New Zoned Safety Approach Reduces Complexity for Functional Safety of Machinery

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Introduction

For both original equipment manufacturers (OEMs) and users, there is considerable interest and focus today on production machine safety. Manufacturing companies must ensure the safety and health of their employees who are engaged in the installation, operation, adjustment, and maintenance of production equipment. This emphasis on safety includes all industries that use machines incorporating pneumatic systems such as automotive, packaging, pharmaceutical, process, stamping, general machining, assembly operations, and tire production.

OEMs and end users must become partners in the quest for an accident-free workplace. While the end-user is responsible for training employees in safe work practices, the OEM must design and build a machine that is safe and compliant with government and industry regulations and directives. To accomplish this task, an OEM must conduct a Risk Assessment to identify the health and safety risks that exist. Then the machine must be designed and constructed using methods to reduce the potential risk.

Over the last 2 decades, standards have evolved to guide OEMs in producing safe equipment. In Europe, Machinery Directive 2006/42/EC became law in 2009. This Directive is intended for manufacturers, importers, and dealers of machinery and safety components and applies to new machines built or used in Europe. It harmonizes the level of safety of products designed and produced by different manufacturers.

The Machinery Directive is supported by various standards. For example, ISO 13849-1 covers the design and construction of safety-related parts of control systems for machinery. These include basic concepts, principles for design, and engineering aspects that can be applied to production equipment to satisfy machinery safety.

ISO 13849-1 introduces three key concepts for the design of machinery and their safety functions:

- The use of a risk analysis prior to design
- Consideration of the quantitative aspects of the safety functions as well as a qualitative approach
- The use of performance levels (PL) to assess the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions. They are defined in terms of probability of dangerous failure per hour

While the Directive has been implemented in Europe, there is still confusion about applying it in North America.

When designing machinery that has pneumatic components, engineers typically employ discrete safety circuits with redundant dump valves to meet the necessary safety requirements. While this approach has been used for many years, it can add significant complexity to machine designs.

In response, a new concept has emerged called Zoned Safety. This concept allows the integration of safety functionality within a pneumatic valve manifold. It gives the designer the capability to create multiple zones or sections within a manifold that can be dedicated to safety functionality. With zoned safety, the designer can "zone" one or multiple sections of the manifold to render a specific part of the machine safe. The zoned safety manifold concept provides for operation or functionality while allowing for a "safe" condition within a zone or section of a machine where and when an operator may be present.

(This approach should not be confused with Lockout-Tagout (LOTO), which is a mode used when a machine is being serviced. In this mode, maintenance personnel engage the dump valve in the machine's pneumatic system, removing and exhausting compressed air energy. Then, the machine power is disconnected and a physical lock is installed on the dump valve. This ensures that the machine's pneumatic system cannot be inadvertently restarted.)

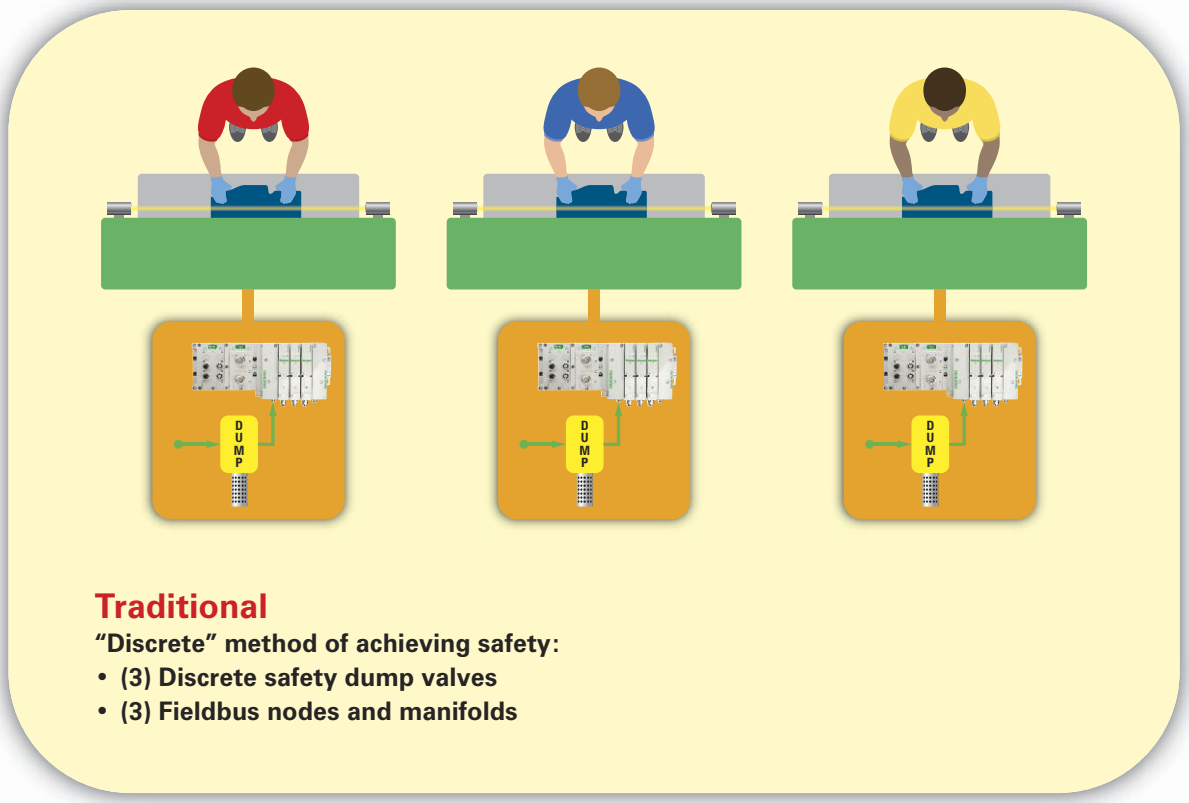
Zoned safety offers many benefits over traditional discrete safety circuits, while allowing for adherence to the Machine Directive and ISO 13849-1 requirements.

