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.
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,
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

Part 1 of ISO 13849 detailing the safety of machinery.
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

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**Figure 7**

ISO 13849 risk estimation and pressure and force tool.

**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

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

\(^a\) 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

<table>
<thead>
<tr>
<th>Safety function/characteristic</th>
<th>Requirement(s)</th>
<th>For additional information, see:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time</td>
<td>5.2.6</td>
<td>—</td>
</tr>
<tr>
<td>Safety-related parameter such as speed, temperature or pressure</td>
<td>5.2.7</td>
<td>4.11.8 e</td>
</tr>
<tr>
<td>Fluctuations, loss and restoration of power sources</td>
<td>5.2.8</td>
<td>4.11.8 e</td>
</tr>
<tr>
<td>Indications and alarms</td>
<td>—</td>
<td>4.8</td>
</tr>
</tbody>
</table>

For additional information:
- IEC 60204-1:2005, 7.1, 9.3.2, 9.3.4
- IEC 60204-1:2005, 4.3, 7.1, 7.5
- ISO 7731
- ISO 11428
- IEC 61310-1
- IEC 62061

Figure 9

Assessment and design of fluid power safety solutions.
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.