NuMI Off-axis Electron Neutrino (ν_e) Appearance (NOνA) Experiment Near Detector

Section III - Chapter 5

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III - 5.1 NOνA Near Detector Location on Fermi National Accelerator (Fermilab) Site

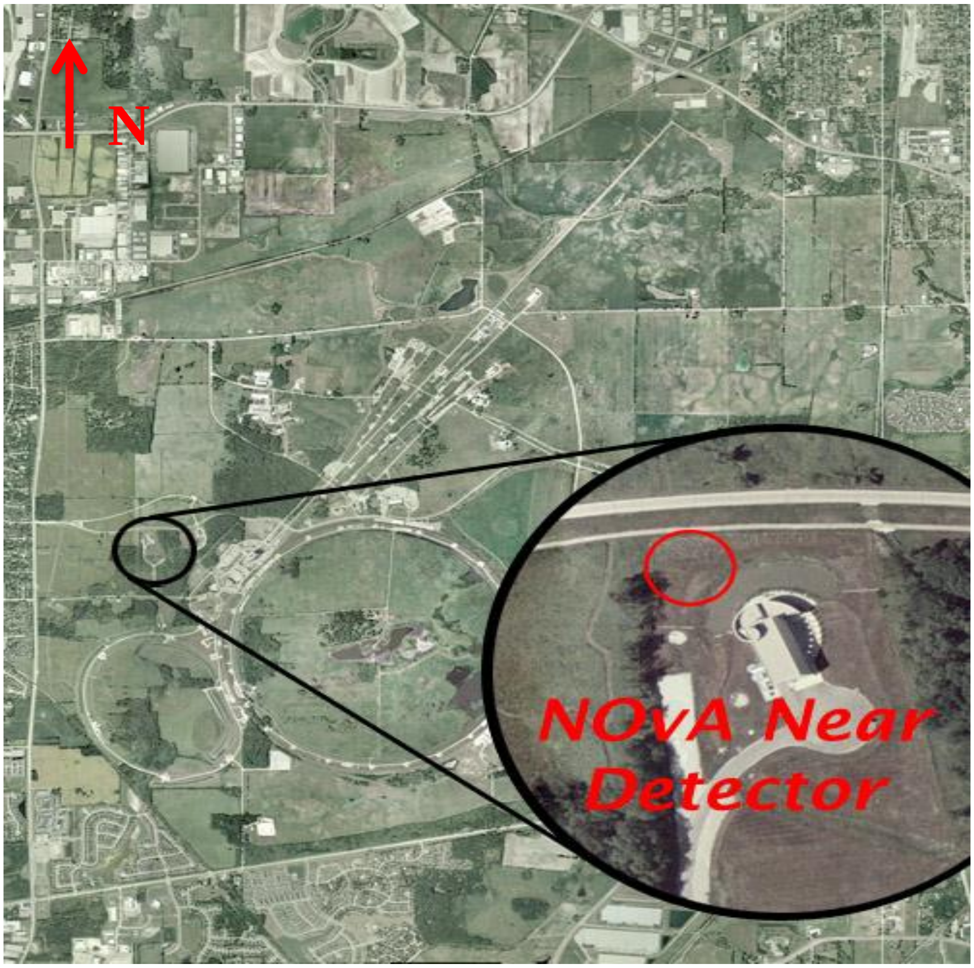

Figure 1 – Bird's eye view of Fermilab

III - 5.2 Inventory of Hazards

The following table lists the identified hazards found at the NOνA Near Detector site. All hazards with an * have been discussed in Chapters 1-10 of the Fermilab Safety Assessment Document and are covered no further in this section. The NOνA project as a whole has been reviewed for environmental impacts according to NEPA and was issued a Finding of No Significant Impact by the Department of Energy[1].

