ENVIRONMENT, SAFETY & HEALTH CONSIDERATIONS FOR A NEW ACCELERATOR FACILITY*

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Abstract

A study of siting considerations for possible future accelerators at Fermilab is underway. Each candidate presents important challenges in environment, safety, and health (ES&H) that are reviewed generically in this paper. Some of these considerations are similar to those that have been encountered and solved during the construction and operation of other accelerator facilities. Others have not been encountered previously on the same scale. The novel issues will require particular attention coincident with project design efforts to assure their timely cost-effective resolution. It is concluded that with adequate planning, the issues can be addressed in a manner that merits the support of the Laboratory, the U.S. Department of Energy (DOE), and the public.

1 REGULATORY MATTERS

Any future accelerator at Fermilab will have to meet specified standards in the area of ES&H. Contractual requirements in ES&H are Fermilab's Work Smart Standards that are updated annually[1]. Requirements in the contract under which a future accelerator might operate could be different.

1.1 Environmental Protection

Any new federally-funded facility must be reviewed under the National Environmental Policy Act (NEPA)[2]. An Environmental Assessment (EA), conducted by DOE, will cover all possible impacts on the environment and the public of construction, operations, and decommissioning. The EA will cover topics that are generally associated with environmental protection such as the discharge of pollutants; effects upon floodplains, wetlands, and groundwater; and exposures of people to chemicals and radiation. Also included are societal impacts such as levels of employment, traffic, noise, and environmental justice. The alternatives of carrying out the project elsewhere or not at all are addressed. DOE may choose to require the preparation of an Environmental Impact Statement (EIS) if impacts identified in the EA are significant and unavoidable. It is likely that an EIS will be required for any facility that extends beyond the present boundary of the Fermilab site. The duration of the EIS process is measured in units of years. Aside from early conceptual design efforts, project funds cannot be issued prior to successful completion of the NEPA process. It is thus crucial that this work be initiated early and conducted in a manner that comprehensively addresses the potential concerns of the public and DOE. DOE will choose the venues for public input.

There are state and federal environmental permits and approvals to obtain from entities such as the U.S. Environmental Protection Agency, Illinois Environmental Protection Agency, U.S. Army Corps of Engineers, and Illinois Department of Natural Resources. The U.S. Fish and Wildlife Service, the Illinois Historic Preservation Agency, and possibly others are likely to have comments on permit issues. These permits would apply to such topics as storm water discharges, discharge of process cooling water, wetlands impacts, construction in floodplains, the pumping of groundwater, and releases of air pollutants both non-radioactive and radioactive. Potential archaeological sites might need further study prior to construction. Lead times of a year or more to obtain an appropriate permit are commonly required. Compared to more conventional facilities a large accelerator is likely to be viewed by regulators as a poorly understood, esoteric technology. Thus, early coordination with regulatory agencies is highly desirable.

1.2 Safety and Health

The preparation of a Safety Assessment Document (SAD) covering the ES&H issues will be required, likely preceded by a preliminary SAD (PSAD)[1]. The PSAD is intended to identify relevant ES&H issues at an early stage (prior to detailed design) while the SAD documents the resolution of these matters. Environmental issues are integrated into the PSAD/SAD process as a part of integrated safety management. DOE will likely choose to review the SAD, perhaps by using an external review team. Just prior to facility operation, a formal readiness review would be required. A careful, consistent approach to NEPA/PSAD/SAD issues at early stages will be of significant benefit.

1.3 Future Conditions

DOE is presently "self-regulating" in the areas of industrial safety and occupational radiation protection. There is a possibility that during the development of the next accelerator facility, DOE activities might become subject to "external" regulation in these areas. Further, the standards in Ref. 1 are subject to modification from time-to-time as are external regulations. The "ground rules" applicable to a particular facility will be the contemporary ones.

