Improving Manufacturing Safety and Performance Using an Integrated Risk Management Model

How Effective Management of Productivity, Quality, Risk and Safety (PQRS) drive manufacturing profitability and sustainability

Rockwell Automation

ZURICH®

P = Productivity
Q = Quality
R = Risk
S = Safety

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How Effective Management of Productivity, Quality, Risk and Safety (PQRS) drive manufacturing profitability and sustainability

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"With the ability to identify the failure and solve problems quickly, we have dramatically increased productivity by reducing up to 70 percent of the safety breakdown time."

The widespread belief that productivity is the sole key to gaining a competitive advantage in today's global marketplace is oversimplified. Forward-thinking manufacturers recognize that driving profitability and a sustainable competitive edge requires a broader, more strategic approach to managing the relationship between Productivity, Quality, Risk and Safety (PQRS).

In the following pages, we will outline a model based on the PQRS construct, and describe in detail how best-in-class manufacturers use automation, real-time risk management, proactive safety programs, and risk performance metrics to improve safety and business performance.

For years, many employers have viewed a productive, competitive operation as being at odds with meeting safety regulatory requirements and reducing injury and incident rates. More recently, updated global standards and technology developments have created an environment in which safety and productivity can not only coexist, but prosper with mutual success.

Employers are required by law, and by social responsibility, to provide a safe working environment, while also being required by shareholders to deliver profit. Best-in-class manufacturers have realized that they can attain both of these critically important yet seemingly conflicting goals by taking a broader, more strategic approach to their operations.

Rockwell Automation and Zurich recommend that manufacturers focus operational efforts to establish standards of excellence and risk performance metrics in the areas of PQRS. By developing initiatives and implementing technologies that support a PQRS model, manufacturers can drive profitability while creating and sustaining a true competitive advantage.

Diving Deeper into the P, Q, R and S

The four key indicators of this strategic approach to manufacturing performance are:

Productivity: Manufacturers should employ programs and technologies that positively impact production by decreasing the frequency and severity of lost time due to injury, equipment outages or maintenance tasks. This could include implementing advanced safety technologies and techniques that integrate the safety system with the rest of the automation system, providing platforms with increased diagnostics, and with capabilities such as safe-speed monitoring and zone control. Unlike conventional systems where safety and standard automation are kept separate, these strategies can enable operators to safely perform maintenance tasks without shutting an entire system down, and reduce nuisance shutdowns and time required to bring a machine back to a safe operational state.

Quality management: A true competitive edge requires an understanding of, and commitment to, established product quality specifications and standards. Manufacturers can improve quality and decrease potential future product liability in several ways, including:

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- Supplier prequalification screening and selection processes that preclude those who do not have established criteria, such as required quality inspections demonstrating compliance to U.S. Consumer Product Safety Commission safety standards. Some criteria may include adhering to a specified reduction of packaging materials or complying with specified percentages of recycled content in product packaging.
- Intellectual property protection efforts that provide a defense against copyright, trademark or patent infringements. Intellectual property not only includes the formulas for producing manufactured products, but may also include the manufacturing techniques, technologies, and software programs that produce products.
- Contractual risk transfer, including specified insurance coverage and limits, indemnification requirements, and hold-harmless agreements.
- Quality inspections during and after production to verify finished product quality matches specifications and inspection forms.

Risk management: A formalized and systematic risk management strategy can help manufacturers put essential risk management controls in place. A formalized risk management strategy utilizes a safety life cycle approach, which begins with a risk assessment to identify the risks and hazards that can negatively impact safety. It also becomes the basis for a risk mitigation plan that includes the design, verification, validation, and maintenance of equipment.

Safety: Best-in-class manufacturers also create a top-down management commitment to, and accountability for, a companywide culture of safety. This includes adopting global safety standards, and implementing safety automation technologies, innovative design approaches, and other initiatives to deliver significant business and economic value.

