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MACHINERY SAFETY challenges machine designers and employers as they try to reduce injuries and costs associated with unsafe worksites.

A safe workplace prevents loss of production, loss of hard assets and lawsuits arising from injuries. Injury prevention, the most important reason for safety, reflects the value that society and employers place on human life.

The biggest problem facing employers and machine builders isn't meeting the requirements; most machine builders are already building reasonably safe equipment. The problem is lack of information about the requirements. This article will examine the scope of workplace injuries, new government regulations geared to increase safety, and how to complete the required pre-start reviews successfully.

The Ontario Health and Safety Act, 1990 (OHS Act) is the law that governs workplace health and safety in the province. Regulation 851, Industrial Establishments, provides specific requirements for industrial workplaces.

Workplace injuries are declining in North America specifically because machine builders have continued to improve machinery safety in response to stricter regulations and to reduce their exposure to lawsuits arising from injuries caused by their products.

The government passed Regulation 528/00 in November 2000, amending Sections 7 and 8 of Regulation 851 and introducing the pre-start review (PSR) on new and modified facilities, processes and equipment. Pre-start safety reviews provide equipment owners with a method to ensure that their equipment meets the minimum requirements outlined in the regulations.

Focus on safety

Workplace injuries are declining in North America specifically because machine builders have continued to improve machinery safety in response to stricter regulations and to reduce their exposure to lawsuits arising from injuries caused by their products.

A paper prepared by the Ontario Ministry of Labour in January of 1998, states: "Worker injury is a daily occurrence in Ontario workplaces. In 1996, there were over 100,000 serious injuries, 241 deaths, and more than six million working days lost. Each injury carries with it the enormous human cost borne by the victims, their families and friends.

There are also financial costs. In 1996, compensation benefits of \$2.4 billion were paid out, and indirect costs have been estimated

to raise the annual total bill for workplace injury to over \$10 billion.

But these figures also show the huge potential savings that could be realized if there were a substantial reduction in workplace illness and injury."

In the drive to reduce workplace injuries, the Ministry began enforcing the legislation more actively than in the past. The Ministry of Labour set the goal of reducing workplace injuries by 30 percent over the five years from 1995 to 2000. In that time, workplace injuries dropped by almost 28 percent (occurring in 1997). Despite the efforts of the Ministry of Labour, from 1997 to 1999, injury claims in the two largest categories, manufacturing and service, increased by almost five percent.

In 1999, most accidents (80,114 or 22.4 percent) reported to the Workplace Safety and Insurance Board (WSIB) took place in the manufacturing sector. The second-highest amount, 79,919 accidents (22.3 percent of the reported accidents), took place in the construction sector. Between 1995 and 1999, injuries decreased 14.2 percent from 118,814 to 100,726.

Indirect costs to the company make up the rest of the total costs, including:

- 1.** Property damage
- 2.** Lost production
- 3.** Manager and supervisor time
- 4.** Compliance costs associated with Ministry of Labour orders
- 5.** Lower employee productivity while on light duty.

Employer obligations

Regulation 851 applies to all Ontario industrial establishments and holds Ontario employers responsible for providing a safe and healthy workplace and for any workplace injuries.

In November 1997, the Ontario government introduced Regulation 450/97 amending Regulation 851. Regulation 450/97 introduced the requirement for safety oriented design review before new plants, processes or equipment could be installed. These reviews were called pre-development reviews (PDR).

Regulation 450/97 had several flaws, the most significant being the breadth of the terminology used to define the actions of engineers when reviewing new designs. After consultation

How to meet pre-start safety review requirements

by Douglas S. G. Nix, C.E.T.

