Why should customers think about Fluid Power Safety?

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Agenda

- Why Fluid Power Safety is Important
- Changes in the Standards
- Fluid Power Safety Requirements
- Risk Assessment Requirements
- Design Requirements
- Closing Comments

The importance of safety in a transparent society.

Today we live in a transparent society.

Digital devices are everywhere and are often used to capture events. Both Good and Bad.

Deaths linked to GM's faulty ignition switch rise to 30

A program that compensates victims of accidents caused by a faulty ignition switch in General Motors vehicles has approved one new death claim, bringing to 30 the total number of fatalities linked to the issue so far, according to a report on Monday.

OCT 27 2014

What happens today is news tomorrow!
Fluid power devices can crush, kill and amputate just like electrical hazards.

Most people say “I don’t have to worry about this. I am in manufacturing.

The problem is:

Every 15 seconds, somewhere in the world:

- 160 workers have a work-related accident
- Someone dies from a work-related accident or disease

This costs companies an estimate **$4.1 trillion** per year.   Source: International Labor Organization

Bumble Bee Foods, Two Managers Charged in Death of Man ...
https://www.nbcnews.com/news/us-news/bumble-bee-foods-2-managers...
LOS ANGELES — Bumble Bee **Foods** and two managers were charged by Los Angeles prosecutors Monday with violating safety regulations in the **death** of a worker who was cooked in an industrial oven with tons of tuna. Jose Melena was performing maintenance in ...

Bumble Bee forced to pay $6M for worker cooked alive
https://www.usatoday.com/story/news/nation/2015/08/13/bumble-bee...
Aug 13, 2015 · (NEWSER) – Bumble Bee **Foods** will fork out $6 million for the horrific **death** of an employee cooked alive in 12,000 pounds of tuna fish, NBC News reports.

Nestle fined £180,000 for failures leading to worker's death
https://www.confectionerynews.com/Article/2012/03/12/Nestle-fined...
Food giant **Nestle** has been fined £180,000 in a UK criminal court after it failed to implement basic safety measures that led to a worker's **death** ... Top **Headlines**.

Officials: Death at Tropicana Atlantic City determined to ...
6abc.com/officials-death-at-tropicana-ac-determined-to-be-suicide/...
Authorities have determined the **death** a man at the **Tropicana** Casino & Resort in Atlantic City was the result of a suicide.

People are dying in industrial accidents and people are being charged.
These were all Fluid Power Related accidents.

The "Best In Class Companies" are overcoming this by taking a holistic approach to machinery safety that includes Fluid Power Safety.

By understanding safety standards and using them to their advantage to implement robust systems that address all modes of operation for all job tasks.

Complete LOTO

-100% Zero Energy State
-Isolation of all equipment energy sources
-For all service and maintenance activities
-May include preventative maintenance activities and cleaning activities

Task Based Isolation

-Depends on job tasks
-May include partial isolation of equipment energy sources
-Must provide same or greater level of protection as LOTO
-Must have documented procedures for each task
-Must have training for each person doing each task

Alternative Means

- Must meet all minor servicing requirements:
  - Part of Normal Production activities
  - Routine
  - Repetitive
  - Integral to maintaining the process

Clarifications:

- Minor servicing that occurs during normal production operations ***may*** be exempt from lock-out/tag-out ***if they meet the requirements of the minor servicing exception*** and can be treated with Alternative Means.
- Tasked based isolation can be used ***if tasks cannot be done using full lock-out/tag-out and are outside of the requirements of the minor servicing exception***. Task based isolation must be as safe or safer than full lock-out/tag-out and must having specific directions on how to accomplish the job task.
- Lock-out/tag-out must be used for all job tasks that do not fall under the minor servicing except or tasks that cannot be done using full lock-out/tag/out.

