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DOE G 420.2-1
7-1-05

Accelerator Facility Safety Implementation Guide

for

DOE O 420.2B, *SAFETY OF ACCELERATOR FACILITIES*

[This Guide describes suggested nonmandatory approaches for meeting requirements. Guides are not requirements documents and are not to be construed as requirements in any audit or appraisal for compliance with the parent Policy, Order, Notice, or Manual.]

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This document is an aid to understanding and meeting the requirements of DOE O 420.2B, *Safety of Accelerator Facilities* (7/23/04). It does not impose requirements beyond those stated in that Order or any other DOE Order. An accelerator safety program may not need to fully implement all sections of this guidance to satisfy the requirements of DOE O 420.2B; a tailored approach, based on the complexity of the accelerator facility, can be used when applying this document. The Guidance is not intended as an audit/assessment tool and should not be used as such without prior agreement between the contractor and DOE.

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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AED	Automatic External Defibrillator
ALARA	As Low as Reasonably Achievable
ANSI	American National Standards Institute
ARR	Accelerator Readiness Review
ASME	American Society of Mechanical Engineers
ASE	Accelerator Safety Envelope
ASO	Accelerator Safety Order (DOE O 420.2B or successor)
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CPR	Cardiopulmonary Resuscitation
CSO	Cognizant Secretarial Officer
DOE	Department of Energy
EG	Evaluation Guideline
EPA	Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
ES&H	Environment, Safety & Health
FHA	Fire Hazard Analysis
ISM	Integrated Safety Management
ISO	International Organization for Standardization
LED	Light Emitting Diode
LO/TO	Lockout/Tagout Procedures
MCI	Maximum Credible Incident
NCRP	National Council on Radiation Protection and Measurements
NEC	National Electric Code
NEPA	National Environmental Protection Act
NESC	National Electric Safety Code
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Administration

NPH	Natural Phenomena Hazard
NRTL	Nationally Recognized Testing Laboratory
ODH	Oxygen Deficiency Hazard
OSHA	Occupational Safety and Health Administration
PAG	Protective Action Guide
PSAD	Preliminary Safety Assessment Document
QA	Quality Assurance
PC	Performance Criteria
PPE	Personal Protective Equipment
R&D	Research and Development
RF	Radio Frequency
RPP	Radiation Protection Program
SAD	Safety Assessment Document
SC	Office of Science
TLV	Threshold Limit Value
USI	Unreviewed Safety Issue

DEFINITIONS

Accelerator is a device employing electrostatic or electromagnetic fields to impart kinetic energy to molecular, atomic or sub-atomic particles and, for purposes of this Guide, capable of creating a radiological area as defined in Title 10, Code of Federal Regulations, Part 835 entitled *Occupational Radiation Protection* (10 CFR 835).

Accelerator Facility is the accelerator and associated plant and equipment utilizing, or supporting the production of, accelerated particle beams to which access is controlled to protect the safety and health of persons. It includes injectors, targets, beam dumps, detectors, experimental halls, experimental enclosures and experimental apparatus utilizing the accelerator, regardless of where that apparatus may have been designed, fabricated, or constructed.

Accelerator Readiness Review (ARR) is a structured method for verifying that hardware, personnel, and procedures associated with commissioning or routine operation are ready to permit the activity to be undertaken safely.

Accelerator Safety Envelope (ASE) is a set of physical and administrative conditions that define the bounding conditions for safe operation at an accelerator facility.

Approve means to confirm that a proposed contractor activity has acceptable safety and health implications.

Authorize means to give a right to undertake an activity; as applied to contractor activities, authorization to commence or resume operations is reserved for the DOE Contracting Officer.

Authorization Basis is defined in this Guide as that set of documents or requirements upon which a decision is made by DOE whether to authorize the commencement or continuation of activities.

Commissioning is the process of testing an accelerator facility, or portion thereof, to establish the performance characteristics. It starts with the first introduction of a particle beam into the system.

Emergency Response Planning Guidelines (ERPG) are values established by the American Industrial Hygiene Association that are intended as estimates of concentration ranges where one might reasonably anticipate observing adverse effects as a consequence of exposure to a specific substance.

Exclusion Area is an area that is locked and interlocked to prevent personnel access while the beam is on.

Experimenters means all persons directly involved in experimental efforts at the accelerator facility utilizing the accelerator or its beams, including visiting scientists, students and others who may not be employees of the operating contractor.

Hazard means a source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to personnel or damage to a facility or to the environment.

Maintenance Personnel means not only those in the specialized crafts generally associated with maintenance activities, but also accelerator operations personnel and experimenters to the extent that they undertake to repair, maintain, or improve safety-related equipment.

Protective Action Guide (PAG) is the projected dose to reference man, or other defined individuals, from an accidental release of radioactive material at which a specific protective action to reduce or avoid that dose is warranted.

Radiation Protection Program (RPP) is the documented program, approved by DOE, including but not limited to the plans, schedules and other measures developed and implemented to achieve and ensure continuing compliance with 10 CFR 835 and to apply the as low as is reasonably (ALARA) process to occupational dose.`

Radiological Area means any area within a controlled area defined in 10 CFR 835 as a radiation area, high radiation area, very high radiation area, contamination area, high contamination area, or airborne radioactivity area.

Risk is a quantitative or qualitative expression of possible harm, which considers both the probability that a hazard will cause harm and the amount of harm.

Routine Operation of an accelerator commences at that point where DOE authorization has been granted either (1) because the commissioning effort is sufficiently complete to provide confidence that the risks are both understood and acceptable and the operation has appropriate safety bounds, or (2) to permit the re-introduction of a particle beam after being directed to cease operation by DOE because of an environmental, safety, or health concern.

Safety Analysis is a documented process to systematically identify the hazards of a given operation; describe and analyze the adequacy of measures taken to eliminate, control, or mitigate the hazards and risks of normal operation; and identify and analyze potential accidents and their associated risks.

Safety Assessment Document (SAD) is the document containing the results of a safety analysis for an accelerator facility pertinent to understanding the risks of the proposed undertaking.

Unreviewed Safety Issue (USI) exists if a proposed change, modification or experiment will either: (1) Significantly increase the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety from that evaluated previously by safety analysis; or, (2) Introduce an accident or malfunction of a different type than any evaluated previously by safety analysis that could result in significant consequences.

FOREWORD

The DOE O 420.2B, *Safety of Accelerator Facilities*, approved by Deputy Secretary Kyle E. McSlarrow on July 23, 2004, provides applicability clarification for all DOE accelerator facilities while unambiguously confirming the fundamental and operative distinctions between accelerator facilities and nuclear facilities. The defining distinction between the requirements for DOE nuclear facilities and DOE accelerator facilities has been clarified by revised exclusion 3.c.(6) of DOE O 420.2B to assure complete consistency with the exclusion of accelerators and their operations in 10 CFR 830, *Nuclear Safety Management*. Where accelerators and their operations are not a nonreactor nuclear facility by definition and because they also are not a nuclear reactor, they are not a nuclear facility subject to any requirements of 10 CFR 830 and its implementing guides/standards, including DOE-STD-1027. The revised 3.c.(6) exclusion reads:

> **(6)** ***Entire DOE/NNSA accelerator facilities or modules thereof when and only when accelerators and their operations involve or produce a sufficient inventory of fissionable materials to create the potential for criticality.***

Further information related to the comments received and the resolution of those comments for DRAFT DOE O 420.2X, *Safety of Accelerator Facilities*, which led to approval of DOE O 420.2B, *Safety of Accelerator Facilities*, can be found in the archives of the DOE Review and Comment (RevCom) System @ http://www.revcom.doe.gov/.

I. Introduction

A. Integrated Safety Management and Accelerator Facility Operations

The DOE *Safety Management System Policy* (DOE P 450.4) commits the DOE to conducting work efficiently and in a manner that ensures protection of workers, the public and the environment. This policy is the foundation for the DOE Integrated Safety Management (ISM) program and a key element of DOE contracts that reflect expectations for the integration of environment, safety and health into work planning and execution (48 CFR 970.5223-1). The ISM program outlined in these documents is founded upon a work-planning approach that integrates safety into the work planning process, establishes a set of agreed-upon standards for performance of work, and provides performance-based measures to determine when agreed-upon levels of safety are achieved. The agreed-upon standards set should be developed by a recognized standard-setting process, such as the Necessary and Sufficient Closure Process (DOE P 450.3) that results in Work Smart Standards (see DOE G 450.3-1 and DOE-HDBK-1148-2002).

The application of ISM in DOE has highlighted the importance of effective work planning as the keystone to safe operations. ISM has also demonstrated that effective work planning is an iterative process and not simply a one-time effort. As part of this process of iterative work planning, the DOE research and development (R&D) community has come to a better understanding of DOE expectations and requirements to achieve effective and safe operations. The DOE O 420.2B, *Safety of Accelerator Facilities*, provides accelerator safety requirements which, when supplemented by other applicable safety and health requirements, serve to prevent injuries and illnesses associated with accelerator operations.

This Implementation Guide has been developed to facilitate understanding of DOE expectations given by DOE O 420.2B. The Accelerator Safety Order (ASO), DOE O 420.2B, was previously issued as DOE O 420.2A in January 2001, DOE O 420.2 in November 1998 and DOE Order 5480.25 in November 1992. The current order, DOE O 420.2B, constitutes a significant improvement over previous versions benefiting from lessons learned from over a decade of safe operating experience accumulated since the order was first issued.

This Implementation Guide is intended to support the effective implementation of the ASO within ISM programs at DOE accelerator facilities. For the purpose of this document, an accelerator is defined as a device employing electrostatic or electromagnetic fields to impart kinetic energy to molecular, atomic or sub-atomic particles and capable of creating a “radiological area” as defined in Title 10, Code of Federal Regulations, Part 835 entitled *Occupational Radiation Protection* (10 CFR 835). The requirements provided in the ASO apply to entire “accelerator facilities (accelerators and their operations) or modules thereof, including injectors, targets, beam dumps, detectors, experiments, experimental halls, etc.” The experimental areas serviced by the accelerator as well as the associated plant and equipment that support accelerator

operations are the areas of the facility where access is controlled consistent with the requirements of 10 CFR 835. Uncontrolled offices and support areas need not be considered part of the accelerator facility.

B. Application of Exclusions in the Accelerator Safety Order

The previous versions of the ASO provided for a number of exclusions. One exclusion included identification of modules or areas of the accelerator facility that could be categorized as a nuclear facility because of the presence of specified quantities of nuclear and/or radioactive materials. The prior DOE O 420.2A was revised to clearly state the applicability of the current Order to all DOE accelerator facilities (accelerators and their operations) except when they have the potential for criticality. Requirements found in nuclear safety rules and orders will supersede the Order for "Entire DOE/NNSA accelerator facilities or modules thereof when and only when accelerators and their operations involve or produce a sufficient inventory of fissionable material to create the potential for criticality" (see paragraph 3.b.(6), DOE O 420.2B).

In the event that a segment of the accelerator facility involves or produces a sufficient inventory of fissionable material to create the potential for criticality, that segment of the facility may be identified as a nuclear facility while the remainder of the accelerator facility may remain subject to the requirements of the ASO. That remainder of the accelerator facility is not subject to nuclear safety requirements, only if it can be demonstrated that the criticality hazards, controls, and operations are entirely defined within the nuclear segment of the facility.

DOE O 420.2B contains exclusions for certain radiation-generating devices that fall within the definition of an accelerator and accelerator facility, as defined above. However, the devices generally have low hazards that experience has shown can be managed safely within the scope of an institutional ISM program and Radiation Protection Program (RPP). These exclusions cover unmodified commercially available units, accelerator facilities not capable of creating radiological areas, non-medical x-ray generators up to 10 MeV, and low-voltage neutron generators incapable of creating high-radiation areas. For these small low-hazard units, specified consensus standards and/or DOE Guide G 441.1-5, *Radiation Generating Devices Guide,* provides an acceptable methodology for establishing and operating a control program that will comply with DOE requirements specified in 10 CFR 835, *Occupational Radiation Protection*. The basic RPP requirements presented in DOE G 441.1-5 also are generally applicable to larger multi-purpose research accelerators. The ASO provides the overarching requirements for these multi-purpose research accelerators.

The exclusions of the ASO might not specifically address all small research or developmental units that logic would dictate be managed by the contractor under the local ISM and RPP. For example, an accelerator that is an experimental unit under development might undergo continuing change in an iterative process as the research and development project progresses. In this case the preparation of a formal Accelerator

Safety Envelope (ASE) and Safety Assessment Document (SAD) might neither be practical nor necessary because of the nature of hazards and/or developmental/ operational characteristics for such experimental units. Instead, ISM has been demonstrated to be an effective safety management tool in the research environment where the R&D work is an iterative process and not an operational routine. Therefore, in cases where an accelerator itself is a research project or developmental unit, the associated safety program should be managed under the local ISM and RPP to allow optimum flexibility to the research protocol.

