

The Locomotive

Risk-Informed Fire Protection

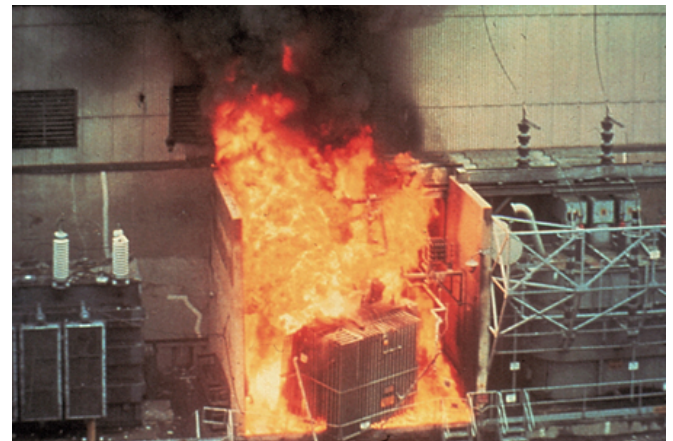
By Thomas F. Barry, P.E., and Theresa Stone, HSB Professional Loss Control, The Hartford Steam Boiler Inspection and Insurance Company

Fire Safety And Tight Budgets

Fire safety specialists are meeting the challenges posed by a decade of downsizing and other corporate restructuring with a new way to look at fire and explosion hazards. The methodology, which has been under development for several years in highly hazardous industries, such as chemical processing and nuclear power generation, is attracting quite a bit of attention as plant managers struggle to stretch already-tight maintenance budgets. As the learning curve for this methodology improves, leaders within other highly hazardous industries, such as nuclear/hazardous waste remediation, seem increasingly eager to test its effectiveness.

A New Approach

A risk-informed, performance-based approach to fire protection offers an increasingly acceptable alternative to strict adherence to code requirements alone. Such an assessment of a facility's fire protection systems may be more reliable for two reasons:



1. Depending on the plant, process, system or budget, strict adherence to code requirements could be too costly to implement and maintain.
2. In addition, codes usually are written to apply to a typical situation or configuration; and no one will deny that exceptional situations arise requiring more or less stringent, or different, fire protection than that called for by the codes.



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Performance-Based

The risk-informed, performance-based approach presents a more realistic prediction of potential fire and explosion hazards for a given system or process or for an entire operation. The approach is performance-based because it provides solutions based on performance to established goals rather than on prescriptive requirements with implied goals. Solutions are supported by data from operators and management about processes, equipment and components, the buildings or structures housing them, operating and maintenance personnel, and the fire protection systems in place. Published performance data pertaining to these aspects also is incorporated into the analysis.

Risk-Informed

The approach is risk-informed because the analyst factors in, not just the severity of a fire or explosion — usually measured in dollars — but also the likelihood that the fire or explosion will occur.

For example, based on the knowledge and experience of the equipment operator, a fire in a given turbine generator is likely to occur 80 percent of the time. Or, based on the knowledge and experience of the fire protection engineer, the sprinkler system protecting that generator is 90 percent likely to be able to contain and suppress that fire. Because the risk-informed, performance-based methodology quantifies the likelihood of a fire hazard — and the likelihood that the fire protection system will contain or extinguish the fire — it provides a more realistic prediction of the actual risk.

Wider Acceptance

Although this method of determining fire and other risks has been used in certain highly hazardous industries for almost two decades, its use has not been evident with other occupancies, such as residential or commercial structures. This may change, however.

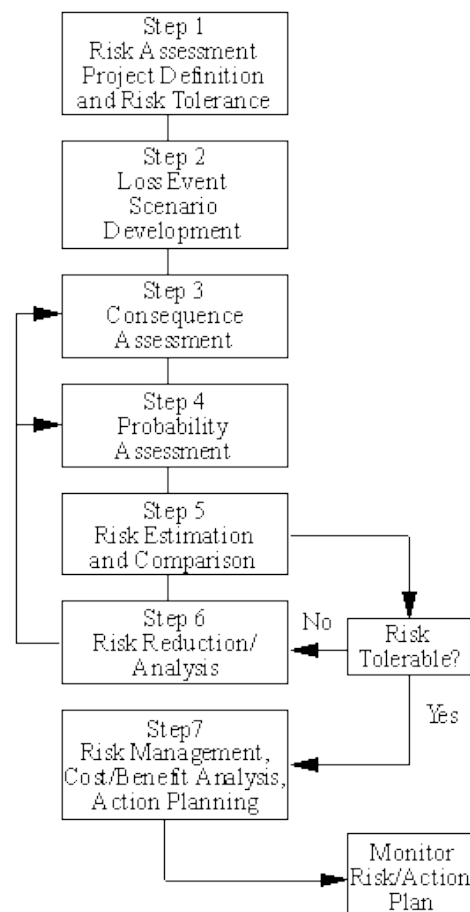
The International Fire Code, which is slated to be issued in the year 2000, is currently incorporating language that will increase the acceptability of performance-based, rather than strictly code-based, fire protection. Similarly, the National Fire Protection Association has begun a process to develop