Traditional Pneumatic Safety Circuit Design – Using Redundant Safety Dump Valves

Envision a production line with an operator loading a part inside a welding machine. When the operator enters or reaches into the machine environment, all equipment motion must stop to ensure safety. In the past, this has been accomplished by dumping the air to the entire machine's pneumatic system.

To meet this requirement, equipment designers have typically employed redundant safety dump valves and other complementary products at each operation. These components implement the safety circuitry that shuts off the pneumatic system's air supply, dumps the air, and disables the operation. This solution can add significant complexity to machine design, manufacture, and installation. Also worth noting, when used in a continuous cycle fashion as identified below (figure 1), a redundant dump valve's life cycle capability may not allow the user to achieve the required PL level. Additionally, employing a redundant safety dump valve at each operation to meet the ISO 13849-1 standard adds unnecessary cost.

Figure 1: Traditional Method

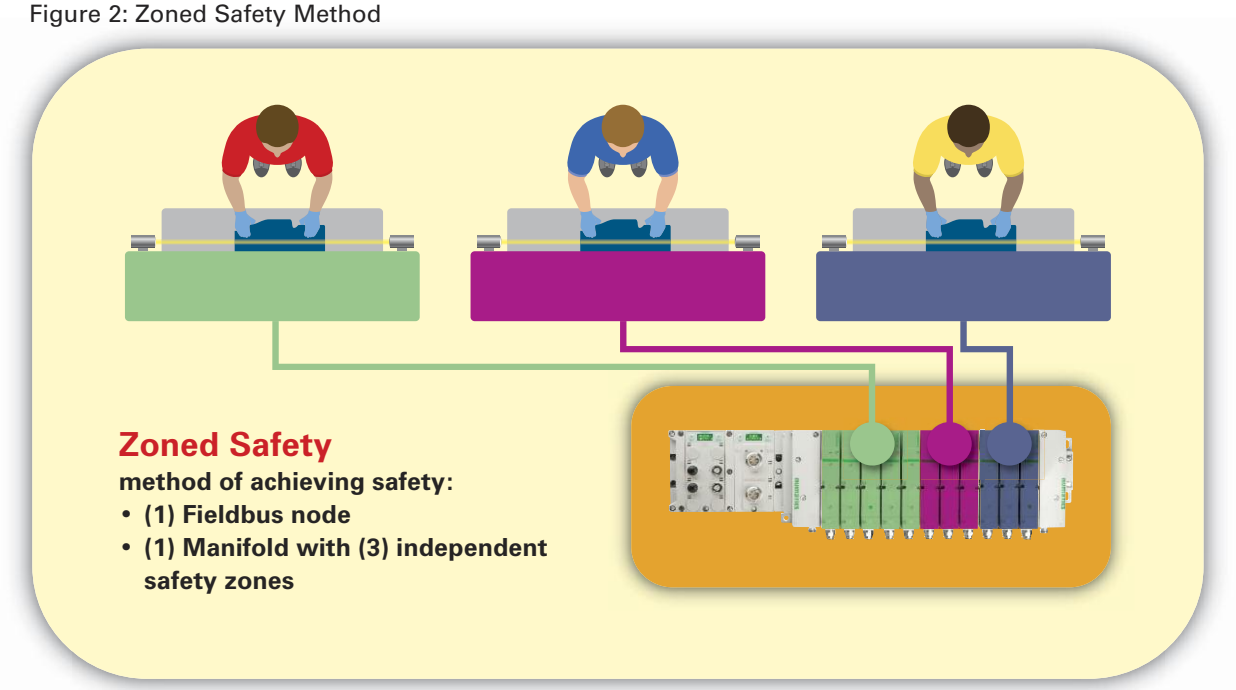


A Better Way to Achieve Safe Machine Operation

While dumping air to an entire machine has historically fulfilled safety requirements, we know there are times when only a section of the machine must be safely disabled while keeping the rest of the machine operational. With this goal in mind, ASCO engineers pursued a simpler and less expensive approach to safety that would meet the requirements of the Machinery Directive and ISO 13849-1. The result was the Numatics 500 Series zoned safety manifold — an integrated scalable approach to safety control. This approach provides multiple safety zones with the ability to have separate and redundant features for each of the safety circuits, while allowing non-safe zones to co-exist on the same zoned safety manifold, taking full advantage of the existing communications and I/O components.

The Numatics 500 Series valve manifold with G3 fieldbus electronics is the platform that delivers zoned safety. It has the ability to control and reliably disable multiple and independent groups of pneumatic valves that operate a section of a machine. By using the 500 Series' capability to integrate up to three electro-pneumatic safety zones within one manifold assembly, air and power are disabled only to the components in the zones that control equipment that will come in contact with the operator. The rest of the machine can remain in operation when these safety circuits are enabled. (See figure 2.)

Figure 2: Zoned Safety Method



Because zoned safety capability is designed into the standard Numatics 500 Series valve manifold platform, no redesign or safety redundant dump valve is required for zone control and the user has optimal choices when selecting valve options, accessories, and flow requirements. The assembled product is very similar to a standard manifold that has been used by OEMs and machine builders for many years.