Radiation Sealed source usage	**Kinetic Energy** Power tools* Pumps and motors*
Toxic Materials Pseudocumene Liquid scintillator oil	**Potential Energy** Crane operations* Heavy equipment and material installation*
Flammable & Combustible Materials Cables* PVC extrusions Wave shifting fiber Liquid scintillator oil Electronics	**Magnetic Fields** N/A
Electrical Energy High voltage*	**Gaseous Hazards** N/A
Thermal Energy N/A	**Access / Egress** Life safety egress

III - 5.3 Introduction

This Section III, Chapter 5 of the Fermi National Accelerator Laboratory (Fermilab) Safety Assessment Document (SAD) covers the NOνA Near Detector site at Fermi National Accelerator Laboratory, Batavia, Il.

III - 5.3.1 Purpose of the NOνA experiment

The NOνA experiment uses a neutrino beam to study the strange properties of neutrinos, especially the transition of muon neutrinos into electron neutrinos. The neutrino beam interacts with the “Near Detector” located on the Fermilab site. Beyond the detector, the neutrino beam travels through the earth from Fermilab to a new laboratory in Ash River, Minnesota, that houses the so-called “Far Detector”. Due to the physical interaction properties of the neutrino beam no tunnel or other physical connection is needed between the Fermilab and the Far Detector. Indeed, there is no detectable ionizing radiation due to the neutrino beam at either detector. The safety assessment of the beamline is addressed in the Neutrinos at the Main Injector (NuMI) Beam Line SAD Chapter. The Far Detector is operated by the University of Minnesota and is located near Ash River, Minnesota. Safety assessments of the Far Detector are addressed by the University of Minnesota and are beyond the scope of this chapter. The experiment will help answer some of the most important scientific questions about neutrino masses, neutrino oscillations and the role neutrinos may have played in the evolution of the universe.

III - 5.3.2 Description of NOνA Near Detector

The NOνA Near Detector resides approximately 350 feet underground in a cavern adjacent to the MINOS detector hall. The NuMI beamline transports protons from Fermilab's Main Injector accelerator (left in figure 2) 1,000 feet down the beam line, where the protons interact with a graphite target to create muon neutrinos that interact with the Near Detector. The NOνA Near Detector site consists of:

- An underground NOνA Near Detector cavern measuring 75’L X 20’W X 22’H, located adjacent to the existing underground cavern that houses the Main Injector Neutrinos Oscillation Search (MINOS) experiment. The cavern is outfitted with an automatic water mist fire suppression system, a Very Early Smoke Detection and Alarm (VESDA) detection system, and secondary containment for the liquid contained within the detector. The cavern also houses the electronics for the detector;
- The NOνA Near Detector, which is an approximately 294- metric-ton structure constructed of modules made of polyvinyl chloride (PVC) and steel. The rigid PVC cellular extrusions are filled with liquid scintillator, which comprises 70% of the total detector mass. The detector contains approximately 41,200 gallons of liquid scintillator oil. Included in this design is 100% secondary containment for the liquid scintillator.

