

Fire Department Response to Emergencies Involving Magnetic Resonance Imaging (MRI)

Magnetic fields can severely hamper firefighter efforts

Advances in medical procedures have greatly enhanced the lives of millions of people throughout the world. One area of advancement has been through the development of Magnetic Resonance Imaging or MRI. Images created by these devices have greatly improved the ability of physicians to see inside a patient's body without performing risky surgery. The MRI far outweighs X-rays in clarity and in many cases the surgeon can see a two-dimensional or three-dimensional image of the organ, body cavity or skull of the patient.

MRI Operation

While there are some differing types and designs of MRI machines, the most common are large cube like structures with average sizes of seven feet tall by seven feet wide and 10 feet long. Essentially the cube structure is a large magnet with a circular "tube" core. This core is called the "bore" of the machine and is where the patient is placed in the machine for imaging to take place. The machine maintains a strong magnetic field inside the bore.

When a patient is placed inside the bore the patient's body distorts the intensity of the magnetic field into varying energy waves. A computer used in conjunction with the machine interprets these energy waves and translates them into picture slices, two-dimensional or three-dimensional. These images are greatly detailed and allow a physician to determine injuries and illnesses such as; tumors, Multiple Sclerosis, torn tendons, tendonitis, and other life threatening injuries and health problems.



Photo by Mark A. Brown
The typical MRI unit set up in a medical facility.



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MRI Hazards

The benefits of these machines far outweigh the hazards. Exposure to magnetic fields has not been determined to be hazardous to humans. However, it is the construction and operation of the machines that produce hazards to firefighters.

First and foremost, MRI units are always on. There are never any times when the unit is shutdown. The magnetic field can extend up to 20 feet from the machine and draw or "pull" metallic objects toward it. These objects may be wrenched from the possessor's hands, fly through the air and into the bore area of the machine. Even small items such as badges, pens, eye glasses, watches and any metallic hand



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The typical MRI unit set up in a medical facility.

tools can become dangerous projectiles. Imagine coming into a smoke filled room in a building on fire and finding yourself literally being sucked into a room by a "force" you are unable to fight against or see, and subsequently losing control of a hoseline, your partner, a piece of equipment or a victim.

This may sound strange or exaggerated but there have been similar incidents. On July 27, 2001 a six-year-old boy was killed when a metal oxygen bottle was pulled into the bore while he was inside. Incidents such as this stress the need to be cognizant of this type of hazard when working on any type of incident, fire or medical, in a room where a MRI unit is present.

Second, a Liquefied Cryogenic Gas is used to cool the interior windings of the magnet while it is in operation. Typically, liquefied helium or liquefied nitrogen are used and are stored in cryogenic cylinders in a separate area or room away from the unit.

Now all of the hazards of hazardous materials response come into play. Temperatures of the liquefied gases range from -250 to -350 degrees F and are kept in low pressure cryogenic containers. Health hazards range from asphyxia, frost bite and frost freeze to pressure hazards from rupturing cylinders from heat of fire. Furthermore, the loss of cooling agent on the MRI magnets can lead to a fire developing in the MRI unit.

Fire Suppression & Alarm Systems and Safety

Rooms and buildings containing MRI units should be designed and constructed to all applicable building and fire codes. Special precautions should be designed into the room to control magnetic issues. Sprinkler pipes or other types of fire suppression system piping should be non-ferrous piping. Sprinkler heads should be approved for the intended application. Fire alarm components should also follow these guidelines. A non-metallic fire extinguisher should also be required when an extinguisher is placed within a room containing MRI equipment.

Ample signs warning against taking metal items into the room containing the MRI unit should be placed just outside the MRI room doorway. NFPA 704 Hazardous Material Identification signs and material specific identification signs should be placed on doors or rooms containing cryogenic cylinders.

Pre-planning on the building should be conducted and safe and magnetic hazard areas should be indicated on plans. Magnet hazard areas can be determined by taking readings with a Magnetometer, Gauss-Meter or other type of meter designed to detect magnetic fields during pre-plan tours.

Computers controlling MRI units are normally placed in separate rooms adjacent to rooms containing a MRI unit. Preplanning should also include a briefing by facility staff on how to control the MRI during an emergency.

Fire Suppression Operations

Upon being dispatched to an incident involving a MRI unit, responders should be aware of all of the hazards mentioned previously. Tactics should involve determining if the MRI unit is involved in the fire or not.