In cases such as the small units discussed above, the DOE/NNSA Field Element Manager (DOE O 420.2B, Section 5.b.(6)) may approve specific exemptions from the requirements of the Order for an accelerator facility or module that does not have the potential for more than minor onsite or more than negligible offsite impacts to workers, the public or the environment.

C. Tailored Application of DOE O 420.2B

It is well recognized that there is a tremendous range of accelerator activities within DOE R&D programs. These activities range from accelerator research demonstration projects that involve a small unit situated on a bench top to those full-scale research facilities that may be miles in length/circumference. Experience accumulated since DOE O 5480.25 was issued, has demonstrated that there is no value-added operational or safety benefit from the imposition of a single implementation approach for all accelerators.

A tailored approach (based on potential impacts) is provided by DOE O 420.2B to determine the DOE managerial level at which approval of the ASE and authorization to initiate commissioning or routine operation must be granted.

A tailored process is presented in this Guide based on the potential impact and complexity of the accelerator facility (see Table 1). For example, an accelerator facility with no potential hazards/impacts beyond the immediate work area/facility could be addressed by a brief Hazards/Safety Assessment Document, which references existing site/facility ISM and RPP, uses simple qualitative hazard assessments, and analyzes the maximum credible incident.

For accelerator facilities that pose potentially minor impacts outside of the immediate work area/facility and negligible impact beyond the site boundaries, DOE authorization is based on a shielding policy approved by top facility management, a suitable ASE to bound proposed activities, and a supporting SAD approved by senior facility management. After determining that an appropriate accelerator readiness review (ARR) was conducted for an accelerator facility, the DOE Site Office would then approve the facility ASE before authorizing the start of commissioning or routine operations.

For those accelerator facilities with the potential for more than negligible offsite impacts, DOE Headquarters may contractually require concurrence with the facility SAD in

addition to determining that an appropriate ARR was conducted, approving the ASE and authorizing the start of commissioning or routine operations.

D. Tailoring Through Facility Modularization

Where a large accelerator facility consists of several elements with widely varying types and magnitude of hazards, dividing the accelerator facility into modules for safety analysis purposes may be considered to optimize the effectiveness and efficiency of facility safety management. In such cases, separate SAD and ASE documentation should be prepared for each module. The following items should be considered in applying a modular approach:

- Safety analysis methodologies and level-of-detail for each module of the accelerator facility should be separately established as appropriate for the potential impacts and level of complexity.

- Where appropriate, consideration should be given to tailoring administrative programs associated with facility operations (e.g., conduct of operations, training and qualifications, and procedures) separately for each module of the accelerator facility as appropriate to hazards and complexity.

- An overarching SAD and ASE should be considered for common support facilities and administrative programs associated with the entire accelerator facility. For facilities that use a modularized approach, particular care should be used to ensure that boundaries between facility modules are clearly established in the facility description and analyses portions of the safety documentation.

Table 1. Tailoring of Accelerator Safety Order Requirements

Accelerator Facility Features	Order Applicability	Approval	ASE/SAD
Small non-complex facilities with local work area impacts only o Radiation generating devices o Small single purpose units o Electron microscopes, ion implanters o X-ray or neutron generators o Not capable of high radiation area o Developmental/experimental units o Bench top, or single room	DOE O 420.2B applies to facilities not explicitly excluded; exemptions may be used.	Contractor manages under local ISM and RPP programs; DOE G 441.1-5 may be useful.	Exemptions may be used.
Complex facilities with negligible[1] offsite impacts o External/extractable beam(s) o Multiple points of entry, caves, users o Multiple active safety systems Unique non-radiation hazards not covered under 10 CFR 835	DOE O 420.2B applies	ASE approval at local DOE site/field office	Tailored, as needed, to address workplace/ onsite hazards and demonstrate no more than negligible offsite impacts
Facilities with credible potential for more than negligible[1] offsite impacts o Normal operations, > 10 mrem/yr at site boundary[2] from potential pathways, and/or o Accident conditions, expect > 1 rem[3] or > ERPG-1[4] at site boundary[2] for a mitigated release	DOE O 420.2B applies	ASE approval at DOE HQ	Tailored, as needed, to address hazards and assess potential workplace/site/offsite impacts
Facilities or module thereof involving or producing sufficient inventory of fissionable materials to create potential for criticality	DOE O 420.2B does not apply	10 CFR 830 applies to facility or module with potential for criticality	10 CFR 830 applies to facility or module with potential for criticality

[1] The following guidance (DOE 5480.25) defines *negligible*, *minor* and *major* impacts:
"*Major*" is that level of impact at which permanent health effects or environmental damage could occur.
(Criteria: injuries that require extensive professional medical attention; > 25 rem effective dose equivalent);
"*Minor*" is that level of impact at which permanent health effects or environmental damage are not expected.
(Criteria: minor injuries; 1 - 25 rem effective dose equivalent);
"*Negligible*" is that level of impact at which the potential for health effects or environmental damage is very slight.
(Criteria: injuries requiring only superficial professional medical attention; < 1 rem effective dose equivalent).

[2] The site boundary will need definition for each facility.

[3] EPA Protective Action Guide (PAG): US EPA, Office of Radiation Programs, Manual of Protective Action Guides and Protective Actions for Nuclear Incidents (400-R92-001)

[4] Emergency Response Planning Guideline (ERPG) values are intended to provide estimates of concentration ranges where one reasonably might anticipate observing adverse effects as described in the following definitions as a consequence of exposure to the specific substance. See: American Industrial Hygiene Association, *2004 Emergency Response Planning Guidelines (ERPG) Update Set (*Stock number: AEAR04-561).

- The ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.
- The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.
- The ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing life-threatening health effects.

II. Implementation of the Accelerator Safety Order

A. Accelerator Facility Preoperational Activities

1. Safety Assessment Document (SAD)

a. Purpose of the SAD

The purpose of the SAD is to describe in sufficient detail all significant hazards presented by the facility and its operations and the controls by which these hazards will be managed to an acceptable level of risk. The contractor processes of preparing, reviewing, and implementing a SAD constitutes the application of the core functions of ISM to an entire accelerator facility or modules thereof. This assessment need not be duplicative of other activities carried out in the development of a facility's overall environment, safety, and health program such as the development of Work Smart Standards and/or the implementation of a site-specific ISM system.

b. General Considerations

The objective of the safety analysis is to identify hazards, credible impacting events, initiators of events, assumptions used in estimating impacts and consequences of an event, controls required to reduce risks, and in some cases, the acceptability of risk to workers, the public and the environment.

It is recognized that there are several methods and techniques for performing safety analyses that will provide a sufficient basis for the DOE to approve the requirements and limits of the ASE. The safety analysis should be tailored to a specific accelerator facility and the specific hazards of that facility.

- The SAD should describe the overall process of how safety analysis is done for the facility. The description should cover the contractor's approach to reviewing and approving safety analyses, how hazards are identified, as well as methods used to perform the hazard, accident or risk analyses.
- The safety analysis methodology may reference the analytical approach used in the safety analysis as appropriate. A bibliography of some useful references on hazard and risk analyses methods is provided in Appendix A.
- The hazard identification portion of the safety analyses should include the characterization and quantification of the inventory of hazards, energy sources and potential sources of environmental pollution, including the form, type, location, and total quantity of radiological hazards. The following hazards may be found at accelerator facilities:
    - Ionizing and non-ionizing radiation
    - Electrical

- Fire
- Vacuum and pressure
- Magnetic fields
- Cryogenic
- Chemical
- Oxygen deficiency
- Noxious gases
- Mechanical

- A safety analysis includes hazard analyses and evaluation of safety controls. Hazard analyses involve analyzing each hazard as it relates to impacts on the safe operation of the facility, and the safety of the workers, the public, and the environment. Evaluation of controls should include a description of engineered and administrative barriers that will be credited as controls or mitigation of potential injuries or environmental impact.

The safety analysis should provide the basis for development of accident scenarios. For accelerator facilities, the focus is typically on the worker and facility impacts since most accelerators do not have the potential for significant impacts on the public or the environment.

A range of accident scenarios should be evaluated to identify the bounding scenarios for the facility. The accident scenarios should evaluate impacts with and without credited engineered and administrative controls. Part of the accident analysis typically includes the identification of a maximum credible incident (MCI). The MCI is that credible accident scenario with the maximum or worst-case consequences. Identification of the MCI provides a useful perspective on the potential hazards associated with the facility and can provide information helpful for emergency planning or site assistance agreements.

While the MCI is often found to be the maximum credible radiological incident that could occur in the facility, there may be non-radiological accidents that are more limiting in terms of consequences. These non-radiological scenarios also are to be captured in the accident analysis.

- Once the consequences and likelihood of occurrence are understood, conclusions concerning acceptable risk may be made. Demonstrating that a risk is acceptable confirms the basis for the existence of engineered controls and administrative controls. If the analysis should show that a risk is unacceptable, this signifies the need for additional controls to reduce risk to acceptable levels.

  A rigorous quantitative determination of risk is not usually required. Simply using best professional judgment and process knowledge is often sufficient for estimating risk. Risk estimates can be improved by using published failure rates for equipment when available. Semi-quantitative and qualitative

estimates should be acceptable in most cases. A low-energy accelerator facility with no off-site consequences and few failure mechanisms probably will not need to consider a detailed risk analyses, whereas an accelerator facility with the potential for greater impacts might find this to be very important.

The risk analyses should conclude that all marginal and unacceptable risks have been mitigated to acceptable risk either through controls and/or limits on the operation of the facility. See Appendix A for references providingguidance on levels of risk.

c. SAD Content and Format

The ASO sets forth specific requirements for a SAD. The requirements and corresponding citations in the ASO are provided below.

- **A Safety Assessment Document (SAD) must identify hazards and associated onsite and offsite impacts to workers, the public, and the environment from the facility for both normal operations and credible accidents [4.a.(1)].** Although the SAD need not include a listing and description of every hazard at the facility, it should be sufficiently detailed to provide DOE confidence that the contractor has performed a comprehensive safety analysis. The amount of descriptive material and analysis that needs to be presented should be related to both the complexity of the facility and the nature/magnitude, respectively, of its potential hazards/impacts consistent with a tailored approach. Hazards of the type and configuration commonly found in general industry that are adequately addressed by pertinent federal regulations (e.g., OSHA regulations), consensus professional and engineering standards (e.g., ANSI standards, ASME standards, and ISO qualifications) need not be addressed in detail in the SAD.

- **The SAD must contain sufficient descriptive information and analytical results pertaining to specific hazards and risks identified during the safety analysis process to provide an understanding of risks presented by the proposed operations [4.a.(2)].** The level of detail necessary depends largely upon the complexity of the facility and magnitude of the hazards. A purpose of the SAD is not only to detail the hazards identified but also to demonstrate that a rigorous study of facility work activities has been completed where all corresponding hazards have been analyzed. Supplemental documents can be summarized or referenced in the SAD to provide this information.

- **The SAD must provide appropriate documentation and detailed description of engineered controls (e.g., interlocks and physical barriers) and administrative measures (e.g., training) taken to eliminate, control, or mitigate hazards from operation [4.a.(3)].** The SAD should demonstrate

that controls are sufficient to satisfy requirements and manage identified conditions associated with the hazards. Supplemental documents summarized or referenced in the SAD can provide an acceptable approach. In most instances, this does not necessitate quantifying risk, but can be accomplished by qualitatively describing the method that will be implemented to mitigate the hazard to the extent prescribed by the applicable requirements, codes or consensus standards. In some areas, particularly those associated with assessment of radiation dose, quantitative analysis may be a useful method for communicating residual risk.

- **The SAD must include or reference a description of facility function, location and management organization in addition to details of major facility components and their operation [4.a.(4)].** The description of facility function, location and management should be of sufficient depth and breadth that a reviewer familiar with accelerator operations, but unfamiliar with the particular site and facility, can readily understand the identified potential hazards and populations or environments at risk. Site and facility characterization is necessary to provide the framework within which the reviewer can relate accelerator operations to the hazards and potential impacts. Links to web sites can be used to provide access to background documentation.

- **The SAD must be prepared as a single document addressing the hazards of the entire accelerator facility or as separate SADs prepared for discrete modules of the facility such as injectors, targets, experiments, experimental halls, or other type modules [4.a.(5)].** Changes to an accelerator facility should be documented in a revision of the SAD. Changes to a module of an accelerator facility should be documented for that particular module. A benefit to the preparation of SAD documents in modular fashion is that changes in hazards or control measures necessitate revision only to those documents describing activities impacted by the changes. An important point for the preparation of modular SADs is that the aggregate assembly of SADs must comprehensively describe the entire facility in an integrated fashion. Relationships between various operations must be clearly identified and described. Care must be taken to assure that operational changes are integrated into all affected SAD documents.