performance-based fire standards. The Life Safety Code (NFPA 101) is among the National Fire Codes that will contain performance-based provisions by the year 2000.

Within the next five years, facility designers and managers will witness increasing tolerance within these codes toward performance-based alternatives to code requirements.

The Basic Method

The basic methodology, which is also known as quantitative risk assessment, is very similar to what the nuclear power industry dubs probabilistic risk assessment; and it can be applied to a wide variety of risks. Although variations of the methodology are used, a typical risk-informed, performance-based assessment would follow the basic sequence of events depicted in the flow chart (see figure below).



A Case Study

A recent application of this methodology by HSB Professional Loss Control at a large fossil-fuel power plant illustrates the approach. The primary objective of the plant was to determine the most effective budgetary allocations. In this case, the plant had undergone several years of downsizing. Equipment in many areas of the plant also was nearing the end of its life cycle.

Step 1.) Project Definition and Risk Tolerance: The fire-protection analyst met with key decision makers to ascertain what information the plant needed from the analysis and the objectives of the plant for using the information. Those individuals defined the performance goals for the fire protection systems by determining the plant's risk tolerance levels — how much they were willing to assume from a fire incident. In this case, management determined that \$25,000 per year per production unit was acceptable.

Step 2.) Loss Event Scenario Development: Based upon personnel interviews and other data, including as-built drawings and manufacturers' specs, the analyst compiled loss-event scenarios. These scenarios usually are developed using event trees, which plot potential sequences that could lead to a loss event such as a fire or explosion. For example, an event tree was developed which revealed that a fire on a coal-conveyor belt would be detected 89 percent of the time, and extinguished 38 percent of the times it was detected.

Step 3.) Consequence Analysis: Based on the data collected and the scenarios developed, the analyst developed event trees and fault trees to determine potential causes and consequences of each loss-event scenario. Consequence levels were determined also by using industry wide historical incident data and computerized fire models such as FPETool.

Step 4.) Probability Assessment: Again, based on plant-specific and published industry data, the analyst determined the likelihood that such a loss event would occur, as well as the likelihood that the consequences would occur. For example, the reliability of the heat detector protecting the coal conveyor belt was based upon data found in "Guidelines For Process Equipment Reliability Data, With Data Tables," published by the American Institute of Chemical Engineers. Because the detector was located in the harsh outside environment, the analyst used the upper bound heat detector failure probability from this document.

Step 5.) Risk Estimation and Comparison: Based on these probabilities, the analyst compared the existing risk to the risk tolerance levels established by management. For example, the existing risk for a coal-conveyor belt segment was more than \$58,000 — approximately 43 percent over the \$25,000 risk tolerance level established in Step 1.

Step 6.) Risk Reduction Analysis: Alternatives to reduce risks to within the tolerance levels were then evaluated. Traditional fire protection measures (e.g., detection or sprinkler systems) and management safety controls (e.g., such as loss prevention programs and emergency procedures) were evaluated to determine if their implementation would reduce risk within the established parameters. Risk Reduction Cost Evaluation Worksheets also were developed which incorporated initial installation cost, acceptance testing cost, annual maintenance cost and estimated useful life.

Step 7.) Risk Management, Cost/Benefit Analysis, Action Planning: The analyst ranked and provided a cost/benefit analysis of the risk reduction opportunities according to the estimated annualized change in risk, estimated annualized cost, and reduction in structural fire fighting response potential. Plant personnel prioritized the opportunities over a three-year and five-year implementation schedule based on a projected budget for fire and explosion loss control improvements.