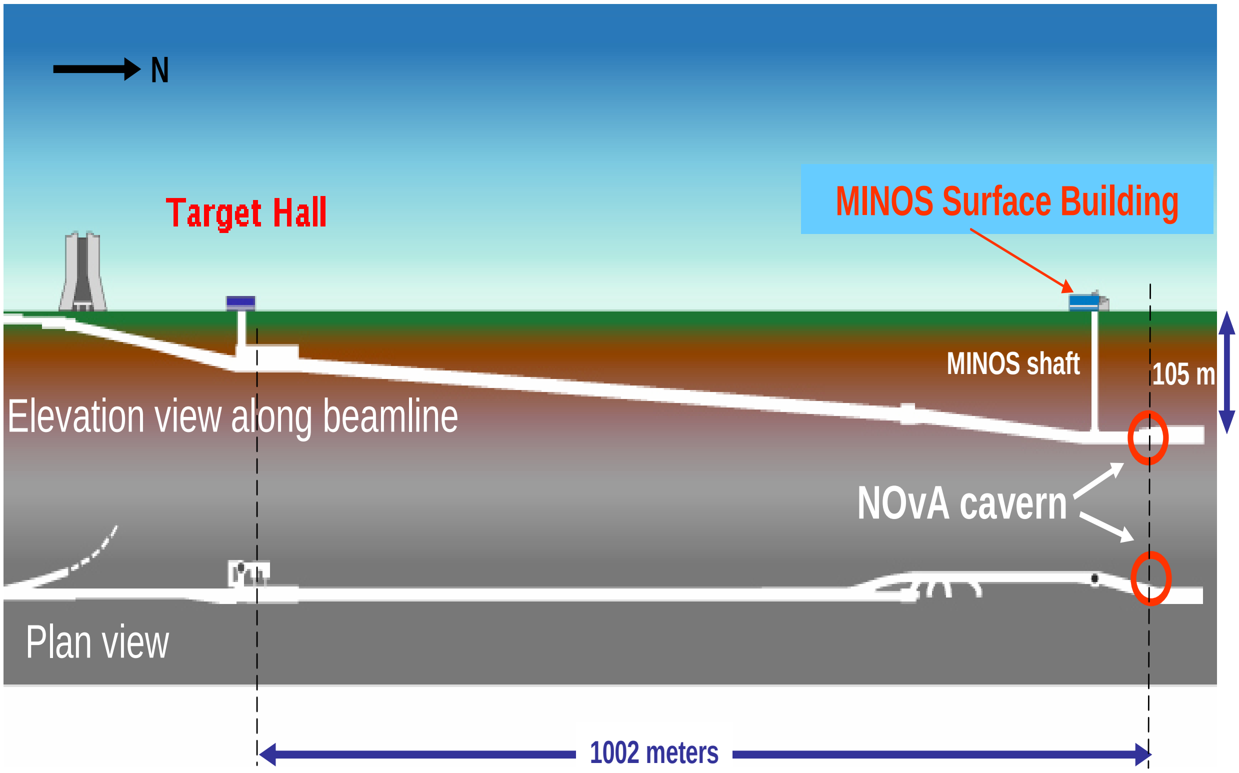

Figure 2 – Neutrino transport path to NOvA Near Detector hall.

III - 5.3.3 Operating Modes

The NOνA Near Detector operates as a neutrino detector which is geographically separated from AD-managed accelerators. The PPD is responsible for the operations of the NOνA detector.

III - 5.4 Safety Assessment

The unique hazards of the NOνA Near Detector are analyzed in this section.

III - 5.4.1 Radiation

During the course of commissioning and operating the NOνA Near Detector, it may be necessary to calibrate the response of the detector with sealed radioactive sources. The usage of these sources is governed by Chapter 4 – Radioactive Materials of the Fermilab Radiological Control Manual (FRCM)[2]. All radioactive source usage will adhere to the sealed radioactive source controls section contained within the chapter.

III - 5.4.2 Toxic Materials

III - 5.4.2.1 Pseudocumene – A component of the liquid scintillator oil

NOvA's liquid scintillator oil contains 5.35% pseudocumene. The pseudocumene is an eyes, skin and respiratory irritant, central nervous system depressant, and is toxic to marine life. A job-specific hazard analysis and procedure govern filling the detector and prescribe Personal Protective Equipment (PPE) to prevent worker contact with the liquid scintillator. The PVC modules, once filled, completely contain the pseudocumene, resulting in no further exposure. Emergency spill equipment, an eye wash and PPE are stationed near the detector in the event of a release. The entire detector is inside of a secondary containment membrane that has the capacity to contain 100% of the liquid scintillator oil and prevent a release to the environment.