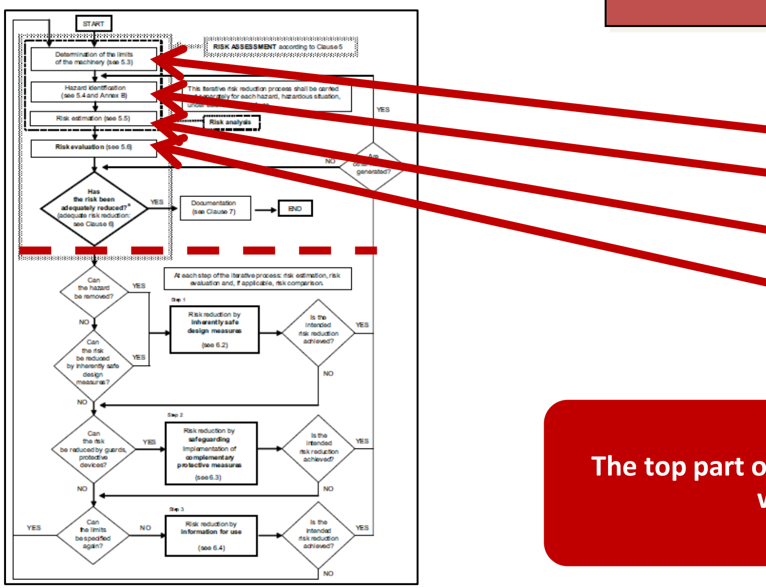
They understand the need to include Fluid Power Safety because they know that it is included in today's modern safety standards.

	European Machine Directive 2006/42/EC	⇄	OSHA Machine Safety 1910.xxx
General Safety Requirements	Machine Safety - Basic concepts EN/ISO 12100	⇄	Machine Safety - General Safety Requirements ANSI B11.0
Risk Assessment Requirements	Machine Safety - Principles for Risk Assessment EN/ISO 14121	⇄	Machine Safety - Principles for Risk Assessment ANSI/RIA TR15.306
Design Requirements	Machine Safety - safety-related parts of control systems EN/ISO 13849-1 Machine Safety - Functional safety of EEPES control systems IEC 62061	⇄	Machine Safety - Selection of Programmable Electronic Systems (PES/PLC) for Machine Tools ANSI B11.19
Fluid Power Requirements	Pneumatic Safety – EN/ISO 4414 Hydraulic Safety – EN/ISO 4413	⇄	Pneumatic Safety – ANSI B11.0 Hydraulic Safety – ANSI B11.0
Electrical Requirements	Machine Safety - Electrical equipment of machines IEC 60204-1	⇄	Electrical equipment of machines ANSI/NFPA 79

Notice that there are specific standard for Fluid Power Safety.

ISO12100 and ANSIB11.0 outline the basic requirements for risk assessment and risk reduction.

The ISO12100 and ANSIB11.0 methodologies provide a systematic approach as shown in the flow chart below.



