Improving Fire Prevention through Fire Hazards Analysis

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New pieces of equipment and techniques for fire mitigation seem to become available every day. New automatic sprinklers, detection devices, or emergency response methods are constantly being developed. This visible focus on fire control technologies might lead one to think that fire prevention is a thing of the past. To the contrary, fire prevention is more relevant than ever. Fire inspections and other traditional fire prevention techniques have proven themselves over time, but the use of new analysis methods is creating an opportunity for rational applications of fire prevention requirements that might not be evident to the casual observer.

Basic approaches to fire safety design acknowledge that fire prevention is an important facet of overall fire safety. This is clearly illustrated at the very top of the NFPA Fire Safety Concepts Tree, which is routinely relied upon as a framework for comprehensive approaches to fire safety design (see Figure 1). However, by using a more formalized approach to fire hazards analysis, issues related to fire prevention can be identified that are not necessarily addressed by prescriptive controls or fire protection systems. The use of a fire hazards analysis framework can identify the limits of traditional approaches and can be used to structure and integrate fire prevention and protection programs accordingly. Combining fire hazards analysis with risk assessment, system design, and performance-based analyses, specific fire prevention needs can be identified and effective controls can be developed.

WHAT IS A FIRE HAZARDS ANALYSIS (FHA)?

There is no specific definition of a fire hazards analysis but there are several ideas to keep in mind. An FHA should include a comprehensive evaluation of the causes of, impacts from, and consequences of fire in a specific location. It is a process, in a building, considering the effects of engineered systems, administrative programs, and manual intervention.

To a limited extent, an FHA is performed whenever fire or life safety design or evaluation is undertaken. When making decisions regarding the capabilities of engineered systems, the design must consider the type, quantity, and location of combustibles in the area protected. The design of sprinkler systems for high-piled storage requires an evaluation of the commodity classification and configuration of the storage. Performance-based design for egress systems and structural fire resistance also require consideration of the fires that might occur. Regardless of whether a prescriptive or performance basis is used, a fire prevention element is inherently introduced into each of these scenarios and is crucial to the success of the system.

On a larger scale, developing a formal FHA for a process, building, or multibuilding complex can identify concerns beyond a specific system or condition. Documenting an FHA and carrying it forward for the life of a building or process is rarely done, and structured fire prevention plans are not often considered part of design solutions. However, formalizing an FHA via a structured framework can have many benefits. One is that the analysis can introduce fire prevention elements as solutions to specialized concerns that typical fire protection strategies either cannot address or cannot do as cost-effectively. Often these solutions are more complex than those offered in traditional fire prevention methods or programs (such as periodic “combustible loading” inspections, signage, or housekeeping) and require higher levels of attention and management. They can also be much more effective tools than one-dimensional reliance on engineered systems.

The insurance industry has been tracking buildings and facilities with written evaluations for decades. Several of the larger insurers have even standardized their ideolo-
gies into loss prevention standards and policies. Large corporations with national and international interests have followed suit, establishing their own policies and guidelines. In both cases, fire prevention strategies are considered alongside their mitigation counterparts as part of an overall approach.

Several United States federal government departments began following this same pattern as early as the 1960s. The General Services Administration (GSA) developed a performance-based framework that defined a set of expectations for FHA and used it as a basis for alternatives to prescriptive codes and standards, particularly for historic and existing structures. The Department of Defense (DoD) and the Nuclear Regulatory Commission (NRC) have, or are in the process of developing, their own methodologies. Notable, however, is the FHA framework used by the Department of Energy (DOE).

THE DEPARTMENT OF ENERGY APPROACH

The DOE approach to FHA is a model that allows for individual buildings or processes to be evaluated using both prescriptive and performance-based methodologies to achieve specific fire safety goals. By requiring a thorough evaluation of many elements of a fire safety program, the DOE process compares fire risk against established criteria. Additionally, comparative risk on a case-by-case basis can be assessed against fire safety concerns that are not so easily defined, such as release of hazardous materials, business interruption, and damage to items of national interest. The DOE approach advocates strong, comprehensive fire safety strategies, giving weight to fire prevention plans and administrative programs, as well as to active and passive fire control requirements and engineered systems. The FHA methodologies and implementation structure provide this capability, and the result is a rational reliance on specific fire prevention controls. The approach and methodology is included in DOE Orders 420.1A and 440.1A, as well as the associated fire safety

Figure 1. Portion of NFPA Fire Safety Concepts Tree
program implementation guide. These documents can be found on the Internet at http://tis.eh.doe.gov/fire/ or http://www.directives.doe.gov/.

The strength of the DOE approach begins with acknowledgment of the need for fire safety by the Secretary of Energy. Several memoranda from the Secretary have been issued, reinforcing the need for a strong fire safety program, and particular aspects of the program when necessary. Overall policies are established in documents known as Orders. The DOE Orders contain the overriding criteria for establishing fire safety programs, including the need to perform FHA on “all nuclear facilities, significant new facilities, and facilities that represent unique or significant fire safety risks.”