The Benefits for OEMs and End-Users

There are multiple benefits that OEM machine builders will derive from the zoned safety manifold concept. Perhaps the most important is the ability to greatly simplify the design of a redundant pneumatic safety circuit with a manifold system. No longer is a discrete safety circuit — with multiple redundant dump valves and other components that add complexity and higher cost — required to safely isolate sections of the machine.

Multiple independent safety circuits can easily and cost effectively be designed into a single pneumatic valve manifold. This can reduce the number of safety system components by up to 35%, optimizes the use of safety networks, and requires less plumbing. The approach also shrinks the size of the safety system and permits valuable real estate within the machine and manifold to be used for other purposes.

For most OEM machine builders, designing multi-zoned safety circuits with a Numatics 500 Series manifold will be a familiar and user-friendly experience. Only the ability to redundantly remove power and pilot air to the safety system valves has been added. In addition, the product selection and ordering process is very similar to purchasing a standard Numatics 500 Series valve manifold.

For equipment owners and operators, zoned safety will simplify and reduce cost while optimizing the safety of their machines. Best of all, productivity and asset availability will be improved, since the user does not have to shut down the entire machine when safety circuits are enabled.

Conclusion

The implementation of the Machine Directive 2006/42/EC and ISO 13849-1 has put an emphasis on the design and manufacture of safe production equipment. Traditionally, discrete pneumatic safety circuits have been designed using dump valves and other components to achieve diverse redundancy. However, these safety systems are complex, costly, and frequently require the shutdown of the entire production machine.

ASCO engineers have developed a new approach called zoned safety. This concept is an integrated approach to safety control that leverages the unique capabilities of the Numatics 500 Series valve manifold. The 500 Series can create up to three independent

electro-pneumatic safety zones, while also allowing independent non-safe sections to co-exist within one manifold assembly. Air and power are disabled only to the components controlling equipment that might come in contact with the operator. The rest of the machine can remain in operation when these safety circuits are enabled.

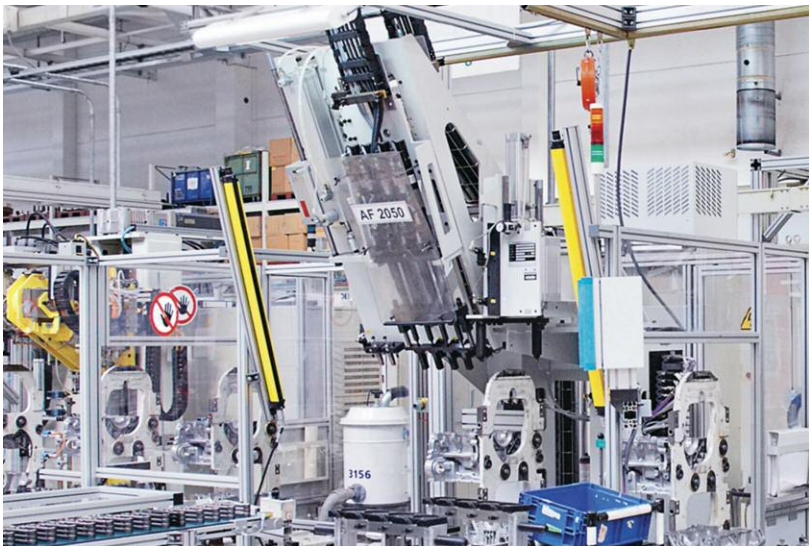
Zoned safety greatly simplifies safety circuit design and reduces the number of system components. Its use is strongly recommended for any pneumatically controlled production equipment requiring Machine Directive 2006/42/EC and ISO 13849-1 compliance.