Risk Assessment

Assessment

Determine the Limits

Identify the Hazards

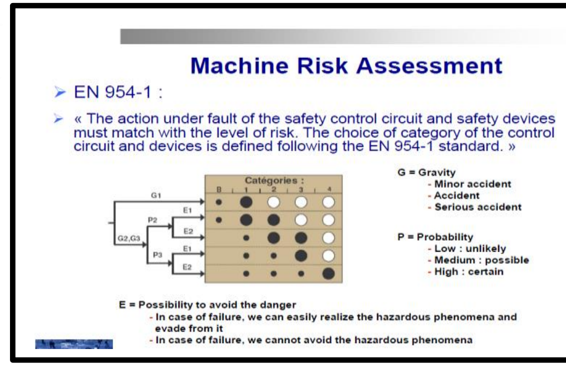
Estimate the Risk

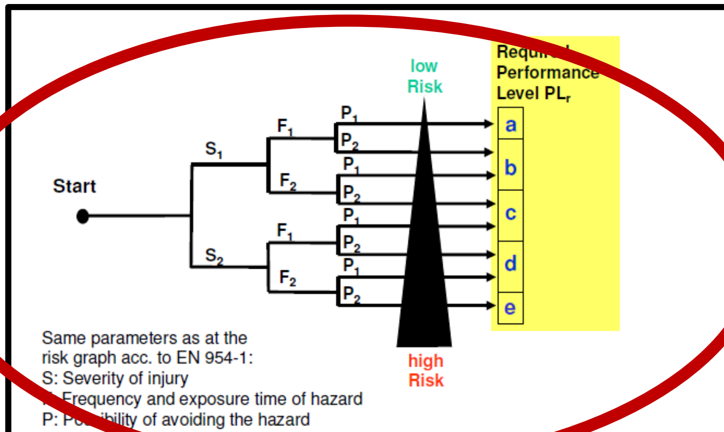
Evaluate the Risk

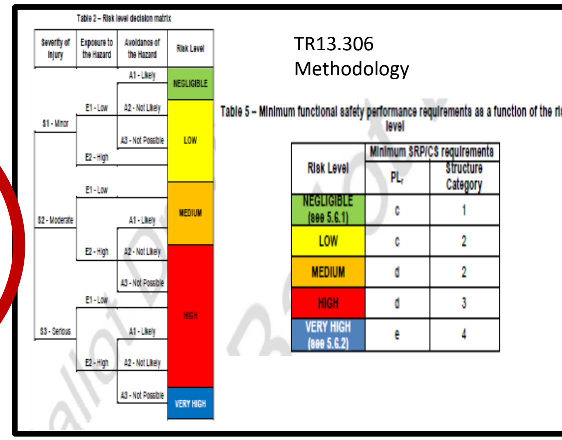
The top part of ISO12100 and ANSI B11.0 deal with assessing risk.

There are a number of risk estimation methods that yield varying results. ISO13849 has become one of the most widely used methodologies.

Insignificant	Category 1	Category 1	Category 1	Category 1	Category 1
Minor	Category 1	Category 1	Category 2	Category 2	Category 2
Moderate	Category 2	Category 2	Category 2	Category 3	Category 3
Serious	Category 3	Category 3	Category 3	Category 3	Category 4
Critical	Category 3	Category 3	Category 3	Category 4	Category 4







The reason that many companies have adopted ISO13849 is because it addresses all technologies and provides a more holistic approach to machine safety.

EN 954-1	EN ISO 13849-1
Electrical Control Circuits	Control circuits all technologies : • Electrical • Pneumatic • Fluids • Hydraulic Not just electrical anymore!
Safety Categories B, 1, 2, 3 & 4	Performance Levels PLa to PLe
Safety provided by the structure of the control circuit	Safety provided by: • The architecture/structure (EN954-1 categories) • The reliability of the system ($MTTF_d$, $B10_d$) • The diagnostic coverage of the system (DC) • The preventive measures against common causes of failure (CCF)
Draw a diagram (schematic)	Draw a diagram and verification of PL Does PL(achieved) = PLr (required) ?

ANSI B11.0 – 2015 Annex K NOTE: OSHA uses B11.0 to enforce policy.
Companies following ISO13849 will comply with the risk reduction process.

AMERICAN NATIONAL STANDARD B11.0 – 2015 (Annex – K)

