Fluid Power Safety Considerations

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

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Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

Safety is a challenge that all companies face, and many still think adding safety devices or safety systems to machinery reduces productivity. This can be true in many cases because, quite often, important steps are overlooked in the assessment and implementation process. Unfortunately, it is not uncommon for safety system designers to address hazards caused by electrical systems but overlook hazards caused by fluid power devices.

Many companies are starting to look at safety using a holistic approach that includes electrical safety, fluid power safety and energy isolation/lockout safety. This has resulted in a multi-step risk assessment approach that includes task type evaluation, basic risk assessments, fluid power pressure and force analysis.

Task-based assessment separates tasks into three categories:

- The first category is for maintenance, service and repair tasks that are treated with energy isolation/lockout-tagout.
- The second category is for normal production tasks that are considered routine, repetitive and integral to the production process that are treated with safeguarding solutions.
- The third category is for abnormal job tasks that might use partial energy isolation and partial safeguarding solutions and require a combination of safeguarding solutions, administrative procedures and partial energy isolation/lockout-tagout.

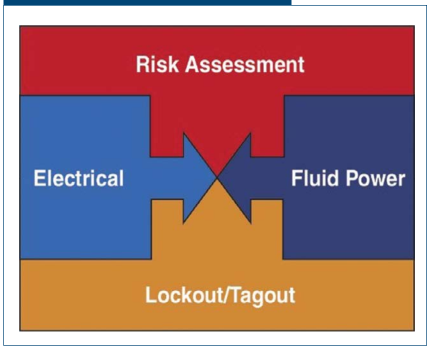
Maintenance, service and repair tasks should evaluate all sources of energy in order to determine the best method control. Requirements and best practices for energy isolation devices include:

- U.S. Occupational Safety and Health Administration (OSHA) Requirements:
  - A manually operated valve.
  - Not be used for any other function.
  - Located outside of hazardous areas.
  - Easily identified and easily operated.
  - Tamper-resistant.

- American National Standards Institute (ANSI) and additional international requirements:
  - Unique in appearance.
  - Full-diameter exhaust.
  - Lockable in only the off position.
  - Have a means to verify that energy has been dissipated.

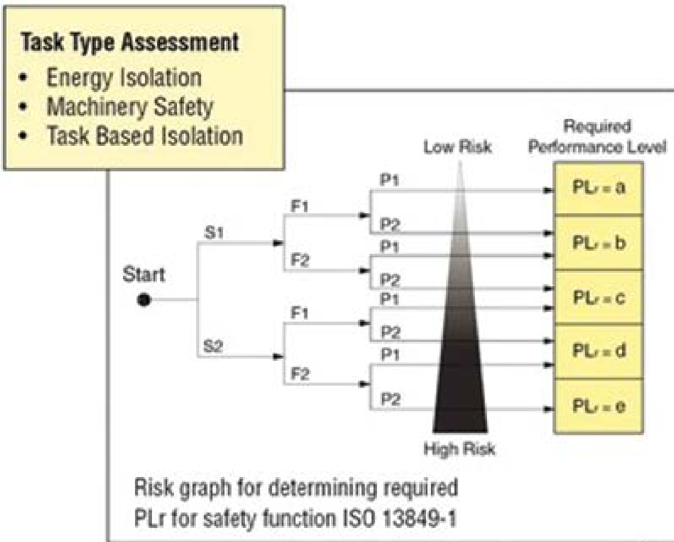
Some companies are starting to implement modern energy-isolation/lockout-tagout solutions that use energy isolating devices that can be isolated from a single isolation

Figure 1



Multi-step risk assessment approach.

Figure 2



Cylinder Bore Diameter mm	Area mm²	Force Newtons lbf		
		5.5 Bar	7 Bar	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

Multi-step risk assessment approach that includes task type evaluation, basic risk assessments, and fluid power pressure and force analysis.

switch with diagnostic feedback to indicate that isolation is complete.

These modern energy isolation/lockout-tagout solutions streamline the energy isolation/lockout-tagout process which enhances system performance, provides standardized procedures, eliminates missed steps and ultimately improves uptime and performance.

