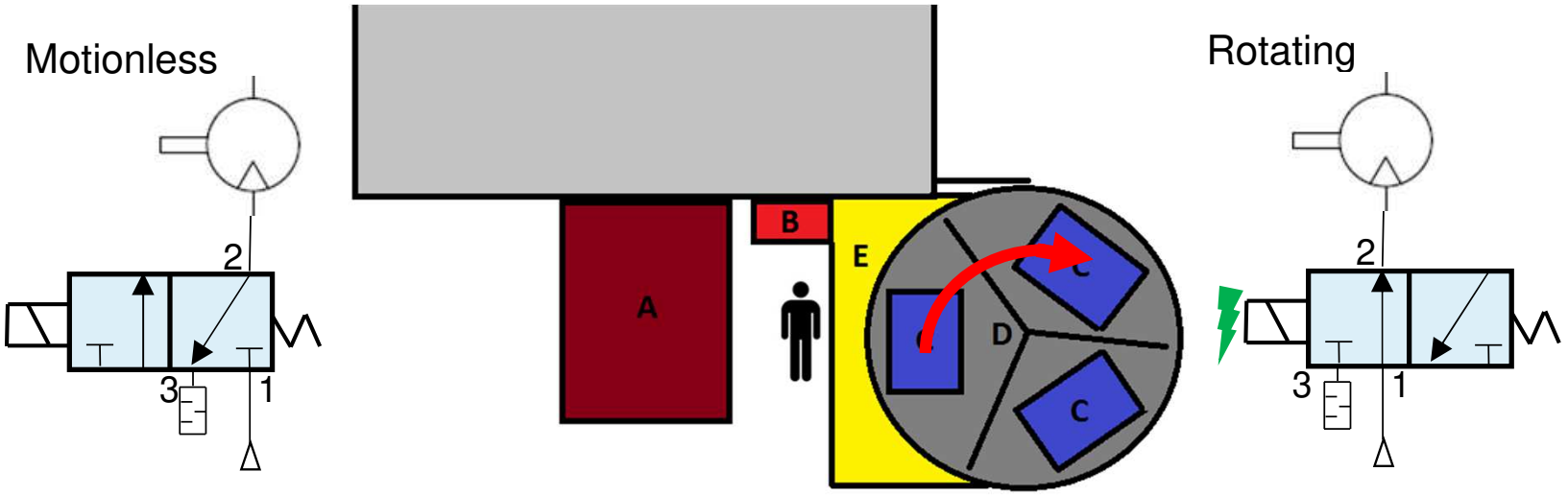
Pneumatic safe-exhaust - Example

- Hazardous situation
  - Once rack C is full table D must rotate
  - Operator controls 3/2 NC valve at control panel B
  - Rotation creates crushing/shearing hazard



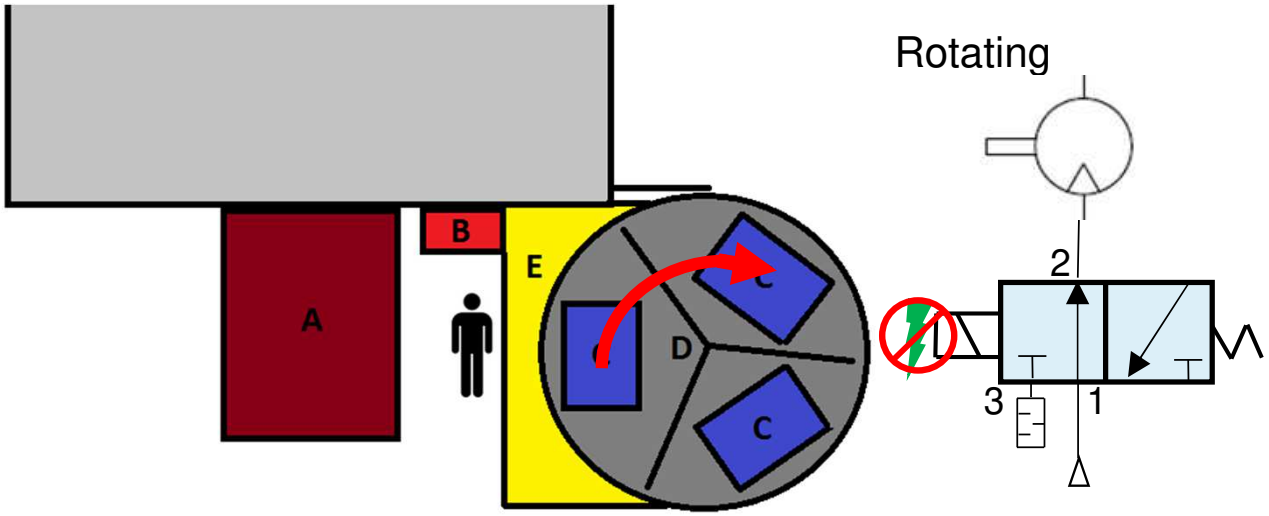
Pneumatic safe-exhaust - Example

- Safety controls
  - Electrical push button controls 3/2 NC valve
  - Valve supplies air motor controlling rotation
  - Light Curtain E ensures no exposure to crush point



Pneumatic safe-exhaust - Example

- Valve failure mode – Stuck in shifted position
  - Rotation continued
  - Light Curtain & relay had no effect



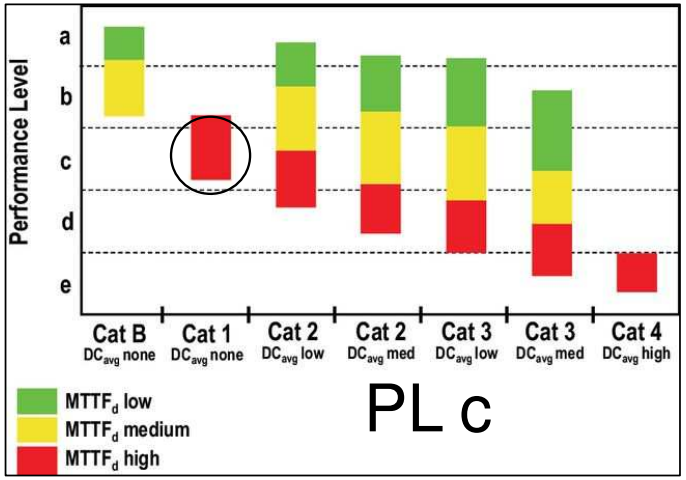
Pneumatic safe-exhaust - Example

- Light curtain cycle rate = every 1 minute
- Valve cycle rate = every 15 minutes

	Light Curtain	Valve
cycle time (sec)	60	900
hours per day	8	8
days per week	5	5
weeks per year	52	52
cycles per year	124800	8320

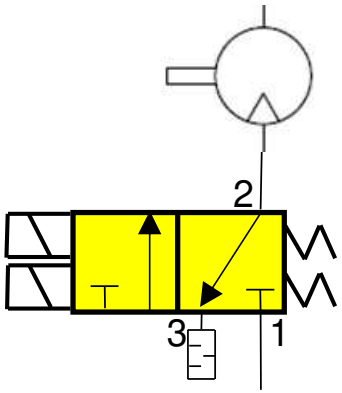
	Input	Logic	Output
Description	Safety Mat	Safety Relay	Valve
B_{10D}			20000000
n_{op}	124800		8320
$MTTF_D$	**100**	**100**	**100**
DC	**99%**	**99%**	**0%**
Category	**4**	**4**	**1**

System $MTTF_D$	**33**	**High**
System DC	**66%**	**Low**
System Category	**1**	
PL	**c**	



Pneumatic safe-exhaust - Example

- Fluid power solution
  - Redundant, internal or external-monitored double-valve
  - Fail safe (exhaust)
  - Removes supply when de-energized (stops rotation)



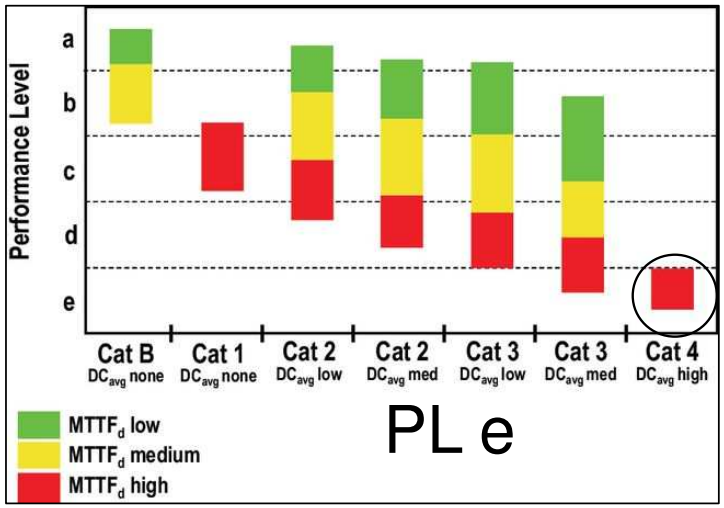
Pneumatic safe-exhaust - Example

- Safety light curtain cycle rate = every 1 minute
- Valve cycle rate = every 15 minutes

	Light Curtain	Valve
cycle time (sec)	60	900
hours per day	8	8
days per week	5	5
weeks per year	52	52
cycles per year	124800	8320

	Input	Logic	Output
Description	Light curtain	Safety Relay	Valve
$B10_D$			20000000
n_{op}	124800		8320
$MTTF_D$	**100**	**100**	**2500**
DC	**99%**	**99%**	**99%**
Category	**4**	**4**	**4**

System $MTTF_D$	**49**	**High**
System DC	**99%**	**High**
System Category	**4**	
PL	**e**	

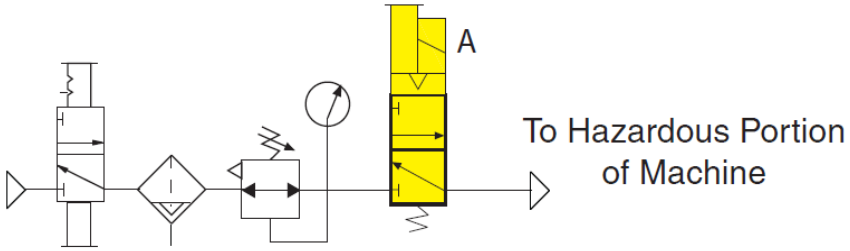


M35 – Valve Operation

Safe exhaust / block & bleed examples

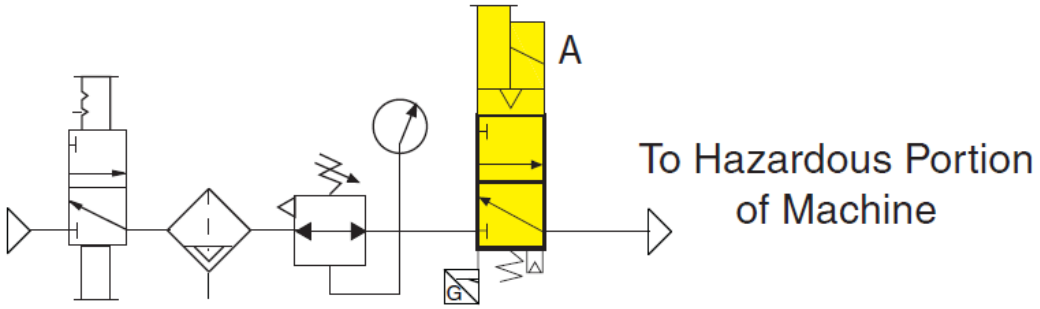
Pneumatic Safe Exhaust Example 1 – Category 1

3/2 single channel solenoid-operated spring return control valve with no feedback. A Category 1 control system may not require a safe exhaust valve for general operation but may be needed for emergency stop or removing the air supply to vacuum systems or other air driven devices.



Pneumatic Safe Exhaust Example 2 – Category 2

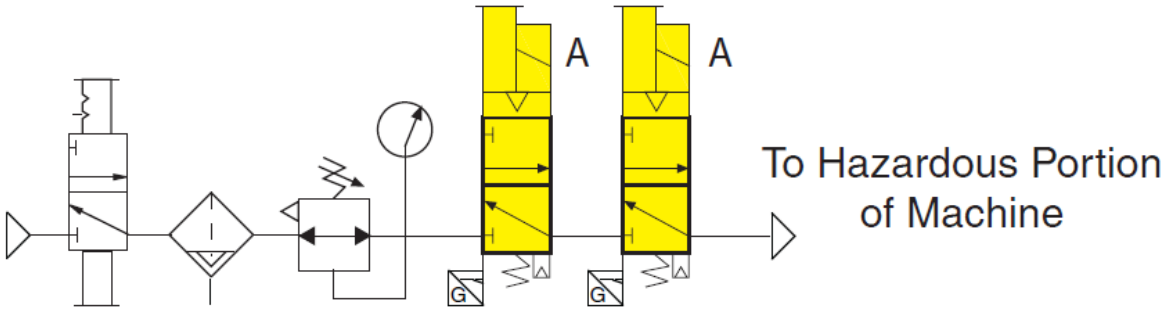
3/2 single channel solenoid-operated spring return control valve with feedback - must be monitored by the safety controller.



