FIRE PROTECTION FOR INACTIVE CONTAMINATED STRUCTURES

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ABSTRACT

In general industry and construction, destruction of an inactive/surplus facility by fire may be considered a blessing. However, in a decommissioned contaminated structure, where radiological and other hazardous materials exist, such a fire could be a major catastrophe. The losses from this type of fire are not only property (i.e., structure and its contents) but also the resulting environmental damage, required cleanup, offsite releases, and public relations and reactions.

As the U.S. Department of Energy (DOE) has transitioned its mission to environmental restoration, managing the hazards during restoration operations has become an increasingly important aspect of waste management. The DOE has done excellent work in promoting, through the DOE Orders and Policies, full compliance with Federal, State, and local environmental, health, and safety standards. Though DOE Orders do well to address the subject of fire protection design and operations requirements for new and existing operational facilities, some have misinterpreted the applicability of DOE Order fire protection requirements to inactive/surplus facilities. As the DOE mission evolves, and new directions for restoration and remediation are developed, fire protection order objectives must be developed and incorporated into operations to ensure worker and public safety.

The Tiger Team Assessment Program was begun in 1989 to address environmental issues and was later expanded to include safety and health issues, including fire protection. One of the Tiger Team performance objectives related to fire protection was public protection. The objective stated that all onsite facilities should provide adequate protection to prevent any added threat to the public as the result of an onsite fire causing the release of hazardous materials beyond the site or facility boundary. A second performance objective, property protection, stated that a maximum credible fire, as defined in DOE 5480.7 (DOE 5480.7A [DOE 1993] maintains the same definition), should not result in an unacceptable property loss. It is to these objectives that the analytical and operational approaches to fire protection engineering are presented herein.

The purpose of this presentation is to 1) promote an awareness among the waste management community of fire protection engineering aspects that must be considered for inactive/surplus contaminated structures, and 2) present to the fire protection community an opportunity to become involved in the decommissioning process while promoting the DOE objectives to manage the risks associated with these structures.

U. S. DEPARTMENT OF ENERGY WASTE MANAGEMENT FACILITY CRITERIA

The message is clear, as documented in several of the applicable DOE Orders, that DOE is committed to protecting workers, the public, and the environment. This can only be done by managing all facilities in the DOE complex by the most safe and effective means possible.

DOE Order 5820.2A, *Radioactive Waste Management*, establishes the policies and guidelines for the management, decontamination, and decommissioning of radioactively contaminated facilities under DOE ownership or control (DOE 1988). This Policy states that "radioactively contaminated facilities for which DOE is responsible shall be managed in a safe, cost-effective manner to assure that the release of, and exposure to, radioactivity and other hazardous materials comply with Federal and State standards."

DOE has issued a draft of it's *Policy for Acceptance of Facilities for Environmental Restoration* (February 1991). The scope of the draft policy is applicable to the environmental restoration of all DOE, contractor, or privately owned facilities and sites that are inactive/surplus and have been wholly or partly contaminated with radioactive, hazardous/toxic, or mixed wastes or substances as a result of DOE nuclear program activities. Further, it outlines the DOE environmental restoration policy, the process by which facilities are accepted for environmental restoration activities, and the requirements for turnover from operations to decommissioning and demolition. These requirements are outlined as follows.

- Complete and document the final deactivation/shutdown of the facility.
- Place any structures at the facility in a safe secure condition, removing any immediate threats to human health and safety.
- Assess the compliance of the facility with respect to environmental, health, and safety regulatory requirements.
- Ensure that any facility structures and their required systems are structurally sound to permit deferred final decommissioning of such structures for up to five years after turnover.

U.S. DEPARTMENT OF ENERGY FIRE PROTECTION CRITERIA

The objectives of DOE Order 5480.7A, *Fire Protection* (DOE 1993), which applies to all structures owned or leased by DOE, include the following.

- Minimize the potential for the occurrence of a fire.
- Ensure that fire does not cause an onsite or offsite release of radiological and other hazardous material

that will threaten the public health and safety or the environment.

- Establish requirements that will provide an acceptable degree of life safety to DOE and contractor personnel to ensure there are no undue hazards to the public from fire and its effects in DOE facilities.

DOE Order 5480.7A further requires contractor organizations to provide and maintain a level of fire protection to meet these objectives and the fire protection program requirements. Each contractor's fire protection program must also include, at a minimum, the programmatic, administrative, and physical features outlined by DOE Order 5480.7A.