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2 ISSUES DURING CONSTRUCTION

2.1 Safety and Health

Any of the accelerators being considered will involve a great deal of underground construction. Where the conventional "cut and fill" method is used near the surface, the Occupational Safety and Health Administration's (OSHA's) regulations on the safety of construction activities will be followed[1]. Particular requirements for excavations, personnel protective equipment, emergency response measures, means of egress, fire safety, chemical safety, and electrical safety will apply. In some candidate facilities significant slopes may be involved. Effective means of preventing accidents due to heavy objects moving downhill are needed.

Several candidate facilities involve considerable tunneling in bedrock, in some places horizontal and in others at significant slopes. Regulations pertaining to underground operations (e.g., "mining") supplement more general requirements. These include concerns about tunneling safety and transport of material as the tunneling proceeds. Construction methods will likely utilize a combination of drilling and blasting and tunnel boring machines. Provisions for emergency response and means of egress are needed and underground rescues must be planned for. The current NuMI project is providing valuable experience with regard to these issues. In addition, the prevention of tunnel flooding must be accomplished in harmony with environmental protection concerns related to water discharge (see Section 2.2).

During construction, industrial radiography is likely to be employed to provide adequate quality assurance of pipe welds, etc. Radioactive sources used in such work produce much more intense radiation fields than do those commonly used in particle physics experiments. Likewise, radiation-generating machines used for this purpose present significant hazards. The radiographic operations must be conducted in compliance with specific regulatory requirements.

Finally, noises heard, vibrations felt, or lights seen at night by members of the public can present public relations problems that must be addressed successfully.

2.2 Environmental Protection

All candidate facilities would be placed nearly entirely underground. Some portions will be located near the surface, in the glacial till, while others will be located deep underground in bedrock. Both point and non-point sources of surface water contamination will require one or more permits under the National Pollutant Discharge Elimination System (NPDES). Well-engineered erosion control measures, consistent with relevant regulatory guidance will be needed to limit dust and runoff from spoil piles and to manage stormwater discharges.

Tunneling in bedrock produces a considerable volume of spoil, such as pulverized rock, that must be properly managed. Construction in aquifers will result in the need to protect drinking water resources from contamination. The dewatering of tunnels will motivate the use of measures to prevent the depletion of wells and effectively manage surface water discharges to meet permit conditions. Water quality standards for both individual and municipal wells must be met. Careful hydrogeologic studies will be needed to create successful engineering solutions to these issues. The current NuMI project is providing valuable experience in some of these issues.

During construction activities, precautions are needed to guarantee that spills of chemicals, including lubricants and fuels from the construction equipment, are captured before they enter surface or groundwater.

3 ISSUES DURING OPERATIONS

3.1 Safety and Health-"Ordinary" Hazards

A number of occupational safety hazards, addressable using standard techniques, that are found at other large particle accelerators will be present in all of the candidate facilities. The following is a short list:

- Large electrical currents needing lockout/tagout,
- RF generation and other non-ionizing radiation,
- Fire protection concerns associated with cables,
- Radiation damage of safety equipment,
- Flammable materials, including detector gases, and
- Movement and alignment of large components.

3.2 Safety and Health-"Novel" Hazards

Some proposed facilities involve novel hazards not previously addressed on a similar scale. These are discussed here. The technique of peer review may be useful in addressing these issues by enlarging the base of available expertise.

Large Scale Use of Cryogens-The next generation of accelerators are likely to use superconductors and cryogenics in magnets and RF structures. Standard engineering practices and review mechanisms should be employed to assure cryogenic safety and mitigation of oxygen deficiency hazards. Longer tunnels may create new problems not found at present accelerators.

Ionization Cooling Technology-The use of ionization cooling in a liquid hydrogen (LH_2) medium is under consideration for some facilities. While in some ways this is preferable to the use of toxic materials, the fire/explosion hazard associated with LH_2 must be adequately addressed.

High Power Lasers-The use of high power lasers in the new facilities to manipulate particle beams or as photon sources presents potential hazards that must be addressed at an early stage in accordance with specific standards.