Safe exhaust / block & bleed examples

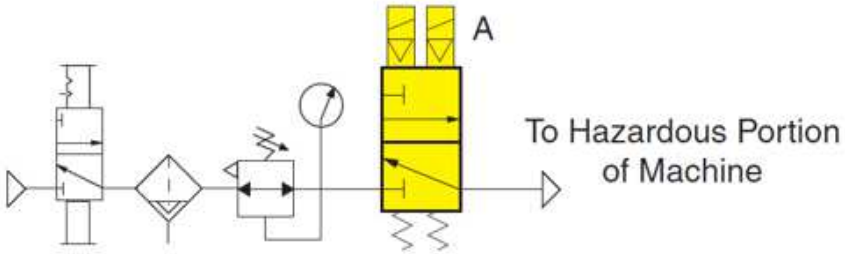
Pneumatic Safe Exhaust Example 3 – Category 3 or 4

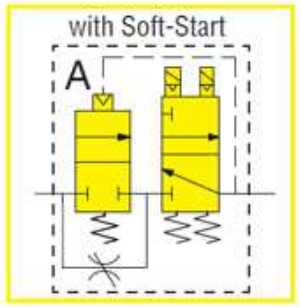
Two 3/2 single channel solenoid-operated spring return control valves with feedback - must be monitored by the safety controller.

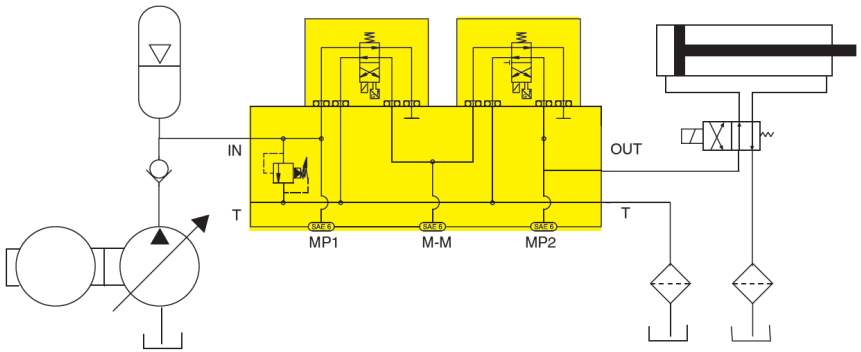


Pneumatic Safe Exhaust Example 4 – Safe Block & Bleed Example 1 – Category 4

3/2 dual channel solenoid-operated spring return control valve – monitoring may be internal or external depending on valve series selected.







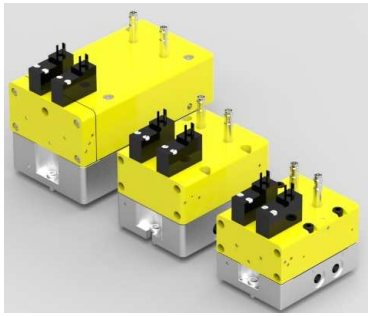
3/2-safety Cat 4/ PL e valve solutions

Internally monitored

w/o
soft-start

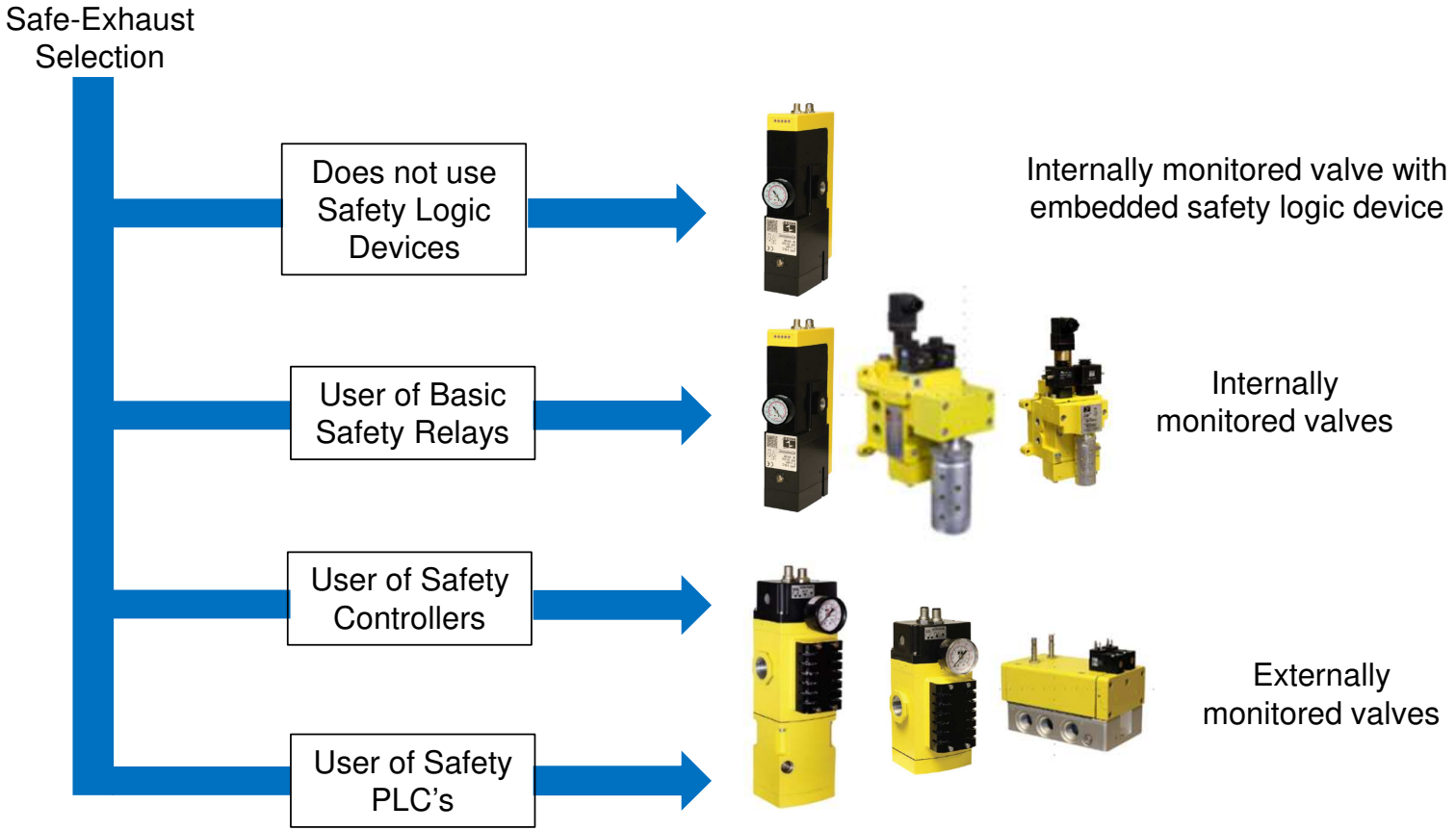
with soft-start

Externally monitored



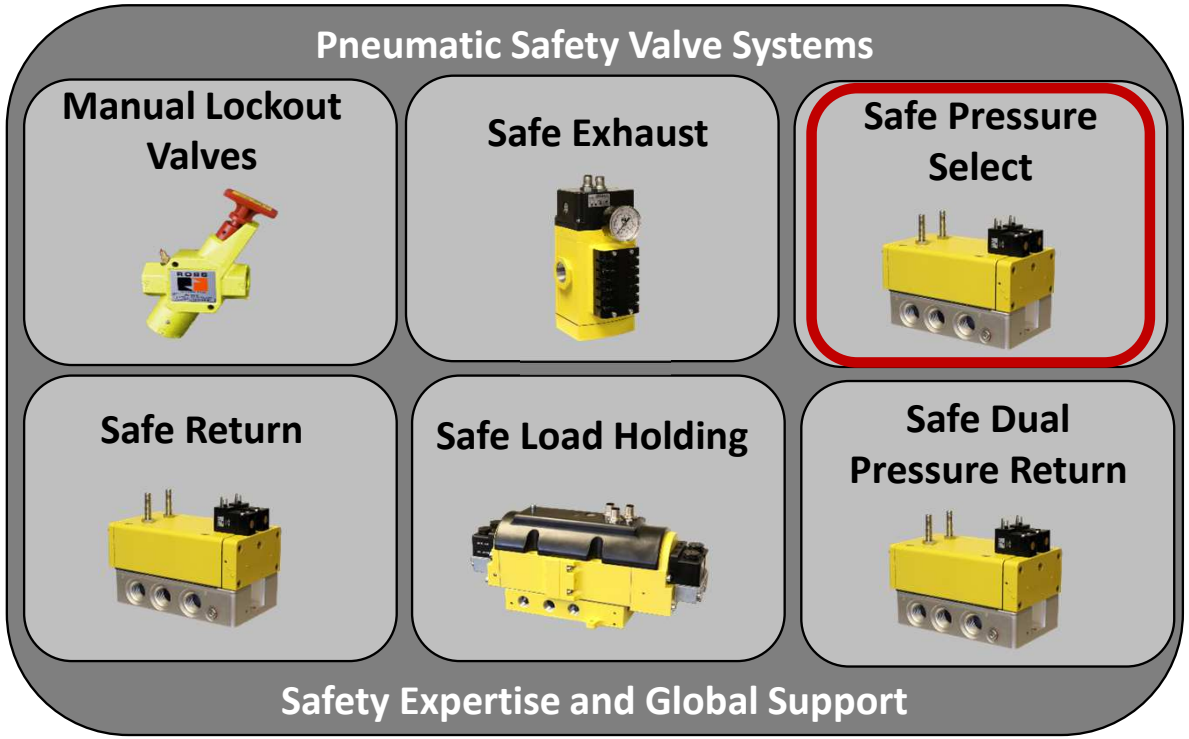
w/o soft-start

Which exhaust valve to use and when?



The externally monitored products are the cheapest and smallest of the 3 ROSS types.

Pneumatic Safe-Dual Pressure Select solutions



Superior Value in Pneumatic Safety

- Broadest safety valve portfolio
- Superior pneumatic safety technology
- Externally Monitored
- Longest lasting valves in the market

Moderate, Serious & Catastrophic injuries require the use of safety solutions that meet Performance Levels C, D and E according to ISO13849

- Per **EN 16092-4** here is a Risk of injury if:
  - Force > 150 N (33.8 lbf)
  - Weight of tooling > 15 kg (33 lbs)

- Per ANSI B11.0 the Risk is:

Moderate	150 N (33.7 lbf) < Force < 400 N (90)	PLc
Serious	400 N (90 lbf) < Force < 2000 N (450)	PLd
Catastrophic	Force > 2000 N (450 lbf)	PLe

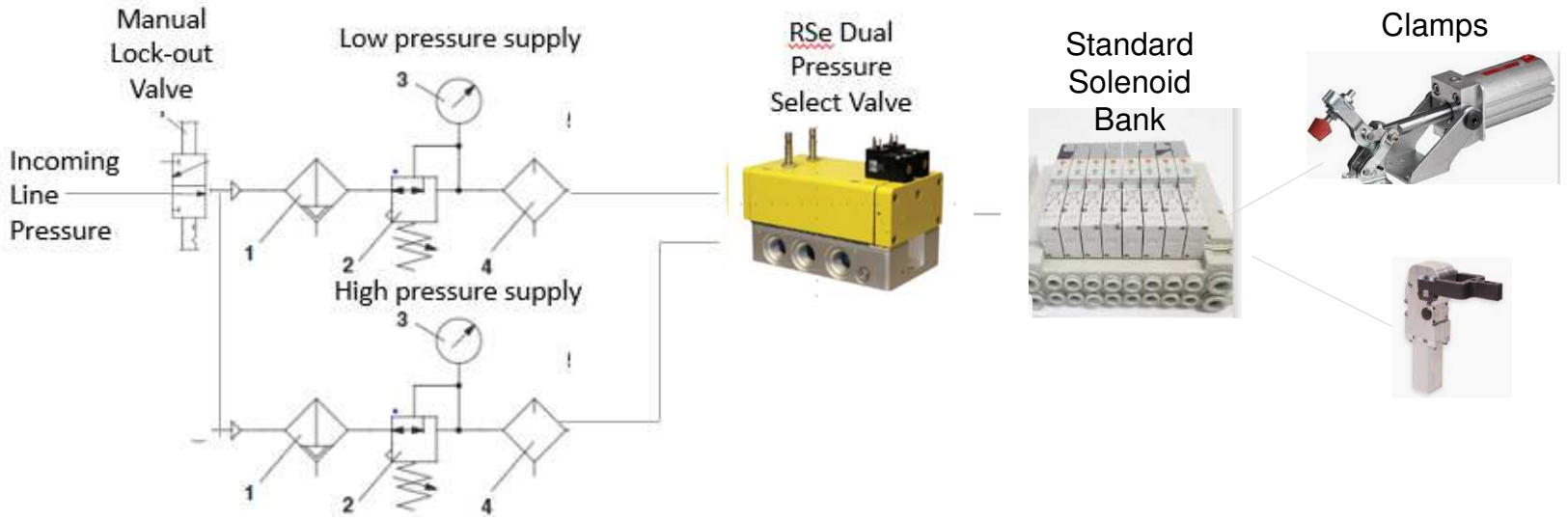
Bore	Area	Force (60 psi)	Force (80 psi)	Force (100 psi)
0.75	0.44	27	35	44
1	0.79	47	63	79
1.25	1.23	74	98	123
1.5	1.77	106	141	177
2.5	4.91	295	393	491
3	7.07	424	565	707
4	12.57	754	1005	1257

Bore	Area	Force (5.5 BAR)	Force (7 BAR)	Force (10 BAR)
14	153.94	85	108	154
22	380.13	209	266	380
27	572.55	315	401	573
50	1963.49	1080	1374	1963
63	3117.24	1714	2182	3117
80	5026.54	2765	3519	5027

If fluid power hazards are moderate, serious or catastrophic the safety solution has to meet PLc, PLd or PLe.

