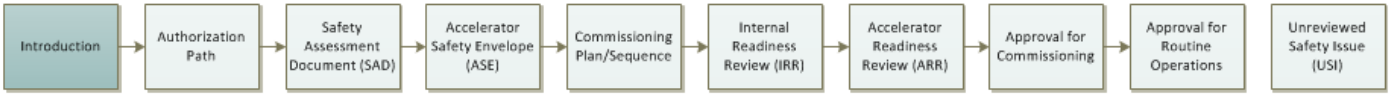
SUBJECT AREA CONTENT

Accelerator Safety Subject Area

Effective Date: **Jun 17, 2015** (Rev 6.0)
Periodic Review Due: **Jun 17, 2018**



Introduction

This subject area provides the requirements and standardizes the processes necessary for BNL accelerator facilities to comply with DOE Order 420.2C, Safety of Accelerator Facilities.

Following this subject area ensures that all facilities that can be categorized as accelerators establish the required documentation needed to establish an authorization basis for the facility. See the Facility Hazard Categorization Subject Area for more information on hazard categorization, and see the Facility Authorization Basis Program Description for information on the Laboratory's overall program. This subject area also helps to standardize the content and format of the initial Accelerator Safety Analysis for Exempt classification, Safety Assessment Document (SAD) and Accelerator Safety Envelope (ASE) for Non-Exempt classification, and other required submittals to facilitate review at all levels. This subject area provides templates that may be used to meet the requirements of DOE Order 420.2C.

Requirements of this subject area apply to the entire accelerator facility. An accelerator facility is the accelerator and associated plant and equipment using, or supporting the production of, accelerated particle beams and the radioactive material created by those beams, to which access is controlled to protect the safety and health of persons. It includes injectors, targets, beam dumps, detectors, experimental halls, non-contiguous support and analysis facilities, experimental enclosures and experimental apparatus using the accelerator, regardless of where that apparatus may have been designed, fabricated, or constructed, including all systems, components, and activities that are addressed in the Safety Assessment Document.

For an inventory of accelerator facilities, see the Accelerator Safety webpage on the Safety and Health Services Division website.

This subject area contains the following sections:

1. Establishing the Authorization Path to Achieve Approval for Routine Accelerator Operations
2. Developing the Safety Analysis and Safety Assessment Document (SAD)
3. Developing the Accelerator Safety Envelope (ASE)
4. Developing the Commissioning Plan/Commissioning Sequence (CP/CS)
5. Chartering an Internal Readiness Review (IRR) Team and Conducting an IRR
6. Chartering an Accelerator Readiness Review (ARR) Team and Conducting an ARR
7. Obtaining Approval for Commissioning
8. Obtaining Approval for Routine Operations
9. Unreviewed Safety Issue (USI) Process

Standards of Performance

Each facility shall have a defined business mission and defined operating boundaries to govern work assignments.

Facility configurations, operating envelopes, and the design basis shall be documented and controlled.

Managers shall analyze work for hazards, authorize work to proceed, and ensure that work is performed within established controls.

All staff shall identify, evaluate, and control hazards in order to ensure that work is conducted safely and in a manner that protects the environment and the public.

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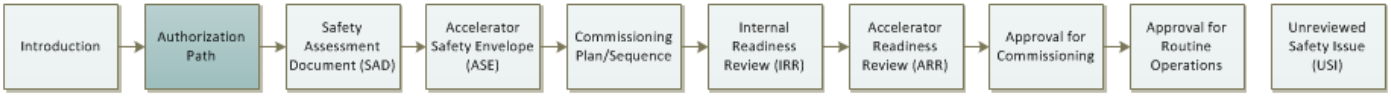

These requirements apply to managers and staff planning to develop, install, commission, or operate accelerators.

Establish the Authorization Path for Routine Accelerator Operations Approval

1.1 Authorization Path for Exempt/Equivalent Accelerators
1.2 Authorization Path for Non-Exempt Accelerators
1.3 Authorization Path for Accelerators Seeking Authorization Using Alternate Standards

1.1 Authorization Path for Exempt/Equivalent Accelerators

This section provides the requirements establishing the Authorization Path for Exempt/Equivalent Accelerators. See the Authorization Path for Exempt/Equivalent Accelerators Flowchart for an overview of the process.

This section applies to facilities that could be classified as accelerators, but who's hazards can be safely managed under the provisions of 10 CFR 835 and 10 CFR 851 that are non-complex in nature and that produce only local work area impacts, or for facilities that DOE may Exempt from the requirements of DOE O 420.2C. This step is optional; if the organization prefers, they can follow the process to operate that facility as a non-exempt accelerator facility in compliance with DOE O 420.2C and this subject area.