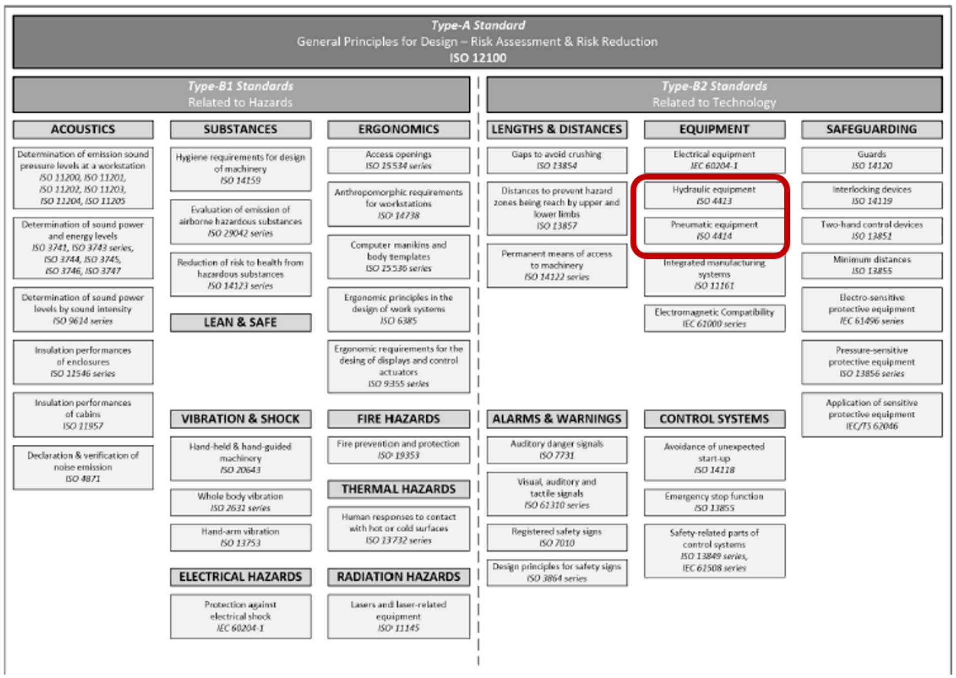


Figure 12 — International standards (ISO & IEC only; other international standards may apply)

This means that we need to think about…

- Pneumatic & hydraulic risk
  - Does it create motion?
  - Vertical or Horizontal?
    - Gravity – Weight of Tooling?
    - Speed – Inertia to stop?
    - Tooling – Crushing? Piercing? Cutting?
    - Pressure/Force

- Pneumatic risk
  - Force with pneumatic energy
    - 1” Bore at 100 psi = 79#
    - 2” Bore at 100 psi = 314#

We need to think about powered and unpowered hazards, like falling loads!

The reason companies ignored fluid power hazards was because they didn't know how to assess it.

AMERICAN NATIONAL STANDARD B11.0 – 2015 (Annex – C)

Table 4 — Injury and Severity Correlations

Following are some values extrapolated from literature referenced in the notes below the Table. Values may differ based on application specific data or individual susceptibilities

Injury Type	Catastrophic	Serious	Moderate	Minor
Burns, Thermal **Hot Surface** *[1] The severity of injury is relative to the amount of body surface area, the duration of exposure, and the temperature of the hot surface.	3rd degree burns typically caused by temperatures > 68° C (>154° F) with exposure durations of one second, and on skin surface areas over 1% or more of the body i.e., palm of hand.	3rd degree burns typically caused by temperatures > 68°C (>154° F) with exposure durations of one second, and on skin surface areas less than 1% of the body.	2nd degree burns typically caused by temperatures 60° - 68°C (140°F – 154°F) with exposure durations of one second.	1st degree burns typically caused by temperatures (44 °C - 59°C (111°F – 139°F) with exposure durations of one second.
Burns, Thermal **Vapor or splash of viscous material** [1] Vapor exposure assumes instantaneous contact; viscous materials assume continuous contact greater than 1 second.	3rd degree burns typically caused by temperatures > 60°C (>140° F) and on skin surface areas over 1% or more of the body i.e., palm of hand.	3rd degree burns typically caused by temperatures > 60° C (>140°F) and on skin surface areas less than 1% of the body.	2nd degree burns typically caused by temperatures 44° C - 59° C (111°F – 139° F).	1st degree burns typically caused by temperatures 38° C – 43° C (100° F – 110° F).
Lacerations** [2] Amputation force is derived from literature search that identified pain and fracture thresholds at 150 N (33.7 lbf), 400 N (89.9 lbf), 2000 N (449.6 lbf) 80 mm (3.15 in)diameter load cell.	Lacerations or amputations that could result in death or permanently disabling injury such as blindness.	Lacerations of the head or face requiring sutures or other closure in lieu of sutures or partial blindness typically caused by: • flying projectiles; • stationary sharp edges; • blunt, sharp edges. Amputation, typically caused by: • sharp edges mechanically in motion (e.g. rotating, reciprocating, shearing); • offset, blunt edges with loads exceeding 28 kPa (4psi).	Lacerations, not involving the face, requiring sutures or other closure in lieu of sutures typically caused by: • stationary sharp edges; • blunt, sharp edges.	Minor cuts requiring bandaging treatment; typically caused by: • stationary blunt surfaces; • offset, blunt edges with loads less than 28 kPa (4psi).
Fracture [2] Fracture and amputation force are derived from literature search that identified pain and fracture thresholds at 150 N, 400 N and 2000 N using an 80mm diameter load cell. 150 N (33.7 lbf), 400 N (89.9 lbf), 2000 N (449.6 lbf) 80 mm (3.15 in).	**399.9 kPa (58 psi)**	Fracture of long bones in arms, legs or fracture of the skull or spine, typically caused by loads exceeding 297 kPa (43 psi) and 399.9 kPa (58 psi)under certain test conditions.	Fracture of small bones (e.g., hands, fingers, toes), typically caused by loads between 297 kPa (43 psi) and 399.9 kPa (58 psi).	Contusions and skin abrasions typically caused by loads between 83 kPa (12 psi) and 297 kPa (43psi)under certain test conditions. No physical signs typically caused by loads less than 83 kPa