Let’s take a look at a welding station

Most welding work-cells uses clamps that are actuated by foot-pedals. These systems are generally operated at full line pressure (100psi), most companies dump pneumatic pressure when the operator is loading parts.

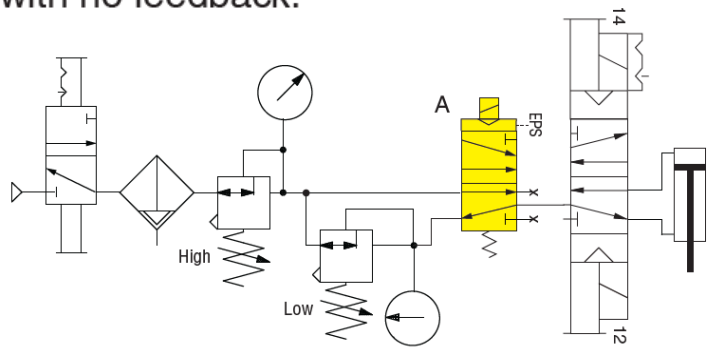


Welding and riveting machine manufacturers are using safe pressure select valves to switch between high and low pressure when operators are in the load area.

Safe pressure select examples

Safe Pressure Select Example 1 – Category 1

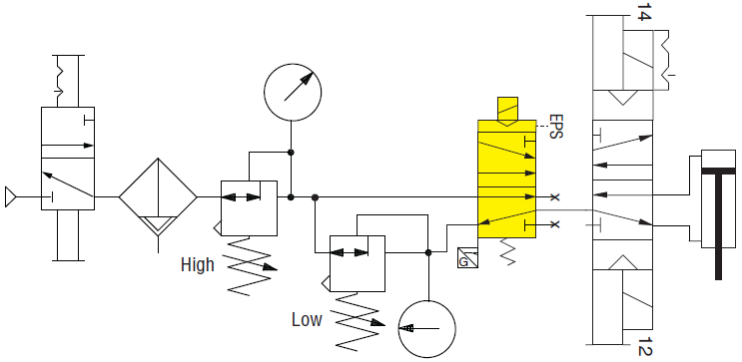
5/2 single solenoid-operated spring return control valve with no feedback.



NOTE:
The use of Safe Pressure Select solutions requires the force to be reduced to below the safe limited force of 150N.

Safe Pressure Select Example 2 – Category 2

5/2 single channel solenoid-operated spring return control valve with feedback - must be monitored by the safety control system.

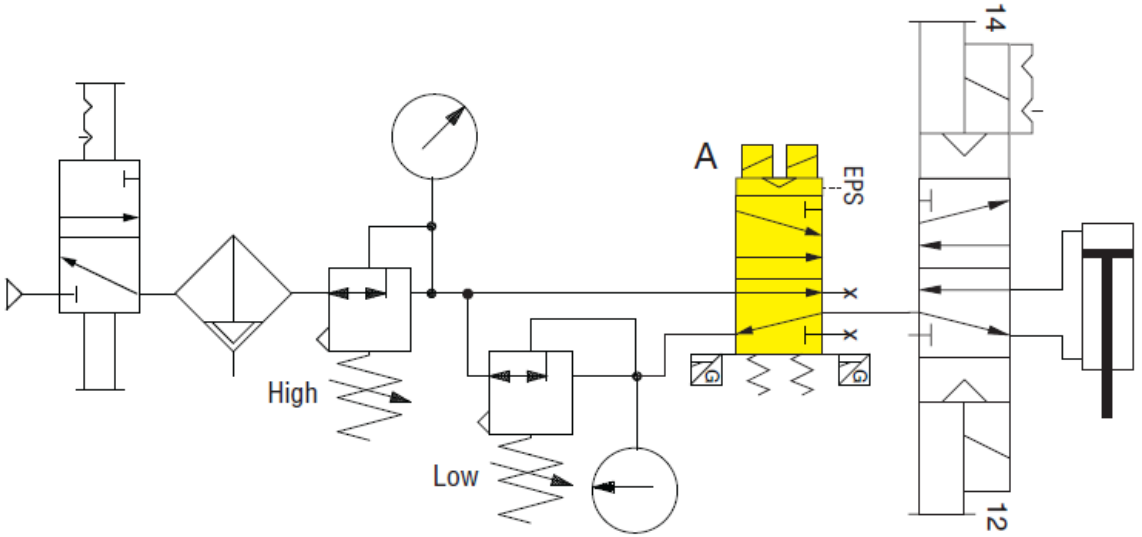


NOTE:
The use of Safe Pressure Select solutions requires the force to be reduced to below the safe limited force of 150N.

Safe pressure select examples

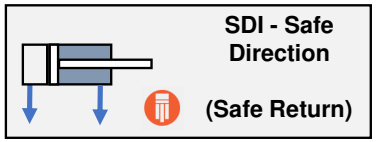
Safe Pressure Select Example 3 – Category 4

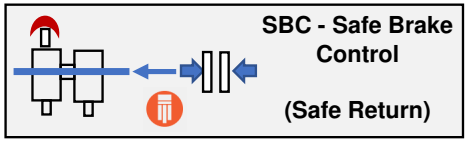
5/2 dual channel solenoid-operated spring return control valve with feedback - must be monitored by the safety controller.

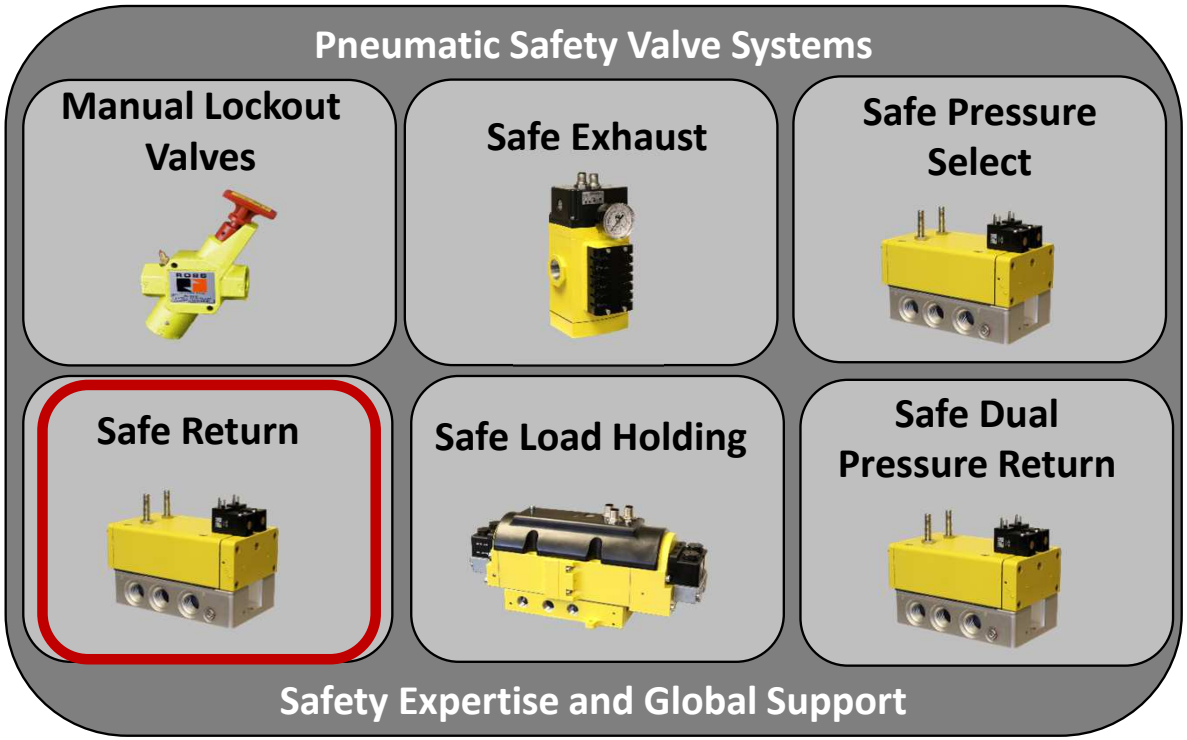


NOTE:
The use of Safe Pressure Select solutions requires the force to be reduced to below the safe limited force of 150N.

Pneumatic safe-return valve solution





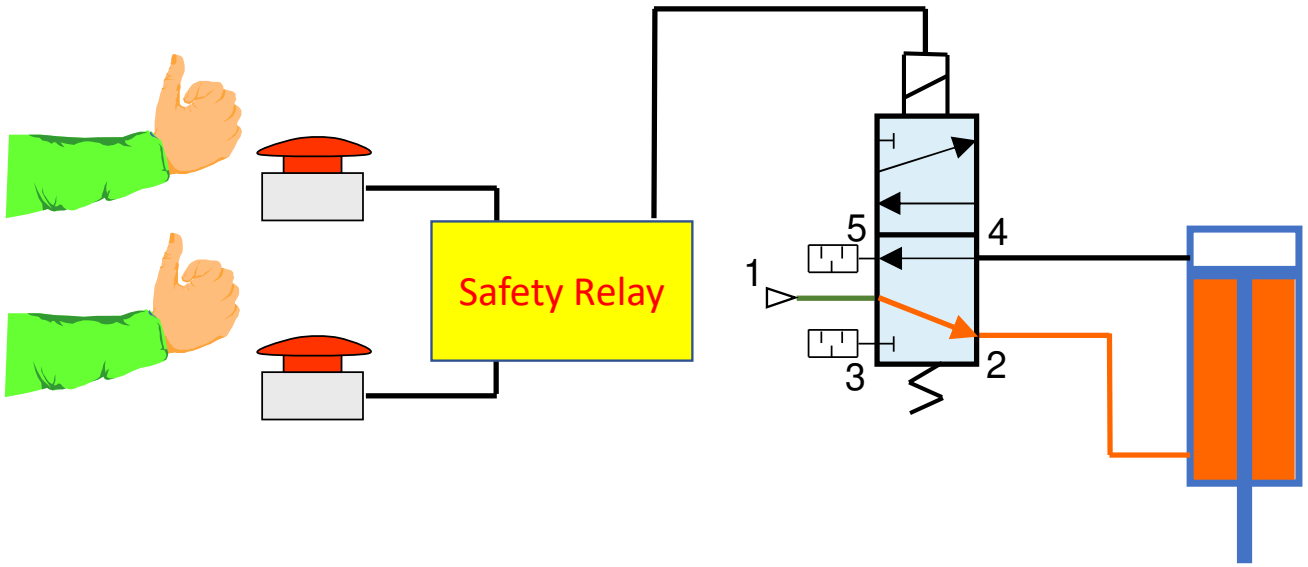


Superior Value in Pneumatic Safety

- Broadest safety valve portfolio
- Superior pneumatic safety technology
- Internally or externally Monitored
- Longest lasting valves in the market

