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Technical Article

Automatic Sprinkler Selection for Magnetic Resonance (MR) System

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The design of automatic sprinkler systems has always been a technically challenging and demanding process. Advances in computer technology, construction processes and modern sprinkler innovations have added significantly to the considerations that must be taken into account during the sprinkler system design and installation. This is particularly true in healthcare environments where Magnetic Resonance (MR) system rooms are being constructed. The increased use of MR scanners in hospitals and outpatient clinics adds another level of consideration into the sprinkler systems design that is not covered in NFPA 13 Standard for the Installation of Sprinkler Systems. In addition to the performance and design of the sprinkler system, the fire protection designer may also be required by the project specification to identify and provide sprinkler system components and materials that will not present a potential safety hazard for the occupants of the MR area or have a negative impact on the performance of the MR system.

MR scanners are used to provide specialized imaging for medical diagnosis. At the core of the MR system is a powerful magnet. The static magnetic fields of these MR system magnets range from 0.2 to 3-Tesla. This magnet may cause severe damage to the surrounding area or injury to patients and medical technicians if proper safety precautions are not followed.

For the automatic sprinkler system design, the safety concerns are related to the proper selection of the sprinklers, piping and hanging materials. This article will concentrate on the type of materials that are commonly used in sprinklers and the testing that is performed to evaluate the use of automatic sprinklers in the MR environment.

Ferrous Metals

Ferrous metals are defined as those metals that include iron and all iron derivatives. Ferrous metals are naturally attracted to magnets. Metals such as aluminum, brass, and some blends of stainless steel that are not attracted to magnets are referred to as non-ferrous. Given the wide variety of sprinklers available and various applications where they are installed, several different metals can be used in the construction of a sprinkler. These can include metals such as brass, nickel, steel, copper or stainless steel.

There are two principle concerns associated with objects made from ferrous material in the MR environment. Safety concerns exist where there is the potential for these objects to be drawn into the core of the magnet. This is commonly referred to as the “missile effect”. Unfortunately there are documented cases where ferrous objects were not identified during patient screening or inadvertently introduced to the MRI area that resulted in severe injuries or even fatalities. In addition, there is the concern that the ferrous material will have a negative impact on the image produced by the MR scanner due to the interference produced in the magnetic field. This is only a concern if the object is within the area or near the anatomic site of MR imaging.

Currently there are no specific listings or approvals for automatic sprinklers used in MR system rooms. However, the fire protection designer can check with the sprinkler manufacturer to verify the types of metals used in the sprinkler components and if any testing has been done with those sprinklers in an actual MR environment. This type of testing is available at several laboratories in the United States.

The MR Environment

There are a number of misconceptions about the magnetic field associated with MR scanners and the shielding used in these spaces. Unlike the lead shielding used in x-ray rooms that are designed to keep the hazard within the room, the RF-shielding (radio-frequency) used in MR system rooms is used to keep stray radio waves out of the room to prevent interference with the magnet. The only material that is capable of containing the magnetic field from an MR scanner is plate steel. Most current designs incorporate what is called “active-shielding” which uses additional magnets to “compress” or contain the static magnetic field. It is important for the fire protection designer to work with the design engineer and the MR system manufacturer to ensure the sprinkler system is installed in a manner that conforms to the shielding requirements.

Testing Objects in Association with an MR System

The most common testing that is done with automatic sprinklers, escutcheons and concealed cover plates is done in association with a 3-Tesla MR scanner in a clinical-use environment. The 3-Tesla MR System is the most powerful, commercially available MR system in use today. However, there are more powerful MR scanners used in some research and development facilities, including 7-, 8- and

9.4-Tesla scanners. If the designer is faced with an environment using an MR scanner more powerful than 3-Tesla, they must verify that the sprinklers have gone through the appropriate testing. It is important to understand that the sprinklers and associated components are not intended for use inside of or close to the bore of an MR scanner (See Figure 1). Accordingly, the method of testing and the measurements obtained must represent worst-case scenarios and determine the level of magnetic field interactions relative to the intended use of the object.

**Figure 1. The 3-Tesla MR system located at University Hospital, University of Southern California, Los Angeles, CA.*

Figure 2. Set up for deflection angle testing of sprinkler.

The primary testing standard that is used to evaluate the materials in the MR environment is The American Society for Testing and Materials (ASTM) Designation: F 2052. Standard test method for measurement of magnetically induced displacement force on passive implants in the magnetic resonance environment. Each sprinkler or component is attached to a test fixture to measure the deflection angle at an appropriate position in the 3-Tesla MR system. The test fixture consists of a structure capable of holding each device in the proper position without deflection of the sprinkler and contains a protractor with 1°-graduated markings, mounted to the structure. The 0° indicator on the protractor is oriented vertically (See Figure 2).

The test fixture also has a plastic bubble level device attached to ensure proper orientation in the MR system during the test procedure. All sources of forced air movement within the scanner's bore are turned off during the measurements. Each sprinkler is suspended from a thin, lightweight string that is attached at the 0° indicator position on the protractor. The length of the string must be long enough so that each sprinkler or object undergoing testing can be suspended from the test fixture and hang freely.

Measurements of the deflection angles are taken at the position within the 3-Tesla MR scanner that produces the greatest magnetically induced deflection, or relative to the intended position of use for the object. The direction of the magnetic field for the 3-Tesla MR system is horizontal. The test fixture is placed at this point. Each sprinkler is held on the test fixture so that the string is vertical and then released. The deflection angle for each device from the vertical direction to the nearest 1-degree is measured three times and then a mean value is calculated.

Figure 3. Sprinkler with large deflection angle. This may pose a hazard in the MR environment.

Figure 4. Sprinkler with small deflection angle and, thus, low magnetic field interactions.

The results of this testing assist the sprinkler manufacturer in identifying which sprinklers, escutcheons, and concealed cover plates may be best suited for the MR environment.

Conclusions

For those involved in the design and installation of sprinkler systems in an MR environment, care should be taken in the selection of the automatic sprinklers. This unique environment poses additional concerns outside of design guidelines typically encountered with sprinkler design. The manufacturers of automatic sprinklers can provide the installing contractor with the technical information required to identify the metals used to construct a sprinkler and whether or not the sprinkler has been tested in an actual MR environment with zero deflection angle or only limited magnetic field interactions relative to the intended use. Although this type of testing is not a formal listing or approval, it does provide an important level of confidence to the equipment selection for the sprinkler system design.

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* Figures 1-4 provided courtesy of Magnetic Resonance Safety Testing Services, www.MagneticResonanceSafetyTesting.com, Frank G. Shellock, Ph.D., President and CEO