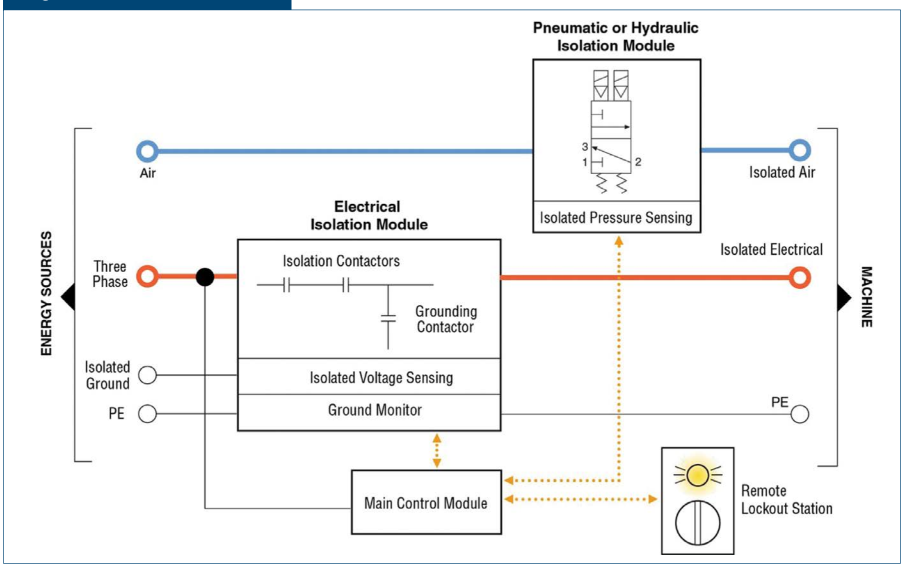
Normal production tasks use safeguarding solutions. Safeguarding solutions are selected through risk assessments and risk reduction plans according to ISO 12100 or ANSI B11.0. The risk assessment should also evaluate all hazards, even those caused by fluid power devices because ISO 13849 and various ANSI machine safety standards identifies fluid power as part of the safety-related part of the control system (SRP/CS).

Most assessors use a basic risk estimation tool or method that uses basic factors like severity, frequency,

Figure 3

Steel safety valve.

Figure 4



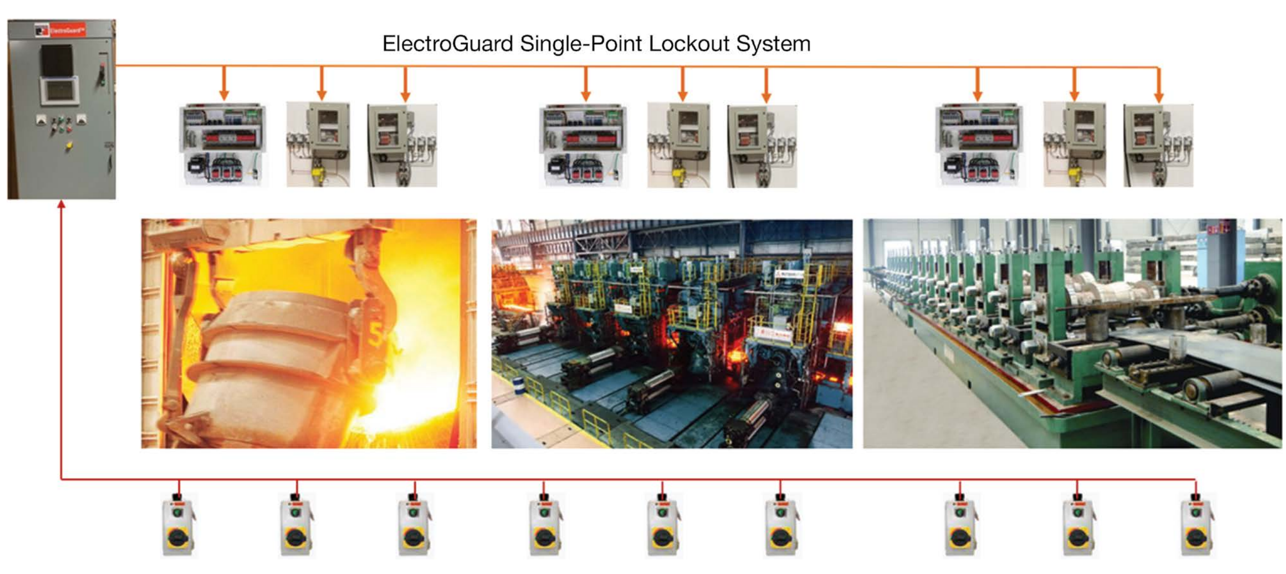
Workflow of remote lockout-tagout stations.

