Fire Protection For Anechoic Chambers: The Current State of The Art

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Advances in room technology necessitate a re-evaluation of the fire hazard represented by state-of-the-art anechoic chambers.

INTRODUCTION

Just as the state of the art in anechoic facilities has advanced, the fire protection problems represented by these facilities have also evolved. In 1996, a new fire protection landscape exists, a landscape that is very different than that of 1990 or 1985. The fire protection needs of a facility can affect the choices made in design, construction and costs. Consequently, it is critical that the fire protection implications of a specific design be reviewed before the design is frozen and construction has begun. This simple step can save the owner considerable expense.

Anechoic enclosures have historically been classified as high risk assets. In order to understand why, the concept of "risk" as employed in the fire protection and insurance communities must be considered. Risk is the product of the severity of a loss and the probability that such a loss will occur. A risk can be managed by either reducing the severity of the loss or the probability that it will occur.

The severity of the loss is measured in dollars and is governed by the value of the assets destroyed or damaged by the fire, as well as the cost of the interrupted operations resulting from the loss of the use of those assets. When there is a reasonable probability that a fire can spread from one location to an adjacent location, the value of that adjacent location must be considered in assessing severity. Traditionally, anechoic environments have been constructed within structures or buildings which house other operational facilities. These may include laboratories, data centers and research and development assets. This is an environment which represents considerable capital investment in physical assets and a serious loss exposure.

Constructed to exacting performance standards with specially-formulated wall surfaces and expensive instrumentation, anechoic chambers represent a considerable investment. The equipment under test within the chamber is also a valuable asset, often representing the culmination of substantial research and development effort in the form of a one-of-a-kind prototype.

Another factor is an important consideration in fire protection for anechoic chambers. When the interior chamber surfaces are comprised of carbon-filled polyurethane foam, the quantity of combustible material concentrated in the anechoic chamber and the heat-release rate attainable from that material exceed the fire suppression capabilities of the sprinkler systems normally found in buildings. This increases the probability that fire will spread to adjoining areas within the building. The smoke produced when the polyurethane anechoic foams are burned is particularly destructive. This adds to the loss potential represented by these assets. These factors all contribute to the assessment of an anechoic chamber as a "high value" hazard area with a high severity assessment.

The probability of ignition is the second part of a risk assessment. Traditionally, anechoic chambers have been regarded as facilities with a high ignition probability. Whenever electrical equipment is being tested to establish the limits of its performance, there is the possibility of catastrophic failure and ignition of the unit under test. There is also the possibility of catastrophic failure of the test equipment supplying energy to the chamber. The large electrical power available to the area brings with it an increase in the available energy from ignition.

Finally, in the older design anechoic chambers, the carbon-filled polyurethane anechoic foam absorbs radiation by converting it to heat. The process of testing represents an intrinsic ignition source. As more energy is introduced into the enclosure in the form of radio frequency electromagnetic energy, that energy must be dissipated by the absorbent wall surface. That dissipation is always in the form of heat. When the absorptive wall surface is made of a combustible material, the fire hazard represented by the anechoic chamber is substantially increased. Consequently, with a high

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inherent value and a relatively high probability of ignition, anechoic environments are high risk assets.

CONVENTIONAL STRATEGIES

The ease of ignition and the large heat release for the carbon-filled, polyurethane foam interiors traditionally used in anechoic chambers represent a fire risk that cannot be adequately managed with a conventional sprinkler system. Consequently, for many years the conventional fire protection strategy for protecting these assets included a spot-type smoke detection system (either ionization or photoelectric) connected to a total flooding Halon 1301 extinguishing system. This design approach was not without its shortcomings. The individual spot-type smoke detectors had to be inserted into the crevasses between foam wedges to minimize both reflections from the detectors and possible interference in the detector circuitry from the electromagnetic energy being used for testing. Unfortunately, this also minimized the ability of the detection system to respond to incipient fires. In spite of these precautions, the EMI/RFI in the chamber occasionally caused spurious smoke detector alarms and resulted in the discharge of the extinguishing system. Even with these limitations, this was the recognized and recommended approach for the protection of anechoic chambers.

The changes in both the chamber and the fire protection technologies that have occurred over the past few years have had a profound effect on the fire risk associated with the anechoic chamber as well as the means available to manage that risk. The changes in the fire protection technologies are centered around the withdrawal from the market of Halon 1301, the universally accepted and recommended extinguishing agent for this type of hazard. Halon 1301 is one of the gases covered under the Montreal Protocol. Having been implicated in the deterioration of stratospheric ozone, Halon 1301 is no longer being manufactured. While there may be some localities where authorities have insisted that systems be removed, there is no nationally enforced legal requirement that existing Halon 1301 systems be retired. To the contrary, if these extinguishing systems are properly maintained, they can remain in service indefinitely. However, the availability of agent for recharging these systems is restricted to reclaimed and recycled gas, making it subject to wide fluctuations in price and availability. No new gas is available. Nevertheless, as long as an existing system does not discharge, there is no pressing need to replace it with one of the alternatives.