ANSI B11.0 identifies several risk levels based on the risk of fluid power energy and categorizes them into Catastrophic, Serious, Moderate and Minor.

ANSI B11.0 – Provides performance requirements based on pressure & force figures from the table on the previous page.

- Per EN 13736 there 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

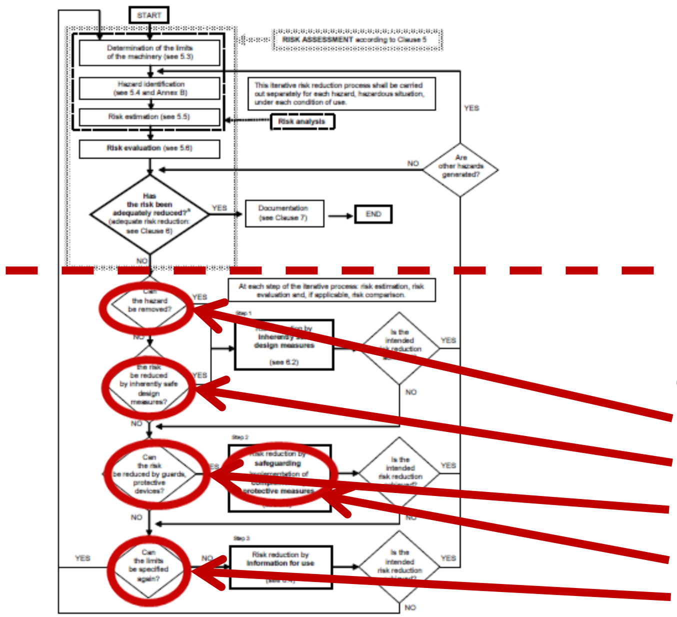
Bore	Area	Force (60 psi)	Force (80 psi)	Force (100 psi)
0.75	0.44	27	35	44
1	0.79	47	63	79
1.25	1.23	74	98	123
1.5	1.77	106	141	177
2.5	4.91	295	393	491
3	7.07	424	565	707
4	12.57	754	1005	1257

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.

Once we are done with the assessment, we need to determine how to reduce risk. This should include fluid power risk as well.

BS EN ISO 12100:2010
ISO 12100:2010(E)



* The first time the question is asked, it is answered by the result of the initial risk assessment.

Figure 1 — Schematic representation of risk reduction process including iterative three-step method

Risk Reduction

- Reduction by Elimination
- Reduction by Design
- Reduction by Guarding
- Reduction by Safeguards
- Reduction by Information & PPE

The bottom part of ISO12100 and ANSI B11.0 deal with risk reduction.

If a machine safety solution is required it must be designed to meet a standard to prove compliance.

Since EN954-1 was withdrawn in December of 2011 and IEC62061 only deals with electrical. Electronic and programmable electronic systems. ISO13849-1 has replaced has the most commonly used machine safety standard because it addresses all technologies..

EN954-1	ISO 13849-1	IEC 62061
Basic electrical circuits	Electrical Electronic Hydraulics Pneumatics Fluids	Electrical Electronic Programmable Electronic

The ISO series of standards have great guidance and are being harmonized with many of the North American standards.

ISO 13849-1 – 2015 requires users to include fluid power safety as part of the safety control system.

- Pneumatics and hydraulics are part of the SRP/CS
  - safety related parts of the control system
  - Requires “proven in use” or “well tried components”
  - Requires “well tried safety principles”

	PFH_D (1/h)	Cat. B	Cat. 1	Cat. 2	Cat. 3	Cat. 4
PL a	2*10–5	•	O	O	O	O
PL b	5*10–6	•	O	O	O	O
PL c	1,7*10–6	-	•2*	•1*	O	O
PL d	2,9*10–7	-	-	-	•1*	O
PL e	4,7*10–8	-	-	-	-	•1*

• Applied category is recommended.