possibility of avoidance and/or probability of occurrence to determine the safety system performance requirements, but often skip fluid power analysis. Fluid power risk assessments should evaluate the pressure and force generated by fluid power actuators. Many companies have realized that omitting or disregarding fluid power safety is a mistake, and have adjusted their approach and are using a basic assessment tool along with a pressure and force calculation tool to determine the overall performance level (PL) requirement for the machine or system.

Risk parameters:

- S — Severity of the damage.
- F — Frequency of the risk.
- P — Possibility of avoiding the risk or limiting the damage.

Figure 5



Flow of remote lockout-tagout and isolation panel procedures.

Figure 6

Safety of machinery — Safety-related parts of control systems

Part 1: General principles for design

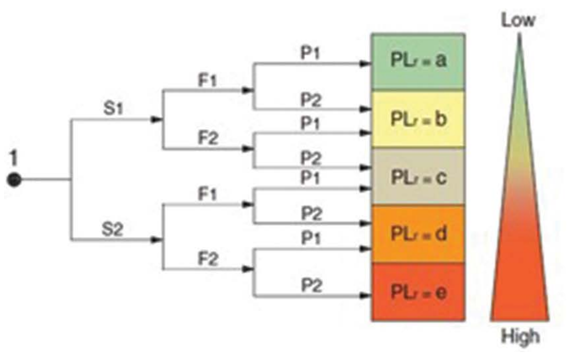
1 Scope

This part of ISO 13849 provides safety requirements and guidance on the principles for the design and integration of safety-related parts of control systems (SRP/CS), including the design of software. For these parts of SRP/CS, it specifies characteristics that include the performance level required for carrying out safety functions. It applies to SRP/CS for high demand and continuous mode, regardless of the type of technology and energy used (electrical, hydraulic, pneumatic, mechanical, etc.), for all kinds of machinery.

Part 1 of ISO 13849 detailing the safety of machinery.

Figure 7

ISO13849 Risk Estimation



Pressure & Force Tool

System Data	Imperial		Metric	
Bore	2	in	50.8	mm
Tooling contact area	1.5	in^2	967.74	mm^2
High pressure	80	psi	0.5516	mpa
Low pressure	20	psi	0.1379	mpa
Bore Area	3.142	in^2	2027	mm^2

Calculations	Units	High Pressure	Low Pressure	B11.0 PLr at High Pressure	B11.0 PLr at Low Pressure
Force	lbf	251.3	62.8	d	c
	N	1118.0	279.5		
Pressure at tool	psi	167.6	41.9	d	c
	N/cm^2	115.5	28.9		