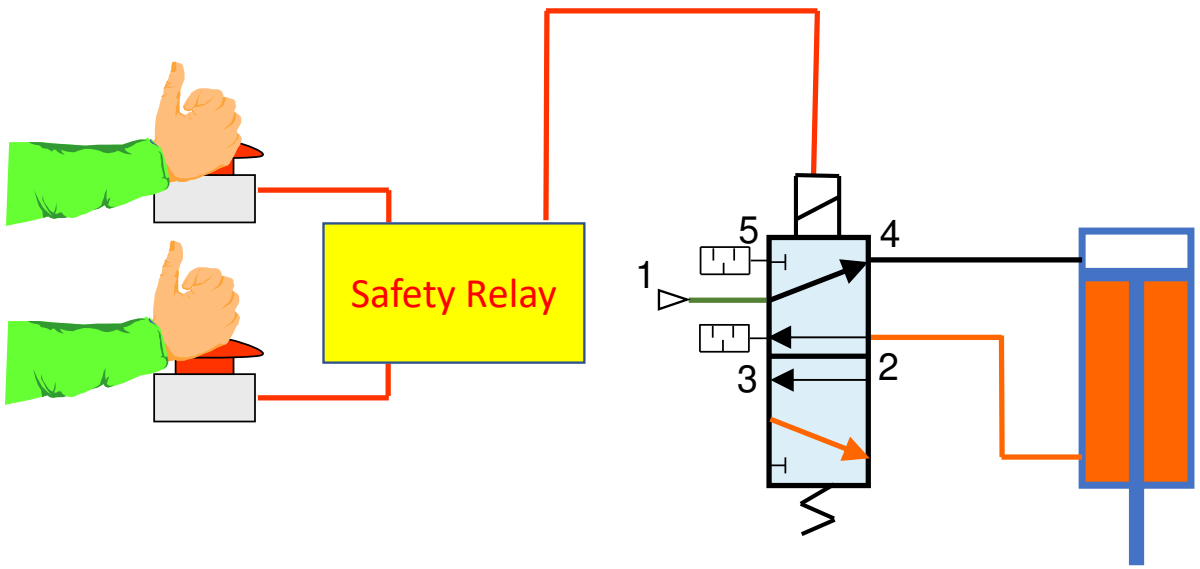
Safe return example – Vertical Cylinder

- Single channel example



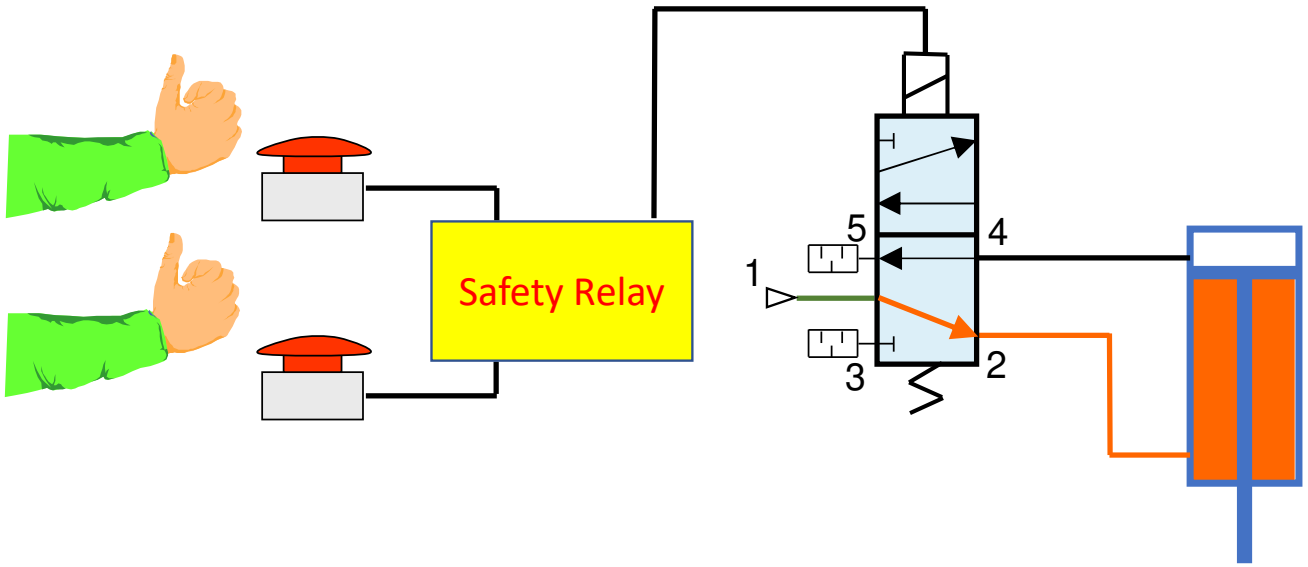
Safe return example – Vertical Cylinder

- Single channel example



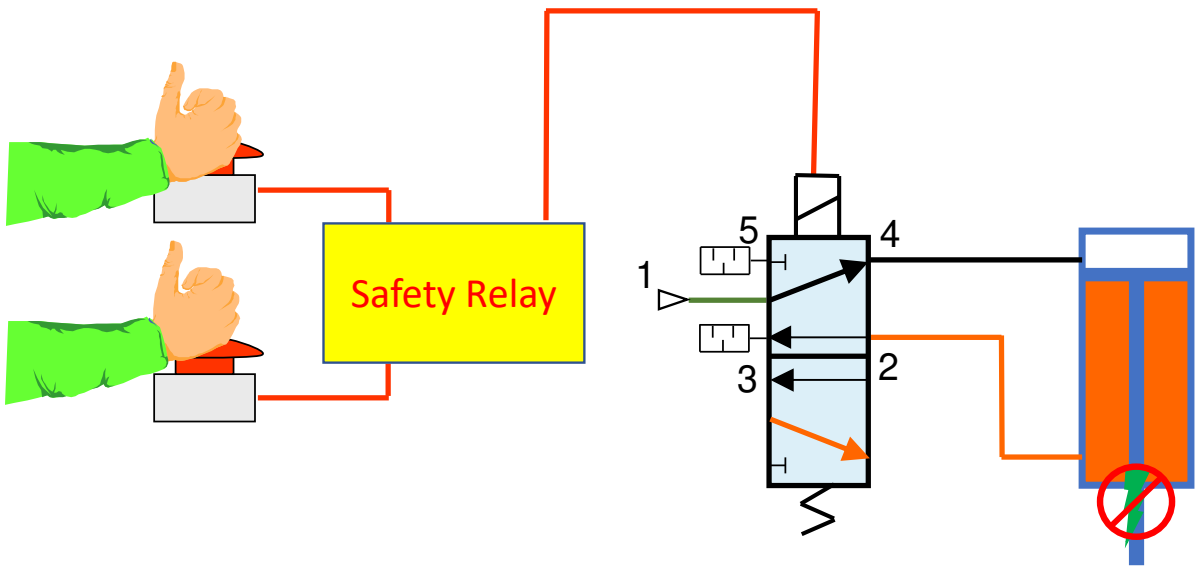
Safe return example – Vertical Cylinder

- Single channel example



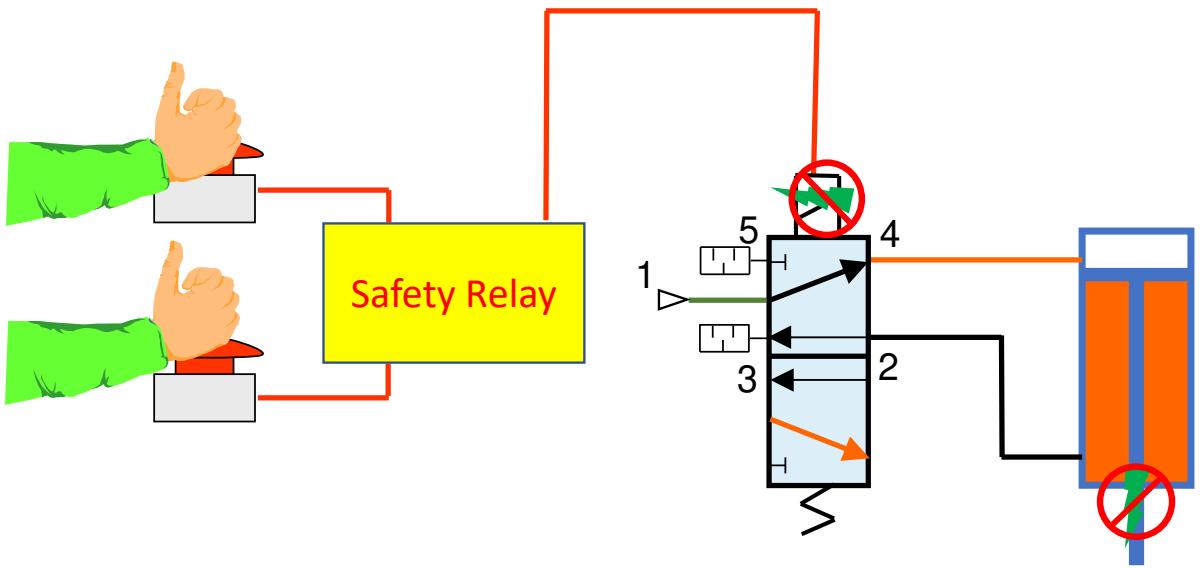
Safe return example – Vertical Cylinder

- Single channel **failure** example



Safe return example – Vertical Cylinder

- Single channel **failure** example



pinched

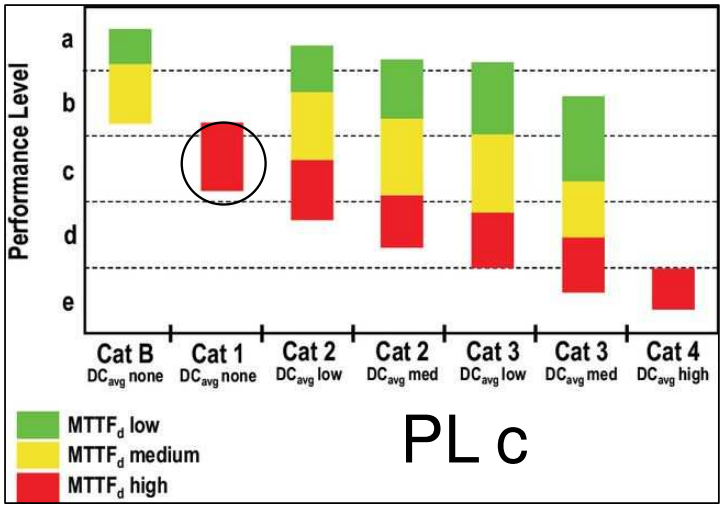
Safe return example – Vertical Cylinder

- Two hand control system = 1 min cycle rate

Cycles	Two Hand	Valve
cycle time (sec)	60	60
hours per day	8	8
days per week	5	5
weeks per year	50	50
cycles per year	120000	120000

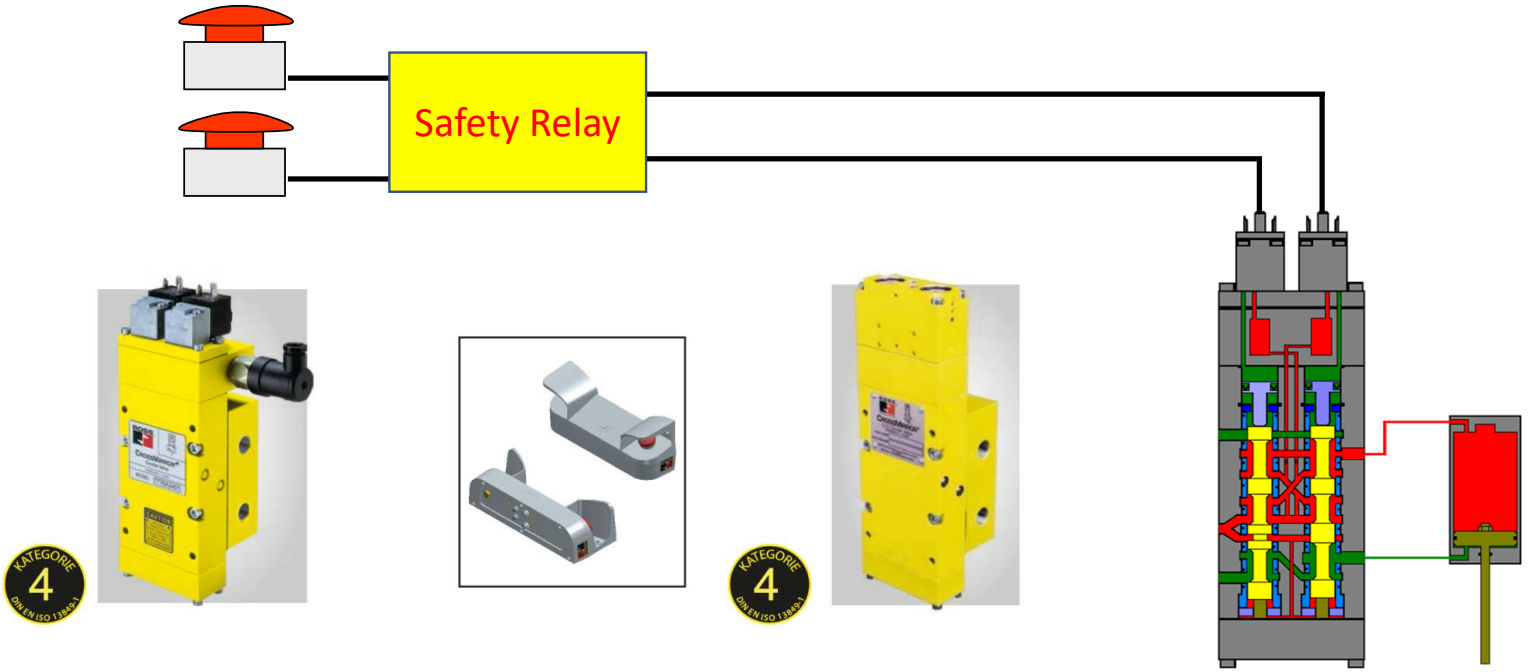
	Input	Logic	Output
Description	Two Hand	Safety Relay	Valve
$B10_D$	1000000		20000000
n_{op}	120000		120000
$MTTF_D$	**83**	**100**	**100**
DC	**99%**	**99%**	**0%**
Category	**4**	**4**	**1**