Automation Safety Improves Productivity

Today, manufacturers around the globe are proving that protecting workers on the plant floor can also help improve efficiency, productivity, and business performance, ultimately helping create differentiation in the marketplace.

A recent study by the Aberdeen Group and sponsored by Rockwell Automation measured the relationship between automation safety and productivity. The study found three categories of manufacturers: best-in-class, industry average and laggards (see chart). The study defined best-in-class manufacturers with four key performance indicators (KPIs) deemed critical to the success of the safety program and plant safety:

1. Overall equipment effectiveness (OEE),
2. Repeat accident rate,
3. Injury frequency rate and
4. Unscheduled asset downtime.

To help achieve success, everyone, including operators, maintenance technincians, risk managers and safety professionals, must value safety and embrace it daily.

Best-in-class companies achieved significant improvements over their counterparts, including:

- 5 percent higher OEE
- 4 percent less unscheduled downtime
- Significantly fewer injuries (1 in 2000 employees vs.1 in 111 employees) and repeat accidents (0.2 percent vs. 2.4 percent) than the industry average

Many of today's manufacturing applications keep safety technology separate from standard automation systems. However, the Aberdeen study revealed that best-in-class manufacturers are integrating the two systems. A single, uniform control platform minimizes the need to manage two disparate systems while reducing hardware, software and labor costs. Most importantly, integrated safety systems provide excellent diagnostics that assess overall machine status when determining potentially unsafe conditions to help reduce nuisance shutdowns and prolonged restarts. Diagnostics also provide operators and maintenance personnel with information and direction that can significantly reduce unscheduled downtime.

To help achieve success, all production team members, including operators, maintenance technicians, risk managers and safety professionals, must value safety and embrace it daily. This can mean a real change in a company's culture. To enable real change, an organization needs to have a long term vision and appoint an executive to drive this vision.

The Aberdeen study found that 82 percent of best-in-class manufacturers have an executive sponsor driving safety initiatives. With buy-in of everyone from upper management down, safety can become a core value throughout an organization, making it easier to adopt new safety technology.

Without executive sponsorship of programs that place safety above competing interests, manufacturers risk developing a culture in which workers and supervisors believe that overriding safety systems is acceptable in the interest of increasing production.

Clearly, companies that foster a safety culture and invest in advanced automation technologies, including systems that integrate standard and safety automation control, can create a safer work environment and increase productivity.

Defining Best-In-Class Performance

Definition of Maturing Class	Mean Class Performance
Best-in-Class: **Top 20%** of aggregate performance scorers	• 90% OEE • 0.2% Repeat Accident Rate • 0.05 Injury Frequency Rate • 2% Unscheduled Asset Downtime
Industry Average: **Middle 50%** of aggregate performace scorers	• 85% OEE • 2.4% Repeat Accident Rate • 0.9 Injury Frequency Ratev • 6% Unscheduled Asset Downtime
Laggard **Bottom 30%** of aggregate performace scorers	• 76% OEE • 10% Repeat Accident Rate • 3.0 Injury Frequency Rate • 14% Unscheduled Asset Downtime

Source: Aberdeen Group, September 2010

Real-Time Risk Management Using Performance Metrics

Risk management metrics provide a tool for effectively assessing manufacturing risks. Traditionally, manufacturers have used lagging indicators to determine risk, such as the number of fatalities, total OSHA recordable cases, total lost workday cases, and average claim costs. Also called downstream measures or trailing indicators, these lagging indicators provide feedback on data collected and analyzed *"after-the-fact"*. However, these are passive metrics of prior results and don't provide insight into the prevention-based activities that may have influenced results (or lack thereof, if improvement over time is not experienced).

In contrast, current and leading indicators provide nearly immediate feedback on present activities. They are designed to influence real-time outcomes. Current indicators typically include a supervisor's same-day completion of an incident report or the number of on-the-job safety observations completed in a factory, plant warehouse, loading dock, or production line each day compared to an established goal. Moreover, leading indicators proactively measure defined activities to help prevent incidents of a general or specific nature. Also called upstream measures, these metrics are *"before-the-fact"* and can predict future performance.