  A separate SAD is not required for an accelerator facility module where the risks are adequately addressed in the safety analysis document of another operation, because of the integrated contribution of the module to that operation. This means that duplication of effort is not necessary where hazards, control measures and the subsequent risk of operating an accelerator facility module are adequately addressed in documentation for another operation. This modular approach can be particularly advantageous for small accelerators, experimental set-ups, or frequently changing experiments. Facility Modularization is also addressed in Section I.D of this Guide.

The SAD should be prepared by cognizant representatives of the contractor organization responsible for designing, constructing, and operating the accelerator facility. The level of detail should be commensurate with the size, and scope of the facility. Professional engineering and professional environment, safety, and health expertise should be utilized to assure performance of an effective assessment. While a centralized organization may prepare the SAD, participation of the line organization ultimately responsible for the facility should be sufficient to assure development of a relevant product. The document should be prepared well ahead of initial operation of the facility or modified operations addressed by a revision to an existing SAD to insure timely availability for relevant reviews/use of the documentation.

In order to implement the general requirements discussed above, the preparation of the SAD should be initiated as early in the life of a project as possible. For accelerators that are large and complex in nature, the details of civil design and facility engineering may not be available in sufficient detail to provide for an effective assessment at an early stage. In these situations, a preliminary safety assessment document (PSAD) may be prepared to provide an effective tool to document an initial assessment. A PSAD can, for example, provide a convenient mechanism to document the issues that must be addressed during design, construction, operation, and decommissioning to be discussed in greater detail prior to initial operations.

The following suggested outline is a generally accepted SAD format, which has proven effective in communicating requisite information. Other formats may be used that might be more amenable to the complexity of the facility. Whatever format is selected, the ASO requirements for the SAD must be met.

Chapter 1: Introduction

This chapter should provide a basic understanding of facility activities and the intentionally-designed protection afforded the public, the workers, and the environment. The design codes, consensus safety standards, regulations and DOE orders that were used to establish acceptable safety for workers and the public are appropriately listed or referenced here, or elsewhere in the document.

Chapter 2: Summary/Conclusions

The summary chapter should provide an overview of the results and conclusions of the analyses provided in the SAD. The comprehensiveness of the safety analysis and appropriateness of the proposed ASE should be addressed. It is also within this chapter that proposed exemptions from the ASO can be identified referencing other sections of the SAD for justification as appropriate.

Chapter 3: Site, Facility and Operations Description

The purpose of this chapter is to accurately depict: 1) the environment within which the facility will be constructed, 2) those facility characteristics that are related to safety, and 3) the management methods to be used in operating the accelerator facility. The following items should be addressed in this chapter:

- The accelerator site location should be characterized including any special site requirements or unusual design criteria. Information typically addresses site geography, seismology, meteorology, hydrogeology, demography and adjacent facilities that may impact accelerator safety or be adversely impacted by accelerator operations. The treatment of these items need not be duplicative of analyses performed in compliance with National Environmental Policy Act (NEPA) requirements. A tailored approach should be used that narrows this discussion to those points relevant to the safe operation of the accelerator facility. Small or bench-top accelerators, for example, may have a greatly abbreviated site description. References to other site characterization documents may be cited to provide further detailed information.
- Design criteria and as-built characteristics of the accelerator, its supporting systems and components with safety-related functions should be detailed in this chapter or in appropriate references cited. Particular attention should be given to those design features that exclude or minimize the presence of hazardous environments such as confined spaces, and assist in achieving chemical and radiation exposures as low as reasonably achievable (ALARA) during operation, maintenance and facility modification.
- Administrative functions should be addressed in the chapter with a summary presentation of the contractor and the facility organizational structure, perhaps with links to more detailed references, and a delineation of responsibilities. The functioning of administrative controls should be described both for routine operation and emergency conditions. Critical operational procedures to prevent or mitigate accidents should be specifically identified to direct attention to relevant hazard/accident scenarios, identify operations instructions linked to limits addressed in the ASE, and assure that significant procedures are verified during an ARR. Other site documents that can be referenced are an acceptable means of providing this information. The topics may include emergency preparedness, configuration control, administrative controls, calibration and testing, unreviewed safety issues (USIs), radiological and environmental programs, and records management.
- The experiments to be conducted in the accelerator facility should be described, including those design criteria and characteristics of the experimental equipment, and systems and components having safety

functions. These descriptions may be done more efficiently in a separate SAD, which could be supplemented or revised as the experimental program develops.

Chapter 4: Safety Analysis

This chapter should document 1) identification of potentially hazardous conditions associated with operation of the accelerator, 2) evaluation of potential impacts to workers, the public, and the environment, and 3) selection of control measures that reduce risks to acceptable levels. The level of detail included should be correlated with the size, complexity, hazards, potential impacts and risks associated with facility operation.

Numerous methods for performing hazards analysis have been effectively used at DOE accelerator facilities. A tailored approach is appropriate, and each accelerator facility should choose a suitable approach based on complexity of the facility and the magnitude of its potential impacts. In all cases, the hazards analysis should be comprehensive, and explore the full range of consequences each hazard could have on workers, the public, and the environment. It is expected that the analysis will be based on sound assumptions so that effort is focused on analysis of credible and realistic consequences.

The SAD should document or reference a survey of the hazards present at the accelerator facility, including prompt radiation, radioactive materials, non-ionizing radiation, hazardous materials, and sources of energy. Standard industrial hazards normally do not need to be addressed in the SAD. Standard industrial hazards are those that are routinely encountered and accepted in general industry and for which national consensus codes and/or standards exist to guide safe design and operation. However, standard industrial hazards should be evaluated for the potential to serve as initiators for accidents related to specific accelerator processes.

The impacts of the hazards should be evaluated using sound and realistic assumptions. Where considerable uncertainty exists, assumptions should be selected carefully to assure a sensible and defensible outcome whose limitations are readily understood. Analysis of estimated consequences and likelihood of occurrence may identify the need for mitigation. In most circumstances, engineered controls are preferred to administrative control. The hazard evaluation information in the SAD should include credible initiating events, the assumptions used in estimating the impacts, the impacts, and controls required to reduce hazards and associated risk to acceptable levels.

Identified controls should be evaluated to determine which, if any, should be designated as credited controls. A credited control is one determined through hazard evaluation to be essential for safe operation directly related to the protection of personnel or the environment. The number of credited controls

should be a limited subset of the total number of controls employed for overall facility operation. Credited controls should be assigned a higher degree of operational assurance than other controls. A listing of all credited engineered and administrative controls should be included in the SAD. Since credited controls are essential for acceptably safe operations, they should be suitably addressed in the ASE.

A suitable description of the maximum credible incident for the accelerator facility should be presented to provide perspective of the potential hazard associated with the facility and information helpful for emergency planning or site assistance agreements.

Implicit in the above discussion is that analysis of hazards, impacts, and types and reliability of controls involve professional judgment. This judgment is to be based on sound technical and/or scientific bases using accepted methods for hazard analysis suitable for the types and magnitudes of hazards present.

Chapter 5: Basis for Accelerator Safety Envelope

This chapter provides a connection between the engineered and administrative bounding conditions and the ASE. The focus here on this connection facilitates greater details being provided elsewhere, as appropriate. Impacts to workers, the public and the environment should be shown acceptable for normal operations within the bounding conditions of the ASE. The impacts associated with abnormal operations should be adequately addressed to assure that the level of risk to a person offsite or outside the facility is maintained at an acceptable level. The ASE must include consideration of both routine and non-routine operating conditions.

Chapter 6: Quality Assurance

This chapter should describe the quality assurance (QA) program to be applied to the accelerator facility, focusing upon the activities that impact protection of the worker, the public or the environment, as well as accelerator maintenance and operations. The QA program should address the ten management performance and assessment criteria of DOE O 414.1B.

Chapter 7: Post-Operations Planning

A description of structural and internal features, which would facilitate future decommissioning/dismantling of the facility, should be provided in this section. Operations considerations to minimize the generation of radiological and/or hazardous materials may also be included. A consideration of long-term records management to facilitate post-operations activities should be included. Waste management of radiological and hazardous material generation from the post-

operations period should be discussed within the context of existing DOE requirements. Post-operations planning is also addressed in Section C of this Guide.

Chapter 8: References/Glossary/Acronyms

Documents that provide supporting information for the SAD (e.g., shielding policy, site/facility environmental assessment, etc.) should be included in the reference section. If it is necessary to include a copy of such a document in the SAD, the document can be included as an appendix to the SAD.

d. SAD/ASE Review and Approval Process

The following steps are recommended for the internal review of SADs and/or ASEs by DOE contractors:

1) Representatives of an organization approved by contractor management should provide an internal review of the SAD. It is highly desirable that some of the reviewers be significantly independent of the preparers of the document to render an impartial review. It is not uncommon for multiple iterations to be required to assure a credible, comprehensive, unified, and understandable safety assessment document.
2) The contractor management review should be documented with a level of formality that expedites completion of the document and convergence of responses to comments.
3) Senior contractor management should demonstrate approval of the SAD by means of a documented protocol.
4) The approved SAD should be maintained in the contractor's permanent records in accordance with applicable DOE requirements. While the posting of a SAD on a web site may be an acceptable mechanism for accessibility, particular care should be taken to assure permanent retention of the document.
5) The DOE organization having jurisdiction for the accelerator facility should be made aware of the SAD preparation status and receive advance notification of changes to safety assessment activity that may affect the ASE and/or project milestone completion status specified by other DOE requirements.

2. Accelerator Shielding Assessments

a. Shielding Policy

The contractor must approve and implement a written statement of the shielding policy for ionizing and non-ionizing radiation [4.h.]. The purpose of the shielding policy is to:

- Define the contractor's radiation control guidelines for the facility (e.g. facility worker, non-facility worker, member of public, groundwater activation, etc.).
- Describe the process for identifying engineering and/or administrative controls that will be utilized to assure radiation control guidelines are not exceeded.
- Define the initial and periodic assessments that will be conducted to demonstrate compliance with the shielding policy.
- Identify a process for configuration control of facility shielding.

It is expected that the shielding policy should address workers and the general public as well as any other special considerations deemed appropriate by facility management. The shielding policy typically is included in the SAD. It may be useful to specify the roles, responsibilities, and authorities associated with this policy. If the shielding policy is not included in the SAD, it should be approved by facility management and be included within the accelerator facility document control system. The contractor shielding policy does not require DOE approval.

b. Shielding Assessment Preparation

As a part of the accelerator safety assessment process in support of the preparation of the SAD, a shielding assessment is often necessary to assure proper control of prompt and residual radiation hazards and to fully support the adequacy of the ASE with respect to the radiological hazards. For small installations, this process may well be integrated into the overall safety assessment that is covered by the SAD. For large, complex installations, it may be preferable to conduct this portion of the safety assessment process as a separate endeavor, as the shielding assessment may be a series of documents. The topics that might be covered by such an assessment and adapted to the needs and conditions of individual facilities include:

1) Radiation exposure related calculations and measurements, radiation shielding, beam optics, soil and groundwater contamination, airborne radionuclide releases and any associated required monitoring activities where relevant.
2) Conditions and controls that serve to limit the intensity of the maximum beam loss and/or its duration.
3) The occupancy status and radiological posting requirements of affected areas in accordance with the accelerator facility RPP.
4) Changes to shielding when determined to be significant. Modifications to shielding should be formally reviewed and the need for a revision determined.

c. Shielding Assessment Review Process

The contractor should specify a formal protocol for reviewing completed shielding assessments including, where practicable, a reasonable level of independency of review. Where applicable, results of the shielding assessment should support the SAD and, where relevant, the ASE.

3. Accelerator Safety Envelope (ASE)

a. ASE Preparation

1) Purpose of the ASE

A documented Accelerator Safety Envelope (ASE) must define the set of physical and administrative bounding conditions for safe operations based on the safety analysis documented in the SAD [4.b.(1)]. An ASE serves to define the physical and administrative parameters where the hazards of operation and experimentation are limited to acceptable levels and managed using engineered and administrative controls. This is not to say that operations outside the envelope will necessarily result in an accident or unacceptable risk, but that the safety limitations and/or authorization bases established by the contractor and approved by DOE for commissioning or operation of the facility are not satisfied. It is expected that all operating limitations of the ASE will be readily verifiable.

2) Basis of the ASE

The basis of the ASE is the safety analysis conducted and appropriately documented in the SAD. While the ASE is a safety-driven requirements document, close communication between accelerator designers and end-users is critical to ensure that machine performance and beam characteristics meet desired specifications while controls are adequate to assure safe operation.

