7 Integrated Safety Management

The MINERνA Project will implement the principles of Integrated Safety Management (ISM), in accordance with terms of Fermilab's contract with the Department of Energy. Briefly, there are five basic principles of ISM:

- Define the scope of the work;
- Identify hazards associated with the work;
- Develop and implement ES&H controls;
- Perform work safely;
- Assess the performance for continuous improvement.

These principles are very general and can be applied to a wide range of tasks. At the project level, this Technical Design Report represents the implementation of the first principle, as it defines the scope of the MINERνA detector. The MINERνA Hazard Analysis [179] specifies the anticipated hazards associated with the project. The development and implementation of ES&H controls is facilitated through the MINERνA ES&H Review Committee, which is appointed by the Particle Physics Division Head. The final two principles will be implemented as the project proceeds.

7.1 Fermilab ES&H Requirements

Fermilab's ES&H policies and requirements are set forth in the Fermilab Environment, Safety and Health Manual (FESHM). All work performed at Fermilab is done in accordance with the specifications of the FESHM. Pursuant to Chapter 2010 of the FESHM, the MINERνA Project will prepare a Safety Assessment Document and undergo safety reviews at several levels. These include internal reviews organized by the Project Manager, subsystem design reviews by the MINERνA ES&H Review Committee, project reviews by the Department of Energy, and a final operational readiness review before operations may commence.

Chapter 2060 of the FESHM describes the hazard assessment process and includes a matrix of hazards that may be encountered in activities at Fermilab. These hazards and their impact on the design and construction of the MINERνA are considered individually in the following sections.

7.2 Safety Off-site

Some of the work on the MINERνA detector subsystems will be performed at university laboratories and workshops. This work includes the fabrication, assembly and/or testing of several elements or subsystems of the detector. These activities are subject to the safety regulations of the respective institution. One of the goals of the internal reviews is to verify that these are equivalent to the safety standards of the FESHM. In the event that any special ES&H guidelines are needed, these are explicitly stated in a Memorandum of Understanding between Fermilab and the university.

7.3 Fire Safety

The plastic scintillator core of the MINERνA detector is the primary concern for fire safety. The scintillator constitutes a large fuel load, approximately 17 metric tons of polystyrene plastic. Its location underground in the MINOS Hall implies that, in the event of a fire, the smoke would present a hazard to any personnel in the hall. This hazard is addressed by occupancy limits in the hall and by the emergency exit corridor, which is physically separated from the detector hall and has a separate ventilation system.

Significant material damage to both the MINERνA and MINOS detectors could result from a fire. Smoke deposition on electronics can be an especially expensive form of damage, due to the corrosive effects of halogens in the smoke. The airflow in the hall at the MINERνA location is toward the MINOS detector. Electronics racks will be equipped with smoke detectors as described below. The MINOS racks are also equipped with smoke detectors.

Fire safety is integrated into the design of the detector in two ways: Potential sources of ignition are isolated and the fuel load is minimized or mitigated. Materials in the detector are chosen to optimize fire safety and are reviewed by the Fermilab ES&H Section. The ES&H section tests samples of the material in accordance with industry standards. Examples of fuel load minimization and mitigation include:

- Electronics are contained in fireproof PMT boxes.
- Welding operations are carried out away from the fuel load.
- The scintillator module covering is fire retardant.
- Cable jackets and connectors are made of low-smoke, low-flammability materials. To minimize the potential for smoke damage in the event of a fire, non-halogenated materials are selected for cable jacketing where other technical requirements allow.

7.4 Electronics Safety

The MINERνA ES&H Review Committee reviews all custom-built electronics that are installed in the MINERνA detector.

7.4.1 Rack Protection System

External electronics racks will be equipped with a Rack Protection System (RPS) similar to those designed for the MINOS experiment. The RPS triggers an alarm and shuts off power to the rack in the event of an abnormal situation, the specifics of which can vary from one rack to another but which may include a smoke alarm, cooling fan failure, or voltages or currents out of tolerance.