Existing accelerator facilities with approved Accelerator Safety Envelopes (ASE) may, at their option, follow the Authorization Path for Exempt/Equivalent Accelerators Flowchart. However, they must meet exempt requirements before their existing SAD and ASE expire. The accelerator facility cannot be operated without a current ASE or approved Exemption.

1. The organization seeking exempt status evaluates the device against the following criteria:
   DOE facilities whose hazards can be safely managed under the provisions of Title 10, Code of Federal Regulations (CFR), Part 835 and Part 851 that are non-complex in nature and that produce only local work area impacts. Examples of such facilities include:
   a. Radiation or current generating devices. If this device is adequately covered by the Radiation-Generating Devices Subject Area, no further authorization under this subject area is required;
   b. A room-sized accelerator with a single external/extractable beam, an active safety system, and a single point of entry into the room;
   c. (X-ray generators (below 10 MeV) or neutron generators (accelerating potential below 600 keV) that are bench top in size and that have a single external/extractable beam and a single operator such as those that are operated in accordance with American National Standards Institute (ANSI) N43.3-2008, or National Council on Radiation Protection and Measurements (NCRP) Report 72-1983 or other applicable Program consensus standard; and
   d. Unmodified commercially available equipment including, but not limited to, electron microscopes, ion implant devices, and x-ray generators.

   DOE may approve other accelerator exemptions, in addition to those examples listed above, from the requirements of DOE O 420.2C.

   If the organization seeking exempt status believes the device meets the above criteria, then proceed to step 2. Otherwise, proceed to subsection 1.2 Authorization Path for Non-Exempt Accelerators.
2. Prepare a Safety Analysis in accordance with subsection 2.1 Developing the Safety Analysis in this subject area.
3. Submit the Safety Analysis to the Secretary for the Laboratory Environment, Safety and Health Committee (LESHC) and schedule a review by the Committee.
4. The LESHC reviews the Safety Analysis and makes a determination on Exempt status.
5. If the LESHC determines the facility meets the Exempt criteria of DOE O 420.2C 3.c.(1), it recommends to the Assistant Laboratory Director, Environment, Safety & Health (ALD ES&H) that the facility be added to the list of Exempt facilities.
   If the LESHC determines that the facility could meet the Exempt criteria of DOE O 420.2C 3.c.(2), they advise the organization, and submit the request to the ALD ES&H to request approval from BHSO. If the LESHC determines that the facility does not meet the Exempt criteria of DOE O 420.2C 3.c.(1) or DOE O 420.2C 3.c.(2), they advise the organization and request that they follow subsection 1.2 Authorization Path for Non-Exempt Accelerators in this subject area to establish the authorization path to achieve approval for commissioning or routine accelerator operations.
6. The ALD ES&H advises the organization of the determination by DOE on the Exemption request, and adds the facility to the appropriate list for accelerator facilities.

1.2 Authorization Path for Non-Exempt Accelerators

In the development or acquisition of the facility, managers and staff must define the authorization basis documents and commissioning modules as early as possible. Refer to the Accelerator Commissioning and Operation Authorization Path Flowchart for the details on the path to achieving approval for routine accelerator operations.

1. Establish the number and type of commissioning modules.
2. Develop Authorization Path: Establish roles and responsibilities for
   - Construction, commissioning, and operations;
   - Major milestones (sequences and deliverables) for the path for achieving commissioning and routine operations.

3. Obtain concurrence of the organization's management, the organization's Associate Laboratory Director, and the BNL Associate Laboratory Director (ALD) for Environment, Safety & Health (ES&H).
4. Submit the Authorization Path (list of planned authorization documents and planned commissioning modules) to the Brookhaven Site Office (BHSO). **Note:** The organization may commission the accelerator facility in modules using a SAD for each module and obtaining an ASE and approval to commission for each module.
5. The organization proceeds with the authorization path by preparing a SAD (using the Accelerator Safety Assessment Document (SAD) Template. Proceed to section 2.2 Developing the Safety Assessment Document (SAD).

1.3 Authorization Path for Accelerators Seeking Authorization Using Alternate Standards

In the development or acquisition of the facility, managers and staff must define the applicable safety standards and authorization path as early as possible. Refer to the Accelerator Commissioning and Operation Authorization Path Flowchart for the details on the path to achieving approval for routine accelerator operations.