III - 5.4.2.2 Secondary Containment for Liquid Scintillator Oil

The NOvA Near Detector contains approximately 41,200 gallons of liquid scintillator oil. A pliable PVC membrane secondary containment is installed around the entire detector. The NOvA Near Detector secondary containment has been reviewed and certified in the Fermilab Spill Prevention, Control and Countermeasure (SPCC) Plan, July 15, 2013[3]. The scintillator distribution system design has minimal joints and connections to limit the potential for spills. The Fermilab SPCC plan dictates that the secondary containment be included on the monthly inspection schedule. The SPCC is periodically revised in accordance with regulatory standards. The secondary containment of the NOvA Near Detector will be included in the SPCC on a continuing basis.

III - 5.4.3 Flammable and Combustible Materials

The Near Detector cavern underwent a fire hazard and life safety analysis[4] using the International Building Code and NFPA 520 provisions as appropriate. Hughes Associates, Inc. completed this evaluation during March 2010. The liquid scintillator, as delivered to Fermilab, is a Class III B combustible liquid according to the flash point indicated by the MSDS. The liquid scintillator presents a potential fire hazard during detector filling. The cellular structure of the detector significantly mitigates this hazard by containing the liquid scintillator within fire retardant cellular PVC extrusions. A burn test performed on the rigid PVC extrusions and contained in the *NOvA Rigid PVC Flammability Testing and other Fire related issues*[5] concluded that this design and the liquid scintillator's high flash point of >202°F reduce the opportunity for ignition. Hazard mitigation includes restricting open flames or other sources of ignition present in any areas containing liquid scintillator via Fermilab Environment, Safety, and Health Manual

(FESHM)[6] Chapter 6020.2 - Welding, Burning, and Brazing chapter, an automatic water mist fire suppression system, a VESDA smoke detection, and Fermilab Fire and Utilities Monitoring System (FIRUS).

The large quantity of wavelength shifting fiber is a combustible, but does not constitute a fire hazard because it is completely enclosed inside the individual PVC cells.

Filling the cells with liquid scintillator oil presents a fire hazard due to static accumulation and discharge on the plumbing. This hazard is mitigated using plumbing that is conductive, grounded and bonded. Also, an anti-static additive is added to the scintillator in concentrations that increase conductivity to reduce the steady state electric current flow in the main distribution lines by a factor of ~100, reducing the charge delivered to the module by this factor. An additional risk from scintillator-initiated fire would stem from improper storage and disposal of oil-soaked rags. Spills are dealt with promptly, and fire-proof disposal receptacles are provided where needed. Appropriate interlocks and controls on the scintillator filling machines reduce the probability of spills during scintillator liquid transfer. If removal of the scintillator is required, similar provisions will mitigate these hazards.

The installation of electronics, power supplies, and all other electrical components of the experiments performed in the Near Detector cavern are in accordance with the Particle Physics Division (PPD) Electrical Department guidelines and FESHM to ensure that they do not constitute a fire or shock hazard. All installations have been reviewed according to the ORC process.

III - 5.4.4 Access/Egress

III - 5.4.4.1 NOνA Cavern Access/Egress

Primary egress for workers (general access and emergency evacuation) is the personnel elevator located in the MINOS building. Secondary emergency egress is along the decay pipeline to MI-65 to a stairwell that leads to the surface. The NOνA Near Detector cavern access/egress is governed by NuMI/MINOS underground training and coordination with the MINOS Area Coordinator. Access requires current training, at least one other trained individual, a hard hat, closed toe shoes, and a flashlight. Depending upon work in the underground area, the PPE required for entry may change as appropriate.

Specially-trained crane operators transport all heavy equipment and materials underground via the house crane through the shaft. The MINOS area crane requires special on-the-job training due to its unusually long wire rope and swing potential. The MINOS Area Coordinator and the MINOS Work Permit/Tour system coordinate all underground work.

III - 5.5 Credited Controls

III - 5.5.1 Passive Controls

As described in Chapters 1-10 of the Fermilab SAD, passive controls are designed to reduce the risk of accelerator operations hazards to an acceptable level. The NOνA Near Detector site is geographically separated from the accelerator components. The passive controls implemented in Section 5.4 exist to ensure safe operations during all conditions at the NOνA Near Detector and are not specific to accelerator operations.

