MRSO Exam Prep Course

Module 9

System Quench

Section 9.1 Quench

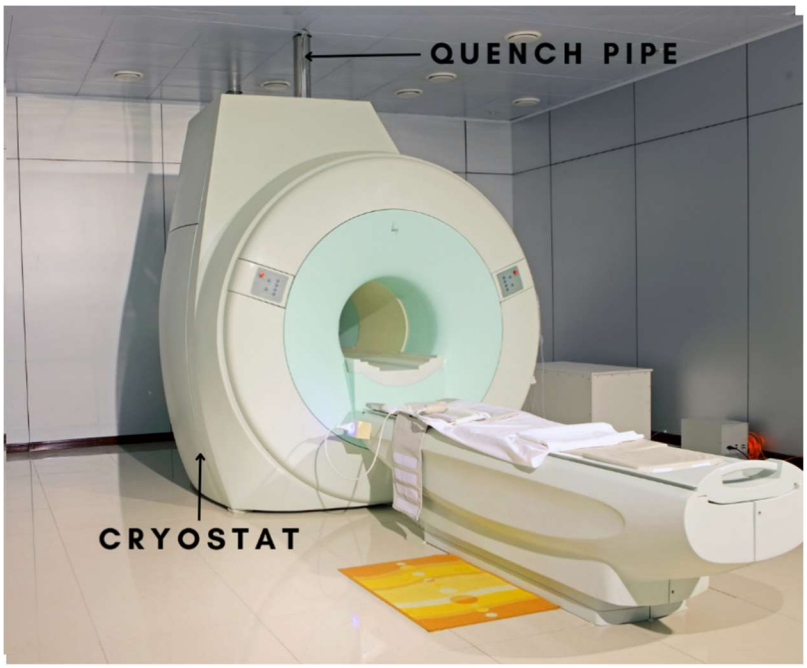

Image 9.1

A system quench refers to the sudden loss of superconductivity that occurs when the temperature of a superconductor is raised beyond its critical temperature (Tc). In the superconducting state, the electrical resistance of the magnet coil is zero, which means that no energy is required to maintain current flow. However, if the coil temperature rises above the critical temperature, the windings suddenly develop a resistance. This increase in resistance causes the circulating current passing through the windings to generate heat, leading to an explosive boil-off of the liquid helium used to cool the superconductor.

When the quench button is activated, the process begins with 5-10 seconds of a mild hissing sound caused by a small volume of helium escaping through the boil-off valve. This is followed by a roaring or loud hissing sound for about 20-30 seconds as larger quantities of gaseous helium are released. Most of the released cryogen is vented outside through a vent tube to the rooftop, where a large cloud of vapors can be seen billowing into the sky. However, it's important to note that some cryogen may escape the scanner room, filling it with a smoke-like mist. The release of cold vapors results in a marked chill in the air, causing a sudden drop in room temperature by at least 10-15 degrees.

While gaseous helium is lighter than air and tends to float to the top of the room, there is a risk that large quantities can completely displace oxygen from the entire room, leading to the potential for asphyxiation and loss of consciousness within seconds if inhaled. Therefore, immediate evacuation of patients and staff is necessary if a quench occurs.

In the event of a blocked or disconnected quench tube during the quench process, there is a risk of lethal quantities of helium escaping into the scanner room, potentially increasing the pressure and making it difficult to open the door. In addition to asphyxiation, high concentrations of gaseous helium could cause thermal injury to the eyes or skin.

An interesting fact is that in the event of electrical power loss or a shutdown of the cryogen pump system, MR magnets are designed to be well-insulated enough to remain cold for several days to a week without the risk of quenching. This feature allows manufacturers to pre-fill the magnets with liquid helium at the factory and transport them cold to the receiving facility, thereby reducing installation time and ensuring safe operation.

9.1.1 Quench Vent

This is where the cryogen exits the system. The quench vent is usually situated outside of the facility. As an MRSO, you should inspect the quench vent to ensure it meets the following standards:

- **Exit pipe to have a warning posted:** Should anyone become close to the pipe and a quench occur, the velocity and temperature of the cryogen exiting this pipe could cause severe injury to anyone near it. This warning sign will help reduce injury of personnel coming near it. Warning signs should prohibit personnel from approaching within 25 feet of this pipe.
- **Screening to be welded or securely fastened to the pipe**: This will ensure no animals do not make their way into the pipe. Animals entering the pipe could result in damage to the MRI system when the unit does not need to be quenched, or death to the animal should a quench be initiated.
- **Pipes must be in the range of 45° - 180° from the wall or rooftop at which the pipe is directing the cryogen out of the facility**: This is for the protection of the building itself. If the pipe is less than 45° coming out of the facility, the cryogen may strike the building with such a force that it may cause damage to the facility.

Image 9.2

Courtesy of Spartan Shielding - Quench Vent Systems | Spartan Shielding - RF Shielding & Magnetic Shielding for XRay CT MRI

9.1.2 What Happens After a Quench?

Once the cryogen leaves the magnet, Ohm's Law will start to apply to the magnet. With electrical resistance applied to the magnet and no electrical supply present, the magnet will be reduced to a magnetic capacity of 15mT – 25mT within less than a minute.

Once the cryogen leaves, you cannot get it back. The medical facility will then have to pay to have the MRI unit refilled with liquid helium. If we consider that most MRI units will require an average of 1700 liters and that the cost per liter is around $35/ liter, it will cost around $59,500. This can be an extensive cost; however, when we consider injury to people and property, if you choose not to quench, those costs incurred can be significantly more.