1. Establish alternate standards and obtain approvals to use these alternate standards from the BNL Director, the BHSO, and the DOE Program Secretarial Officer (PSO).

   Note: Alternate standards would be standards primarily for those accelerator facilities or modules thereof and their operations when they contain, use or produce fissionable materials in amounts sufficient to create the potential for criticality based on configuration of materials. These standards must provide equivalent or greater protection than the requirements of DOE Order 420.2.C.

   Establish the number and type of commissioning modules.
2. Develop Authorization Path: Establish roles and responsibilities for
   - Maintaining alternate standards and derived SBMS Subject Areas complete and up-to-date;
   - Reviewing and approving the safety analysis and hazard controls documents;
   - Constructing, commissioning, and operating the facility;
   - Performing readiness reviews;
   - Obtaining BNL authorization for commissioning and operations;
   - Obtaining DOE authorization for commissioning and operations.
3. Obtain concurrence on the Authorization Path from the organization's management, the organization's Associate Laboratory Director, the BNL ALD for ES&H, and the BNL Laboratory Director.
4. Request the BNL Laboratory Director submit the Authorization Path document to BHSO.
5. Follow the requirements in the DOE PSO-approved alternate standards and the Authorization Path.

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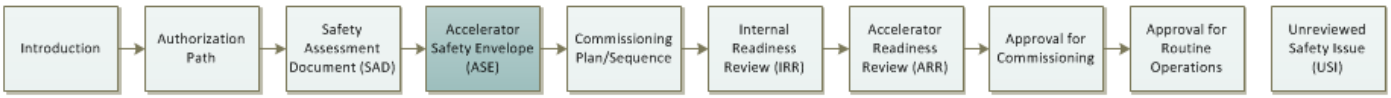

These requirements apply to managers and staff planning to develop, install, and operate accelerators.

Developing the Accelerator Safety Envelope (ASE)

Note: If the modules of the accelerator will be commissioned individually, an Accelerator Safety Envelope (ASE) must be developed for each module. Once the Accelerator Readiness Review on the commissioned modules is performed, a final Accelerator Safety Envelope (ASE) is established for operations.

1. Develop and provisionally approve the Accelerator Safety Envelope (ASE) in accordance with the Accelerator Safety Envelope (ASE) Template, using the safety analyses chapter of the Safety Assessment Document (SAD), and its associated risk assessment forms, and results of environmental assessments.
   The accelerator owner or manager, typically the Department Chair or ALD, provisionally approves the ASE.A documented ASE must define the

set of verifiable physical and administrative credited controls that define the bounding conditions for safe operation and address the accelerator facility hazards and risks.

2. Establish the roles and responsibilities for change control of the ASE.
3. Perform internal review of the ASE using ES&H SMEs, as appropriate.
4. Submit the ASE to the Laboratory Environment, Safety and Health Committee (LESHC) for review. This is best reviewed at the same time as the SAD.
5. The LESHC reviews the ASE and provides any comments or recommendations to the organization. Upon satisfactory resolution of any comments or recommendations, the LESHC recommends to the Associate Laboratory Director, Environment, Safety & Health (ALD ES&H) that the ASE be forwarded to BHSO for approval.
6. The ALD ES&H acts upon the recommendation of the LESHC.
7. BHSO sends the ASE approval letter to the ALD ESH.
8. After approval by BHSO is received, the Secretary of the LESHC posts a copy of the signed ASE to the institutional listing of Accelerator Facilities at BNL.
9. Place the ASE in change control with the SAD. The organization updates the ASE at least every 5 years, including the review process established in this section. Each version of the ASE must reference the version of the SAD to which it applies.
10. The organization monitors proposed changes to the accelerator facility for impact to the credited controls listed in the ASE using the USI process (see section Unreviewed Safety Issue [USI] Process). USIs that have a positive determination on a credited control listed in the ASE require a revision to the ASE and approval by BHSO prior to operation with the change.
11. The organization commissions/operates the accelerator within the safety envelope defined by the ASE upon approval to commission/operate by DOE.
    A planned activity expected to exceed the bounding conditions of the ASE requires prior DOE approval.
    Any activity violating the ASE must be terminated immediately and be put in a safe and stable configuration. Any activity that was shut down by DOE must not recommence until DOE approves the activity.