III - 5.5.2 Active Controls

As described in Chapters 1-10 of the Fermilab SAD, active systems are designed to reduce the risk of accelerator operations hazards to an acceptable level. The NOνA Near Detector site is geographically separated from the accelerator components. The NOνA Near Detector does not have any accelerator components and thus does not require active controls.

III - 5.5.3 Administrative Controls

Administrative controls and procedures have been put in place to ensure safe operations at the NOνA Near Detector site. Operational readiness of the experiment is governed by *PPD ESH 006 ES&H Review of Experiments*. Subject matter experts review each aspect of the experiment prior to operations to ensure safe operations. The review includes procedure, hazard analysis and document reviews and walk-throughs of the experiment components. Division head(s) of the area(s) in which that experimental components reside grant approval for operations.

III - 5.5.3.1 Description of detector operations

Commissioning, normal operations, and emergency management of the NOνA Near Detector site are all conducted under the auspices of the PPD Headquarters, the PPD Environment Safety & Heath Department, and the PPD Intensity Frontier Department.

III - 5.6 Summary & Conclusion

This chapter of the Fermilab Safety Assessment identifies and assesses specific hazards associated with commissioning and operation of the NOνA Near Detector. The chapter identifies and describes designs, controls, and procedures to mitigate NOνA Near Detector specific hazards. Further, in addition to the specific safety considerations presented in this chapter, the NOνA experiment is subject to the global and more general safety requirements, controls, and procedures outlined in Section 1 of this Fermilab Safety Assessment Document.

The NOνA experiment has been constructed, commissioned, and will be operated within the specific and general considerations of this safety assessment. The preceding discussion of the hazards presented by the NOνA experiment operations and the credited controls established to mitigate those hazards demonstrate that the experiment can be operated in a manner that will produce minimal hazards to the health and safety of Fermilab workers, researchers, members of the public, as well as to the environment.

III - 5.7 Glossary, Acronyms

AD	Accelerator Division
DOE	United States Department of Energy
ES&H	Environment, Safety and Health
EA	Environmental Assessment
EPA	Environmental Protection Agency
Fermilab	Fermi National Accelerator Laboratory
FESHM	Fermilab Environment, Safety, and Health Manual
FIRUS	Fire and Utilities Monitoring System
FONSI	Finding of No Significant Impact
FRCM	Fermilab Radiological Control Manual
MINOS	Main Injector Neutrino Oscillation Search
MSDS	Material Safety Data Sheet
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NOνA	NuMI Off-axis Electron Neutrino (ν_e) Appearance Experiment
NuMI	Neutrinos at the Main Injector
PPD	Particle Physics Division
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
SAD	Safety Assessment Document
SPCC	Spill Prevention Control and Countermeasures
VESDA	Very Early Smoke Detection and Alarm

III - 5.8 References

[1] Construction and Operation of Neutrinos at the Main Injector (NuMI) Off-axis Electron Neutrino (ν_e) Appearance Experiment (NOνA) at the Fermi National Accelerator Laboratory, Batavia, Illinois, and St. Louis County, Minnesota (DOE-EA-1570) – U.S. Department of Energy Finding of No Significant Impact, Peter Siebach, June 2008

[2] Fermilab Radiological Control Manual. - The current web link is: http://esh.fnal.gov/xms/ESHQ-Manuals/FRCM

[3] Spill Prevention Control and Countermeasures Plan, Fermi Research Alliance, LLC, Fermi National Accelerator Laboratory, Revision 4, July 2013

[4] Lab Safety/Fire Protection Analysis for Fermilab NOνA Near Detector Cavern, Hughes Associates, Inc., March 5, 2010

[5] NOνA Rigid PVC Flammability Testing and other Fire Related Issues, NOνA Document Data Base, document #358, James Priest, February 2005

[6] Fermilab Environment, Safety, and Health Manual. – The current link is: http://esh.fnal.gov/xms/ESHQ-Manuals/FESHM