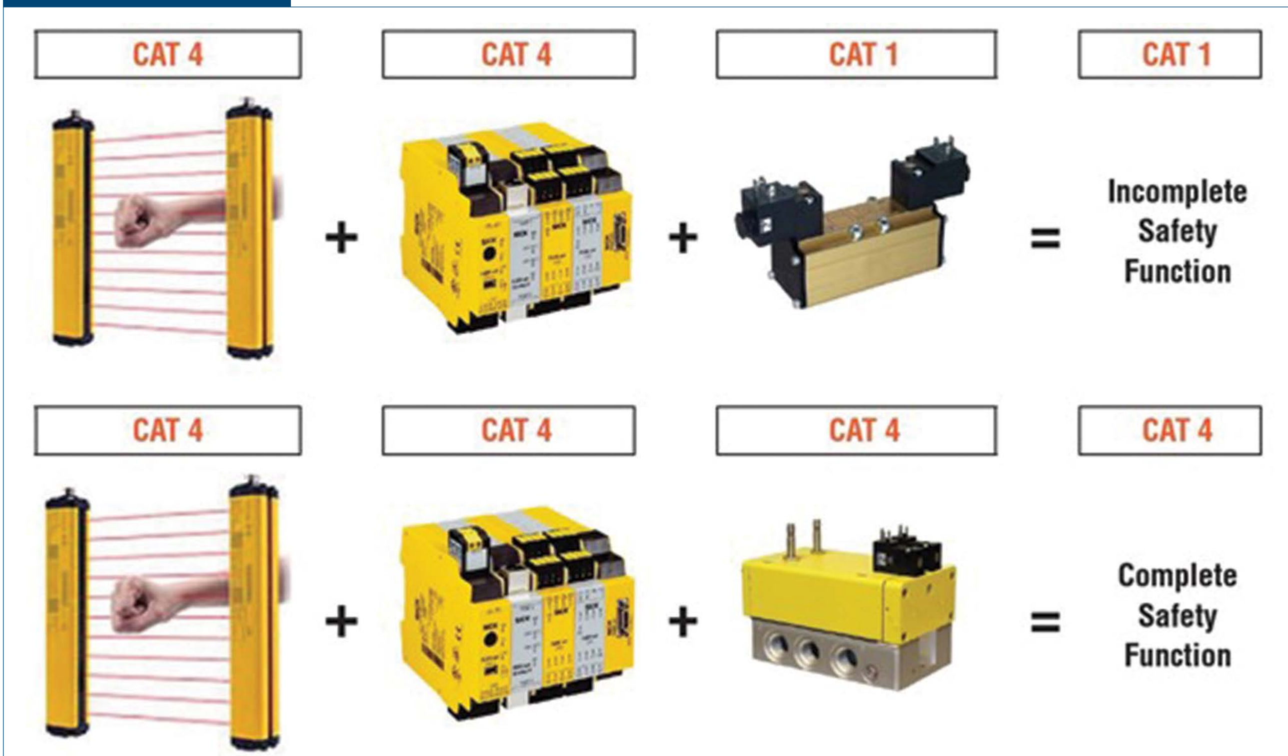
ISO 13849 risk estimation and pressure and force tool.

Any time safeguarding solutions are implemented they are required to follow a standard. The most referenced safety system design standard has become ISO 13849 because it is globally recognized, and it addresses all sources of hazardous energy. ISO 13849 requires the use of well-tried or proven in use products. This means that they must be tested by the manufacturer or an authorized representative to prove that they are suitable for a particular application.

In many cases, companies are using standard fluid power control devices that are not "well-tried" or "proven in use" which results in incomplete safety solutions.

Many machine builders and end users are applying safety solutions based on the safety function and

Figure 8



Examples of complete and incomplete safety functions.

characteristics requirements of ISO 13849-1, shown in Tables 1 and 2, but struggle in understanding how fluid power devices tie in. This results in people ignoring fluid power safety solutions.

One of the main causes of incomplete safety solutions is the lack of knowledge of fluid power safety requirements. ISO 4413, ISO 4414, the VDMA and ANSI B11.26 provide guidance on assessment and design of fluid power safety solutions as shown in Fig. 9.

The most common fluid power safety solutions are safe-energy isolation valves that block supply pressure and exhaust/bleed pneumatic or hydraulic energy from the machine resulting in a "zero energy" state. This is very similar to opening a pair of safety contactors or turning off a safe-torque-off drive. This meets the requirements of safe de-energization from Table 1. Provided these devices are control reliable (category 3 PL d or better), they also meet OSHA requirements for alternative measure used for minor servicing during normal production tasks that are considered routine, repetitive and integral to the production process.

Dumping or bleeding pressure can cause additional issues when dealing with vertical loads due to effects of gravity. The removal of pressure can cause loads to fall or drift. This unwanted motion should be addressed through the use of load-holding valves like pilot-operated check valves or dedicated load

Table 1

Some International Standards Applicable to Typical Machine Safety Functions and Certain of Their Characteristics