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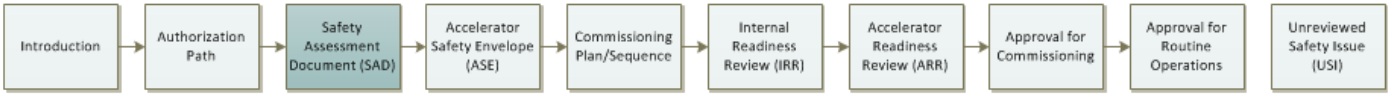

These requirements apply to managers and staff planning to develop, install, commission, or operate accelerators. These requirements apply to accelerators that have approval to operate on January 1, 2012, and all future accelerator facilities, including facilities that meet the requirements for Exemption.

Developing the Safety Analysis and Safety Assessment Document (SAD)

2.1 Developing the Safety Analysis
2.2 Developing the Safety Assessment Document (SAD)

2.1 Developing the Safety Analysis

Managers and staff develop a Safety Analysis for exempt accelerator facilities.

1. The organization gathers the appropriate reference documents, e.g., design criteria and specifications; operation characteristics; environmental assessments; documents that may describe the impact on facility staff, staff outside the facility, the public and the environment; prior SADs, and preliminary assessments.
2. Prepare and approve a safety analysis using the Accelerator Safety Analysis Template for Exempt Accelerators to demonstrate that the hazards can be safely managed under the provisions of Title 10, Code of Federal Regulations (CFR), Part 835 and Part 851 that are non-complex in nature and that produce only local work area impacts. The accelerator owner or manager, typically the ALD or Department Chair, approves the safety analysis.
3. Present the Safety Analysis to the Laboratory Environment, Safety and Health Committee (LESHC). Schedule the meeting through the LESHC Secretary.

4. The LESHC reviews the Safety Analysis and provides any comments or recommendations to the organization. Upon satisfactory resolution of any comments or recommendations, the LESHC recommends that the Assistant Laboratory Director, Environment, Safety & Health (ALD ES&H) concur with the Safety Analysis.
5. The ALD ES&H acts upon the recommendation of the LESHC.
6. The Secretary of the LESHC provides a copy of the signed Safety Analysis to the organization and retains the original signed document. A copy of the signed Safety Analysis is posted to the listing of Exempt Accelerator Facilities at BNL.
7. The organization places the Safety Analysis in change control. The organization updates the Safety Analysis whenever there is a change that impacts the hazards or hazard controls in the safety analysis, or at least every 5 years, including the review process established in this section. See the Document Control Subject Area.
8. Establish a Configuration Management Program for the controls that are the basis for the exemption.
9. The organization reviews all changes to the facility for possible impact to the controls that are the basis for the exemption.
   If the changes have no impact on the controls that are the basis for the exemption, then document this analysis and maintain the record on file until such time as the analysis is incorporated into the Safety Analysis. If the changes have an impact on the controls that are the basis for the exemption, then document this analysis and present it to the LESHC for a determination on the impact on Exempt status.

2.2 Developing the Safety Assessment Document (SAD)

Managers and staff develop a Safety Assessment Document (SAD) for non-exempt accelerator facilities.

Note: Accelerator management should consider their schedules when preparing the SAD. The review and approval process has taken several months to iterate before final approval.

1. The organization gathers the appropriate reference documents, e.g., design criteria and specifications; operation characteristics; environmental assessments; documents that may describe the impact on facility staff, staff outside the facility, the public and the environment; prior SADs, and preliminary assessments. Review these to understand the hazards of the facility.
2. Identify appropriate subject matter experts (SMEs) and assign roles and responsibilities for writing the SAD.
3. Develop and approve the SAD using the Accelerator Safety Assessment Document (SAD) Template. The accelerator owner or manager, typically the ALD or Department Chair, approves the SAD.
   Note: For accelerators capable of creating soil activation, prepare a section in the SAD that addresses capping to prevent rainwater infiltration, use the Design Practice for Known Beam Loss Locations.
4. Establish the roles and responsibilities for change control of the SAD.
5. Perform internal review of the SAD using ES&H SMEs, as appropriate.
6. Submit the SAD to the LESHC for review.
7. The LESHC reviews the SAD and provides any comments or recommendation to the organization. Upon satisfactory resolution of any comments or recommendations, the LESHC recommends that the Assistant Laboratory Director, Environment, Safety & Health (ALD ES&H) concur with the SAD.
8. The ALD ES&H acts upon the recommendation of the LESHC.
9. The Secretary of the LESHC informs the accelerator owner that the ALD ESH has concurred. A copy of the signed SAD is posted to the institutional listing of Accelerator Facilities at BNL.
10. The organization places the SAD in change control. The organization updates the SAD at least every 5 years, including the review process established in this section.
11. The organization develops a USI process based upon the credited controls defined in the SAD and in accordance with the section Unreviewed Safety Issue Process. Activities resulting from USIs that have a positive determination on a credited control in the SAD require prior BHSO approval. **Note:** The USI determinations may be appended to the SAD and incorporated during the 5-year review cycle.
12. The organization maintains an ASE and USI program in accordance with sections Developing the Accelerator Safety Envelope (ASE) and Unreviewed Safety Issue Process, respectively.