Reduced Risk

This risk-informed, performance-based assessment of the plant's fire and explosion hazards and protection systems resulted in information which far exceeded that gained from a simple code compliance review. For example, instead of just focusing on the presence or absence of sprinkler systems, the assessment recommended other means to reduce risk. These included design changes (e.g., to contain combustible oil by piping and flexible hose modifications); program changes (e.g., improved emergency response training); and additional measures (e.g., reliable detection-emergency control system interlocks to enable quick shutdown of conveyors, oil pumps and electrical equipment).

Lower Costs

In addition to performance-based recommendations for improving safety, the plant was provided with a prioritized list of risk reduction opportunities. This allowed the key decision makers to optimize their existing budget for fire protection improvements and achieve the greatest risk reduction. Reducing the risk of fire and explosion exposures — and the associated unplanned shutdown of critical production systems — resulted in estimated cost savings of \$60,000 to \$80,000 per year. The cost of conducting the fire and explosion risk assessment was approximately equal to the estimated expense of three to five days of unplanned total production shutdown.

A Supplemental Tool

Given these types of results — improved plant safety, cost savings — the growing interest in this risk-graded methodology is not surprising. This is not to say that the methodology is without its limitations. The most significant limitation is the relative scarcity of industry and equipment data available, which requires analysts to extrapolate available data to the process or equipment being analyzed. Experienced analysts will factor into their assessments a certain degree of uncertainty based on such limitations.

This uncertainty seems to cause uneasiness in those who have a superficial knowledge of the methodology. The practitioners in the international fire protection arena, however, view the methodology as a way to articulate or organize knowledge about the risk, rather than adding to that knowledge base. This type of assessment should be used as one of many decision making tools, as a supplement to the tool used most often — good engineering judgment.

Summary

Taking The Guesswork Out Of Fire Protection

Uncertainty is inherent in every decision making process. The risk-informed, performance-based methodology provides a logical, documented tool for decision making to optimize investment in risk reduction expenditures. It thus provides a degree more certainty than the usual educated guess.

[This article originally appeared in "Workplace Protection," a supplement to "Consulting-Specifying Engineer" and "Security" magazines published by Cahners Business Information (www.cahners.com).]

For More Information

Additional information about fire protection issues is contained in the following technical publications authored by HSB Professional Loss Control staff:

Chapters in the NFPA Fire Protection Handbook, 18th edition:

- "Simplified Fire Hazard and Risk Calculations," Thomas F. Barry, P.E., HSB PLC, and Dr. John Watts, Fire Safety Institute.

Provides an overview of fire hazard and risk estimation used in making hazard and risk reduction decisions. It includes a five-step approach, based on the quantitative risk assessment steps developed by CCPS and AIChE.

- "Nuclear Facilities," Wayne Holmes, P.E., HSB PLC

Describes the unique fire protection needs and solutions for nuclear power plants, nuclear research and production reactors, and other facilities handling nuclear materials.

Proceedings of the National Fire Protection Research Foundation Fire Risk and Hazard Symposium

- "Fire Protection Engineering Quantitative Risk Assessment," Thomas F. Barry, P.E., and Wayne Holmes, P.E., HSB PLC

Presents a systematic approach to evaluating fire-risk-reduction design. The methodology focuses on design objectives while optimizing risk-reduction investment in plant equipment and protection. This provides a risk-based cost-benefit-analysis method for decision making.

SFPE Handbook of Fire Protection Engineering, 2nd edition

- "Quantitative Risk Assessment in Chemical Process Industries," Thomas F. Barry, P.E., HSB PLC

Fire and explosion risk, which can involve property damage, business interruption, life safety, environmental issues, corporate image, and future profitability, presents a major threat to corporate goals and survival.

"Quantitative fire and explosion risk assessment offers the capability of being able to identify weak links in loss prevention and protection systems before an accident occurs. It also affords the capability of optimizing loss control investments with the greatest allocation going to the area giving rise to the highest risk."

For more information on this subject see Section 5, Chapter 12 of the SFPE Handbook, available from the National Fire Protection Association. Or contact Wayne Holmes of HSB PLC at 860-722-5621.

About the Author

Thomas F. Barry, P.E., is director of Risk Based Services in HSB Professional Loss Control's Tennessee headquarters. Tom has a B.S. degree in Industrial Engineering and M.S. degree in Fire Protection Engineering, with 20 years experience in assessing fire and explosion risks in high hazard occupancies including chemical, oil and gas, pulp and paper, and electronic industries. He is the developer and lead instructor for HSB Professional Loss Control's seminar, "An Introduction to Fire and Explosion Risk Assessment."

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