The most important outcome of a leading indicator approach is that it focuses on continuous risk reduction. Shifting from lagging data to leading indicators can help a company reduce risk and the total cost of risk, thereby improving competitive advantage.

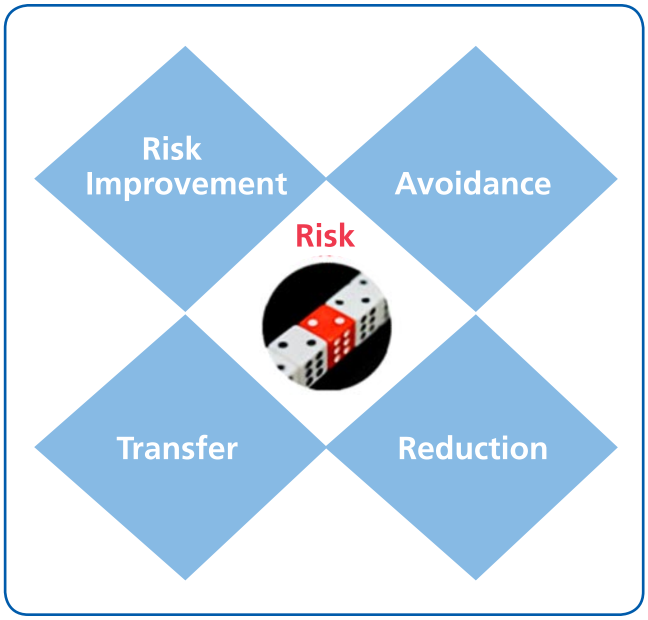
Examples of lagging, current and leading indicators for safety

Lagging (past results)	Current (present snapshot)	Leading (prevention activities)
• Workers' Comp Experience Modification Rating • OSHA Total Recordable Incident Rate (TRIR) or Days Away from Work Restricted or Transferred (DART) • Total lost workdays • Average cost per claim	• Daily record of incidents • End-of-shift record of inspections conducted • Daily job safety observations conducted • Unsafe conditions or *"at-risk"* action/corrected	• Number of safety orientations conducted • Percentage of safety and quality inspections completed • Number of safety briefings/meetings held • Number of root cause analyses conducted on actual and "near hit" (in italics) incidents

Example of PQRS leading indicators for a manufacturing organization

Productivity	Quality	Risk Management	Safety
Average production costs per unit	Cost of reject products	Number of vendors and suppliers pre-approved with signed contracts in place	Average number of hours required to investigate safety violations, near misses, or accidents
Average overtime hours per employee	Defective rate (#, %)	Percent of vendors/suppliers pre-qualified on basis of risk criteria	Employee safety suggestions implemented (#, %)
Average time incurred per product	First pass yield	Percent of loss costs charged back to departments	Number of safety violations, near misses, or accidents caused by unsafe acts
Reduced variance in cycle times	Good components in final assembly (%)	Indirect costs as a percent of sales	Number of safety violations, near misses, or accidents caused by unsafe conditions
Idle or nonproductive time as a percentage of total time	Parts per volume accepted (%)	Operating expenses as a percentage of net sales	Production loss due to safety violations, near misses, or accidents ($, #)
Increased labor utilization efficiency rate	Products meeting specifications (%)	Percentage of preventive maintenance costs to total maintenance costs	Number of safety orientations conducted within an allotted time frame for all new or transfer employees (ratio)
Number of products using common processes (flexibility of production design)	Reject rates (%)	Profits as a percentage of sales (%)	Safety behaviors (e.g., safety training and awareness activities, safety monitoring/ inspections) (range)
Total downtime or process stoppages due to process problems (equipment out of spec)	Rework cost as a percentage of total production cost (%)	Top five types of health and worker's compensation insurance claims (#, $)	Safety results (e.g., number of days with no safety violations or incidents)
Production rate (e.g., # per production run, per employee, per labor hour, or per machine hour)	Rework cost or rate (e.g., number / percent of off-spec products)	Turnover of full time permanent employees (%)	Safety violations noted per week and corrected within an allotted time frame
Total productivity factor (outputs/inputs)	Number of suppliers pre-qualified based on quality standards	Unit cost versus competitors' unit cost	Training time/investment per employee (total time, or time / employee)