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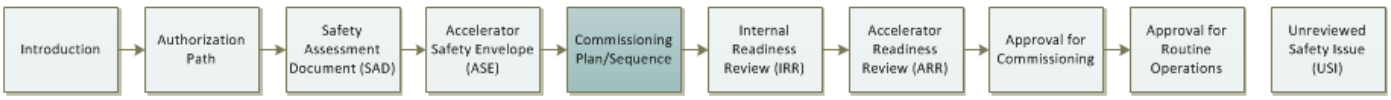

These requirements apply to managers and staff planning to develop, install, and operate accelerators.

Developing the Commissioning Plan/Commissioning Sequence (CP/CS)

The Commissioning Plan (CP) is a narrative document, authored and approved by the line organization that describes the scope, stages, preparations, and schedule for bringing an accelerator facility through the Internal Readiness Review (IRR) and Accelerator Readiness Review (ARR) process. The Commissioning Sequence (CS) is a separate document, similar to a procedure, that specifies the planned sequence of commissioning steps, measurements, authorizations, and equipment performance verifications that are required to meet commissioning plan objectives.

1. The organization prepares the CP and CS. Use the Commissioning Plan/Commissioning Sequence Template.
2. Perform internal review of the CP/CS.
3. Incorporate any changes, if necessary, and finalize both documents.
4. The organization ensures the CP and CS are current prior to the IRR/ARR.
5. The organization prepares for the IRR by following the section, Chartering an Internal Readiness Review (IRR) Team and Conducting the IRR, or the ARR by following the section, Chartering an Accelerator Readiness Review (ARR) Team and Conducting an ARR.

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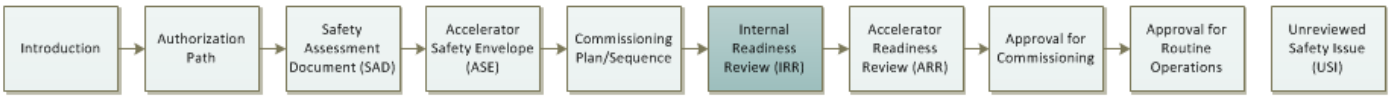

These requirements apply to the managers and staff involved in chartering, conducting, and closing out an Internal Readiness Review (IRR).

Chartering an Internal Readiness Review (IRR) Team and Conducting an IRR

An IRR is a process for confirming readiness to perform an ARR. An IRR is always a pre-requisite to conducting an ARR when an ARR is required. An IRR process may also be used in lieu of an ARR. It has been useful when multiple repetitive ARRs are required (e.g., multiple beam lines that will be commissioned over several months or years) and for large detector upgrades (e.g., PHENIX or STAR) where an ARR has been performed in the distant past. Using the IRR process in lieu of a subsequent ARR requires approval from the ARR Team and concurrence from the DOE BHSO if a new accelerator facility is being placed into operation. For modification or expansion of an existing accelerator facility, using an IRR without the subsequent ARR requires concurrence of the DOE BHSO. Using the IRR process to help transfer a facility to an operating accelerator facility would not require an ARR.

1. The organization determines that an IRR is required for a new or significantly modified accelerator facility (e.g., a large increase in beam power, facility additions, etc.).
   or
   the receiving organization determines that an IRR is required for a facility that will be transferred to their accelerator facility.
2. The line organization defines the scope of the IRR in a narrative document or report.
3. The line organization appoints a Point of Contact (POC) who coordinates IRR activities.
   Note: The POC must be familiar with the readiness of the accelerator and will accommodate and assist the IRR Team, directing the IRR Team to appropriate staff and documentation, and ensuring the appropriate staff and documentation is available to the IRR Team. The line organization should use the Topics to Guide the Accelerator Readiness Review (ARR) Team as guidance on the materials and topics the IRR Team will be reviewing.
4. The organization appoints the IRR Team Leader and Team Members.
   - Consideration should be given to using one or more subject matter experts (SMEs) from outside the organization.
   - Individuals serving on an IRR Team should be independent from the accelerator facility, or project or beam line being reviewed. Independent persons are persons who did not participate in the design phase, or construction-phase of the accelerator, and do not have any direct responsibility for commissioning or operations.