Non-Fire Involvement: If the unit is not involved in the fire, medical facility staff should be consulted on the condition of the unit (A MRI unit is always "on" - whether it is in use or not). If it is in operation, the staff should be consulted and make sure that all patients and staff are accounted for. Once rescue considerations have been considered, the room containing the unit should be checked for any fire extension from the doorway or from a safe distance within the room. While in proximity of the machine, the operation of the machine should be assessed. If the unit is within its proper operating parameters, the room containing the unit should be isolated and monitored until the incident has been controlled.

Once the incident has been stabilized and if safe to do so, facility staff (with fire department personnel escort) should be allowed to enter the room and assess the condition of the MRI unit. Power and coolant gases to the unit should only be turned off as a last resort. While it is possible to perform emergency shutdown of the magnet through a process known as "quenching the magnet", this process is dangerous and

involves bleeding off the cryogenic gas from the magnet housing. Improperly performing this operation could create an oxygen deficient atmosphere in the MRI room and cause the machine to internally overheat and ignite.

Fire Involvement: If the MRI is in close proximity to the fire or is part of the fire, fire suppression crews should enter the room and assess the involvement of the MRI unit from a safe distance. Non-metallic fire extinguishers may be available, if so, small fires should be extinguished from a distance using the fire extinguisher.

Larger fires should be extinguished from a distance using a hoseline. Fire suppression crews should take into account that an electrical hazard and a magnetic hazard exist while attacking the fire and suppression tactics should be adjusted accordingly. Safety officers should stress that all tactics be performed at a safe distance from the MRI unit.

Each fire situation will be different and medical facility personnel should be involved as much as safety will allow in the salvage and overhaul process.

Once fires are extinguished, medical facility staff or maintenance personnel should be permitted to enter the area if safe to do so, with fire department personnel escort and assess the condition of the MRI unit. After an assessment has been performed a plan of action to safely shutdown the unit and perform salvage/overhaul operations should be developed by fire and medical facility personnel. Once the plan is developed it should be implemented accordingly. Safety officers should constantly ensure that all electrical hazards have been eliminated and the magnetic hazard has been minimized during these operations. The incident commander should ensure the MRI unit receives minimal damage during salvage and overhaul operations due to fire investigation concerns.

Fire Investigation Considerations

Another area of concern is fire investigation. Investigators should check with fire command and the incident safety officer prior to entering the MRI fire area. The investigator should ensure that all electrical and magnetic hazards have been minimized or eliminated prior to their entry.

Prior to beginning the investigation the fire investigator should make sure that "right-of-entry" has been secured. After gaining entry the investigator should remember and conduct the investigation from a perspective that does not create "spoliation of evidence" issues. The MRI unit is a complex machine. If the unit appears to be involved in the ignition of the fire, proper investigation techniques should be used during the investigation to not destroy any critical fire origin and cause evidence.

While performing the fire investigation, the investigator should have (if safety permits) medical facility maintenance personnel present. These personnel should be kept at a distance as to not impede with the investigation but be available to answer any questions the investigator may have.

The room containing the MRI unit should be documented using nationally recognized standards and proper evidence gathering techniques should be used. Non-metallic tools should also be used to dig and recover any evidence around the MRI Unit due to the magnetic hazard. All details of the investigation should be documented, photographed and included in the investigator's report of the incident.

Upon completion of the fire investigation, the fire investigator should ensure that the room is secured as much as possible. Medical facility personnel should be directed to not enter the MRI room, tamper or destroy any evidence and to remain out of the room until all insurance parties with a vested interest have been made aware of the fire and had a chance to inspect and analyze the room and equipment.

Mobile MRI Units

Magnetic Resonance Imaging units can be housed, contained and transported in a mobile unit. The MRI unit is in a semi-tractor trailer unit and may be equipped with a HVAC system and diesel generator. The idea behind this design is to transport MRI units to medical facilities that do not have an onsite unit. This makes the technology available to a wide geographical area and provides the life saving service to more individuals than a stationary MRI unit.

In this case the MRI hazards and operations are the same as previously mentioned but now you can factor in a diesel automotive apparatus with a diesel fueled electrical generator. Fuel sources should be monitored and removed during suppression operations. If possible disconnect the semi-tractor and remove it from the fire area.

As stated previously the MRI unit medical personnel should be involved in suppression, salvage/overhaul and investigation operations as much as safely possible.

Incidents involving Magnetic Resonance Imaging units pose a unique challenge to firefighters. MRI unit operational procedures and hazards must be thoroughly understood and preplanned. Strategies and tactics for fire suppression and investigation should be developed incorporating all known hazards to effectively and safely control incidents involving these types of machines.