Discreet expectations are described in guides, manuals, and handbooks that are prepared by the Headquarters division responsible for program development. DOE contractors at individual operating sites generally have implementing procedures that define how FHA documentation will occur. While there are a number of sites and frameworks, the general criteria that is evaluated is common to all of them, since it is prescribed by the DOE (see inset).

The DOE approach requires that qualified fire protection engineers perform FHA, and establishes expectations as to capabilities and level of experience required to perform such analyses. By doing so, an established minimum level of consideration is anticipated to be given to the identified criteria. Further, the detail of the evaluation is expected to be sufficient to be used as input to other DOE evaluations, including those for nuclear safety, criticality safety, hazardous material storage and release, and general industrial hazards. These related evaluations present risk information to DOE relative to other hazards and programs with which fire safety is related.

Using this framework, fire hazards can be defined and compared to existing engineered systems and manual intervention methods to determine if specific objectives can be achieved. From the description of fire hazards, specific fire scenarios of concern arise. Qualitative or quantitative methods can be used to develop consequences for both mitigated and unmitigated conditions. The resulting consequences can then be evaluated with respect to probability of occurrence, direct financial losses, indirect business interruption, effects on workers and the surrounding public, and other tangible and intangible consequences.

In many cases, the analysis may point out the limitations of engineered systems or the inadequacies of traditional fire prevention approaches. In these cases, quantitative methods such as fire models are used to more discreetly analyze a scenario. From that quantitative analysis, specific improvements related to fire prevention and/or fire protection strategies result.

FHA-based evaluations routinely lead to changes in a particular suppression system, modifications to a mechanical process, replacement of materials with their less flammable or noncombustible counterparts, or installation of location-specific engineered controls. Also, changes in existing inspection, testing, and maintenance programs might come about, based on the identification of significant need for a change to improve the operational reliability of a particular engineered system. It is likely, however, that fire prevention issues will be identified as well.

**IDENTIFICATION OF FIRE PREVENTION NEEDS THROUGH FHA**

While building codes, fire protection standards, loss prevention guidelines, and other such documents identify required engineered systems and controls for general situ-
Improving Fire Prevention

Traditional fire prevention measures typically focus on general strategies such as reduction or elimination of combustibles and/or ignition sources. The FHA framework refines this approach to provide mitigation approaches to specific concerns, as opposed to a generalized condition of safety. From the analysis, specific issues of fire spread, smoke movement, damage to specific pieces of equipment, and dangers to life safety can be identified. If required engineered features do not adequately address such issues, discreet fire prevention measures may be available to mitigate the condition. Control of combustibles around specific pieces of equipment may be needed. The use of grounding in situations not normally required could be used to eliminate ignition sources. Conditions where specific fire prevention programs or strategies can be relied upon as part of an effective fire safety design for a unique application are routinely identified through the use of formalized FHAs such as that used by DOE (see inset).

To illustrate, consider the design of smoke control systems. In designing smoke control for atria, a fire size must be chosen in order to perform the various calculations needed to design the system. That design fire inherently defines a fire prevention control (i.e., maximum allowable design fire) that would need to be continually maintained for the future of the facility. Future furnishing purchases and arrangements would need to correspond to the original fire assumptions, and purchases and installations coordinated accordingly. Furthermore, the introduction of additional combustibles for receptions, demonstrations, holiday decorations, and other events would need to be closely observed to ensure that the design-basis fire size is not exceeded. Failure to control combustibles within the space would invalidate the design of the smoke control system and could potentially place people exiting the building in danger.

Using this type of analysis, time-honored fire prevention programs can take on new importance. In cases where hot work is determined to be a fire hazard beyond that generally assumed, the implementation of a structured approval process would reduce the probability of a resulting fire. Approving the type and arrangement of personal space heaters could become a required compensatory measure in an existing file storage area that is otherwise unprotected. An FHA points out whether these seemingly routine fire prevention items are really simple property loss issues or are intrinsic to a much more serious fire protection and loss prevention program.

IMPLEMENTING FIRE PREVENTION CONTROLS

With few exceptions, implementing fire prevention controls re-

A Simple Example

Performance Criteria
A large manufacturer of computer hardware examines its production stream and determines that the loss of production in a particular plant cannot exceed two weeks. Any recommendations must be limited in cost, as the company is experiencing financial difficulties.

Fire Scenario and Hazards Analysis
From observed conditions, a scenario is identified that involves a small quantity of combustibles in the operations computer control room. The type, quantity, and location of combustibles were found via modeling to be inadequate to activate the room's fire sprinkler system, which is the only provided suppression system. As well, the resulting fire was determined to be limited enough to not cause thermal damage to the computer cabinet and the electronics inside. The resulting smoke, on the other hand, would damage the equipment and require replacement schedules in excess of the allowed two weeks.