System $MTTF_D$	**31**	**High**
System DC	**68%**	**Low**
System Category	**1**	
PL	**c**	



Safe return example – Vertical Cylinder

- Two hand control
- Valve to extend cylinder
- Dual safety circuit

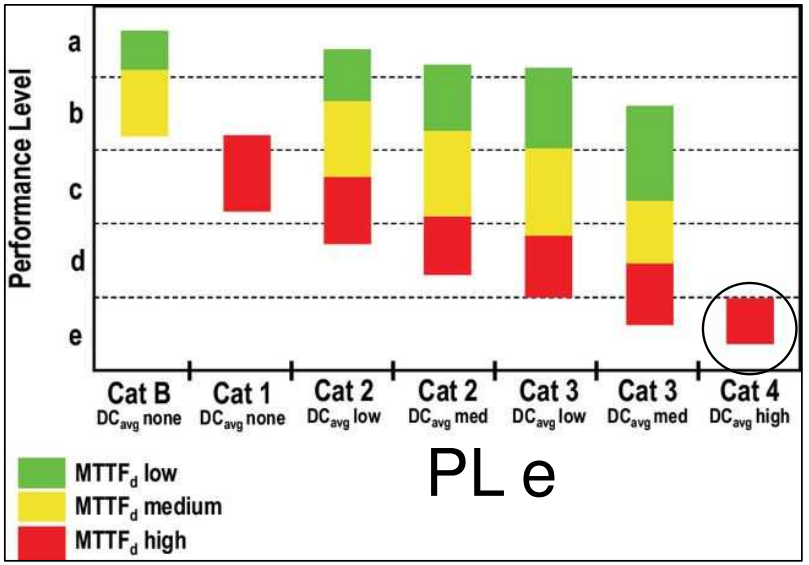


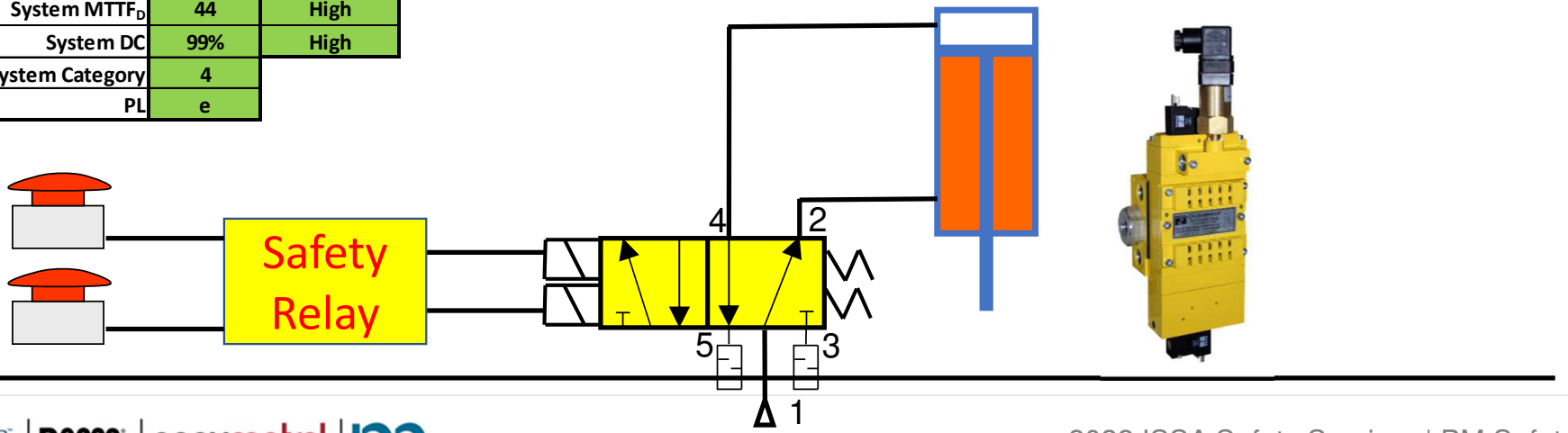
Safe return example – Vertical Cylinder

	Two Hand	Valve
cycle time (sec)	60	60
hours per day	8	8
days per week	5	5
weeks per year	50	50
cycles per year	120000	120000

	Input	Logic	Output
Description	Two Hand	Safety Relay	Valve
$B10_D$	1000000		20000000
n_{op}	120000		120000
$MTTF_D$	**83**	**100**	**1667**
DC	**99%**	**99%**	**99%**
Category	**4**	**4**	**4**

System $MTTF_D$	**44**	**High**
System DC	**99%**	**High**
System Category	**4**	
PL	**e**	

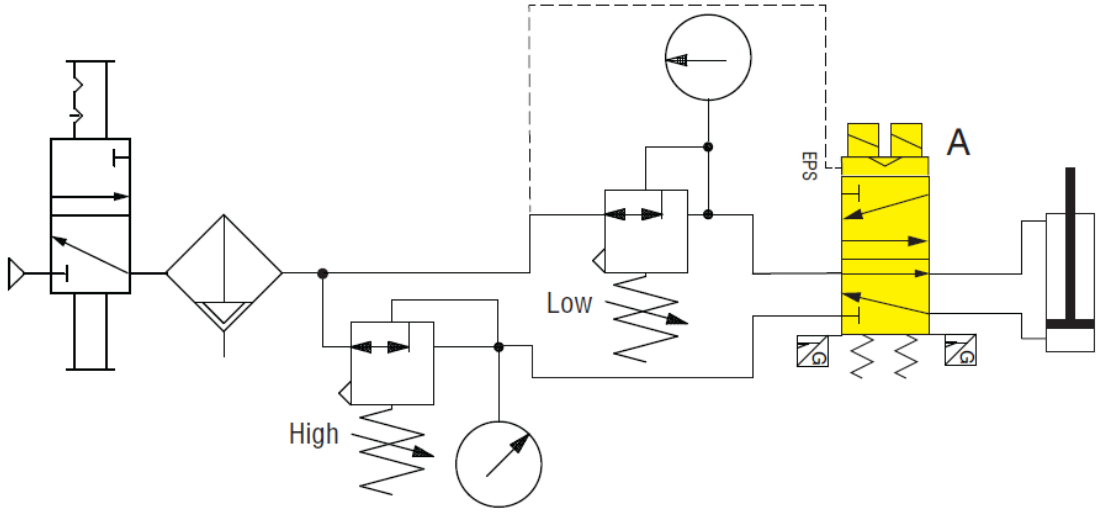




Safe return dual pressure examples

Dual Safe Return Dual Pressure Example 3 – Category 4

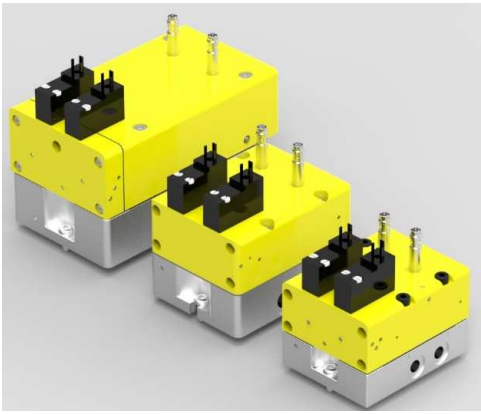
5/2 dual channel solenoid-oprated spring return control valve with feedback - must be monitored by the safety controller.



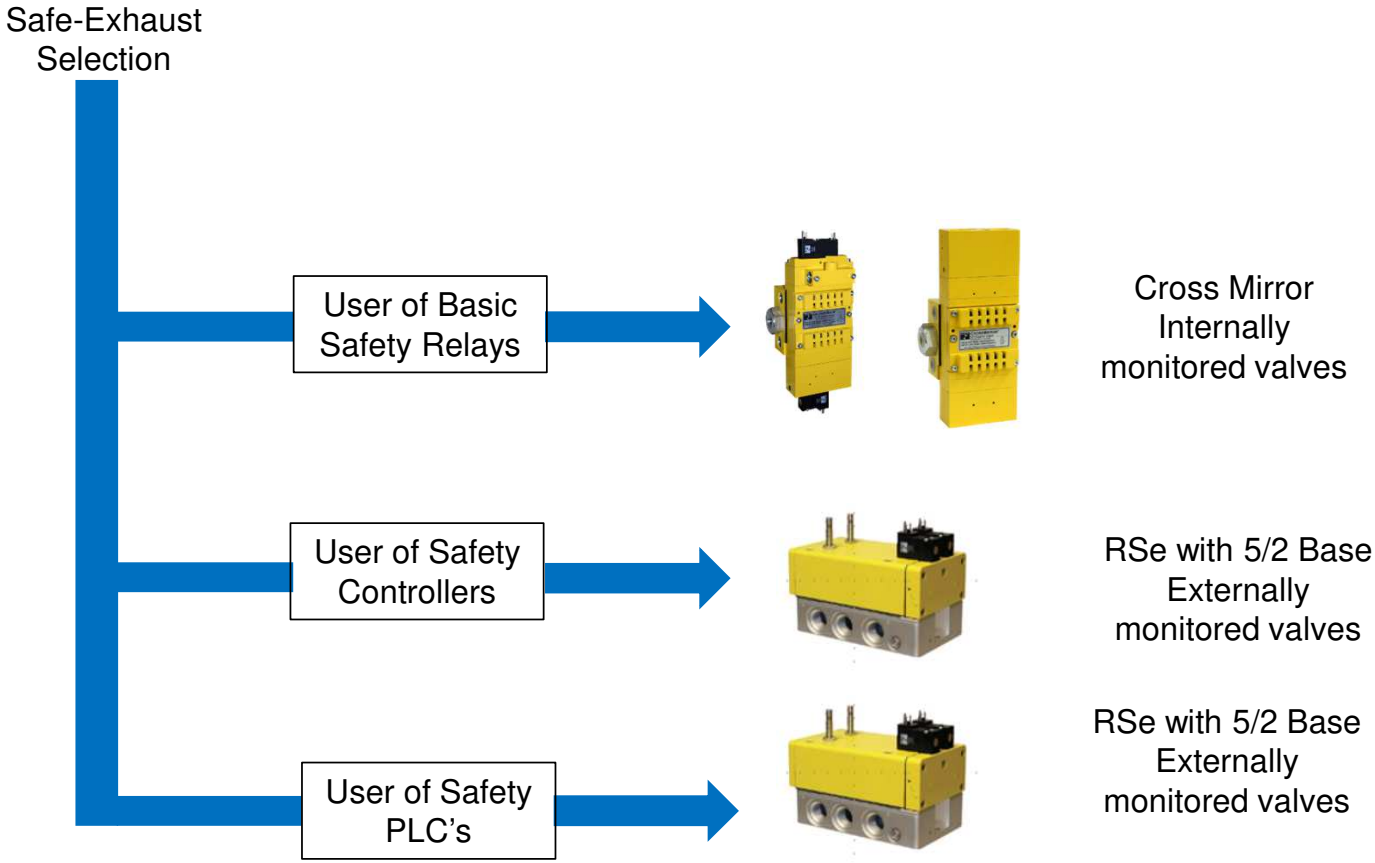
5/2-safety Cat 4/ PL e valve solutions

Internally monitored

Externally monitored

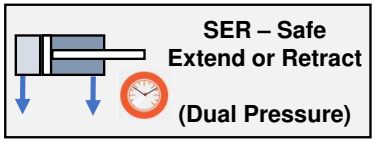


Which safe return valve to use and when?



The externally monitored products are the cheapest and smallest of the ROSS cylinder return valves.