Emergency Response/Life Safety Considerations-The longer tunnels at larger depths under consideration pose special problems of this kind that need to be successfully resolved. For example, special means of underground communication will need to be provided, possible refuge locations incorporated, and adequate means of transport of both healthy and injured personnel to the surface established.

Fire Performance Characteristics of Materials-In view of the tunnel lengths and egress conditions, enhanced importance must be attached to the hazards associated with the toxicity and corrosiveness of smoke from burning plastics, both halogenated and halogen-free. Thus, fire performance characteristics, or effective means for mitigation, are important considerations in the selection of materials.

3.3 Radiation Safety and Environmental Protection

Prompt Radiation Shielding-All future accelerators will require significant thicknesses of passive shielding to attenuate prompt radiation to levels acceptable to the members of the public, with details dependent upon the particle type (lepton versus hadron) and the beam power. As at present accelerators, neutron shielding will generally dominate laterally while muon shielding may dominate longitudinally. The shielding needs must be well-defined in early shielding design studies to be accurately reflected in the NEPA analysis.

Department of Energy and other federal requirements are not completely clear concerning radiation fields beyond the boundaries of DOE sites. DOE has specified an annual limit of 100 mrem (1 mSv) on the radiation dose equivalent that can be received by general "non-radiation" workers and members of the public[1,3]. This limit applies to that received by actual people or to locations where people could reasonably be present. Special reporting requirements apply if the annual dose equivalent received by an individual exceeds 10 mrem (0.1 mSv)[3]. For comparison, in the U.S. the average dose equivalent received by an individual from natural sources is about 300 mrem (3 mSv)[4]. In view of public concerns and these requirements, the design of new facilities should minimize exposures to members of the public. Higher limits at underground locations inaccessible to people but beyond the surface footprint of a laboratory might be allowed. However, it would be best to have the limits specified prior to the NEPA analysis.

While many shielding problems are conventional, new ones may arise. First, the likely large dimensions of a new facility coupled with the long ionization ranges and enhanced importance of the range-straggling of muons of increased energies require that the curvature and profile of the earth's surface be taken into account to adequately range them out. Second, for some facilities the prompt radiation dose due to neutrinos is a new consideration of significance[5]. Both of these issues could significantly impact the selection of the "footprint" of property needed by the facility.

Residual Radioactivity-New accelerators will result in unprecedented levels of beam power, a reliable figure of merit for radioactivation. The consequences of high residual activity levels need to be addressed in early design stages of collimation systems, targets, ionization cooling apparatus, and places of high beam loss. The use of "unusual" metals such as lithium or mercury as targets merits specific attention. Remote handling equipment may become necessary on a large scale. The minimization of the generation of radioactive wastes to avoid the creation of so-called "mixed wastes" is vital.

Airborne Radioactivity-Stringent federal regulations limit the annual dose equivalent to 10 mrem (0.1 mSv) to any member of the public from airborne releases of radioactivity from DOE facilities such as accelerators, with yet more stringent thresholds for monitoring and reporting[6]. This may be a major issue for future facilities, best addressed in the design stage.

Radioactivity in Soil and Groundwater-The placement of any of the future facilities in either the glacial till or underlying bedrock requires that the production of radioactivity in these hydrogeologic units be given careful attention, especially with enhanced beam power. Prior to selecting the exact footprint, the hydrogeologic studies mentioned in Section 2.2 should determine relevant parameters precisely, as local variabilities can be large. The objective is to be able to protect groundwater resources and confidently address public concerns.

4 SUMMARY

All new facilities under consideration result in a number of challenges in ES&H. Some have been effectively addressed in the past while others will need new solutions. Given the new scale and nature of possible facilities some of these issues may be more important than in the past. It is concluded here that with sufficient planning in the design stages, these problems can be adequately addressed in a manner that merits the support of DOE, and the public. We acknowledge the helpful comments of our colleagues on this paper; Deborah Grobe, Timothy Miller, and Kamran Vaziri of Fermilab and Jonathon Cooper of DOE.

5 REFERENCES

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