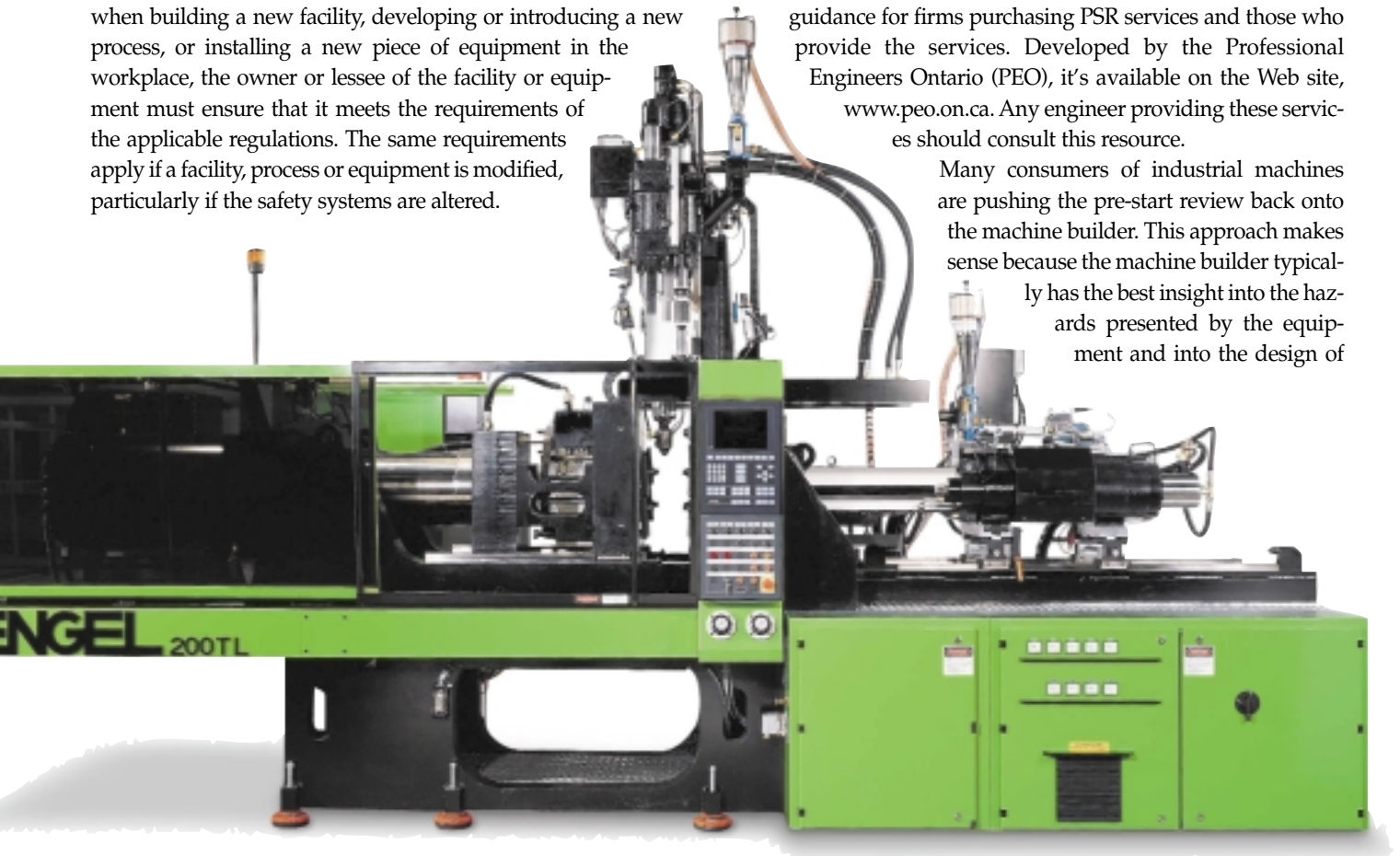
with industry and engineering firms providing PDRs, the government released a revised regulation in December, 2000 to replace 450/97, clarifying the requirements for engineers and employers and introducing the pre-start health and safety review (PSR).

Section 7 of Regulation 851 now provides the tools to ensure that workers and employers are protected. This section says that when building a new facility, developing or introducing a new process, or installing a new piece of equipment in the workplace, the owner or lessee of the facility or equipment must ensure that it meets the requirements of the applicable regulations. The same requirements apply if a facility, process or equipment is modified, particularly if the safety systems are altered.

The Ministry of Labour's Guidelines for Pre-Start Health and Safety Reviews, available in hardcopy and on the Internet (see sidebar), provides useful flowcharts to help reviewers determine the need for and the scope of the review.

Professional Engineers Providing Reports for Pre-Start Health and Safety Reviews (November, 2001) provides excellent guidance for firms purchasing PSR services and those who provide the services. Developed by the Professional Engineers Ontario (PEO), it's available on the Web site, www.peo.on.ca. Any engineer providing these services should consult this resource.