Within its ASE, an accelerator facility can experience unplanned events that interrupt operation but do not compromise safety at the facility. An unscheduled electrical power outage is an example of such an unplanned event. The ASE should be formulated clearly so that the effects of such unscheduled, but anticipated events fall within the bounds of the ASE.

Accelerators should be designed to accommodate transient events during normal operation, such as the partial or total loss of beam, without degradation of safety. Such events would not be expected to exceed the ASE. However, such events may cause beam termination or less efficient operation, which could result in remedial actions being taken because of machine operability or beam quality concerns.

Limits specified in the ASE may apply to the conduct of experiments if necessary to protect workers (including experimenters), the public or the environment as determined in the SAD. Where the research mission of the accelerator facility requires frequent reconfiguration, new hardware, new experimental setups or new materials, the careful specification of the ASE is important. The contractor may choose to prepare a separate ASE for each experiment, each group of experiments, or include the entire facility and anticipated experiments into a single ASE.

3) Content of the ASE

Bounding conditions and limitations specified in the ASE should be based on engineered and administrative controls identified in the SAD as being necessary for safe operation of the facility. The credited controls should be addressed in the ASE with provisions to assure that these controls are maintained. Categories of items that should be considered for inclusion in the ASE are:

i. limits on operating variables (e.g., currents, voltages, energy potentials, beam power, pressures, temperatures, flows, etc.) as identified in the SAD needed to preserve physical barriers or to otherwise prevent excessive short-term or long-term risk to persons;

ii. shielding criteria adopted for different operational modes;

iii. requirements related to the calibration, testing, maintenance or inspection of credited engineering controls identified in the SAD to ensure their continued reliability;

iv. requirements related to assuring that credited administrative controls identified in the SAD are promulgated;

v. monitoring, release control of ventilation effluent and mitigation measures for the protection of the environment as identified in the SAD;

vi. administrative controls such as minimum staffing levels, qualification, and training for operation, minimum operable equipment, critical records to be retained, procedures to be maintained current, and immediate mitigative actions to be taken if the ASE is exceeded; and,

vii. procedures addressing the ASE-required minimal administrative or engineered controls for operation. Alternative procedures may be necessary for certain minimal ASE requirements when they will not be met for particular conditions and where alternative requirements are specified in the ASE. The authorized use of such alternative ASE requirements must not decrease the overall level of safety.

An alternate approach used at some accelerator facilities involves basing the ASE on specification of radiation levels or potential maximal exposures derived from operational experience and extrapolation of empirical data, in lieu of machine parameters. When carefully applied, use of prior measurements and analyses of empirical data can be used to establish radiation levels or maximal exposures, which are then specified as ASE-bounding conditions.

The scope and level of detail given in the ASE generally is a function of the size, complexity and hazards of the operations involved. For a simple accelerator operating in a single room, the safety envelope might be only the maximum beam energy and current. The supporting safety analysis would then show that facility shielding reduces the dose rate in all relevant areas to acceptable levels. If a system operates with several particle types, the impact of the beam that will generate the largest source of radiation exposure would be analyzed, as a minimum. The radiation levels from other type beams would be sufficiently analyzed to demonstrate why they are of lesser consequence than the selected particle beam type.

Radiation levels from some beams may be low enough that it is acceptable for persons to be in or adjacent to target enclosures during operations. If operation is proposed while an area is occupied, the safety envelope should identify acceptable combinations of beam type, energy, and current or other critical parameters as well as administrative controls that ensure that no unacceptable levels of radiation will be generated in that area while it is occupied.

For many accelerators, especially large ones, the containment shielding is often not uniform. Here, the safety envelope might include the energies of the beam and loss intensities at various specified locations. The safety analysis would then show that beam interactions and losses from all operations conducted within ASE limits would not cause unacceptable radiation levels or exposures at any location where personnel occupancy is allowed during facility operations.

The safety envelope should identify those parameters that ensure acceptable operation when the system is operated. The examples above apply primarily to radiation concerns, but other safety concerns, particularly those associated with experiments, should be similarly bounded in order to constrain operations within the defined regions shown to be safe.

b. ASE Approval

The ASO requires DOE review and approval of an ASE for both commissioning activities and for routine operations. The six steps for internal review and approval that were earlier described for the SAD Review and Approval Process could be used here. In any case, these actions by DOE should be conducted using a tailored approach based upon the scope and nature of the accelerator facility or

module. In general, the review and approval of the ASE should occur before an Accelerator Readiness Review (ARR). However, for new facilities or modules, the review of the ASE may be conducted as an integral part of the overall assessment of accelerator readiness. The ARR process is addressed in greater detail later in this section of the Guide.

At most accelerators, improvements in operations, enhancements in accelerated beam power, and reductions in beam losses represent an ongoing process of continuous improvement as operational experience is gained and technological advances are implemented. From time-to-time, the need arises to revise an ASE based upon improvements achieved, operational experience gained, or updated analyses. The technical basis for a modification to the ASE should be supported by analysis, preferably in the form of a revision or addendum to the SAD. The revised ASE should be submitted to DOE for approval. The methodology to be used by DOE to review and approve the revised ASE should be scaled to the scope and nature of the accelerator facility and level of significance of the proposed revision. All revisions to an ASE should be documented as part of the permanent record of the facility.

c. Oversight of ASE

Any activity violating the ASE must be terminated immediately, and the activity must not recommence before DOE/NNSA has been notified. [4.b.(2)] Upon determination that approved ASE limitations have been exceeded, the contractor should terminate activities impacted by or causing the violations at the earliest time it is safe to do so. The contractor should notify the local DOE authority when an ASE is exceeded and begin an investigation into the cause and consequences of the activity. A report outlining the cause of the incident and describing actions taken to mitigate future occurrences should be completed. DOE should be notified before activities are resumed, and informed of any corrective actions taken and the intention to restart the activity.

Strict adherence to the approved bounding conditions of the ASE is expected during all commissioning and operations activities. The contractor may choose to establish an operations envelope within the ASE for each subset of operations. By defining the nominal operating parameters beyond which the operating procedures would require adjustments to be made, an operations envelope serves to prevent the ASE from being exceeded. Having different operations envelopes for different operating modes of an accelerator would be expected, since the combinations of operating parameters may need to change to carry out different sets of experiments. Variations of operating parameters within an appropriate operations envelope of an accelerator would be considered normal operations. Variation outside the operations envelope but within the ASE merits appropriate attention; it does not require termination of activities or notification of DOE. In

summary, DOE is to be informed of: 1) USIs and 2) proposed changes to ASE-bounding conditions that DOE must approve.

4. Accelerator Readiness Review (ARR)

   a. DOE and Contractor Commissioning Roles

   Accelerator Readiness Reviews (ARR) must be performed before approval for commissioning and routine operation and as directed by the DOE Cognizant Secretarial Officer/NNSA Deputy Administrator or a DOE field manager [4.d.]. An ARR is not a method for achieving readiness, but for verifying it. An ARR is conducted both to verify the information that is submitted in support of a request to undertake accelerator activities and to assure that the data address the full scope of activities proposed. An ARR is not an extensive wall-to-wall assessment of all the contractor analyses, but rather an overview of the operation, inspection of the hardware and a sampling based on a review of supporting documentation and, if available, past operational experience. Where commissioning of an accelerator facility is accomplished in discrete segments, the ARR must also be performed incrementally. Generally, an ARR is not required when the contractor identifies a safety concern and subsequently ceases operations to correct the problem.

   The ASO places the requirement to perform an ARR solely on the contractor and requires [i.e. 5.b.(1)(b)] that DOE ensure that the contractor's review was conducted with appropriate scope and depth. DOE also has the responsibility to verify that the findings/observations of the readiness review have been satisfactorily addressed/ resolved by the contractor. The ARR team may be composed of DOE employees, contractor personnel and/or consultants and all should possess expertise in their assigned area. To the extent practicable, the team members should have minimal current involvement with the activity being reviewed, and past involvement should be sufficiently distant or of such a nature that they have reasonable independence from the activity being assessed. However, whenever deemed warranted, DOE may require an ARR be performed following a self-imposed shutdown by the contractor.

   A readiness review may be undertaken and accomplished using a variety of methodologies, provided that it truly verifies the readiness of the proposed activity. The ARR should include applicable portions of support functions such as training, maintenance, health physics, environmental monitoring, waste management, and pollution prevention. While this guidance addresses verifying the readiness of items important to environment, safety and health, the scope of an ARR can be expanded as desired by the contractor's senior management to address other “best management practice” topics. The review should be conducted within the facility’s ISM program.

The ARR should verify that:

- An acceptable SAD (or its equivalent) has been properly developed in accordance with DOE O 420.2B requirements, and has been reviewed and approved in accordance with the contractor internal safety review system.
- An adequate ASE has been developed in accordance with the ASO and is supported by the SAD.
- An appropriate commissioning plan has been developed.
- An appropriate USI process has been developed.
- Procedures necessary for the safe operation of the activity have been developed, reviewed, and approved, and an appropriate process for the development, review and approval of new and revised procedures is in place.
- Procedures to deal with abnormal and emergency situations have been prepared and are approved for use.
- Records important for operational and post-operational activities are controlled.
- Equipment and systems having safety importance meet criteria established in the SAD and have been appropriately tested.
- Training and qualification programs relevant to safe operation in compliance with the ASO and ISM have been established.
- Staffing requirements specified in the ASE are met.

The ARR report should adequately document the activities of the review committee and be formally transmitted to DOE Site Office or other designated DOE official specified by the Contracting Officer. The role of the responsible DOE organization in the ARR process is to:

- Maintain cognizance of the contractor plans for conducting an ARR and obtain and evaluate detailed information related to this activity as necessary as a component of operational awareness activities;
- Provide sufficient real-time oversight, supplemented where needed by first-hand sampling to support a determination by DOE of the appropriateness of the contractor ARR results;
- Provide authorization to proceed when satisfied that the findings identified by the ARR have been adequately addressed;
- Keep Headquarters informed of the progress and results of the ARR; and,
- Require the contractor to perform an ARR when changes in operations warrant.

b. Accelerator Commissioning Process

Commissioning is the process of bringing a new, or significantly modified accelerator facility or associated experiment on-line in a safe, efficient manner that assures protection of workers and members of the public, provides protection of accelerator components, experimental equipment, and other capital resources, and assures compliance with the site requirements, DOE Orders including the ASO, and applicable laws and regulations. DOE responsibilities for approving the ASE, the start of commissioning, and the commencement of routine operations are specified in Section 5, RESPONSIBILITIES, of the ASO.

Commissioning often can be done in phases or modules, where each module is brought on-line safely before proceeding to the next module. These modules can follow or correspond to geographical locations within a facility (e.g., a specific beam line) or can represent stages of operation (e.g., step functions of increased intensity, energy, or beam power) or combinations of both factors dependent upon the configuration of the facility.

Under some conditions, commissioning activities may encompass operations under restricted conditions that are necessary in order to accomplish specific tasks. An example would be the need to conduct specified measurements of the prompt radiation levels needed to support the ASE. Other examples could include magnetic field measurements, measurements of beam losses, flammable gas levels, or airborne radioactivity levels.

A commissioning plan should be developed and should be reviewed as part of the ARR. The plan should specify the milestones to be achieved and the process for assuring safe operation. Completion of the milestones should be documented prior to the commencement of routine operations. Consideration should be given to allowing some possible form of public participation as part of the commissioning plan. The scope of public participation could be based on the NEPA process.

Commissioning an accelerator facility incrementally can be advantageous, particularly when the contractor desires to operate portions of the facility while others are still under construction. In a typical installation, the modules could be as follows: the beam source, injector, main accelerator, storage ring, experimental halls, etc. As each module is completed and tested, a commissioning ARR is conducted on that particular module. The commissioning activity for each separate module requires DOE approval before it is initiated unless the contractor receives DOE approval for an overall commissioning program. The development of an overall commissioning program plan tends to focus on the required approval by DOE and reduce the likelihood of delays in obtaining a number of discrete approvals. A commissioning program plan should include:

- A description of the content of each module;
- Identification of any additional administrative and technical controls and contingency plans beyond those established for prior modules;
- A description of the content of that portion of the overall facility ARR that is needed for each module; and,
- The schedule for commissioning each module.

c. Unreviewed Safety Issue (USI)

The contractor should have a formal USI process. The USI process should be evaluated during the ARR.

5. Procedures

Procedures should be established to provide specific direction, where appropriate, for processes, systems, and equipment during routine and non-routine conditions. These procedures should be designed to ensure that there is compliance with the ASE, and that facility operation remains within the operations envelope where this concept is employed.

a. Preparation of Procedures

Written procedures must include descriptions of the tasks to be performed; appropriate safety and health precautions and controls; and requirements for initial conditions to be verified, operating conditions to be maintained, and data to be recorded, as applicable [4.f.(2)]. The actual format of the written procedure can be customized for the specific facility or task but should include the above-mentioned information at a minimum. Uniformity in the format of written procedures at an individual facility is highly recommended as it minimizes the possibility of confusion, which can result in an incident affecting safety. The use of formats developed in the implementation of other DOE requirements such as ISM and regulatory requirements is encouraged.