To determine if these objectives are met for a particular facility, DOE 5480.7A requires a fire hazards analysis (FHA); a comprehensive assessment of the risk from fire in that facility. Currently, it is only specified that a FHA be performed for 1) all new facilities as directed by DOE 6430.1A, and 2) existing nuclear facilities where safety analyses are required, and 3) as directed by the program secretarial officer. Thus, for an existing facility that is not by definition a nuclear facility, the FHA is not mandatory. The FHA is discussed later in more detail.

The term "fire loss" is defined in DOE 5480.7A as the dollar loss of restoring damaged property to its prefire condition (DOE 5484.1). In determining loss, the estimated damage to the facility and contents includes replacement cost less salvage value. Loss excludes the costs of restoration of property that 1) is scheduled for demolition, 2) is decommissioned and not carried on books as having a value, or 3) has no loss potential. Loss includes the costs of decontamination and cleanup, the loss of production or program continuity (most likely not applicable), the indirect costs of extinguishing fires (e.g., contaminated or damaged fire department equipment), and consequent effects on related areas.

ANALYTICAL APPROACHES TO FIRE PROTECTION

As previously discussed, the FHA, which reflects the risk of fire in a facility, is to be performed under the direction of a qualified fire protection engineer (DOE 1993). The level of detail taken in this analytical overview is directly related to the complexity of the facility and the potential risk to the public and site employees; DOE 5480.7A calls this a "graded approach." For example, an inactive contaminated structure with large quantities of radioactive and hazardous materials may require a much more thorough assessment of the potential for release than another facility with much smaller quantities of similar materials. In the following discussion, minimum aspects of the FHA are addressed.

Description of Building Construction

The FHA must include a description of the building construction with a summary of the materials and methods used. This description will reveal areas of concern with respect to hazards and risk reduction. Understandably, some structures may be of combustible construction, making removal of all combustible materials impossible. For these, special attention must be paid to assessing, mitigating, and protecting the hazards. As the fuel loading for such structures is ample, complete decontamination and demolition may be considered a higher priority.

Fire hazard analyses for high bay locations shall consider the effects of smoke/hot gas stratification that may occur at some intermediate point below the roof or ceiling. Similarly, the effect of smoke movement through doors and dampers held open by fusible links shall be addressed.

The focus of the fire hazard analysis shall be the individual fire areas that comprise the facility. The boundaries of exterior fire areas (yard areas) shall be as determined by the program secretarial officer or delegated authority. A fire area is defined as a location bounded by fire-rated construction, having a minimum fire resistance rating of 2 hours, with openings protected by equivalently rated fire doors, dampers, and penetration seals. Where a facility is not subdivided by fire-rated construction, the fire area shall be defined by the exterior walls and roof of the facility.

Description of Fire Hazards

Details of known and potential fire hazards within the structure must be included in the FHA. Fire hazards within inactive surplus structures must be eliminated to the greatest possible extent. This will include removal of as many combustible materials as possible from the structure. Exterior combustibles (e.g., vegetation and storage sheds or similar structural attachments) must also be removed from around the structure. Deactivated electrical transformers that pose an exposure to the main structure must be removed or drained of their combustible oils. Storage of flammable or combustible liquids must be eliminated. Storage containers, including aboveground and underground tanks, should be emptied and secured either by purging or removing the container, or filling with sand or concrete.

The quantity and associated hazards of flammable and combustible materials that can be expected to be found within the structure, or within each fire area of the structure, shall be factored into the analysis. Consideration must also be given to the presence of transient combustibles associated with storage and maintenance activities. This may include the performance of a analysis of combustible material heat of release rates and fire dynamics in support of the decommissioning plans. Average combustible loading techniques are no longer acceptable methods of characterizing fire severity as required by DOE Order 5480.7A and state-of-the-art fire dynamic principles. This implies that analytical techniques involving computer modeling must be used. DOE has suggested that an acceptable tool for use in developing the FHA is a fire model, as applied by a qualified fire protection engineer (DOE 1993).

Risk from fire and related perils expected in inactive/surplus contaminated structures may include direct flame impingement, hot gases, radiant heat, smoke migration, and fire fighting water damage.

Security Considerations Related to Fire Protection

Security considerations related to fire protection are many and must be documented. Physical security of a structure provides multiple benefits. Secured doors, windows, building ventilation, and other openings prevent unauthorized entry and limit natural draft. Natural draft can contribute considerably to the severity of an unplanned fire. Control of damage caused by vandals, arsonists, and vermin are important benefits as well.

Life Safety Considerations

Life safety shall be considered to the extent that access into and egress from locations within an inactive building are necessary for maintenance and surveillance personnel. Elements of the egress system that must not be overlooked include, but are certainly not limited to, doors, corridors, and

electrical (lighting) systems. For example, though doors must be secured to prevent unauthorized entry, they must continue to provide the necessary safe means of egress to personnel.