PQRS Operational Impacts: Risk Examples



Risk in the PQRS model focuses on risk avoidance, reduction and transfer to explain potential perils that can jeopardize safe and productive plant operation. A comprehensive risk analysis identifies potential perils and enables a systematic review that helps put the necessary risk management controls in place to help prevent risk.

Risk avoidance means manufacturers should evaluate the inherent risk in a current or proposed business practice to determine if the risk-to-reward ratio justifies the activity. If not, that activity should be avoided. Exercising risk avoidance frequently stems from realizing the company lacks requisite expertise or equipment to successfully compete in the market. Risk avoidance may also stem from realizing that significant operational risk may result in poor financial results. For example, a company may not accept a low-bid offer from an untested, new supplier or subcontractor before ensuring the vendor partner delivers quality product that meets specifications on time and within budget.

Risk reduction occurs when a manufacturing company intentionally decreases the amount of an activity being performed to minimize the company's risk profile. By doing so, the company decreases exposure to known or suspected perils. Sometimes risk reduction is a means to diversify or reduce aggregations of risk. It can also help reduce concentrations with any single customer or from multiple customers in a single industry. A practical example of risk reduction is when a manufacturer evaluates the relative risk of using one supplier versus multiple suppliers. A manufacturer could also decide to use a secondary or tertiary supplier of important raw materials used in production.

Risk improvement means implementing corrective risk management actions after conducting a comprehensive risk analysis of a core operation. Risk improvement is the set of strategic actions to correct, counter, or otherwise control known or suspected exposures that could result in a significant production disruption, insurance claim, or uninsured loss. A practical example of risk improvement is to evaluate machine guarding in factories experiencing a "near hit" incident. The company may investigate the root cause and contributing factors of a "near hit" incident and institute a risk improvement plan to evaluate all machine guarding in the plant and all other production locations.

Risk transfer is a deliberate process involving manufacturers and various stakeholders engaged in legal agreements. Examples include contracts, purchase orders, vendor agreements, change orders, product specifications and design drawings. Risk transfer involves allocating the risk to the party that is most closely responsible for performing risk-generating activities. For example, a manufacturer can transfer the risk exposure associated with substandard product quality to a supplier or a sub-tier manufacturer to contractually obligate them to rectify the defective product. Risk transfer is best accomplished in a binding legal agreement and when it addresses both insurance and indemnification requirements. Insurance is a form of risk transfer known as risk financing, whereas indemnification refers to one party agreeing to provide a legal defense in the event of an insurance claim or loss.

Developing a Proactive Safety Program

Too often, manufacturers implement safety programs and technology as an afterthought in response to an accident or new industry standard, instead of in anticipation. In the past, the limitations of safety technology also contributed to this reactive approach. The technology often required machines to come to a full stop and be in a safe state for repair or maintenance. Because downtime decreased productivity, operators and maintenance personnel often bypassed safety systems and put people and equipment at the risk of injury in the process.

Rigorous global safety standards, technology innovations and thorough risk management techniques now make it possible to develop a more proactive approach to safety programs. While each manufacturer should customize a safety program to its specific needs, following are eight best practice steps for creating a proactive safety program:

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1. Conduct a thorough risk assessment

   A risk assessment identifies the areas of risk on a machine or within a facility, and helps pinpoint the best people and technology to help minimize those risks. A risk assessment also helps companies establish acceptable levels of risk for their operations, which in turn helps determine what safety products they need. Performing a risk assessment up-front helps guide the direction for an effective machine guarding strategy, which is designed to help protect a company's investment in both personnel and machinery.