A typical written procedure would include:

- the objective of the procedure,
- roles and responsibilities for individuals or organizations as they pertain to the successful execution of the procedure,
- identification of the hazards associated with the activity and safety and health precautions/controls to be applied during the activity,
- detailed instructions for performing the task,
- requirements for record keeping and logs, and

- review and approval status, and effective date.

b. Implementation of Procedures

At a minimum, the contractor must prepare procedures for operation startup, normal operation, emergency conditions, conduct of maintenance, approval and conduct of experiments, review and approval of facility modifications, management of safety-related changes, and control of facility access [4.f.(3)]. The scope and level of detail of written procedures should be a function of the facility hazards, operational complexity and workforce expertise.

Procedures should be implemented through the contractor chain-of-command directly responsible for operation of the accelerator, experiment, or module. This is a clear line management responsibility as part of the facility's implementation of ISM, and where applicable, Work Smart Standards.

Requirements for appropriate responsible parties to indicate by signature their acknowledgement of having read and understood the procedure(s) have been found to be effective. Electronic "signatures" are considered equivalent to handwritten ones.

c. Control of Procedures

Written procedures and instructions for conducting activities safely must be maintained; must be clear, current and consistent with management systems and the configuration of the facility and equipment; and must be approved by a facility contractor's senior line manager who is actively involved in the day-to-day operation of the facility [4.f.(1)]. The review and approval of written procedures by technically-qualified professionals is essential to assure that the information and instructions provided to workers promote consistency and reflect safe work practices and environmental policy. Issues such as task complexity and associated hazard will dictate the technical disciplines and level of management attention necessary for approval and the frequency of revalidation.

Procedures should be maintained as controlled documents with approval status and effective dates clearly indicated. Revisions should be communicated to the responsible parties in a manner that clearly identifies obsolete versions. Electronic methods can provide an effective way to assure the presence of current versions and disappearance of obsolete versions of written procedures.

6. Training and Qualification of Personnel

a. Development of Training Program

Training and qualification requirements must be established for each individual at an accelerator facility whose activities could affect safety and health conditions or whose safety and health could be affected by facility activities. Training and qualification must be documented and kept current [4.e.(1)]. A trained and qualified workforce is essential to the safe and environmentally responsible operation of accelerators. Training serves as the primary means of familiarizing personnel with hazards and communicating the actions required. A qualification process for those personnel whose activities affect the safety and health of themselves or others is necessary to formalize the evaluation of a person's competence to undertake the proposed activity as required. Qualification may be granted based upon a review of a person's credentials and experience or through a formal testing procedure or a combination of both. The major elements of this training program should be in place prior to initial commissioning activities, subject to revision later as operational experience is gained. The guidance for the major elements of the training program are thus discussed in this section while subsequent sections will be limited to specific expectations on training pertinent during operations and decommissioning.

The overall training program should be approved by a designated senior line-management official and evaluated periodically for adequacy. It is recommended that the accelerator training program developed to implement the ASO be incorporated into the contractor's overall training program.

b. Training and Qualification Records

An auditable system of records documenting training content and results should be established to demonstrate achievement of training goals. Records recommended for retention in electronic or conventional format include:

- course syllabus,
- instructor's handbook/lesson plan,
- handouts provided to trainees,
- copies of written examinations with date given, answers expected and results, and
- attendance sheets.

Requirements and processes for measuring proficiency and granting qualification should be established that set the minimum levels of proficiency for qualification to perform safety related functions without direct supervision, and describe how the acquired qualification will be maintained. Qualification should be valid for a specified time established by management for each position, by which time the person must be re-qualified in accordance with established re-qualification requirements.

Standards and processes should be established for granting exceptions to specific areas of the training program based on education and experience. The basis for granting an exception should be documented thoroughly.

Documentation to be maintained for each individual should include an auditable record of training received, examination results and qualifications acknowledged. Suggested documentation may include:

- education, relevant experience,
- status of health evaluation where directly relevant to facility and personnel safety and maintained in compliance with medical-privacy requirements,
- most recent, graded, written examinations in each training element,
- written critiques of task performance during training, including tasks observed and overall conclusion of the evaluator,
- summary of training attendance, training completed, proficiency demonstrated, and other information used as the basis for judging whether the individual was qualified for confirmation,
- copies of acknowledgment of qualification, and
- documentation of the basis for granting an exemption to a training element.

B. Accelerator Facility Operations Activities

This section describes operational programs and activities important to the safe operation of an accelerator facility. While many required controls will come from hazards analysis, many of these plus others are compliance-based controls. The intent of this section is to provide a useful list of compliance-based programs and activities that address federal requirements and national standards pertaining to safety of accelerator facilities (e.g., OSHA, DOE, NFPA, ANSI, ACGIH, CGA and NCRP). However, a tailored approach based on a facility's complexity and potential impacts should be considered when applying this guidance. For example, a simple low-energy accelerator might require only minimal programs to assure safe operations while a high-power complex facility might require very comprehensive programs. Additionally, a tailored approach to the level of operational rigor applied to different modules within the same facility can be advantageous when a particular module has a significantly different type of hazard than the other modules of the same facility.

1. Operational Planning and Procedures

a. Organization and Administration

Accelerator operations may require a high degree of flexibility for the effective execution of experiment programs and/or R&D activities; but these activities also must be conducted in a safe and environmentally sound manner. Specific guidelines and appropriate procedures for accelerator operation and for conducting experiments will ensure that a high level of performance is achieved in a safe and environmentally-sound manner, and in accordance with applicable rules, regulations, and contractor environment, safety, and health policies.

Procedures or other definitive documentation should describe lines of authority and responsibilities for the safe execution of program goals, staffing requirements, availability of resources and interfaces to other groups, relationships to safety organizations, operations performance, monitoring guidelines, accountability, training policies, and safety planning policies.

It is especially important that the control room staff of operators and other relevant personnel document the receipt and understanding of governing procedures and modifications on a real-time basis.

b. Operational Practices and Control Room Activities

Guidelines for maintaining a professional atmosphere in control centers of the facility should be established, commensurate with the importance of the control room as an operating base and coordination center for important facility activities. Policy regarding authorization for, and supervision of, the operation of equipment should be specified, both for routine shift operation and for research development activities conducted from the control room.

Standards for the conduct of work practices for operations staff should be established. These standards should address adherence to operating procedures and equipment specifications, status awareness and response practices of operations staff, and emergency response requirements. The operations records should contain a narrative log of the facility's status and of all events as required to provide an accurate history of facility operations. Proper use of a required reading file, or equivalent, by operations personnel has proven useful in ensuring that appropriate individuals are made aware of important information that is related to job assignments. Logkeeping and reporting requirements should also be specified. Electronic logkeeping provides an effective means for tracking activities provided it is implemented in a manner that provides for proper archiving. In particular, electronic logkeeping systems should track all changes made to the record without deletion. Mistakes in electronic logkeeping should be documented as subsequent revisions, not as overwrites of the original record.

Guidelines should be established to ensure that R&D programs at the accelerator facility are properly reviewed and conducted consistent with all facility safety requirements. The guidelines should ensure appropriate safety controls for access

of accelerator specialists and experimenters to the facility equipment for the purpose of research, development, and experimentation.

c. Non-Routine Conditions

Personnel responsible for control room operations should be trained to discriminate between routine operation and abnormalities that could indicate the onset of problems, in particular those events that are indicative of imminent hazards to personnel, property, or the environment or may be precursors to potential violations of the ASE. This ability should be instilled through training procedures and discussion sessions. In some cases, it may be feasible and advisable to conduct exercises to develop these skills.

Control Room personnel frequently may be called upon to respond to a variety of emergencies. If so, proper training documented in accordance with site policies should be conducted to assure readiness for such circumstances.

d. SAD Maintenance

The SAD must be maintained current and consistent with the administrative control measures and physical configuration of the facility and major safety equipment [4.a.(6)]. The SAD should be maintained such that it accurately reflects the engineered and administrative status of safety systems at the facility. The contractor and DOE organization approving the ASE should agree upon the significance of modifications requiring an update to the SAD. Proposed revisions to the SAD should be evaluated to determine if the change constitutes a USI. An updated SAD may be required in the event that other DOE requirements are changed such that safe operation of the facility is impacted. Also, updated SADs are commonly needed to reflect altered operation conditions and significant modifications to the experimental program. The system used to document and implement updates between SAD revisions is left to the discretion of the contractor as long as the associated analyses are available for review. Updates may be appended to the most current SAD until a SAD revision is conducted.

e. Access Control

1) Discussion

Control of access at accelerator facilities is necessary to protect persons working at the facility and casual visitors from injury, including unauthorized visitors; to protect property from damage or theft; and to provide reasonable assurance that all persons at the accelerator facility are either aware of the potential hazards and the emergency procedures, or are under the guidance of someone who is fully aware of these matters. Access controls should be

consistent with programs established to meet the requirements of 10 CFR 835, Subpart F.

2) Unsupervised Occupancy

All persons who are given unsupervised access to controlled areas of the accelerator facility must be given appropriate orientation and training concerning the hazards and safety requirements related to the relevant areas. No exemption for unsupervised occupancy qualification should be granted to any personnel, including research staff, employees of the facility, and DOE employees.

3) Two-Person Rule

Implementation of a two-person safety rule for selected areas of the facility should be considered. The Two-Person Rule has proven effective at many facilities for specific areas of the facility in concert with certain activities such as electrical work, welding, transfer of toxic chemicals, or access to areas with the potential for having a hazardous, or oxygen-deficient atmosphere.

4) Access Control Mechanisms

Remote mechanisms for access control should be considered for enhanced assurance that only trained and qualified personnel are permitted entry to hazardous or sensitive locations. Commonly implemented remote access controls include closed circuit television monitoring of access points. Key card systems may provide this assurance as well.

f. Communications

Guidelines covering the correct use of communications systems including radios, telephones, public address and paging equipment should be issued. This should include emergency communications and the announcement of changes in operating conditions.

g. Lockout/Tagout (LO/TO)

The purpose of LO/TO is to provide a method for equipment status control through component tagging, locking, and verification, which is intended to protect personnel from hazardous energy in any form. The important elements of a LO/TO program can be found in 29 CFR 1910.147.

h. Maintenance

Procedures should be established to ensure that the facility configuration is maintained in accordance with design requirements; changes are properly authorized; and operating staff are aware of the status of the equipment and systems.

i. Shutdown

Termination of operations may pose hazards that need to be controlled. Procedures may be needed to address items such as radiation surveys, securing of electrical equipment, placement of other items posing potential hazards in a safe condition, etc. Shutdown activities should follow documented procedures that have been developed in accordance with applicable requirements that assure protection of the accelerator and any experimental apparatus.

2. Training and Qualification of Personnel

a. Training Program Requirements

Requirements must be established for each individual at an accelerator facility whose activities could affect safety and health conditions or whose safety and health could be affected by facility activities. Training and qualification must be documented and kept current [4.e.(1)].
Only appropriately trained and qualified personnel, or trainees under the direct supervision of trained and qualified personnel, are permitted to perform tasks that may affect safety and health [4.e.(2)]. In addition to initial qualification requirements, and a general safety orientation addressing facility specific hazards, re-qualification requirements should be established for operations, maintenance, and support personnel, and experimenters to carry out their responsibilities safely. For some procedures, the appropriate monitoring and training of personnel may need to be confirmed with periodic testing or performance reviews.

The facility-specific portion of training is intended to communicate information about local work hazards and their control, and to convey knowledge of safe operating procedures. Facility-specific training may include, but is not restricted to such topics as:

- self-contained breathing apparatus
- oxygen-deficiency hazards
- controlled-entry procedures
- radioactive, hazardous, and mixed-waste generator rules
- radiation-safety practices
- facility-emergency procedures
- respirator use

- confined-space location and rules
- lock and tag process
- control of activated material
- hoisting and rigging
- primary and secondary-beam control
- forklift operation
- cryogenics handling
- electrical work
- compressed-gas handling
- working at elevated surfaces
- environmental protection.

Accelerator operations personnel training should emphasize safe and efficient operation of the facility. An appropriate understanding of the physics and engineering principles underlying key operations and the development of diagnostic skills for early recognition of abnormal equipment performance is important. Training should also convey an understanding of the regulatory requirements associated with a particular hazardous operation.

Training for maintenance and other support personnel should include an emphasis on the accelerator structures, systems and components related to safety and identified in the SAD, and experimental components and systems that are important to worker safety and health and/or protection of the public and environment. The training should also take into account specific duties the individuals will perform and the level of supervision required.