7.5 Radiation Safety

The MINERνA detector will not contain any radioactive materials, nor will it be located in an experimental area where radioactivation of its components would be a concern. Hence, the radiation safety issues in the detector design are minimal.

7.5.1 Non-Ionizing Radiation

The light injection system will employ ultraviolet LEDs, which will send calibration pulses of UV light to the optical fibers. Safety measures include enclosing the LEDs in a pulser box and placarding in accordance with the FESHM.

The detector will not contain any lasers. During the detector installation, the module locations will be surveyed. This process may involve the use of some Class 1 lasers by trained surveyors.

7.5.2 Ionizing Radiation

The response of each scintillator module will be mapped with a scanner using radioactive sources. From studies for similar mapping devices on the MINOS experiment [181], the radioisotope $^{137}Cs_{55}$ has been identified as having good radiation safety characteristics for this device. The sources are of approximately 5 mCi activity and when in use they may produce dose equivalent rates of more than 5 mrem/hr. The area in which the dose equivalent rate exceeds 5 mrem/hr is classified as a Radiation Area. Work in the Radiation Area will be conducted in accordance with the requirements of the Fermilab Radiological Control Manual (FRCM), which is part of the FESHM. Personnel working in the Radiation Area will have the appropriate training and dosimetry. The mapper operation procedures will be detailed in a separate document. When not in use, the radioactive sources will be secured in accordance with Fermilab policy.

7.6 Chemical Safety

The MINERνA detector construction will involve the use of some hazardous or toxic materials. The project will maintain a set of Material Safety Data Sheets (MSDS) for such materials. The following subsections describe the ES&H considerations for each.

7.6.1 Epoxies and Adhesives

The scintillator planes are assembled with epoxies and adhesives. Some of these may present hazards of inhalation, eye irritation, or skin damage while they are being applied. While working with such materials, the plane assembly teams will use personal protective equipment such as face masks, safety glasses, and gloves as necessary.

7.6.2 Solvents

Small amounts of solvents, such as ethanol or isopropyl alcohol, may be used to clean the optical elements of the detector and test stands. Such solvents will be handled in accordance with FESHM guidelines and stored in a flammable materials cabinet when not in use.

7.6.3 Electrostatic Painting

The PMT boxes will be painted electrostatically. Electrostatic painting has safety and health advantages over brush painting in that fumes from the process are greatly reduced. Furthermore, it eliminates the need to use solvents for touchup and cleanup. Training will be provided for the personnel doing the painting.

7.6.4 Lead Safety

The MINERνA detector will contain approximately 3.5 metric tons of lead. The lead will be painted or otherwise encapsulated and hermetically enclosed in the detector. Technicians installing the lead will be trained as lead workers in accordance with Fermilab standards.

The module mapper will contain a relatively small amount of lead for shielding the radioactive sources. The shielding will consist of lead collimators and ”garages” made of lead blocks, in which the sources will be parked when not in use. The lead will be painted or otherwise encapsulated by Fermilab ES&H personnel before it is installed.

7.7 Steel Handling

Safety in the fabrication of the steel parts of the detector at assembly is primarily ensured by allowing only trained staff to operate the cranes and forklift. All steel pieces will be deburred by flame cutting. The steel support structures and other steel devices are built to industry standards [182]. All lifting fixtures are required to be designed and constructed according to the American National Standard [183]. Any lifting fixture must have an engineering note reviewed by another mechanical engineer and then load tested in front of witnesses at 125% of rated load. All of the documents for any mechanical equipment for the experiment will be reviewed by the experiment's Particle Physics Division Safety Review Panel. All procedures and engineering notes are approved by this panel before first use is allowed.