Control of Facility Operations

Facility operations, including surveillance and maintenance activities, must be carefully controlled and access monitored. Fire prevention is an important part of the life of an inactive/surplus facility. As decontamination and demolition activities commence, all the hazards associated with the operations must be carefully reviewed and planned to mitigate the fire hazards.

Damage Potential

Damage potential to a facility, measured in dollar loss amounts, must be described. Further narrowing the definitions of fire loss in DOE 5480.7A, the maximum credible fire loss (MCFL) is the property damage that would be expected from a fire, assuming that 1) all installed fire protection systems function as designed, and 2) the effect of emergency response is omitted except for postfire actions (e.g., salvage, water isolation, and restoration activities). The maximum possible fire loss (MPFL) is the value of property within a fire, excluding land, unless the FHA demonstrates a lesser (or greater) loss potential. The intent of the DOE Order in "excluding land" is that the land underneath a structure destroyed by fire still exists and should not be included in the loss calculation. However, if the land is contaminated as a result of a fire, the cost of restoring the land and any other cleanup cost must be included in the fire loss calculation. The MPFL assumes the failure of both automatic fire suppression systems and manual fire fighting efforts. Where a facility has no automatic fire suppression, the MCFL and the MPFL are the same value; such is the case for most older facilities. DOE 5480.7A limits the acceptable loss to $1 million (assuming fire protection systems function properly).

Potential for Toxic, Biological, and/or Radioactive Release

The potential for toxic, biological, and/or radiation incident caused by a fire must be assessed in the FHA. The fire protection engineer may benefit in this area by coordinating his analytical work with others specializing in radiological and chemical release analysis. One area in particular where this assistance is needed is in determining the costs associated with cleanup to prefire conditions. Chemical and radiological material loading analysis, inventory, and documentation of background, together with a fire dynamic analysis, contribute to the overall assessment supporting the MPFL calculations. These analyses also provide a means to determine the extent to which a fire would create an onsite or offsite release.

Fire Department and Fire Brigade Response

Fire department response is another important element of the review of decommissioned facilities. Responding personnel's knowledge of the facility (i.e., construction, hazard content, and fire protection features) are essential. Communication, cooperation, and coordination with the fire department are as important for a facility that is in inactive/surplus status as for an operating facility. As the status of a given structure changes, fire department officials must update their prefire plans. The area fire department must be kept informed of facility status and decommissioning activities.

Fire brigade response shall also be reviewed where an inactive structure is located in close proximity to an active facility with a fully trained fire brigade.

Emergency Planning

The FHA shall define an emergency plan for the building. The plan provides a system of responses to minimize risks to personnel, equipment, buildings, and the environment in the event of an emergency. The emergencies considered for an inactive facility may include the following:

- Fire
- Natural events (e.g. flood, tornado)
- Nonradioactive hazardous material hazards
- Radioactive materials
- Criticality
- Explosion.

Planned responses are those activities that are intended to provide direction to control a fire, minimize the immediate effects of an explosion, contain a spill or release, and minimize the immediate affects of a criticality incident. These responses include, for example, notification of the appropriate personnel, emergency organizations, and the building emergency director.

Natural Hazards Impact on Fire Protection

Natural hazards, such as earthquake, flood, wind, tornado, or lightning, have an impact on fire safety and should be analyzed. Particular attention shall be made to the effects of such events on the fire protection systems.

Exposure Fire Potential

Exposure fire potential which would include the possibility of fire spreading between fire areas (e.g., between buildings) must be reviewed. Of particular concern are those locations where an inactive contaminated structure either poses an exposure threat to nearby structures, or would be threatened by an exposure fire. Exposure by wildfire (i.e., range or forest fire) must also be analyzed.

Utility Services Required for Fire Protection

As a savings in operational costs, utilities that are determined to be unnecessary are often discontinued. This most often will include gas, electricity, water, and telephone. Those utilities that serve active fire protection systems are required to remain operational (i.e., water for automatic suppression systems, electrical power for fire alarm systems, and building heat). One means of maintaining an existing fire suppression system, while allowing discontinuation of expensive heat service throughout the facility, is discussed later. A determination of which utilities must remain in service, and to what extent, must be a coordinated effort involving the fire protection engineer.

Other Considerations

There are other aspects of the DOE FHA process that must be considered on a graded approach because they may not be applicable to inactive structures.

- Protection of safety class equipment
- Critical process equipment
- High value property
- Programmatic recovery potential.