5. The organization provides a proposed set of Lines of Inquiry (LOIs) to the IRR Team to help focus their functional reviews. IRR Team Members use their professional judgment to help determine additional specifics that should be reviewed. See the exhibit Examples of Lines of Inquiry (LOIs) from Previous Reviews.
   Note: To the extent possible, meeting-style accelerator system presentations should be minimized to ensure the best use of IRR Team members' time and expertise to engage with operating and commissioning staff and to inspect the facility. The IRR should not be performed as a desktop or classroom exercise. Field verifications and interviews should be emphasized.
6. The organization works with the IRR Team Leader to schedule the IRR.
   Note: Sufficient time needs to be made available for the IRR Team to effectively meet the IRR's objectives. Time throughout the review also needs to be made available for the Team to meet privately to share observations or concerns.
7. The organization makes documentation readily retrievable and personnel available to facilitate the review process.
8. The IRR Team conducts the readiness review.
   Note: Readiness is defined as the state of having completed all construction, equipment testing, procedure writing, and personnel training such that an ARR may be performed.
9. The IRR Team holds a closeout meeting with the organization's management to share the Team's findings and any pre-ARR and post-start action items.
10. The IRR Team prepares a draft IRR Report and provides it to the organization for factual accuracy review.
11. The IRR Team issues the final report once all comments have been resolved.
12. The organization completes all pre-ARR action items prior to conducting the ARR. If the IRR is for facility transfer, then the receiving organization completes all actions items according to a schedule approved by the organization's ALD.

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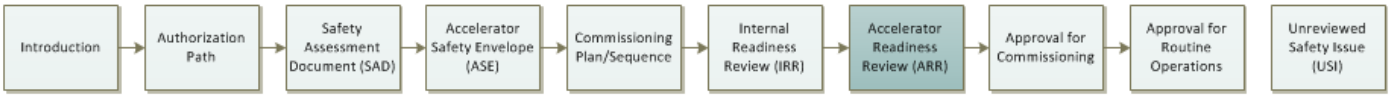

These requirements apply to the managers and staff involved in preparing for or chartering, conduct, and close-out of an Accelerator Readiness Review (ARR).

Chartering an Accelerator Readiness Review (ARR) Team and Conducting an ARR

An ARR is a stand-alone process for confirming readiness, not achieving readiness, and is independent of any other reviews and cannot rely upon any other prior reviews for verification. ARRs must be performed before DOE approval for commissioning and routine operation and as directed by the DOE Program Secretarial Officer/NNSA Deputy Administrator or BHSO. As part of the ARR process, BNL must demonstrate to the satisfaction of DOE that the following processes are in place:

a. a Contractor Assurance System that maintains an internal assessment process;
b. a Facility Configuration Management Program that is related to accelerator safety; and
c. credited controls and appropriate administrative processes related to accelerator safety (e.g., training, procedures, etc.).

Note: The ARR is a prerequisite to the approval for commissioning (see the section Obtaining Approval for Commissioning) or approval for Routine Operations (see the section Obtaining Approval for Routine Operations). However, some steps in the sections Obtaining Approval for Commissioning or Obtaining Approval for Routine Operations may be performed in parallel with this section.

1. The organization ensures the CP/CS are current and reflect the scope to be reviewed.
2. The organization appoints a Point of Contact (POC) to coordinate the ARR preparations within the organization.
3. The organization makes the documentation and personnel available to facilitate the review process. The POC must be familiar with the readiness of the accelerator and will accommodate and assist the ARR Team, directing the ARR Team to appropriate staff and documentation, and ensuring the appropriate staff and documentation is available to the ARR Team. The organization uses the Topics to Guide the Accelerator Readiness Review (ARR) Team as guidance on the materials and topics the ARR Team will be reviewing.
4. In consultation with the Accelerator Safety Subject Matter Expert (SME) and DOE-BHSO, and using the template Considerations for the

Selection of Accelerator Readiness Review (ARR) Team Members, the organization appoints the ARR Team Leader and Team Members.

- Consideration should be given to using functional SMEs from outside BNL on ARR Teams.
- Individuals serving on an ARR Team should be independent from the accelerator facility being reviewed. Independent persons are persons who did not participate in the concept phase, design phase, or construction phase of the accelerator, and do not have any direct responsibility for commissioning or operations.