Many consumers of industrial machines are pushing the pre-start review back onto the machine builder. This approach makes sense because the machine builder typically has the best insight into the hazards presented by the equipment and into the design of



Reviewers must also evaluate any machine modification that could affect the safety of the operators or the maintenance personnel. An exemption exists for equipment that comes from the manufacturer certified to meet the latest health and safety standards, such as CSA Z432 or ANSI Z136.

Review guidelines

Section 7 of Regulation 851 states the requirements for the content of pre-start reviews, but more detailed guidance is available elsewhere.

the safety systems built into the equipment. The drawback is that the depth and quality of the reviews vary from vendor to vendor.

The regulations require that licensed professional engineers (P.Eng.) complete the reviews, although under certain circumstances, other 'uniquely qualified' personnel may contribute. Staff engineers or consulting engineers can complete the reviews.

If the machine builder's staff engineers are completing these reviews, the business needs to carry the appropriate license from PEO for provision of engineering services. The company

and the engineer require corporate and personal liability insurance to protect the business and the individual engineers.

If a staff engineer from the owner is completing the review, the individual engineer carries much higher liability since there is no licensed firm involved, nor is there likely to be any formal review process. This is a considerably more risky approach, at least as far as the individual engineer is concerned.

Preparing successful reports

The regulations do not provide the engineer with much guidance on the specific content of the report. Section 7 (4) of the regulation states:

(4) A pre-start health and safety review includes the preparation of a written report that is made to the owner, lessee or employer and contains:

- (a) details of the measures to be taken for compliance with the relevant provisions of this Regulation that are listed in the Table;
- (b) if testing is required before the apparatus or structure can be operated or used or before the process can be used, details of measures to protect the health and safety of workers that are to be taken before the testing is carried out; and
- (c) if item 3 or 7 of the Table applies, details of the structural adequacy of the apparatus or structure. O. Reg. 528/00, s. 2.

The table mentioned explains how to apply specific sections of Regulation 851. The PEO guidelines best explain what should be in the report. PEO defines four basic steps to a safety review. They are:

1. Data collection
2. Review
3. Hazard analysis
4. Reporting

Data collection

The first step is to gather all the relevant information on the facility, process or machine to make an adequate risk assessment. The PEO guidelines on pre-start reviews suggest the following as a minimum:

- a written description of the process and its purpose, including component equipment, machines and devices, raw materials, products, and by-products;
- a full inventory of the processes that use or



produce designated substances, flammable substances, biological, chemical or physical agents, including details of any equipment, machine or device involved in the process;

- a process flow diagram with a full description of flow of materials, products and by-products, to show the essential flow of material;
- a process and instrumentation diagram showing the process control instrumentation;
- drawings and specifications, where the building mechanical systems are critical to keeping the process or personnel safety;
- drawings and specifications, where the building electrical systems, including the building control system, are critical to maintaining the process or personnel safety;
- material safety data sheets for hazardous materials;
- equipment electrical, pneumatic and hydraulic schematics;
- mechanical drawings;
- installation, operating, maintenance manuals and sales literature;
- bills of material including: all electrical components connected to the AC mains; all electrical and mechanical safety-related components.

The bill of material must include the manufacturer's name, type or model designation, complete electrical ratings and certification or recognition by a third-party certification organization.

Data review

The next step is to review the collected data to ensure it is complete. Then the reviewer documents the risks posed by the equipment and the methods used to reduce those risks.

Hazard analysis

The basic steps in performing a risk assessment are:

1. Identify the hazards.
2. Assess the severity of injury that the hazard presents.
3. Assess the frequency of exposure to the hazard.
4. Assess the probability of involvement with the hazard.
5. Analyze the risk based on the data developed in steps 2-4.

The highest level of safety for the lowest costs starts with inherently safe design, then safeguarding and finally a warning of residual risks. Inherently safe design eliminates hazards by design. Any remaining hazards are safeguarded. In some cases, adequately safeguarding a hazard while maintaining the functionality of the design is impossible. If so, warnings are applied. Each step in this process is less effective than the preceding step; the design stage costs less and most effectively prevents injuries. The final stage is to recommend personal protective equipment.

Assess the risks first with the machinery in the unguarded state, regardless of any guarding that may have been built into the equipment by the manufacturer. This helps the reviewer to understand the risks presented by the process or equipment.