Pneumatic safe dual pressure return valve solution



Pneumatic Safety Valve Systems

Manual Lockout Valves

Safe Exhaust

Safe Pressure Select

Safe Return

Safe Load Holding

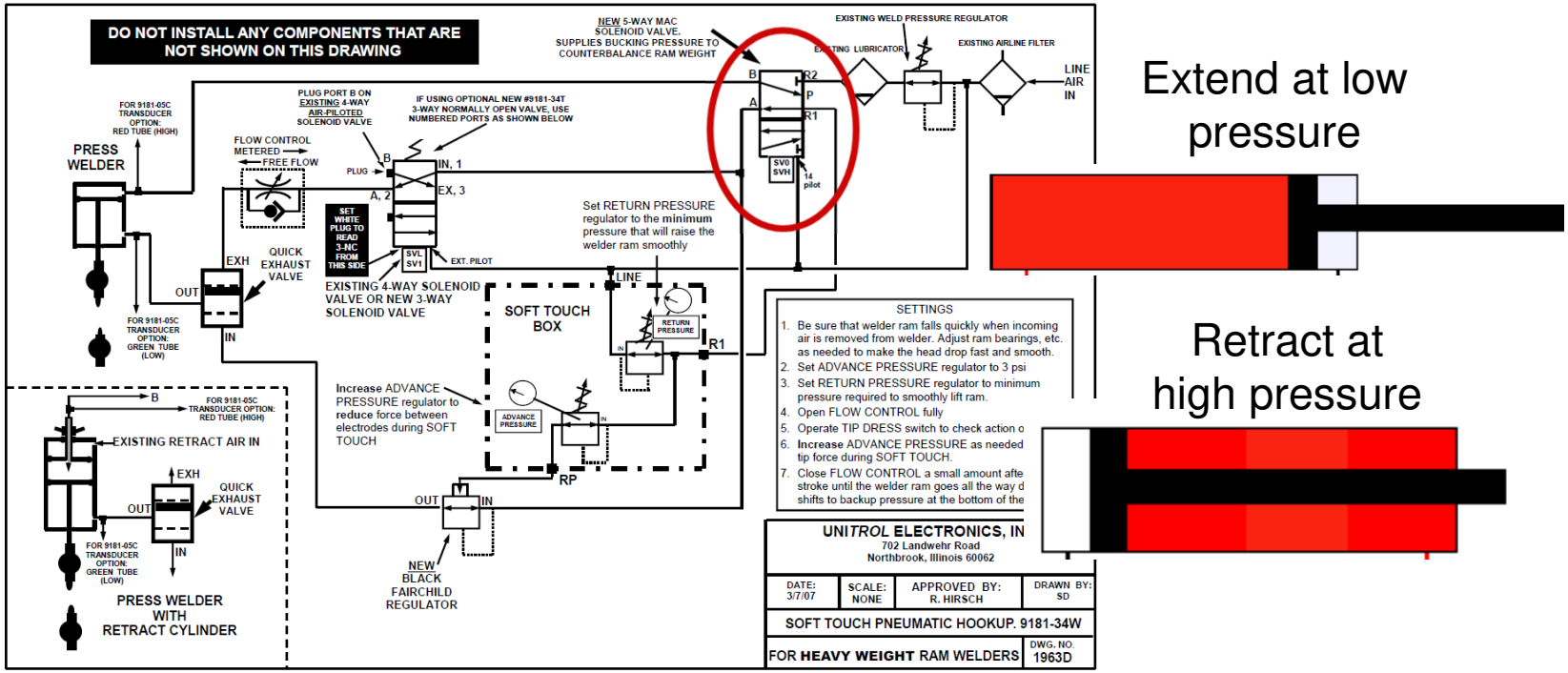
Safe Dual Pressure Return

Safety Expertise and Global Support

Superior Value in Pneumatic Safety

- Broadest safety valve portfolio
- Superior pneumatic safety technology
- Externally Monitored
- Longest lasting valves in the market

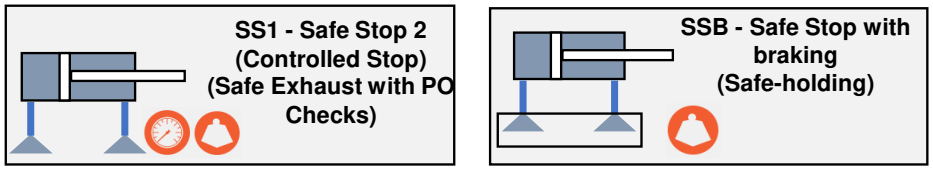
Rse welding extend & retract

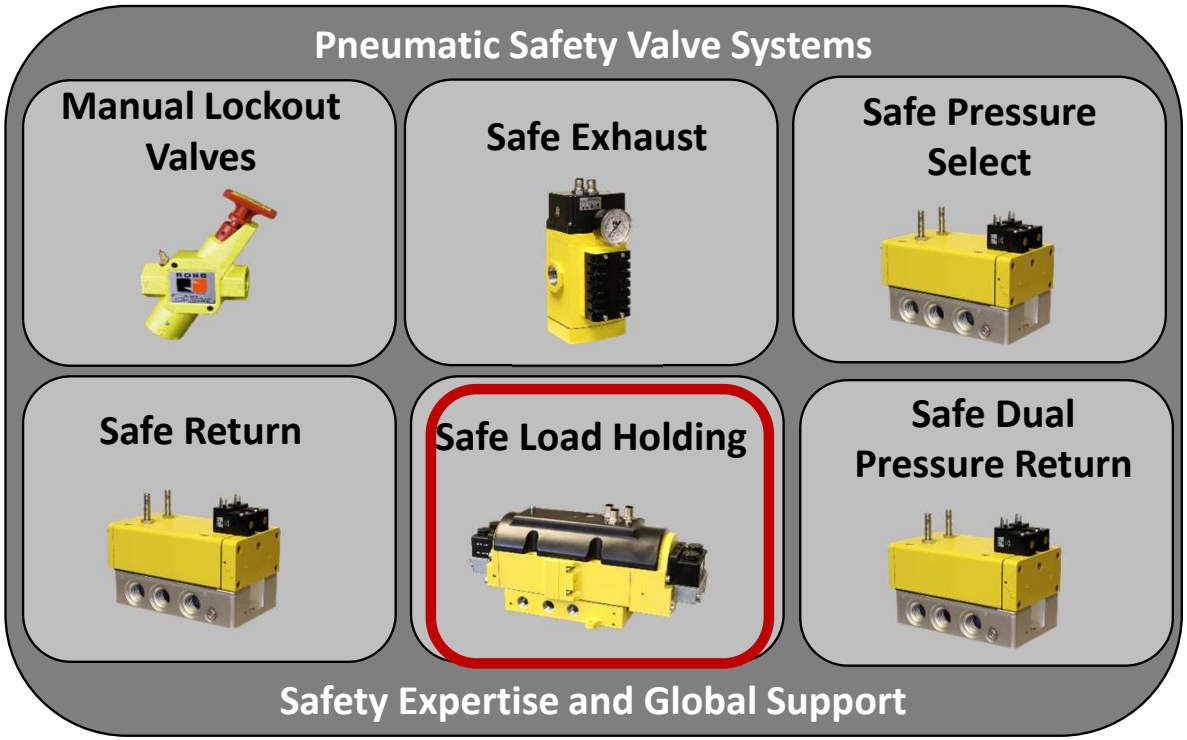


Extend at low pressure

Retract at high pressure

Pneumatic safe load holding valve solution





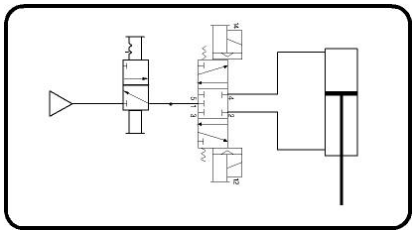
Superior Value in Pneumatic Safety

- Broadest safety valve portfolio
- Superior pneumatic safety technology
- Externally Monitored
- Trapped pressure release
- Longest lasting valves in the market

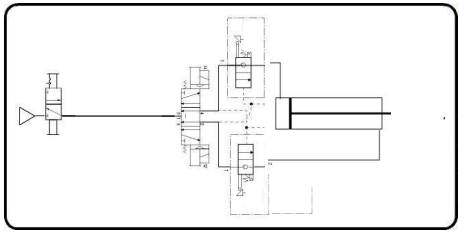
Pneumatic safe load holding valve solutions

- Load holding with one of the most difficult areas for pneumatic safety to implement because there are a number of solutions depending on the safety level that needs to be reached.

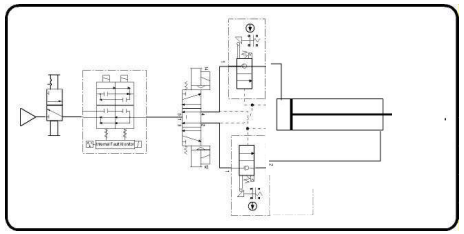
Current CAT B/1 Solution



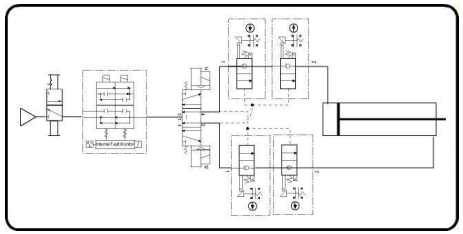
Current CAT B/1 Solution



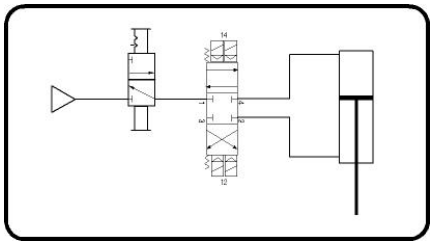
Current CAT 2 Solution



Current CAT 3 Solution



New CrossCheck CAT 3/4 Solution



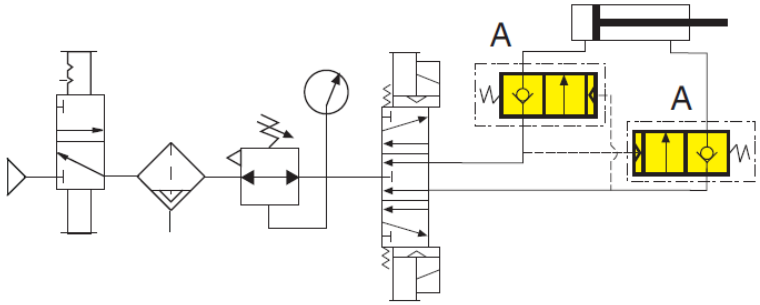
These will be explained in more detail in the following slides.

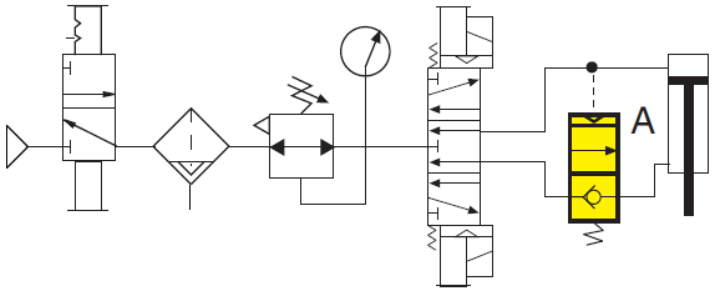
Load holding in the most complex application that you will see and most people do it wrong!

Safe Load holding examples

Pneumatic Safe Load Holding Example 1 – Category 1

Single channel pilot-operated check valve with no feedback.

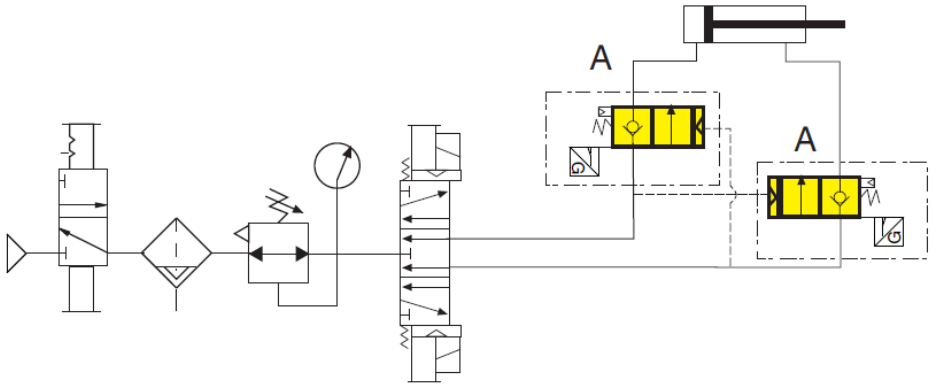


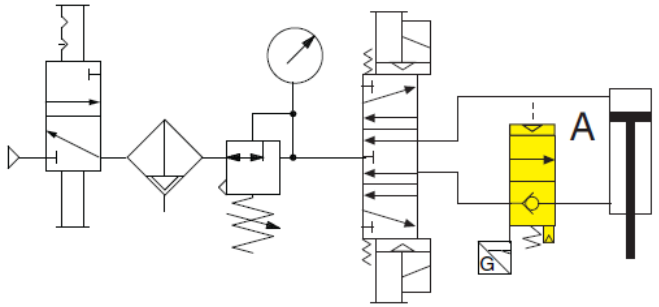


NOTE:
Horizontal applications may need PO check valves on both the rod and cap ends of the cylinder to prevent movement

Pneumatic Safe Load Holding Example 2 – Category 2

Single channel pilot-operated check valve with feedback - must be monitored by the safety controller.