7.7.1 Detector Support Stand

The detector modules will be stored on custom-built steel racks while awaiting installation in the MINOS Hall. The actual detector support stand will be of similar construction. The detector support stand, the underground storage racks, the bookends that keep the detector planes aligned, and all lifting fixtures will be designed by Fermilab engineers. The structures will be reviewed and will undergo appropriate load tests, which will be documented in Engineering notes.

7.8 Installation Issues

The MINERνA detector will be installed in the Near Detector Hall at the downstream end of the NuMI beamline at Fermilab, approximately 100 m underground. The hall is outfitted with utilities, cranes and fire protection systems installed for the MINOS detector. MINERνA may require relatively minor upgrades to these. Once the detector and power distribution designs are finalized, the fire protection systems in the Near Detector Hall will be evaluated to see if additional protection is required.

There are a number of hazards associated with the installation and operation of the MINERνA underground. This environment compounds the normal hazards associated with moving equipment weighing several tons, operation of electrical devices, and possible fringe magnetic fields from the MINOS detector. The following safeguards have been adopted to address these hazards.

Access to the Near Detector is restricted; it is accessible only through the surface building, in which the access to the elevator is locked. Only personnel with underground safety training are permitted to check out a key. Detector components are lowered down the shaft by crane, mounted on a cart, and taken to the detector site underground. The procedures for installing the detector modules, racks and other components will be similar to those employed safely and successfully for the installation of MINOS.

7.8.1 Magnetic Fields

The MINERνA detector design does not include a magnet coil. The nearby MINOS detector is magnetized during operation. Therefore, the installation of the MINERνA detector stand will have to take place at a time when the MINOS detector is turned off. It is still to be determined whether the installation of the MINERνA detector elements can take place while the MINOS magnetic coil is energized. The residual field in the MINOS steel plates does not pose a significant hazard. Any access to the MINERνA area while the MINOS magnet is operating will be made in accordance with the procedures posted in the MINOS Hall.

7.8.2 Life Safety & Egress

Safe passageways for access to detectors and egress from the area are important factors for underground safety. Placement of the MINERνA detector is determined by an acceptable safety factor. Since the MINOS Near Detector may provide useful data on muons produced in neutrino interactions in the MINERνA detector, the muon acceptance in MINOS is a consideration in the placement of MINERνA. Ideally, the detectors should be as close to each other as possible to maximize the acceptance. A passageway between the detectors wide enough to allow safe access is the lower limitation on the detector separation. This limit is taken to be a 56-cm (22-inch) gap between the downstream face of MINERνA and the upstream face of MINOS.

7.8.3 Near Hall Occupancy

The MINERνA detector will be installed in the MINOS Near Detector Hall, approximately 100 meters underground. The considerations of fire protection and life safety for the installation of MINERνA are very similar to those for the NuMI Project, during which the underground hall was built and the MINOS Near Detector installed [184]. There are two specified occupancy limits for the near hall: one for installation conditions and a more restrictive one for operational conditions. In the event that MINOS is operating during the MINERνA installation, an appropriate review by Fermilab ES&H will determine which limit is applicable to the MINERνA installation. Once this decision is reached, the MINERνA installation will abide by the underground occupancy limits, coordinating with the MINOS collaboration and any other groups working in the underground hall. All personnel working in the underground hall are required to take NuMI/MINOS underground safety training.

7.9 Cryogenic Safety

The baseline design of the MINERνA detector does not include any cryogenic systems. However, the possibility exists that a helium target may be considered as an added feature at a later time. In such a case, standard Fermilab procedures for cryogenic safety will apply [185] to the design, fabrication, installation and operation of the liquid helium target. These include design and safety reviews, as well as the preparation of a target safety review book.

7.10 Environmental Considerations

The construction, installation, operation and eventual decommissioning of the MINERνA detector are not anticipated to have any significant impact on the environment. The MINERνA Project submitted an Environmental Evaluation Notification Form to the Department of Energy in accordance with the National Environmental Policy Act (NEPA). The project was subsequently granted a Categorical Exclusion under NEPA on December 2, 2005 [186].

Part I
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