As a minimum, the Accelerator Safety SME or his designee will serve as an ex-offio member of the ARR Team.

5. The ALD for ES&H concurs with the appointment of the Accelerator Readiness Review (ARR) Team.
6. The ARR Team Leader and the POC develop the Plan of Action (POA) using the Template for the Accelerator Readiness Review Plan of Action to guide the ARR.
   Note: To the extent possible, documentation reviews and accelerator system presentations should occur prior to the on-site verification to ensure the best use of ARR Team members' time and expertise to engage with operating and commissioning staff while at BNL.
   Note: Within the scope of the POA, readiness is defined as the state of having completed all accelerator construction, equipment testing, procedure writing, and personnel training such that the accelerator is considered able to be used immediately for commissioning or routine operation.
7. The organization works with the ARR Team Leader to schedule the on-site portion of the ARR.
   Note: Sufficient time needs to be made available for the ARR Team to effectively meet the ARR's objectives. Time also needs to be made available for the Team to meet privately to share observations or concerns.
8. The ARR Team conducts the review. The Team also uses Topics to Guide the Accelerator Readiness Review (ARR) Team as guidance in conducting the ARR.
9. Prior to leaving the site the ARR Team holds a closeout meeting with the organization's management and ES&H Directorate Management to share the Team's findings and any pre- and post-start action items.
10. The ARR Team writes the ARR Report. A suggested template is provided in the Accelerator Readiness Review (ARR) Report Template. The Team also uses Topics to Guide the Accelerator Readiness Review (ARR) Team as guidance in preparing the ARR Report.
11. The organization provides documentation for closure of the pre-start action items to the ARR Team.
12. When the ARR Team Leader concurs with the closure of all pre-start action items, the ARR Team Leader recommends to the accelerator owner or manager that the organization is ready to seek approval for commissioning and/or operations approval.
13. The accelerator owner or manager forwards the ARR Report and the ARR Team Leader's concurrence of closure of all pre-start action items to the ALD ESH.
    Note: For routine operations, skip to the section Obtaining Approval for Routine Operations.
14. The ALD ESH concurs with the schedule of closure of open post-start actions items.

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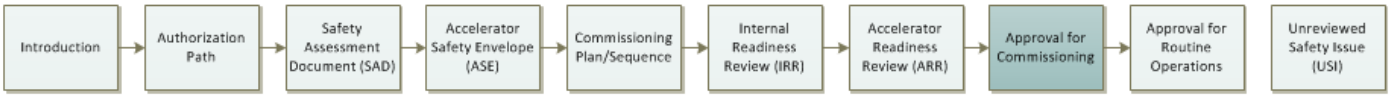
Questions/Comments

SUBJECT AREA PROCEDURE CONTENT

Accelerator Safety Subject Area
Effective Date: **Jun 17, 2015** (Rev 6.0)
Periodic Review Due: **Jun 17, 2018**



These requirements apply to managers and staff involved in the process to obtain approval to commission an accelerator.

Obtaining Approval for Commissioning

1. Based upon the concurrence received from the ALD for ES&H, the ALD for the organization requesting approval for commissioning forwards the ARR Report with the verification that all action items are closed (and the supporting Safety Analysis Document [SAD] or the Accelerator Safety Envelope [ASE], as necessary) to the Brookhaven Site Office (BHSO) and requests approval for commissioning. The ALD for the organization requesting approval for commissioning also sends a copy of this request to the ALD ES&H.
2. BHSO sends the approval letter for commissioning to the ALD for the organization requesting approval for commissioning.
3. The ALD for the organization requesting approval for commissioning notifies the organization and the ALD ES&H on the response from BHSO.
4. The organization commissions within the boundaries defined in the ASE in effect at the time the approval for commissioning was received.

Note: If the accelerator is being commissioned by module, the procedures in the sections Developing the Safety Assessment Document (SAD), Developing the Commissioning Plan/Commissioning Sequence, and Chartering an Accelerator Readiness Review (ARR) Team and Conducting an ARR are repeated for each module.

5. Upon completion of commissioning, the organization returns to section Chartering an Accelerator Readiness Review (ARR) Team and Conducting an ARR to conduct an ARR for Routine Operations.