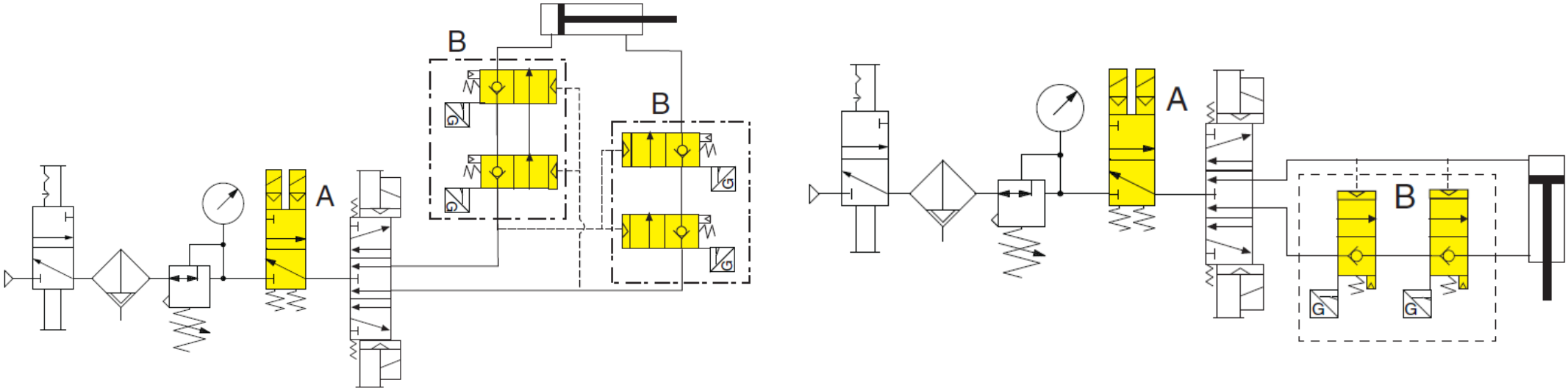


NOTE:
Horizontal applications may need PO check valves on both the rod and cap ends of the cylinder to prevent movement

Safe Load holding examples

Pneumatic Safe Load Holding Example 3 – Category 3

Redundant pilot-operated check valves with feedback - must be monitored by the safety controller. Addition of the safe exhaust valve ensures a failure of the control valve does not override the PO check function. Open-center directional valves are recommended because closed-center valves can hinder operation of the pilot-operated check(s).

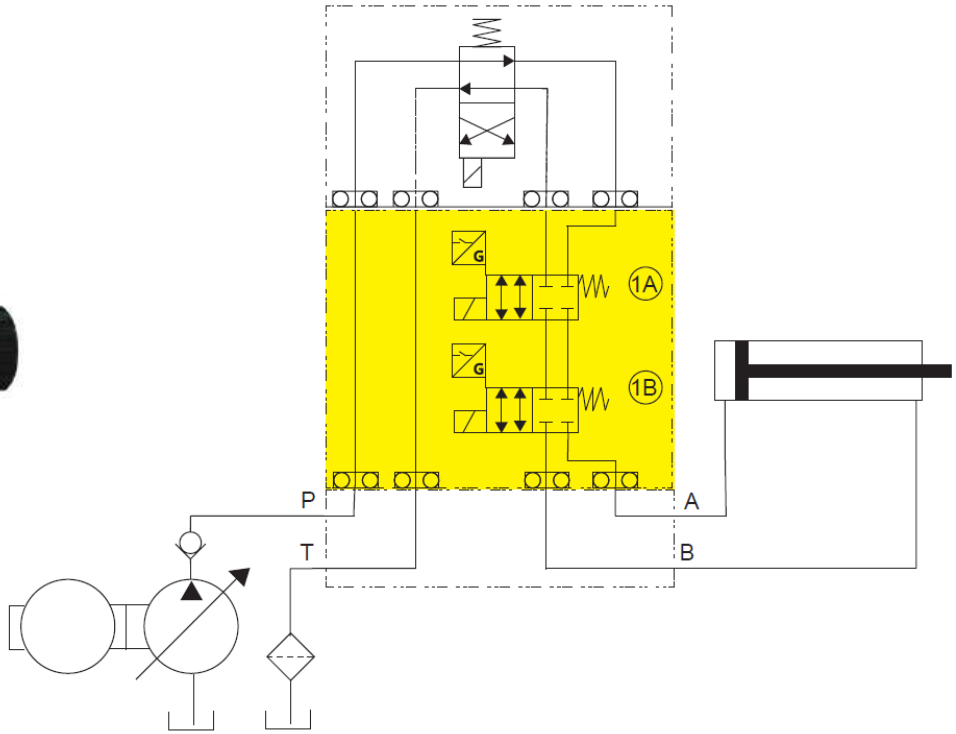


NOTE:
Horizontal applications may need PO check valves on both the rod and cap ends of the cylinder to prevent movement

Hydraulic Dual Safe Block & Stop example

Dual Safe Block and Stop Example – Category 4

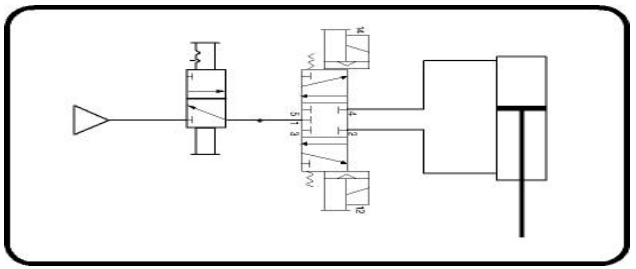
Redundant dual channel solenoid-operated Block and Stop valve with feedback – used to block both cylinder lines - must be monitored by the safety controller.



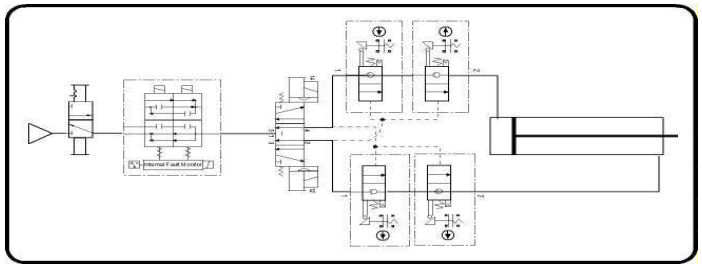
NOTE:
Dual Block & Stop valves are often used with an emergency stop to isolate supply pressure going to the valves that control machine actuators. Dual Block % Stop valves are also typically used on individual actuators to protect one area of a machine/system

CC4 Application

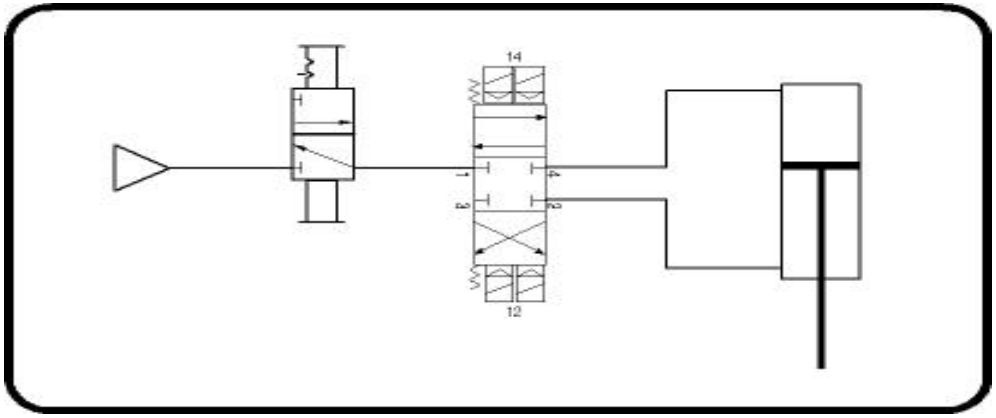
Old Solution – CAT 1



Recent Solution – CAT 3



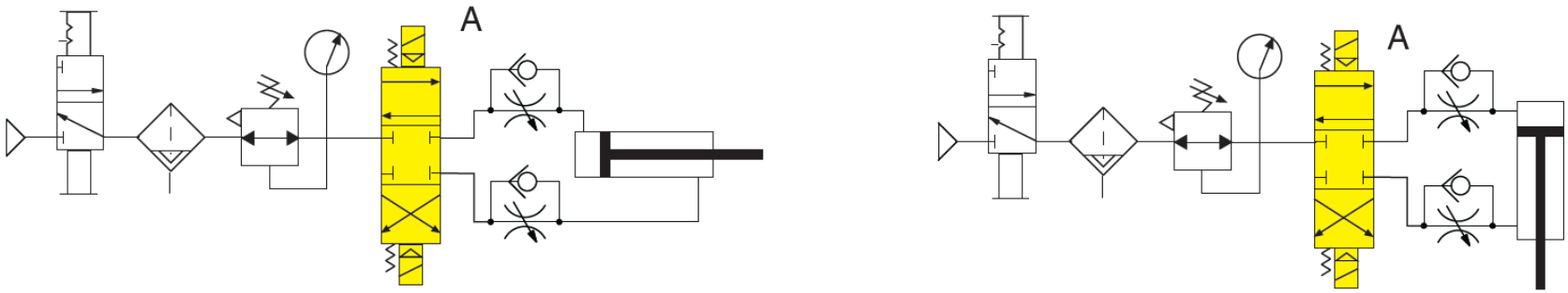
New Solution – CAT 4
CROSS-CHECK



Safe return examples

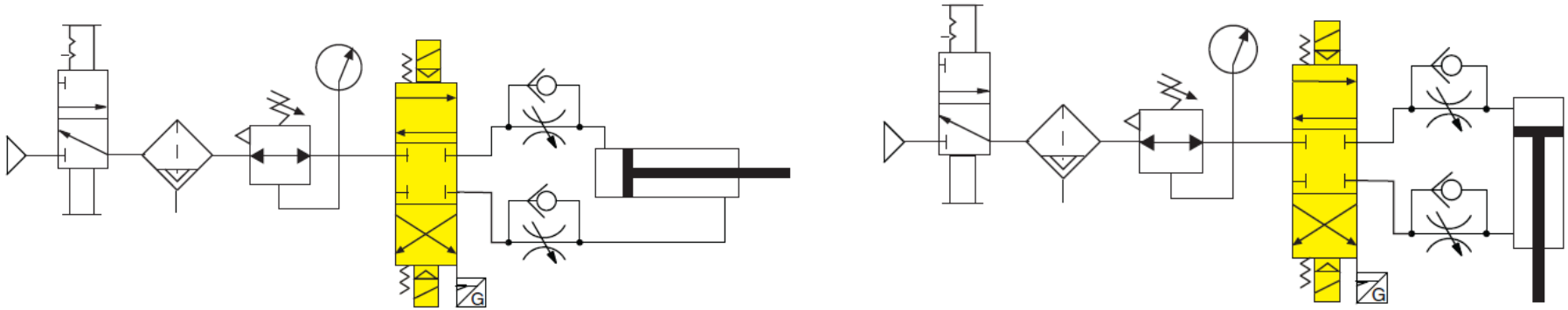
Pneumatic Safe Control and Stop Example 1 – Category 1

4/3 (or 5/3) single channel double solenoid-operated closed-center valve.



Pneumatic Safe Control and Stop Example 2 – Category 2

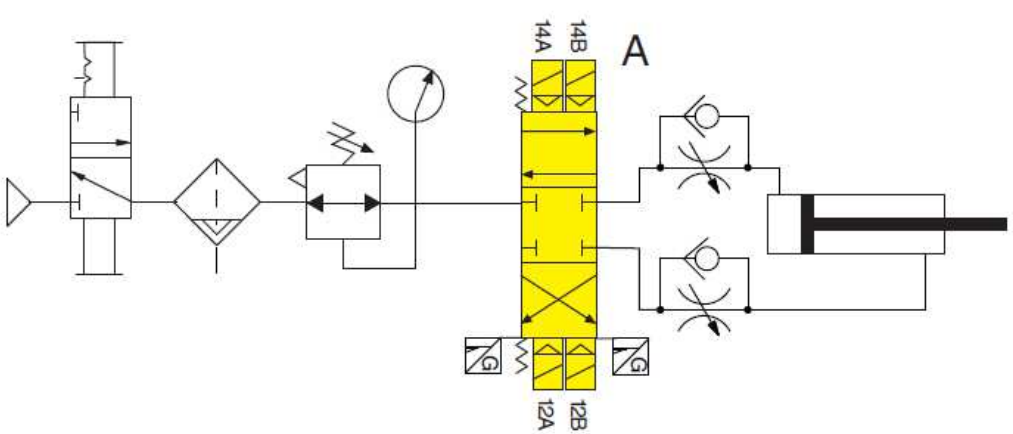
4/3 (or 5/3) single channel double solenoid-operated closed-center valve with feedback - must be monitored by the safety controller.