Applying Zoned Safety in an Automotive Workflow

An automated machine has three loading stations. As parts move down the line, an operator adds a stamped metal part to the welded assembly. To avoid injury, the operator should not put his hands into the active loading area. To ensure safety, the operator must walk through a light curtain that disables the power and pilot air (only to the redundant pneumatic valves controlling the moving components in the work station), preventing unwanted motion. He loads the part into a fixture, walks back out through the light curtain, initiates operation, and the machine restarts.

The operator's safety must be guaranteed while in the loading zones per the Machine Directive and ISO 13849-1. The conventional way to implement a safety function would be to have one manifold dedicated to the safety circuit in the first loading station. Feeding that manifold would be an expensive redundant safety dump valve. A duplicate manifold and dump valve would be installed for the safety circuits in the second and third loading zones, as well.

With a zoned safety approach, a much simpler design is possible that allows safety operation without the need to dump air to the entire manifold. Three independent zones within a single Numatics 500 Series manifold would independently control the safety function in the three loading stations. The additional manifolds, dump valves, and fieldbus nodes shown in Figure #1, would not be required.



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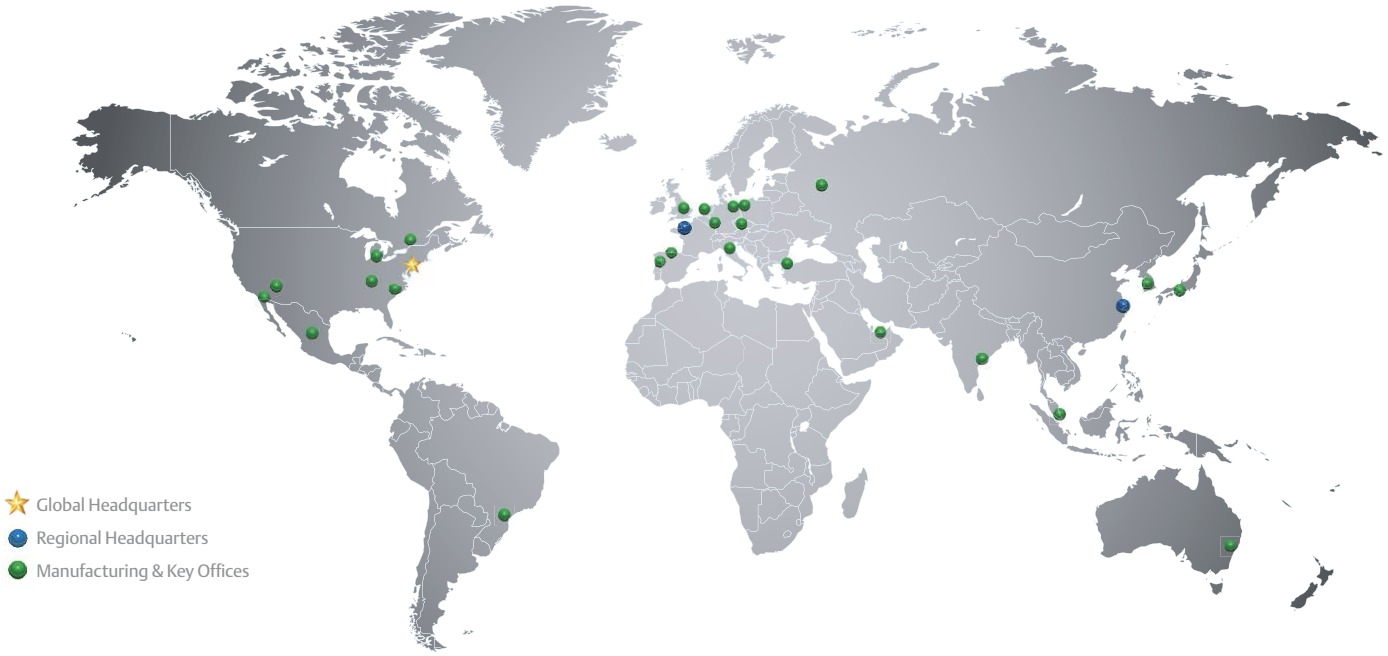

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