O Applied category is optional.

- Category is not allowed.

1* Proven in use (see 3.1.39) or well-tried (confirmed by the component manufacturer to be suitable for the particular application) components and well-tried safety principles must be used.

2* Well-tried components and well-tried safety principles must be used.

For safety-related components that are not monitored in the process, the T10d value can be determined based on proven in use data by the machine manufacturer.

Proven in use means that it has been widely used with documented results.

Well tried means product that has been tested and confirmed to meet safety requirements.

Most companies ignored pneumatics and hydraulics until the standard changed in 2015.

These components must be integrated to meet a standard. The question is….which standard?

EN954-1 ANSIB11.19

ISO13849-1 ANSIB11.26

The correct answer is yes! All of these applicable.

- EN954-1 no longer exists as an independent standard.
- EN954-1 only exists as a subpart of ISO13849-1
- ANSIB11.19 references ISO13849 for guidance on safety system design
- ANSIB11.26 is being re-written to include a practical guide to implementing ISO13849.

ANSI B11.19 – 201# (Estimate is spring of 2019)

- Being updated currently
- Much harmonization and re-organizing occurring to be more similar to ISO13849 and IEC62061
- Emphasis on risk assessment
- Directly references ISO13849 as a sound example for the implementation of safety solutions (This occurred in 2014)

B11.26:2018 will have specific content for Categories to help meet PL requirements of ISO13849.

- Provide examples for various categories and performance levels
  - E-Stop
  - Interlock
  - Guard-locking
  - Optical sensing
  - Safety Mats
  - Two Hand
  - Zero Speed
  - Enabling Devices

B11.26:2018 Pneumatic Selection Flowchart

- Includes pneumatic and hydraulics
  - Selection flowchart
  - Category examples of safety functions
    - Exhaust (Block/Dump)
    - Safe cylinder return
    - Blocking (Load holding)

6.4.1.1 Pneumatic Component Selection Process
Figure J and Figure K are intended as a guide to the proper selection and implementation of components.

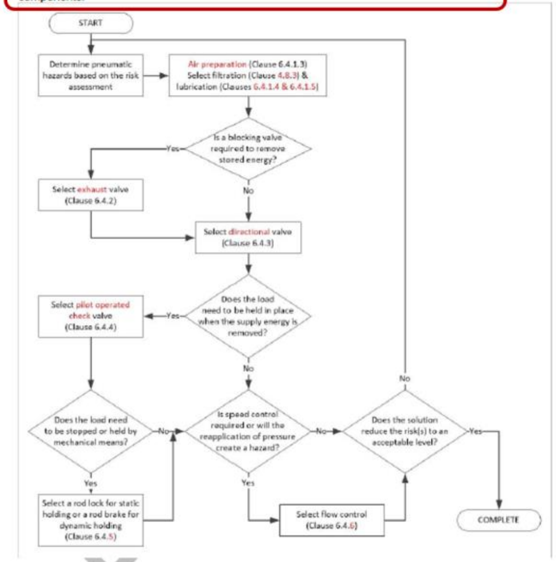


Figure J – Flowchart for pneumatic component selection

There will also be a similar flowchart for hydraulics.

B11.26:2018 - Includes examples and descriptions

- Provides multiple examples for various categories
- Designed to be a road map for the implementation of fluid power safety solutions
- Based on existing electrical and fluid power technology

Harmonization is happening and it will make all of our lives easier.

Closing Comments

- Fluid Power Safety is Important
- The Standards require us to address Fluid Power Safety
- Fluid Power needs to be part of the risk assessment
  - Based on ANSI B11.0 2015 requirements and ISO4413 and ISO4414
- Fluid Power components are part of the SRP/CS
  - Safety Related Parts of the Control System according to ISO13849-1
- The upcoming standards will provide examples of how to address common Fluid Power Applications
  - Cat2, Cat3 & Cat4 examples to help users meet Performance Level C, D & E Requirements
- **We can't ignore Fluid Power anymore!**