OPERATIONAL APPROACHES TO FIRE PROTECTION

The Decommissioning Project Plan, required by DOE 5820.2A, outlines decommissioning, routine maintenance, and decontamination programs, including required schedules and budgeting. This should include the costs associated with development of a graded FHA, engineering for the conversion or removal of existing fire protection systems, engineering new systems (where deemed necessary by the results of the FHA), and an overall review of the plan by a qualified fire protection engineer. The plan must also include schedules and projected costs for fire protection assessments, inspection, testing, and maintenance of fire protection systems.

Regular maintenance of a fire protection system is essential to its operation. Where installed, automatic sprinkler systems must be maintained. Periodic inspection, testing, and maintenance of these systems shall be performed in accordance with the appropriate National Fire Protection Association (NFPA) standards. Fire detection and alarm systems that may include those items necessary for the sprinkler system operation (e.g., flow and supervisory alarms) shall also be inspected, tested, and maintained in accordance with NFPA standards.

The benefits of fire alarm systems should be weighed, especially for structures that do not have a fire suppression system. Though not required by a particular DOE Order, a fire alarm may provide the early warning necessary to initiate a manual response sufficient to contain the fire to within the boundaries of the facility. Where present, fire detection and alarm systems shall be inspected, tested, and maintained in accordance with NFPA standards. One means of maintaining an active fire suppression system in an inactive/surplus structure is to convert an existing wet pipe sprinkler system into a dry pipe system. The dry pipe sprinkler system works on a principle which maintains pressurized air rather than water in the piping. When a fire fuses the sprinkler head to its actuating temperature, the open head allows a release of the pressurized air, thus tripping the dry pipe valve, flooding the sprinkler system which then operates on the same principle as a wet pipe system.

Where heat is no longer needed for any means other than to protect sprinkler piping from freezing, a dry pipe system is an ideal way of reducing heating expenses. This method, common in general industry, is desirable from the standpoint that it reduces the area requiring heat, and consequently a major hazard, in the structure. Special design considerations must be made for such situations. These considerations include heat for the dry pipe riser, installation of an air maintenance device, hanger adjustments to allow proper drainage, addition of low point drains where needed, adequate supervisory functions such as low air pressure, low temperature switch in the riser enclosure, and valve supervision. These design features are extremely important because unoccupied facilities might be entered only monthly or quarterly for surveillances.

Testing of the fire alarm systems associated with this type of a suppression system is imperative. A scenario to be expected from poor maintenance could be a water flow, not transmitted to the central receiving area via the fire alarm system. In this case, an unlimited amount of water could become contaminated because of the lack of alarm receipt and response.

The value of fire protection assessments of inactive/surplus structures must be evaluated, particularly where the building has been formally devalued (i.e., where the book value has been reduced to zero). Assessments of facilities include an evaluation of program- and facility-related details such as the fire protection engineering and suppression organizations, fire suppression equipment, life safety considerations, inspection, testing, and maintenance documentation, among many other elements. Though not exempt from the requirements of DOE 5480.7A, local jurisdictions will do well to determine the programmatic benefits of performing the assessments, and develop local criteria accordingly.

CONCLUSION

The criteria by which the Tiger Team measured the objectives introduced at the start of this presentation are as follows.

- Facility operating procedures acknowledge the risk of fire. Appropriate provisions are in place to ensure safe operation and shutdown, and to ensure that fire protection features are not compromised.
- A safety analysis report, FHA, or similar document has been prepared which evaluates the potential hazardous materials release, beyond the site or facility boundary, as a result of a fire.
- Operations or facility contents that pose a threat to the environment or that are combustible materials are limited to the extent that an offsite release (may be defined as facility release) is not credible from a postulated fire. Construction features including containment, confinement, ventilation protection systems, and automatic fire protection features, are sufficient to preclude an offsite release in the event of a postulated fire.
- Means of controlling liquid run-offs from a credible fire are provided so that contaminated liquids (including nonradiological containments and potentially contaminated water resulting from fire fighting) will not escape from the site.

Clearly, the graded FHA provides an avenue to explore these criteria to a level of detail commensurate with the size of the facility and its hazards.

DOE Order 5480.7A mandates that fire protection program requirements be characterized by a sincere interest by management and employees in minimizing loss from fire and related perils and by the inclusion of preventive features necessary to ensure the satisfaction of objectives related to safety. It is important that the waste management community and the fire protection community become partners in the goal of seeking this objective.

Limiting fire losses in an inactive/surplus contaminated structure prevents costly and unnecessary environmental waste cleanup, and therefore is effective waste management.

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