Training for experimenters should address the safety aspects of the facility and relevant safety and health requirements and practices. Experimenters should be required to demonstrate appropriate knowledge of the hazards for the systems with which they are involved and the means of controlling them before being permitted to interface their experimental equipment to the accelerator and engage independently in experimental work at the facility.

Regulatory required training that is specifically required by federal, state and local regulations should be identified (e.g., OSHA training requirements in 29 CFR 1910, *Occupational Safety and Health Standards*). The contractor should ensure regulatory training is provided to all employees and sub-contractors who have duties governed by these regulations.

All personnel assigned to or using the accelerator facility (including emergency response personnel) must be trained in the safety and health practices and emergency plans consistent with their involvement and the hazards present [4.e.(3)]. The general safety orientation provided to all

personnel who are permitted unescorted access to the facility should at a minimum, address hazards that may be encountered, actions to minimize or mitigate exposure to the hazards, and the person's role in the emergency response plan. Specific topics, which may be addressed, include, where applicable:

- first-aid capability
- Cardiopulmonary resuscitation (CPR) and automatic external defibrillator (AED)
- emergency notification and evacuation procedures
- general hazards present at the facility
- safety characteristics of the facility
- radiation-safety practices
- fire protection
- security requirements

Personnel should not be permitted unescorted access to the accelerator facility until they have satisfactorily completed the general safety orientation and appropriate portions of the facility-specific training.

Particular attention should be paid to the training of experimenters. The procedures that they may follow at their home institutions may not be the same as those required at the host DOE institution. Consideration should be given to providing retraining to experimenters and other personnel who have intermittent experience at the facility, or when site conditions have significantly changed since their initial training. It is critically important to assure the proper training of all users of the accelerator facility, regardless of their time in residence because the activities of an experimenter can, under some circumstances, greatly affect the safety of themselves and others.

b. Accelerator Facility Experimental Users

Users play an important role in the safety program for activities on the experimental floor. In many facilities, particularly at the light sources, as many as 2000 users per year will visit and work within the facility for different periods of time. Since DOE accelerator facilities often operate 24 hours a day, 7 days a week, users will find themselves working nights and week ends on the experimental floor with only limited support and oversight available.

In addition, users come from many different institutions throughout the world, and often may be unfamiliar with the safety expectations of the DOE accelerator community. This lack of familiarity and support, coupled with potential pressures of limited beam time and high research expectations, can create severe challenges to the safety program. In addition, in many DOE facilities, some user groups may

assume responsibility for the operation of a beam line or a module, adding further challenges to the operational and environment, safety, and health programs.

To provide a safe working environment, it is important that facility management incorporate the following ISM principles into the safety program:

- Definition of roles and responsibilities. The roles and responsibilities for safety of users in the operation and maintenance of a beam line and equipment, and for the conduct of an experimental program should be fully defined, particularly at the interface points where facility staff is involved.
- Experimental review. Experiments should be reviewed and approved by facility staff prior to operation. Any changes or the addition of any significant hazards to an already approved experiment should also be reviewed and approved.
- Support and oversight of user research teams. User teams will vary greatly in their experience in working at a beam line and in their understanding of requirements. Facility management should address support and oversight of user activities to ensure safe operation on a 24 hour a day basis.
- Review of experimental apparatus. Frequently user groups will bring experimental apparatus from their home institutions to the facility. Management should implement specific review programs to ensure that such equipment is compliant with facility requirements.
- Configuration control of beam-line equipment and components. There should be a clear understanding by user groups of the type of changes that they are authorized to make during their work on the experimental floor. This always is particularly important for electrical and pressurized systems and for beam-line shielding.
- Training. Each user should receive sufficient training to ensure understanding of facility requirements and emergency response requirements.
- Accountability. Facility management should respond at an appropriate level to users whose actions are non-compliant or irresponsible. The range of response by facility management should include denial of access to the facility.
- Communications. Facility management should establish a communications process that will ensure pertinent environment, safety, and health information is routinely communicated to and from users. Management should make users aware of the environment, safety and health policy and any procedures necessary to conduct their work. Facility management should involve users in the development and review of pertinent policies and procedures aimed at

eliminating or reducing environment, safety and health concerns associated with an experiment, and should provide users with an opportunity and mechanism to voice their concerns.

3. Systems Important to Accelerator Safety

Accelerator systems important to safety should be maintained and associated documents kept current. In addition, administrative controls should be in place to provide for the review and approval of changes in any of the systems important to safety.

a. Beam Interlock System for Preventing Personnel Exposure

A reference standard useful in the design of interlock systems is *Application of Safety Instrumented Systems for the Process Industries*, ANSI/ISA – 84.01 – 1996. Management should designate a qualified custodian of the system documents important to safety. The choice of an appropriate beam interlock safety system to prevent employee radiation exposure above permissible limits and limit access to other hazards associated with accelerator operation affects not only the degree of protection afforded individuals, but also the technical and administrative burden. The level of protection provided and the system's reliability are to be appropriate for the hazards present in order to avoid having users disregarding the system on one extreme or be negligent in providing for protection of persons at the other extreme.

Where the potential consequences are significant, a major design effort including independent reviews, a rigorous program of testing and maintenance, and comprehensive administrative controls should be specified. Use of administrative controls or locks may be particularly beneficial for operations that are temporary or that utilize portable radiation generators in accordance with the scope and nature of the accelerator facility. The interlock system and the administrative controls on it should be summarized in the SAD. Since the installation and maintenance of an interlock system represents a significant technical and administrative consideration, the choice and features of a system should be justified by careful analysis.

1) Technical Design Features

i. The protective functions of the interlock system should be robust against single-point failures, and designed such that they fail in a "safe" manner, including loss of power or pressure, open circuits, and shorts to ground.

ii. System components should be protected from damage, tamper resistant, and conspicuously labeled to reduce the likelihood of inadvertent modification. Cable runs outside of cable trays should be armored cable or in conduit.

iii. Critical devices are specific accelerator or beam line components that are used to ensure that the accelerator beam is either inhibited or cannot be steered into areas where people are present. Common examples are steering magnets, beam stops or collimators. Other examples are systems that operate on the injector or ion source to inhibit the beam. The specification and use of critical devices and the associated redundancy requirements should be governed by a documented criterion.

(a) Two or more critical devices should be considered for use in interlock systems where a very high radiation area, as defined in 10 CFR 835, can be produced during operations.

(b) The status of each critical device should be monitored to ensure that the devices are in the "safe" condition when personnel access is permitted. If the "safe" condition is lost, then the beam should be inhibited by operation of other critical devices upstream. Critical device command systems should be independent of the monitoring systems.

iv. The system could be modular in design so the interlocks for different parts of the facility can be serviced independently. This is particularly important for individual experimental areas, which are often shut down for modification while the rest of the facility is running.

v. The system design should allow for complete function testing.

vi. An independent documented review of beam interlock system design, including modifications, and the system's testing program should be performed.

2) Access Control Features

i. Safety devices should not be used as routine shutdown mechanisms. The equipment design and procedures should provide for an orderly means of turning off beams other than activation of an entry interlock before entry is attempted into a controlled access area. The entry interlocks should not constitute the normally-used means of disabling beam. However, interlocked safety devices should be employed to maintain the disabled status of beams.

ii. An exclusion area is an area that is locked and interlocked to prevent personnel access while the beam is on. A fully enclosed and interlocked area is considered inaccessible. Emergency shut-off devices, which are clearly visible, unambiguously labeled and readily accessible should be provided in exclusion areas where practicable and where advisable,

taking into account the details of all hazards present. In addition, interlocked exit doors should serve as emergency shut-off devices.

iii. Emergency exit mechanisms as required by OSHA standards (29 CFR 1910.37) should be provided at all doors, even when interlocked. Emergency entry features for interlocked doors should not be precluded.

iv. Signs or clearly labeled lights reflecting current interlock or beam status should be provided at all entry doors.

v. Exclusion areas should be searched before the beam is introduced to ensure that no people remain inside. Procedures to ensure the reliability of the search process should be comparable with the design procedures to ensure the reliability of the interlock system.

(a) Search confirmation buttons, or check stations should be placed to ensure that the search team views each area.

(b) After an exclusion area is secured, an audible and visual warning should be provided before the beam is introduced.

(c) If entry control is compromised, the search and warning interval should be repeated before introducing the beam.

vi. A "Limited Entry," also commonly called "Controlled Access," mode could be desirable for larger accelerators. Under this mode with beam operation excluded, a small number of workers are permitted to enter an already searched area to carry out specific tasks. Strict controls, which include issuing an in-tunnel warning and well-defined procedures, are required for this mode to be acceptable. When tight administrative controls are maintained during this mode such that the number of persons entering equals the number leaving, then operations can commence after the workers have exited without a further search. At some accelerators where only secondary particles of low intensity are involved, radiation levels may be sufficiently low to allow such access with beam enabled.

3) Documentation Requirements

The following documentation should be prepared and maintained:

- functional description of the interlock system;
- the physical and electrical configuration of the system;
- a description of the document control and review system for keeping documentation complete, accurate, and current;
- an auditable record of interlock system test results; and,
- the management review and approval of the system as described.

4) Administrative Controls

i. There should be a well-defined and rigidly-enforced configuration control process that provides a mechanism for the review and approval of changes in the system design and of modifications of function and logic. The detail of the review and the level of approval should be commensurate with the degree of hazard involved. This process should protect the circuits and functions against unauthorized or inadvertent modification. Critical devices, security and safety devices, and wiring should be clearly labeled to note that tampering is strictly forbidden.

ii. A notable example of modification of function is the bypassing of an interlock. This should be permitted under very strict controls and only if equivalent safety is provided by procedures or by alternate equipment. The proposed bypassing should be reviewed and approved by management and the interlock system should be tested with bypass in place and again after it has been removed.

iii. There should be a definitive policy for the procedures and restrictions on interlock maintenance work. This policy should assure that:

(a) only authorized persons should do the work;

(b) proper safeguards, e.g. a locked beam stop, should be required before the interlock is taken out of service. The safeguard should be independent from the system being worked on; and,

(c) the system should be returned to service only after suitable testing has been done.

5) Testing Protocols

i. Testing (i.e., validation that the system works as designed under conditions of use) should validate the interlock system at least annually. An interlock system should not be used to provide protection unless it has been validated within the specified testing period. A short grace period could be allowed if specified in the administrative procedures. A successful testing program will depend on a system design, which accommodates testing and the commitment of machine time and resources to accomplish the tests. Testing intervals should also take into account the system reliability and the overall reliability design goal as specified by the probability of the protective electronic system to fail on demand of a safety challenge.

ii. A functional test should also be completed after modification or maintenance work is done on an interlock system. Those maintenance and service actions, which are deemed to be trivial and which do not require functional testing, should be identified and justified generically or individually.

iii. Written test procedures having sufficient detail to ensure a complete functional test of the interlock system should be used. Testing should be executed with a check sheet with a check-off for each observed response, thus providing an auditable record.

(a) The functional test of the interlock system should exercise the system inputs and verify each protective response. If a digital system using software in mission critical applications is employed, then both "black box" functional testing and "white box" structural testing should be performed. The structural testing should include a verification and validation program for the life cycle of the code.

(b) Integrity of redundant interlocks should be determined.

(c) It is important that critical devices are tested in their operating configuration, and at least once during the test the system should be exercised from end to end. For example, it should be verified that opening an entry door causes the expected result.