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ALTERNATIVES TO HALON

While a number of alternative extinguishing agents have been developed to replace Halon 1301, none of these gaseous extinguishing agents is a direct "drop-in" replacement for Halon 1301. New agent storage tanks, valves, piping and nozzles are necessary. Furthermore, some agents are more easily used with some chamber geometries, whereas a different agent will be more cost-effective with some other geometry. Consequently, there is no hard and fast rule regarding the best alternative. The cost of the replacement agents is universally higher than the Halon 1301. This is partially due to the fact that the sales volume of each of these agents is lower than that previously enjoyed by Halon 1301. Also, each of these agents is produced by a single source rather than multiple manufacturers, as was the case with Halon 1301, reducing the competitive pressure on the pricing.

With the removal of Halon 1301 from the market, there has also been a resurgence of interest in the use of carbon dioxide (CO_2) for many applications where Halon was once the favored agent. The principal disincentive to using CO_2 is that it is an asphyxiant and represents a serious hazard to personnel. All spaces which have CO_2 extinguishment must have provisions for personnel evacuation prior to agent discharge. Once the agent has been discharged and the fire extinguished, the agent must be removed from the protected space and safely vented to exterior atmosphere. Since CO_2 is heavier than air, it will settle in low spaces if it is not forced out of the enclosure with a forced ventilation system.

The void left by the removal of Halon 1301 has also been partially filled by water mist extinguishing systems. While water mists do not behave like gaseous agents, there are a number of situations where they can be very effectively used. The water content of a water mist discharge system is comprised of extremely small droplets with diameters ranging from 20 to 200 microns. When water droplets this small are introduced into a space where a fire is in progress they become entrained in the air flow created by the fire and quench the flame with an efficiency that is unattainable with other methods. This is the subject of considerable current research and further developments are expected.

ADVANCES IN FIRE DETECTION & PROTECTION

There has been equivalent technological development in the field of fire detection. The fire detection systems have improved substantially. Smoke detectors have matured into "smart sensors." Smart addressable/analog smoke detectors and microprocessor-based fire alarm system control panels have the ability to compare sensor outputs to fire algorithms, making these systems far more stable and less prone to spurious alarms. If the presence of a smoke detector within the chamber enclosure is a problem, aspirating detection can be used. Also known as air sampling detectors, aspirating detectors employ a system of sampling tubes and an air pump to draw a sample of the air from the protected space to a central sensing unit. This architecture provides a more sensitive instrument without accepting a concurrent decrease in sensor stability. Furthermore, the potentially reflective smoke detector is replaced with a sampling tube orifice that is a mere fraction of the size of the detector it replaces. Air sampling systems cannot suck smoke from the floor of a chamber up to the sampling port and hence into the detector unit. These systems still depend upon the thermal lift due to the heat from the fire to raise the smoke to the ceiling where the sampling tube ports are usually located. However, they still provide significant performance benefits that warrant serious consideration.

These changes in fire protection technology have been paralleled by advances in the construction materials and methods now available to the anechoic chamber designer. The introduction of ferrite and ferrite-like anechoic surface materials has changed both the nature and the quantities of combustible materials in the chamber, critical factors for the fire protection engineer and risk manager. These new construction materials necessitate a re-evaluation of the risk represented by the chamber.

When carbon-filled polyurethane foam is used as an absorbent interior surface, the chamber contains a large quantity of highly combustible and easily ignited material, in close proximity to a known and continuously present ignition source. However, when ferritic surfacing materials are used in lieu of the polyurethane foam, an entirely different situation results. While the source of heat remains, the ferritic surfacing components dissipate the heat in a noncombustible material. Now the chamber contains a large quantity of largely noncombustible material in proximity to a known ignition source. This reduces the risk in two important ways. It reduces the probability of ignition since the ferrite materials are essentially non-ignitable thermal conductors which are able to dissipate heat more efficiently. Since the polyurethane foam which represented the majority of the fuel load has been replaced with noncombustible ferritic tile, the quantity of combustible material available in the event of ignition is a fraction of what it would be if the polyurethane foam had been used.

In many instances, the reduction in fire risk attainable with the use of ferritic surfacing is sufficient to entirely obviate the need for a special agent extinguishing system. If the test equipment associated with the chamber and the units under test does not generally represent irreplaceable assets, automatic sprinkler protection can suffice. This can be an important factor in new as well as refurbished chambers. The increased cost of noncombustible ferritic surfacing technology might be offset, at least to some degree, by the elimination of automatic fire protection systems in excess of the building-wide automatic sprinkler systems.

CONCLUSION

With the new landscape in both anechoic chamber design technologies and fire protection technologies, it is wise to address the risk management issues early in the design process. There may be occasions where a slightly higher expenditure for chamber surfacing materials will save a far greater expense by reducing the need to include a fire protection system. The added costs for system maintenance over the lifetime of the chamber is also a consideration.

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