Safety function/ characteristic	Requirement(s)			For additional information, see:
	This part of ISO 13849	ISO 12100-1:2003	ISO 12100-2:2003	
Safety-related stop function initiated by safeguard[a]	5.2.1	3.26.8	4.11.3	IEC 60204-1:2005, 9.2.2, 9.2.5.3, 9.2.5.5
Manual reset function	5.2.2	—	—	IEC 60204-1:2005, 9.2.5.3, 9.2.5.4
Start/restart function	5.2.4	—	4.11.3, 4.11.4	IEC 60204-1:2005, 9.2.1, 9.2.5.1, 9.2.5.2, 9.2.6
Local control function	5.2.4	—	4.11.8, 4.11.10	IEC 60204-1:2005, 10.1.5
Muting function	5.2.5	—	—	—
Hold-to-run function	—	—	4.11.8 b	IEC 60204-1:2005, 9.2.6.1
Enabling device function	—	—	—	IEC 60204-1:2005, 9.2.6.3, 10.9
Prevention of unexpected start-up	—	—	4.11.4	ISO 14118 IEC 60204-1:2005, 5.4
Escape and rescue of trapped persons	—	—	5.5.3	—
Isolation and energy dissipation function	—	—	5.5.4	ISO 14118 IEC 60204-1:2005, 5.3, 6.3.1
Control modes and mode selection	—	—	4.11.8, 4.11.10	IEC 60204-1:2005, 9.2.3, 9.2.4
Interaction between different safety-related parts of control systems	—	—	4.11.1 (last sentence)	IEC 60204-1:2005, 9.3.4
Monitoring of parameterization of safety-related input values	4.6.4	—	—	—
Emergency stop function[b]	—	—	5.5.2	ISO/IEC 13850 IEC 60204-1:2005, 9.2.5.4

[a] = Including interlocked guards and limiting devices (e.g., overspeed, overtemperature, overpressure).
[b] = Complementary protective measure, see ISO 12100-1:2003.

Table 2

Some International Standards Giving Requirements For Certain Safety Functions and Safety-Related Parameters

Safety function/ characteristic	Requirement(s)		For additional information, see:
	This part of ISO 13849	ISO 12100-1:2003	
Response time	5.2.6	—	ISO 13855:2000, 3.2, A.3, A.4
Safety-related parameter such as speed, temperature or pressure	5.2.7	4.11.8 e	IEC 60204-1:2005, 7.1, 9.3.2, 9.3.4
Fluctuations, loss and restoration of power sources	5.2.8	4.11.8 e	IEC 60204-1:2005, 4.3, 7.1, 7.5
Indications and alarms	—	4.8	ISO 7731 ISO 11428 IEC 61310-1 IEC 60204-1:2005, 10.3, 10.4 IEC 61131 IEC 62061

Figure 9

DIN EN ISO 4414

Pneumatic fluid power – General rules and safety requirements for systems and their components

ISO 4414:2010 specifies general rules and safety requirements for pneumatic fluid power systems and components used on machinery as defined by ISO 12100. ISO 4414:2010 deals with all significant hazards associated with pneumatic fluid power systems and specifies principles to apply in order to avoid those hazards when the systems are put to their intended use.

Status – Current

Publication Date – 2010-11

BS EN ISO 4413:2010

Hydraulic fluid power – General rules and safety requirements for systems and their components (CD-ROM)

Status – Under review, Current

Publication Date – 31 July 2011

ANSI B11.26-2018

Machines - Functional Safety For Equipment: General Principles For The Design Of Safety Control Systems Using ISO 13849-1

Provides both requirements and guidance for the implementation of safety-related control functions (functional safety) as they relate to electrical, electronic, pneumatic, hydraulic, and mechanical components of control systems.