(d) Testing should also verify that the system provides protection in response to likely improper actions.

b. Cryogenic and Oxygen-Deficiency Hazards

Liquefied gases are used as targets, cryogenic fluid in superconducting magnets, radiofrequency (RF) cavities, and other accelerator components at many accelerator facilities. It is well understood that leaks of cryogenic fluids can, under some conditions, displace the oxygen in the accelerator enclosure such that the ventilation and travel distance to an exit would not be sufficient to allow safe egress. Such installations should receive a detailed, documented analysis. General considerations should be given to the gas density of a cryogen; density greatly affects the nature of the hazard. Gases such as helium will travel horizontally along the ceiling of the accelerator enclosure until a vertical opening is reached, where they will follow that upward to perhaps a service building and potentially create an oxygen deficiency hazard (ODH). Gases that are denser than the ambient air, e.g. escaping liquid argon, will concentrate on the floor of the accelerator enclosure and will flow to lower areas, where they may accumulate and create a potential ODH condition. Provisions for entry and egress should account for these conditions. Model programs for control of this hazard have been established at several DOE Laboratories. Qualified engineering expertise should be consulted.

c. Electrical Safety

A wide variety of electrical systems are encountered at accelerator facilities to meet the energy requirements of the accelerator itself and to supply energy to experimental apparatus. Accelerators, by their nature, employ hazardous levels of

electrical energy. Some applications are identical to those common to industrial settings while others are unique to research facilities such as the particle accelerators covered by the ASO. Electrical systems and equipment and all related design, construction, installation, inspection, testing, and operations activities should be in accordance with electrical safety standards to the extent that a standard applies. These standards include:

- 29 CFR 1910, Subpart S, *Occupational Safety & Health Standards*, Electrical Subpart, OSHA
- 29 CFR 1910.137, *Occupational Safety & Health Standards*, Electrical Protective Equipment, OSHA
- 29 CFR 1926, Subpart K, Occupational Safety & Health Regulations for Construction, Electrical, OSHA
- NFPA 70E, *Standard for Electrical Safety in the Workplace*
- NFPA 79, *Electrical Standard for Industrial Machinery*
- NFPA 70, ANSI C1, *National Electrical Code*
- ANSI C2, *National Electric Safety Code*

When systems or equipment lie outside the scope of established standards and specially developed laboratory or division/section policies/procedures, prudent engineering judgment, peer review, and available industry guidance should be employed to ensure safety of personnel and safeguarding property. For unique or non-standard electrical equipment applications, *DOE Electrical Safety Handbook*, DOE-HDBK 1092 (online at http://www.eh.doe.gov/techstds/standard/hdbk1092/hdbk10922004.pdf), should be considered. Compliance with OSHA 29 CFR 1910 Subpart S requires electrical equipment, including custom equipment, be 'accepted' by a nationally recognized testing laboratory (NRTL) or other authority having jurisdiction. Subpart S also defines acceptance methods for equipment that no nationally recognized testing laboratory accepts, and identifies alternatives for determining compliance with the National Electric Safety Code (NESC).

The ISM system of each accelerator facility should assure that there is a suitably comprehensive program in electrical safety. Personnel should be trained to recognize electrical hazards, use proper mitigation techniques including personal protective equipment (PPE), and fully understand and comply with contractor policies. As part of the overall electrical safety program, a specific process for designing, inspecting, certifying, and labeling custom electronics should be instituted to assure compliance with regulatory requirements.

d. Fire Protection and Life Safety Systems

The National Fire Protection Association Codes, including *Life Safety Code* (NFPA Standard 101), provide requirements for life safety and fire protection. It is recommended that qualified engineering experts should be used to determine the status of compliance with the *Life Safety Code* requirements or equivalent requirements.

DOE accelerator facilities and emergency service organizations should have a comprehensive fire protection program to minimize the potential for:

1) a fire or related occurrence;
2) unacceptable onsite or offsite release of hazardous or radiological material that could impact the health and safety of workers, the public, or the environment;
3) interruption of vital DOE programs as a result of fire and related hazards;
4) property loss exceeding limits established by the responsible DOE organization; and,
5) damage to critical process controls and credited engineered systems.

Standards for new construction or modification of DOE accelerator facilities should be identified through a recognized process, such as the Necessary and Sufficient Closure Process (DOE M 450.3-1), that includes identification of applicable building codes and NFPA standards.

DOE Order 420.1, *Facility Safety*, requires that a fire hazard analysis (FHA) be made for all significant new facilities and facilities that represent unique or significant fire safety risks. It is desirable that the FHA use a graded approach and that the results are incorporated in the accident analysis sections of the SAD.

e. Natural Phenomena

DOE O 420.1A, *Facility Safety*, requires contractors to establish a comprehensive natural phenomena hazards (NPH) program to protect the workers, the general public, and the environment from the impact of any NPH event (e.g., earthquake, wind, flood, and lightning). The program should ensure that standards for new construction or modification of DOE accelerator facilities include the standards developed by a recognized process such as the necessary and sufficient closure process (DOE M 450.3-1), or applicable consensus building codes and/or national consensus industry standards.

DOE STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, describes the Performance Criteria (PC) to be used for evaluating building design for earthquake, wind and flood phenomena. DOE-STD-1020-2002 employs the tailored approach in assigning PC categories to DOE buildings. An analysis of the appropriate PC category

should be performed by the contractor for each accelerator facility under their purview.

f. Radiation Protection for Workers, the Public, and the Environment

The primary standard for DOE programs in occupational radiation protection is 10 CFR 835. This regulation contains specific requirements for RPPs at DOE sites. The set of DOE guidance documents related to implementation of this Regulation provides extensive information on how to achieve excellence in occupational radiation protection.

NCRP Report 144, *Radiation Protection for Particle Accelerator Facilities*, provides comprehensive guidance on radiation protection programs at particle accelerators.

The report SLAC-327, *A Guide to Good Practices for DOE Accelerator Health Physics*, also may be useful in establishing basic elements of a health physics program unique to DOE accelerator facilities. Requirements pertaining to environmental protection of the public and the environment are provided in DOE Order 5400.5 and in Environmental Protection Regulations found in 40 CFR. DOE Order 450.1, *Environmental Protection Program,* provides guidance on determining the potential impact to air and ground water quality because of accelerator operations. Environmental Protection Agency regulations specified in 40 CFR and in some cases local, or state regulations apply to DOE accelerators.

g. Non-ionizing Radiation

1) Magnetic Fields

High magnetic fields are present at many particle accelerator facilities. The American Conference of Governmental Industrial Hygienists (ACGIH) specifies guidelines for personnel protection in the form of Threshold Limit Values (TLVs). Use of the ACGIH guidelines for static magnetic fields, in their most current form, is required by DOE O 440.1A as part of worker protection management for DOE contractor employees. The most sensitive population to be protected includes persons with pacemakers. Perceptible or adverse effects have also been documented on persons with other implanted ferromagnetic medical devices (suture staples, aneurysm clips, prostheses, etc.). High magnetic fields may also present safety hazards from the forces that they exert on ferromagnetic materials such as tools (i.e., launching them as projectiles).

An accelerator facility should institute written policies on this topic if there is the potential for human exposure to magnetic fields. Exposures should be assessed, controls established, and appropriate postings applied.

2) Radio Frequency (RF) Sources

To avoid exposure of persons to unacceptable levels of RF fields, engineered control measures, such as shielding, prevention of wave guide leakage, enclosures, interlocks preventing accidental energizing of circuits, and dummy load terminations, should be given first consideration over any use of personal protective equipment. Where exposure in excess of the limits is possible, RF leakage tests should be conducted when the system is first operated and after modifications which might result in changes to the leakage. Area RF monitors are appropriate when RF energy can be expected in occupied areas. The ACGIH specifies guidelines for personnel protection in the form of TLVs. Use of the ACGIH guidelines, in their most current form for RF/microwave fields, is required by DOE O 440.1A as part of worker protection management for DOE contractor employees.

3) Lasers

Lasers are in common use both in the accelerators and in the experiments that they support. Although eye injury from non-ionizing radiation is generally the primary hazard, laser systems can present electrical and chemical hazards as well. Labels on the laser or laser product should provide guidance on the laser beam hazard. Lasers are classified in the categories: 1 (safe) to 4 (dangerous). Most precautions apply to Class 3b and 4 lasers. The use and procurement of these lasers should be discouraged where lasers of a lower classification can be used. The ACGIH provides TLVs for lasers while ANSI Z136.1, *American National Standard for the Safe Use of Lasers*, provides more detailed guidance on acceptable practices to provide safety.

In addition to the non-ionizing radiation hazard, electrical hazards are associated with the high voltage power supplies used in many laser systems. In particular, Class 4 lasers often use large power supplies that carry an appreciable risk of electrocution, especially in maintenance and adjustment procedures. Chemical hazards can be associated with halogen and dye lasers, as well as with radiation decomposition.

Fiber optic communications systems are commonly used to transmit signals at modern accelerators. ANSI Z136.2, *American National Standard for the Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources*, provides recommended practices for these systems.

- It is recommended that accelerator facilities where lasers are used implement a laser safety program implementing the requirements in ANSI Z136.1 and ANSI Z136.

- Modern day high peak-power, femtosecond pulsed lasers are capable of producing x-ray hazards that should be considered as part of the overall hazard assessment.
- A new technology known as laser-plasma wakefield acceleration is currently under development. It involves utilizing two synchronized high peak-power, femtosecond pulsed lasers to accelerate electrons to high energies. Hazard assessments and safety controls for these systems will require consideration of both the laser hazards as well as the ionizing radiation hazards.

4. Experimental Activities

a. General Considerations

The safety assessment of experiments is of special importance and should be initiated at the earliest possible state, especially in view of the considerable cost and long lead-times involved. Each experiment needs to be evaluated for its safety and health implications, and a safety analysis performed if it cannot be shown that the experiment clearly falls within the bounds that have already been analyzed and documented in another approved hazard assessment. The following considerations are of special importance for experimental installations:

1) The safety implications of each experiment or set of experiments should be addressed in the hazard assessment. The experimental activities may, in some cases, be adequately covered by the hazard assessment for an accelerator facility as a whole. To the extent practicable, the safety analysis of experimental work should address sets of experiments and establish the bounding conditions within which each particular set of experiments can be conducted in a safe and environmentally-sound manner.

2) For each set of experiments, the safety analysis should identify the safety training needs, including who needs training, and the nature, content, and frequency of the training beyond the general safety orientation provided to all experimenters.

3) The scope and content of written and approved safety procedures for experiments should be appropriate to the safety, health, and/or environmental impacts the experiments present.

4) For each experiment, a written assessment of the safety and health implications should be made as early as possible in the design of that experiment. The assessment should compare the experimental conditions against the ASE using a checklist to ensure that all issues have been evaluated. The experiment should be briefly described and the hazards identified. The assessment should consider whether additional training and/or controls are

required to perform the new experiment or if it can be reasonably considered as part of an existing set of experiments.

5) The contractor can authorize the initiation of the experiment if the assessment concludes that: the experiment falls completely within the bounds of a previously analyzed, documented, and approved set of experiments; the experiment's environmental, safety, and health characteristics are adequately controlled by the existing ASE; and the contractor's independent internal review supports these conclusions. Where these conditions are not met, a safety analysis will be needed to support a request for DOE approval of a modification to the ASE that encompasses installation and operation of the experiment.

6) Copies of operating safety procedures for experimental activities should be available to all individuals involved in those aspects of the experiment.

7) During the operational phase for most experiments, particularly complex or long lasting ones, periodic audits should be conducted with a frequency no less than annually to verify that no changes to the safety and health conditions analyzed in the hazard assessment have occurred.

8) To avoid inadvertently exceeding the ASE, a system should be employed that identifies which experimental apparatus, monitoring systems, and procedures cannot be changed without prior approval, and who is the approval authority.

b. Electrical Safety

Electrical equipment is fundamental in virtually all modern scientific experiments, including those present at accelerators. Of particular concern is local custom built R&D electrical equipment, which is not NRTL listed. The electrical requirements specified earlier for accelerator operations should also be applied to experimental installations. In addition, there are important unique characteristics of experiments that warrant special attention with respect to the topic of electrical safety:

1) Low-Voltage/High-Current Power Distribution Systems

The distribution of current from a low-voltage power source to one or more loads, though generally not considered to present a personal shock hazard, can present a significant hazard because of possible high-current capability of the power source. This can present a serious burn hazard to the worker, especially if contact is made with tools or jewelry.

High currents, coupled with lack of adequate over-current protection and/or undersized conductors, can lead to overheating of the conductors between source and load, thus presenting a fire hazard. Arcing from improper termination of high-current conductors is an additional fire and

personnel hazard. The designer or user of such a system or systems should take all reasonable steps to assure safe operation under foreseeable fault conditions. In particular, sufficient over current protection with respect to multiple conductors and/or multiple loads must be provided.

Problems of this type have been notable where power is distributed from a low-voltage, high-current source by the conductors of ribbon cable. This problem generally arises in installations designed and built by the experimenters themselves from the "ground up". Commercial systems are manufactured according to specified industrial standards and generally are of less concern. Qualified electrical engineers should make the determination of a safe configuration.

2) Electrical Connections

Experiments use a variety of coaxial cables and other electrical conductors to transmit electrical power, high voltages, and signals efficiently and quickly from the apparatus to the point of data collection. The accelerator facility should have clear policies and specifications on the choice and use of such cables in experimental installations.

Important considerations relate to the need to assure that: high-voltage conductors are not used for signal transmission, signal and control cables are not used to transmit power, cables are properly identified and labeled, any fire-protection requirements pertaining to electrical conductors are observed, and all cables should be used within their designed ratings unless specific tests to assure safety under planned and potential conditions of use are conducted successfully. Safe work practices should assure that cables (e.g., high-voltage and/or high-current) are not disconnected while energized.

c. Flammable and Non-Flammable Compressed Gas Safety

The use of flammable gases in experiments presents a unique type of installation generally not found in general industry, thus requiring special considerations. In many cases, mixing of gases is involved. Large volumes of gases may be present; thus even small leaks or ruptures of thin windows may cause incursions into the flammable concentration region with a large inventory to support fire. Some flammable gases may be stored in the liquid state, increasing the inventory. Electrical equipment is an integral part of such installations and can thus provide an ignition source if such a system is improperly designed, fabricated, or operated. The contractor should establish a policy for assessing the hazards of these systems and assuring proper mitigation.