Evaluation of Strategies
Engineered systems, such as clean agent extinguishing systems, could be recommended. However, the financial situation of the company requires the evaluation of alternatives. The provision of combustible controls can produce the desired effect at a significantly reduced cost. The control could be simply the elimination of combustibles that are not related to the computer equipment, including the removal of cushioned furniture, plastic storage containers, and cardboard boxes.

In addition, controls on ignition sources could be instituted. Disallowing repair operations utilizing soldering irons and other hot surfaces from the room could be an instituted control. Eliminating cooking and heating appliances like coffee pots and space heaters could be another. Consolidation and control of the use of extension cords and multiple outlet devices (like surge protectors) is yet another possible control.

Impacts and Implementation
The impact of each of these strategies must be evaluated against their cost and the ability of the company to implement and maintain them. Once established, the controls must be periodically evaluated to ensure they continue to address the initial concern.
quires time, effort, and funding. As a result, there is generally a tendency to use the easiest methods possible. Posting of signs, daily checklists, random inspections, and other means are often employed as low-cost methods. In other cases, such as instances where the controls are part of a performance-based fire safety design, a more rigid implementation is necessary. Assignment of duties to specific employees, specialized compliance forms, operational checklists, periodic management oversight, and validation by the local Authority Having Jurisdiction could be needed if the situation is identified to have regulatory concerns or is of significant importance.

How thoroughly fire prevention precautions should be implemented depends on many factors. Usually, fire prevention techniques are applied equally to all situations and with equal vigor. Fire prevention methods driven by FHA will likely require more rigorous implementation because of the risks involved. It is necessary as part of the FHA to assess the risk posed by a particular condition and the effect the prevention control has upon minimizing that risk. However, how to best implement the control is a management decision outside the FHA. Factors that influence that decision include, but are not limited to:

- The significance of the risk on an absolute scale (i.e., compared to specified success criteria);
- The significance of the risk on a relative scale (i.e., compared to other risks that could also lead to unacceptable conditions);
- The impact the fire prevention control has upon the risk;
- The level of difficulty in implementing the control;
- The level of difficulty in enforcing the control;
- The cost of the control versus the benefit obtained; and
- The posture toward fire prevention of the people involved.

Cost is always a factor and is sometimes difficult to evaluate when comparing long-term administrative costs against a potential fire loss. There are various cost-analysis schemes that can be undertaken depending on the risk being evaluated. A simple evaluation may compare direct costs against possible loss. Such an evaluation is suitable when the risk is fairly clear. However, risks that are not so well defined may require more detailed cost evaluation to convince all parties involved that the implementation is worthwhile.

Performance-based design introduces a twist to this concept in that the difficulty of implementation and enforcement is unknown, as is the posture of the people involved. In public buildings, the emphasis of an FHA is different because the primary issues are related to life safety. While specific fire prevention assumptions may be justified as part of an analysis, reliable implementation is really the key. Issues such as how to insure long-term validity of vital assumptions, who is responsible, and how failures of those assumptions will be corrected are important implementation factors. In fact, administration of FHA assumptions and outcomes are likely to be an important key to how successful performance-based fire protection designs will be.
KEEPING THINGS CURRENT

To be effective, the FHA needs to be a living document. Periodic reviews and updates should occur to reflect any changes to the original analysis. Large facilities or complexes with multiple operations that are dependent upon each other for successful production may be continuously expanding, replacing equipment, or improving existing operations. Specific construction projects tend to focus on the applicable requirements for the project itself, with collateral considerations limited to the direct impacts on available utility loads, exposures, and integration of existing fire protection features. A project could actually impact the original assumptions and implemented controls established based on the initial FHA performed years prior. In addition, the original FHA may not account for changes in management, ownership, or shifting regulatory requirements.

For example, assume an existing analysis for a facility determines that fire prevention controls for a facility were unnecessary even though there are deficiencies identified in the building’s automatic sprinkler system. This result was based on an overall fire loss that is an acceptable risk based on noncritical or easily resumed operations. A new construction project is initiated to relocate a new operation in the existing facility that contributes a significant and unique process that is critical to the corporate mission. The project engineer’s review is generally focused on the specific portion of the structure to be modified, assuming existing conditions outside of the project scope are acceptable and do not require review. However, the new project shifts the conclusions of the existing analysis and places the critical operation and complex-wide production at risk. This concern may not be recognized for years and could result in much higher costs for implementing controls or correcting the sprinkler protection. Establishing a periodic review and update cycle for the FHA that is performed can assist in avoiding this problem. Additionally, maintaining a complex-wide or facility-wide document that is a required input to any project ensures that new risks or changes to previous risk assumptions are addressed. ▲

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REFERENCES