VDMA

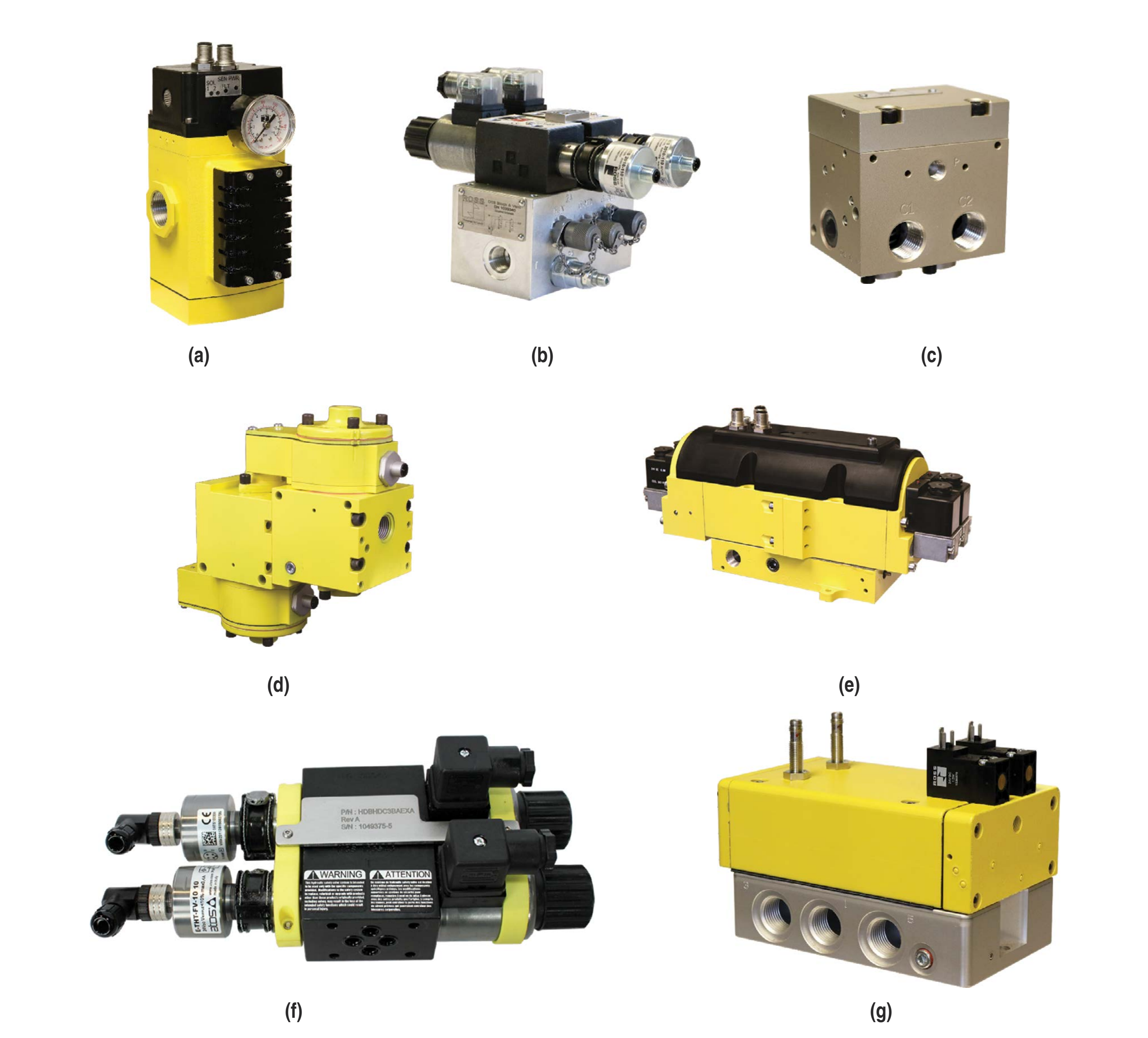
Safety Functions of Regulated and Unregulated (Fluid) Mechanical Systems

Published Date – 02-29-2016

Publisher – Verband Deutscher Maschinen- und Anlagenbau e.V.

Assessment and design of fluid power safety solutions.

Figure 10



Redundant (dual channel) pneumatic safe exhaust valve (a), redundant (dual channel) hydraulic block and bleed valve system (b), non-monitored pilot-operated check valves (c), monitored pilot-operated check valves (d) and load-holding directional control valves (e), safe-return and safe-pressure select valve (f), and block and hold valve systems (g).

holding directional control valves. This meets the requirements of local control function and safe de-energization from Table 1.

These load holding solutions vary and are often misapplied. High risk applications that require Performance Level (PL c, PL D, PLe) may require the use of monitored pilot-operated check valves or monitored load-holding directional control valves.

Other fluid power safety solutions include safe return and safe pressure select solutions that can be used to move hazards away from affected personnel or to reduce pressure to an acceptable range that is below 150 Newtons. This meets the requirements of SRP (safe rated pressure) from Table 2.

Fluid power solutions are part of the SRP/CS according to ISO 13849 and should be considered as part of safety solution for machine applications. This means that designers, machine builders and original equipment manufacturers should assess fluid power risk during the design process in order to reduce risk to acceptable levels. Ultimately, a properly designed safety system saves lives, reduces worker injuries and increases productivity. A focus on safety is a win-win for all steel mills. ✦