For non-flammable gas sources, the principal hazard is that of asphyxiation or oxygen displacement. Such gases may either originate as compressed-gas sources or arise from the use of cryogenics. The methodology employed to address oxygen-deficiency hazards may be used effectively here. Compressed gases can represent considerable hazards that are adequately addressed by standards such as those promulgated by the Compressed Gas Association.

d. Cryogenic Safety

Experiments commonly use cryogenic gases. Precautions described earlier in this Guide should be followed to assure safe handling of the cryogens as well as proper assessment and mitigation of any oxygen-deficiency hazards. In some circumstances, flammable liquefied gases such as liquid hydrogen are used. Use of these flammable materials requires that appropriate fire protection considerations must be addressed and planned for.

e. Special-Materials Safety

Experiments that use materials with unusual safety-related characteristics may have industrial hygiene and waste management implications. Proper assessment of these materials well in advance of experiment operation is essential.

f. Configuration Control

Given the nature of experimentation, it is highly important that the configuration of the current experiment in progress be the same as that reviewed in the pre-operation hazard assessment or be within the scope of allowable change. Proactive review mechanisms should be used to insure configuration control.

5. Continuous Improvement and Feedback

a. Safety Review Process

An internal safety review system must be established and maintained to periodically assess and document the condition of the facility, equipment, and engineered safety systems [4.g.(1)]. The DOE requires the contractor to implement an internal safety review system to provide assurance that contractor management has independent feedback on the safety status at the accelerator facility. Documented reviews by a group of experts independent of the operation provides a “reality check” that should complement the findings of self-assessments performed by accelerator operations personnel.

Both the internal safety review system and operational self-assessments serve to focus management attention on improvements necessary for continued safe operation. A modular approach to safety assessment and review is recommended.

These assessments can be performed as part of the institution's overall self-assessment process.

Appropriateness and implementation of procedures, administrative controls and personnel training and qualifications must be periodically reviewed and documented by the internal safety review system [4.g.(2)]. The contractor internal safety review system may be based on one or more standing or ad hoc committees but should be comprised of persons independent of the accelerator operation under review. This group functions primarily in an advisory capacity to a designated manager having the authority to direct actions based upon the review findings. The rigor with which the review system is implemented should be commensurate with the hazard potential of the facility. While the system is intended to be internal to the contractor organization, independent technical competence in all areas required for an appropriate review may not be readily available within the organization. Consultants from other DOE accelerator facilities may be used as a regular complement to internal staff to provide an additional degree of objectivity and independence as well as nurturing good communications within the DOE.

Administrative aspects of the review system, which should be clearly delineated in a line management approved document, typically include: purpose; objectives; functions; authority; responsibility and composition of membership; quorum; format of documentation reporting results of reviews; and, the format for responding to and closing out recommendations from the reviews. Documentation of actions taken in response to the internal safety review system recommendations should also be retained as should the rationale for altering or rejecting recommendations. Documentation of the safety reviews should be in sufficient detail to permit audit of review system performance.

Audits of each accelerator facility by an internal safety review system should be conducted at least every three years and address the physical condition of the facility, record keeping, compliance with or satisfying applicable requirements and performance of the safety training programs. This review should be incorporated into the facility-wide self-assessment and quality improvement programs. Specific aspects of the accelerator facility that typically merit investigation by the internal safety review system include:

- the safety and environmental aspects of the design of the accelerator facility prior to the start of construction;
- development and modification of a SAD;
- proposed modifications to the accelerator facility, its operation, or any equipment that has potential safety implications;
- accelerator facility procedures related to safe and environmentally responsible operation;

- approved ASE;
- whether proposed activities are within the ASE;
- identified causes of any violation of ASE;
- corrective actions proposed in response to a facility shutdown because of safety concerns; and
- the content of safety training programs.

Reviews should not be limited to documentation and procedures, but should also include field observations to evaluate implementation and execution of the procedures. Interaction with representatives of the facility is encouraged so long as the conclusions of the review are free from pressures and constraints by the program under review. Reviewers should seek to minimize their disruption of activities although facility management should be accommodating to the needs of the reviewers and provide complete access where feasible.

b. Unreviewed Safety Issue

Activities that involve Unreviewed Safety Issues must not be performed if significant safety consequences could result from either an accident or a malfunction of equipment that is important to safety or for which a safety analysis has not been performed. Activities involving identified Unreviewed Safety Issues must not commence before DOE/NNSA has provided written approval [4.c.]. The requirement concerning USIs is a logical extension of the safety analysis requirements in the order. Activities posing significant safety hazards must not be performed until an analysis of the hazards has been conducted and proper controls implemented.

A USI exists if a proposed change or modification to the accelerator facility or an experiment will:

- Significantly increase the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety from that evaluated previously by safety analysis; or
- Introduce an accident or malfunction of a different type than any evaluated previously by safety analysis that could result in significant consequences.

A situation may arise in which a previously unevaluated hazard is discovered in an ongoing operation. This discovery should be evaluated to determine if it constitutes a USI in accordance with the criteria above.

When and how to perform and document a USI evaluation should be addressed in a facility specific procedure.

c. Lessons Learned

A process needs to exist to review internal and external events and conditions having operational or safety relevance to the accelerator facility, for the purpose of increasing the likelihood of repeating positive outcomes, and decreasing the likelihood of negative outcomes. DOE standards DOE P 450.4, *Safety Management System Policy*, DOE M 411.1-1C, *Safety Management Functions, Responsibilities, and Authorities Manual*, DOE-STD-7501-99, *The DOE Corporate Lessons Learned Programs*, and DOE-HDBK-7502-95, *Implementing U.S. Department of Energy Lessons Learned Programs* address this important aspect of ISM.

C. Accelerator Facility Post-Operations

1. Post-Operations Planning Activities

a. Post-Operations Plans

Post-operations activities normally include a transition period, deactivation, decommissioning and remedial surveillance and maintenance activities. These activities will likely require development of a written plan that meets whatever requirements are in place at the time of post-operations. This plan should incorporate budget and schedule realities. For large projects, the expectation for a post-operations plan is that it follows the principles of DOE O 430.1A, *Life Cycle Safety Asset Management*, similar to those illustrated in the associated Guides:

- DOE G 430.1-2, *Implementation Guide For Surveillance And Maintenance During Facility Transition And Disposition*;
- DOE G 430.1-3, *Deactivation Implementation Guide*;
- DOE G 430.1-4, *Decommissioning Implementation Guide*; and
- DOE G 430.1-5, *Transition Implementation Guide*.

The above DOE Guides provide implementation guidance specific to the transition and disposition of excess facilities that are contaminated, but portions of these guides may be useful to accelerator facilities for gleaning perspectives on good planning. It should be noted that accelerator facilities remain under the ASO during post-operations activities.

Many accelerator facilities are large and complex and could contain radioactive and/or hazardous substances long after termination of operations. The plan should be developed by the facility owner when an accelerator facility or module completes its mission and is declared excess. The accelerator or module then passes into a transition period where it is ultimately prepared for disposition. The disposition period of a facility's life-cycle may include deactivation, decommissioning, and surveillance and maintenance activities.

As part of the post-operations plan, specific end-points should be agreed upon by the applicable regulators and stakeholders. End-points are the detailed specifications of conditions to be achieved for the facility space, systems, and major equipment. These end-points should be developed as early in the process as possible as they can be used to determine cost and schedule estimates, demonstrate conformance to previously negotiated agreements, and show compliance with both local and federal regulations.

b. Revisions to the ASE

Surveillance and maintenance activities are conducted throughout the facility life-cycle, possibly continuing after a facility ceases operations. It is important to ensure that surveillance and maintenance activities are adequate to maintain the ASE during the final stages of operations through a seamless transition to the final disposition of the facility. The basis for surveillance and maintenance activities may be described in a revision to the SAD.

Surveillance and maintenance should be adjusted during the facility life-cycle as transition, deactivation, and decommissioning activities are completed. Surveillance and maintenance activities may include periodic inspections and maintenance of structures, systems related to safety, and equipment to ensure, at a minimum, that there is adequate containment of any radioactive or hazardous materials and that the potential hazards to workers, the public, and the environment are eliminated or mitigated and controlled.

c. Project and Task-Specific Hazards and Controls

The process to assess all post-operations jobs for environmental, safety and health risks should be consistent with the facility's ISM program. On-going surveillance and maintenance activities should also be considered when evaluating post-operations jobs. The job identification process should cover non-routine as well as routine post-operations activities.

Some hazards may arise from activities or tasks not associated with a specific job. The facility to be decommissioned may itself present certain exposures to hazards such as electrical equipment, access and egress, fire hazards, asphyxiation hazards, heat or cold conditions, tripping hazards, noise exposures, radiation exposures and chemical exposures.

It may be useful to draw on the personal experience of key operational personnel who may be aware of hazards that are not apparent from records. Interviews with former operating and maintenance personnel may also be useful. Their insights may help develop controls, as well as identify additional hazards.

d. Plan Modularization

Post-operational activities may be facilitated by using a modular approach. The overall post-operations plan may be better prepared as separate plans focused on discrete logical modules of the facility such as injectors, targets, experiments, or experimental halls rather than a single document addressing the entire facility. For example, a modularized approach where only a portion of an operating accelerator is being decommissioned may be advantageous. Another example where a modularized approach may prove advantageous would be when the module to be decommissioned has a significantly different type of hazard than other modules of the same facility.

e. Identification of Legal and Other Documents

Requirements that apply to post-operations activities need to be identified. Requirements may originate from several sources, including regulatory requirements, contract obligations, internal laboratory procedures, and formal commitments made by the post-operations organization's management. A process may be needed to manage requirements in order to identify and have access to legal and other requirements, including occupational safety and health requirements. These requirements may address an acceptable level of environmental protection including any required monitoring and personnel safety.

Requirements may also address appropriate LO/TO of equipment, hazardous chemical and radioactive material storage and/or disposal, periodic walkthroughs/ surveillances to verify continuing safe conditions, and physical security measures to prevent unwanted public access.

f. Identification of Records

An accelerator facility should institute, early in its life cycle, a process for collecting and retaining records on appropriate aspects of facility operations that may be needed to facilitate decommissioning or return of the accelerator site to other uses. The types of records and data to be collected and retained should be determined keeping in mind that the nature and scope of the standards to be met in the future may change. Important elements of records control for the post-operations purposes are as follows:

- A responsible authority/organization for maintaining data records pertinent to post-operations should be identified, preferably early in the life cycle of the facility.
- Consideration should be given to the best media type for the long term storage of records. Recent history has shown a rapid obsolescence in various types of electronic media.
- The records should be reviewed periodically to provide assurance that they are being properly maintained.

- Documentation records should be written with the understanding that they will be utilized by personnel, perhaps in the distant future, who may not be familiar with temporary conditions or jargon.
- Types of records that should be considered for long term retention to facilitate post-operational activities might include items such as:
    - Records that document the use, storage, and disposition of regulated or hazardous chemicals or of radioactive materials.
    - Records that document routine and non-routine facility releases of radioactive or hazardous materials.
    - Records that document parameters (e.g. beam intensity, repetition rate, pulse length, beam energy, etc.) that would facilitate assessments of the extent of component/materials activation because of routine and non-routine operations of the facility including items such as shielding, components and adjacent soils.
    - Records that document routine and non-routine contamination events including decontamination efforts and long-term residual contamination.

2. Concurrent Operations

Operations at adjacent facilities may be ongoing concurrent with post-operational activities. Considerations need to be given to the potential impact from those operations as well as impacts to those operations by any post-operational activities. These considerations should include:

- Safety impacts including radiation burdens, ODH hazards, etc. from adjacent operations;
- Possible disruption of safety systems shared between facilities, e.g. fire alarm system;
- Structural impacts including alignment and stability of nearby structures or equipment; and,
- Operational impacts including disruption of access or services to adjacent operations or restrictions on access and services caused by adjacent operations.

Interfaces with the adjacent operations organization should be established to facilitate communication between projects to define, minimize, and mitigate these impacts. Additionally, the ASE may have to be revised to account for concurrent operations.

3. Completion of Post-Operations

a. Long Term Records Retention

Detailed records from operations as well as records of post-operations activities may need to be archived for proper long-term retrieval consistent with applicable regulations, e.g. DOE O 200.1, *Information Management Program*.

b. Final Verification

Final verification involves completion of the post-operations plan and resolution of any issues raised during the process.

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