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For more information...

- **Ontario Ministry of Labour**

<http://www.gov.on.ca/LAB/main.htm>

- **Occupational Health & Safety Act**

Http://192.75.156.68/DBLaws/Statutes/English/90o01_e.htm

- **Regulation 851**

http://192.75.156.68/DBLaws/Regs/English/900851_e.htm

- **MoL Guidelines on PSR's**

http://www.gov.on.ca/LAB/ohs/g_psre.htm

- **PSR Guidelines from PEO**

<http://www.peo.on.ca/publications/guidelines2001/2001GPEP.pdf>

- **Workplace Safety & Insurance Board**

<http://www.wsib.on.ca>

STANDARDS

- **ANSI**

<http://webstore.ansi.org/ansidocstore/default.asp>

- **Global Engineering Documents**

<http://www.global.ihs.com>

- **ILI-Infodisk**

<http://www.ili-info.com/us/>

Then factor in the original safeguards provided by the manufacturer. If the machinery is a new design, decide on specific risk reduction methods. The reviewing engineer must then re-evaluate risks and the level of residual risk determined. If the residual risks are still too great, the reviewer repeats the risk-reduction process until reaching a tolerable level of risk.

Three European safety of machinery standards offer excellent guidance on this process:

- **EN 292-1** — Basic concepts, general principles for design — Basic terminology, methodology
- **EN 292-2** — Basic concepts, general principles for design — Technical principles and specification
- **EN 1050** — Principles for risk assessment

These standards are also available in a similar form as the following ISO documents:

- **ISO/DIS 12100-1** — Basic concepts and general principles for design — Part 1: Basic terminology and methodology
- **ISO/DIS 12100-2** — Basic concepts and general principles for design — Part 2: Technical principles
- **ISO 14121** — Principles for risk assessment

North American standards that cover these subjects include:

- **ANSI B11.TR3** A guide to estimate, evaluate and reduce risks associated with machine tools
- **ANSI RIA 15.06** Industrial robots and robot systems
- **SEMI S10-1296** Safety guideline for risk assessment

Reporting

The reviewing engineers must develop the report's content based on the machine and the specific portions of Regulation 851 that apply.

The report should contain the design drawings, risk assessments and validation checklists that have been used to assess the equipment. In addition, the reviewer should include any relevant supporting documentation including catalog cut-sheets.

The final and most important document is the letter of confirmation. This is the document that the Ministry of Labour looks at during an inspection. The letter of confirmation attests that the machinery, in the opinion of the reviewing engineer, meets the requirements of Regulation 851. The Ministry will also look at the list of the applicable sections of the regulation.

Common errors

The most common mistake made in this process is to leave the risk assessment process to the end of the manufacturing cycle. The cost of implementation is inversely proportional to the point in the design cycle where the work takes place.

If the design process incorporates both risk assessment and risk reduction, design can eliminate hazards, reducing the need for guarding and other safety management methods. Also, the safer design reduces the manufacturer's liability, helping to control insurance costs and potential civil damages.

The next most common error is to ignore the standards that are available for design. These documents, available for a small cost, provide designers with the necessary basic elements. When the designer applies the standards during the design process, the company may avoid making modifications during the design review stage.

Statistically, the machines posing the greatest liability risk aren't those that a machine builder is designing today, but the 25-year-old machines that are in the field. Several U.S. companies have been held responsible for machines that were built long ago, occasionally by predecessor companies.

Finally, there is the erroneous 'train and hope for the best' approach. The basic risk assessment and reduction process requires that hazards are eliminated first by design, then guarded where they cannot be eliminated and finally warned about where they cannot be eliminated or guarded. This process does not allow for 'train and hope for the best', nor should it. Basic respect for people should preclude this approach.

The highest performance companies are those that are self-sufficient, however, many smaller firms cannot afford the cost of internal expertise. It makes good sense for these companies to hire the services provided by consulting engineers so the small firms can meet the same safety standards as large corporations.

Knowing the process, the materials and the hazards are the first step. The keys are knowledge and the expertise to apply that knowledge. Taking the time to use the standards can provide major cost savings and reduce future liabilities.

The goal of the regulations, the pre-start safety reviews and better machinery design is fewer injuries, lower costs and greater productivity. ■

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