   In addition, global safety programs often include implementing an audit of all existing machines and prioritizing risks based on the frequency of exposure and potential severity of injury.

2. Reduce Potential Hazards through Design

   The best way to reduce a potential hazard is to design it out of the machine. Eliminating a hazard by designing a machine to function without putting workers at risk and implementing the right safety technology in the design phase of machine development is more effective than applying physical guarding (such as fencing or barriers) or monitored access (such as light curtains or safety mats). This includes when guarding or monitored access is combined with administrative means such as signs, warnings or annunciation lights. When machine designers conduct a risk assessment and review the resulting documentation at the earliest stages of inception, they can more effectively reduce hazards – such as pinch points or sharp edges – that would have required guarding. It also helps confirm that machines are designed with the safety and integrity of the machine in mind at an early stage in its development.

3. Consider Machine Guarding

   Sometimes hazards cannot be eliminated through design. In these cases, hard guarding in the form of a physical barrier provides more protection at a relatively low cost. Determining how frequently a machine or area must be accessed helps refine the list of possible solutions. It's also important to make sure the solution itself doesn't cause another hazard.

4. Add Advanced Controls

   If a hazard cannot be designed out, and physical barriers and guarding are impractical for machine operation, engineers can apply machine controls to detect unsafe machine conditions and place the machine in a safe state to help protect workers. Electromechanical safety relays have been the backbone of safety control design for decades, offering a wide variety of functions and features, but there is a strong trend toward configurable or programmable safety-rated controllers because they provide flexibility and help improve productivity. These devices contain software required for critical safety functions and can take direct inputs from most safety devices, such as light curtains, emergency stops and mechanical interlocks. Advanced safety systems may also include safety technology embedded in servo devices or variable frequency drives to further improve functionality, while helping maintain a safe working environment.

5. Promote Awareness

   It's always vital for workers in the vicinity of operating equipment to be aware of their surroundings in order to help protect their safety. Sometimes reducing levels of potential risk can be as simple as encouraging safety awareness throughout the plant. Awareness techniques can include adding appropriate signage, as well as using visual and audible awareness devices and annunciators such as stack lights or alarms. Awareness devices must be positioned where they will best serve their intended purpose. It is also important that audible signals can be heard over normal operating noise, and that they comply with current standards and regulations. A plantwide program to emphasize avoiding particular types of incidents can also help. Signage recognizing the number of days worked without a lost time injury further reinforces safety focus.

Appropriate instruction and training on safety procedures is critical for all employees who could be exposed to machine or process hazards.

6. Provide Training

   Appropriate instruction and training on safety procedures is critical for all employees who could be exposed to machine or process hazards. Participation in training programs should be mandatory for all employees. Employees must be educated on all types of equipment they will be working with and around.

7. Conduct Follow-up Assessments

   After installing safeguards, it's important to conduct follow-up assessments to verify the potential risk level was reduced to an acceptable level. Periodic follow-up assessments of safety policies, procedures, methods and practices are critical to confirm that specific programs are being followed and are still effective.

8. Seek Experience and Expertise

   Suppliers well-versed in automation, safety and the current standards and regulatory requirements that apply to the manufacturing environment are highly valuable when embarking on a safety program design or review. These partners should have a thorough understanding of the risk assessment and risk reduction process as well. Manufacturers often seek third party expertise for safety assessment services to help with objectivity.

Creating a safety program with these eight best practice elements will help set the path for a more proactive approach to reducing risk and improving safety, while increasing productivity. It can also help shift the focus of risk performance from measuring negative outcomes to gauging success based on positive results and forward-looking improvements.

[1] Aberdeen Group, A Risk Management Approach for Improving Safety and Productivity, October 2010

[2] "Risk Performance Metrics," Calvin E. Beyer, CFMA Building Profits, September – October 2007

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