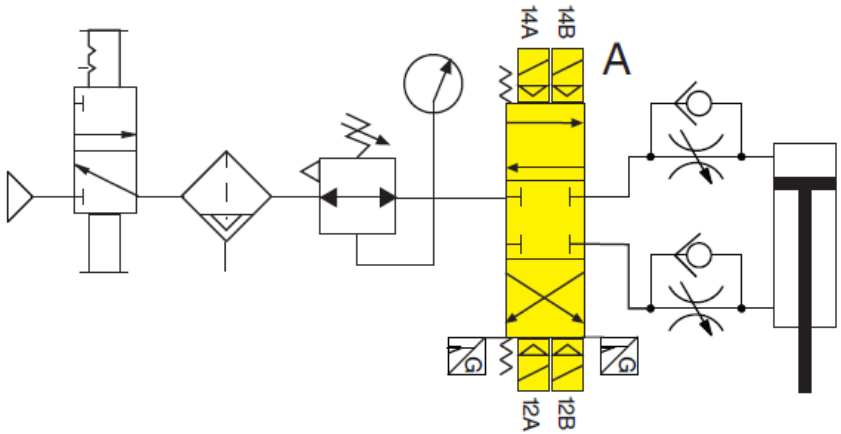


Safe return examples

Pneumatic Safe Control and Stop Example 3 – Category 4

4/3 dual channel double solenoid-operated closed-center valve with feedback - must be monitored by the safety controller.





CC4 - Series

GIT SECURITY AWARD 2020 FINALIST

NEW

PRODUCT DATA SHEET INFORMATION

CrossCheck™ CC4 Series Double Valve

Safety Directional Valve 4/3 – Closed Center

CAT 4, PL e For Safe Cylinder Control and Load Holding

Port Size 1/4 thru 3/4

CAT 4, PL e
(certification pending)

ROSS' new CrossCheck™ CC4 Series Safety directional valve is a redundant, externally monitored 4-ported, 3-position (closed center) pneumatic valve for Category 4, PL e applications, where stopping and holding a cylinder is necessary for safe operator access during production-related tasks. The valve is constructed with tight-sealing, dirt-tolerant poppet-type valve internals.

Features & Benefits:

- Closed Center Valve Function - allows full control of double-acting cylinders, including jog and load-holding functions
- Redundant control with position feedback - can achieve Category 4, PL e, when used with proper safety controls
- Designed for external monitoring - allows full safety control and feedback monitoring of cylinder control circuit
- Mid-position sensing - for detection of safe, closed center position
- ROSS poppet technology - fast, reliable, dirt-tolerant, face-sealing, low friction
- LED indicators on solenoids - aids troubleshooting

HOW TO ORDER

(Choose your options (in red) to configure your valve model number.)

CC4	M	2	2	G	A	E	X	S	A
Series	Basic Size			Voltage		Communication		Revision Level	

Series: Pressure Release — Manual M

Basic Size: 0 2; 2 4

Voltage: 24 volts DC A

Communication: None X

Revision Level

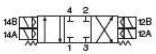
Thread: BSPP G; NPT N; Valve Only X

Monitoring: External E

Pin Configuration: Standard S

Basic Size	Base Port Size Inlet	Outlet	
0	1/4	1/4	2
	3/8	3/8	3
2	1/2	1/2	4
	3/4	3/4	5
Valve Only (No Base)			X

Simplified Schematic



Port Size Inlet	Port Size Outlet	Basic Size	C_v 1-2	C_v 1-4	C_v 2-3	C_v 4-3	Weight lb (Kg)
1/4	1/4	0	1	1	0.8	0.8	11.2 (5.1)
3/8	3/8	0	1	1	0.8	0.8	11.2 (5.1)
1/2	1/2	2	1.9	2	2	1.9	18.3 (8.3)
3/4	3/4	2	1.9	2	2	1.9	18.3 (8.3)

APPLICATIONS: Category 4 applications - e.g., cylinder stop & load holding applications. The CrossCheck™ CC4 Series valve is designed to be controlled by a safety controller or safety relay with dual channel outputs and the capability of monitoring the mid-position feedback sensors. The valve is a redundant valve and is driven by 4 solenoid pilot valves - two for extending and two for retracting.

Standard Specifications

Construction: Redundant dual 4/3 closed center, poppets.
Mounting Type: Sub-base mounted.
Pilot Solenoid: Version as per VDE 0580. Rated for continuous duty. Enclosure rating according to DIN 400 50 IP 65.
Standard Voltages: 24 volts DC.
Pilot Solenoids Power Consumption (each solenoid): 3.5 watts.
Electrical Connections: Three 8-pin, M12 connectors.
Ambient Temperature: 40° to 140°F (+4°C to 60°C).
Medium Temperature: 40° to 176°F (+4°C to 80°C).
Flow Media: Compressed, filtered air according to ISO 8573-1:2010 [7:4:4].

Inlet Pressure: *With Internal Pilot Supply:* 60 to 120 psig (4 to 8 bar). *With External Pilot Supply:* 0 to 120 psig (0 to 8 bar).
Pilot Supply Pressure: 60 to 120 psig (4 to 8 bar). Must be equal to or greater than inlet pressure.
Static Pressure: 0 to 150 psig (0 to 10 bar)
Mounting Orientation: Any, but horizontally with solenoids on top is preferred.
Monitoring: Dynamic, cyclical, external with customer supplied equipment. Monitoring should check state of both valve mid-position sensors with any and all changes in state of valve control signals.

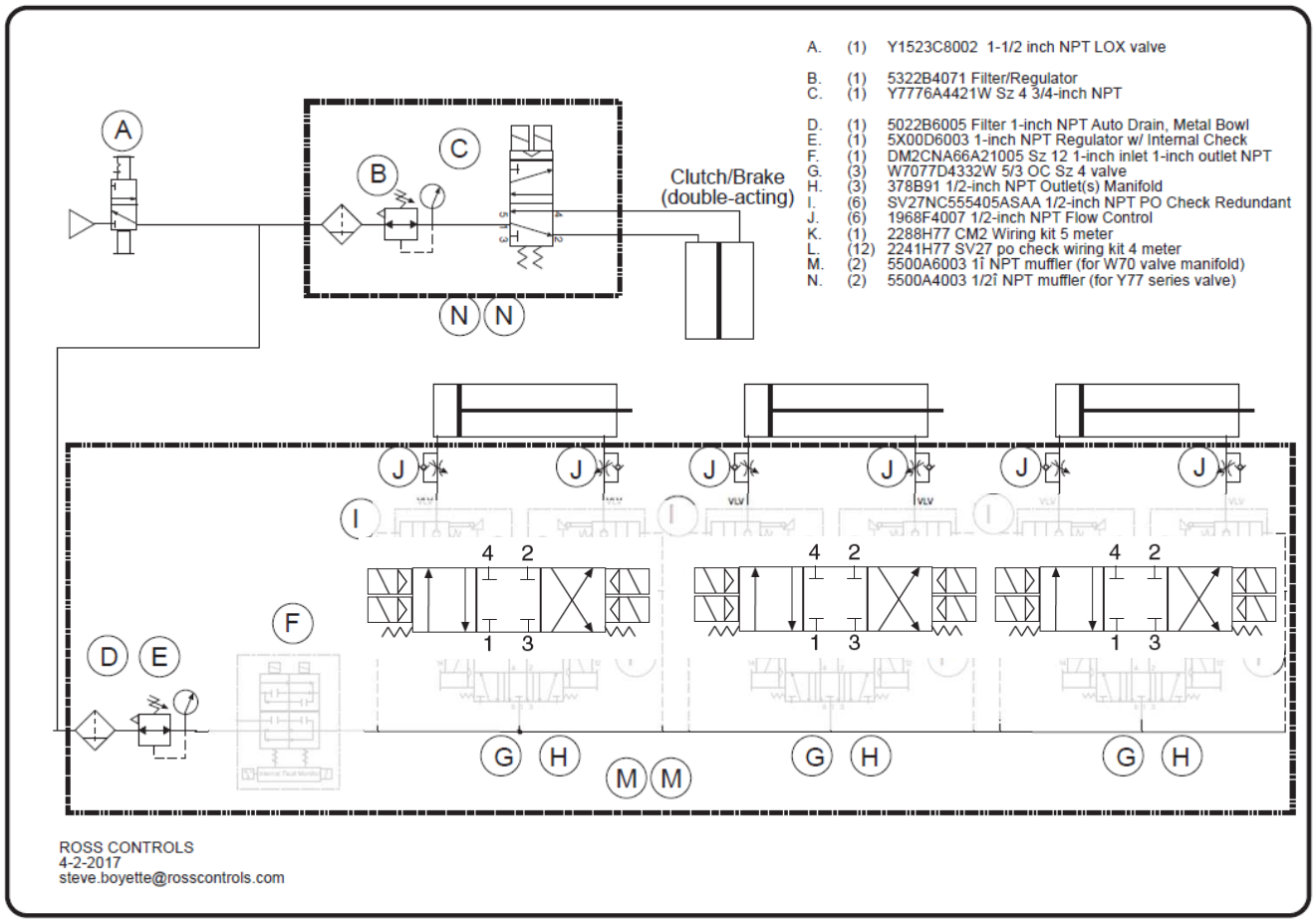
Functional Safety Data: *Pending.*

This valve is not designed for controlling clutch/brake mechanisms on mechanical power presses, see DM2® series D for mechanical power press applications.

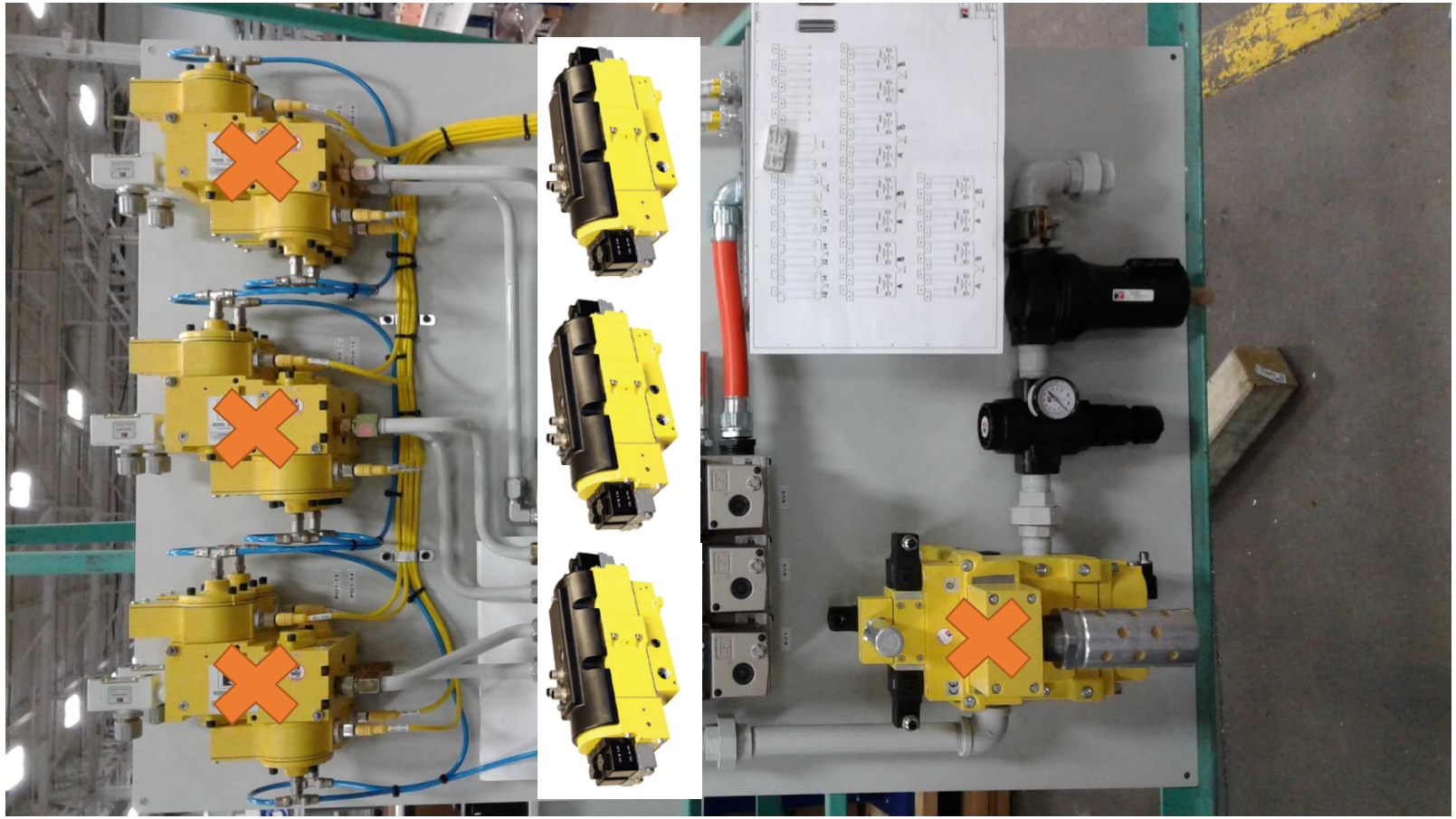
ROSS CONTROLS®

www.rosscontrols.com

CC4 Application



CC4 Application



ROSS – Your partner for pneumatic safety solutions

Thanks for attending

Dietrich Warmbier

FS Eng (TÜV Rheinland, #13530/16, Machinery)
Global Safety Product Manager

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