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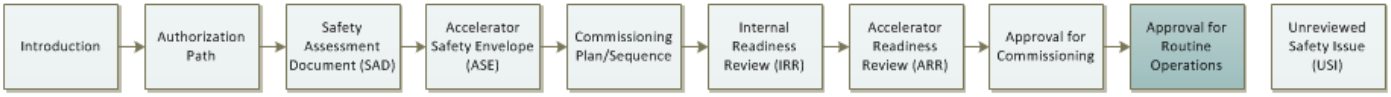

These requirements apply to managers and staff involved in the process to obtain approval to operate an accelerator.

Obtaining Approval for Routine Operations

1. Based upon the concurrence received from the ALD for ES&H, the ALD for the organization requesting approval for routine operation forwards the ARR Report with the verification that all pre-start action items are closed (and the supporting Safety Analysis Document [SAD] or the Accelerator Safety Envelope [ASE], as necessary) to the Brookhaven Site Office (BHSO) and requests approval for routine operations. The ALD for the organization requesting approval for routine operations also sends a copy of this request to the ALD ES&H.
2. BHSO sends the approval letter for routine operations to the ALD for the organization requesting approval for routine operations.
3. The ALD for the organization requesting approval for routine operations notifies the organization and the ALD ES&H on the response from BHSO.
4. The organization operates within the boundaries defined in the ASE that was in effect at the time the approval for routine operations was approved.

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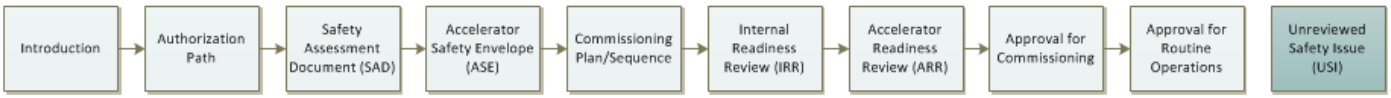

These requirements apply to the organizations that commission and operate accelerators.

Unreviewed Safety Issue (USI) Process

The purpose of the USI Process is to determine who must approve proposed changes or the continued operation after a discovery judged to affect the previously accepted risks of facility operations and to ensure BHSO is the approver of proposed changes or discoveries that significantly increase risk. No activity or facility modification may compromise the credited controls defined in the Safety Analysis Document (SAD) or the Accelerator Safety Envelope (ASE). Proposed changes are to be screened for hazards that lie outside the bounds of those considered in the SAD and in the development of the ASE, or would compromise the credited controls, by implementing this section.

Change control must be clearly identified in facility procedures and must consider items in the USI process. The USI process may result in rewriting portions of the SAD and modifying the ASE. Such revisions require review and approval in accordance with the processes prescribed in this subject area. Reportable events, proposed changes, proposed work, occurrences, discoveries, and lessons learned may also cause the USI process to be initiated. Use the Unreviewed Safety Issue (USI) Process Flowchart as a reference.

1. Develop USI and screening processes based upon the credited controls in the SAD and/or ASE.
2. Screen planned changes and discoveries, as listed below, to determine if there is potential to impact credited controls or existing Maximum Credible Incidents (MCIs) evaluated in the SAD, create new MCIs, or to increase operational risk, such as from low risk to medium risk, as per the risk table in the SAD or other comparable risk matrix.
   - Proposed work;
   - Changes to authorization documents;
   - Changes to operations and organizations;
   - New experiments; and
   - Discoveries, such as
     - Occurrences
     - Events
     - Applicable Lessons Learned

   Note: Discoveries may present an unacceptable level of ES&H risk in a facility's current operations and need to be communicated to BHSO as soon as the issue is validated and prior to completing the formal USI evaluation. Facility managers are allowed a reasonable period of time (i.e., hours, not days) to validate the discovery's potential to raise the operation's risk classification.
3. Following validation and communication of a discovery, the Facility Manager or designee works with BHSO to determine if
   - Existing controls are adequate to allow continued operations; or
   - Additional interim controls are required to allow continued operations; or
   - The operation causing the unacceptable level of risk needs to be stopped.

   Note: Any activity violating the ASE must be terminated immediately and be put in a safe and stable configuration.
4. Use the USI process to evaluate discoveries and planned changes triggered by the screening process as described in step 2.
5. If the USI process determination is that the discovery or planned change will not impact credited controls, existing MCIs, create new MCIs or cause an increase in risk classification as per the SAD risk table, it is not a USI. Using the tailored approach, consider documenting the evaluation, and filing it with the department.
   Note: Small accelerator facilities that are not complex and may not have a risk table in their SAD may use the Graded Approach Risk Assessment Matrix for Processes/Items/Systems in the Graded Approach for Requirements Subject Area, or other comparable risk table, to guide their determination of an increase in operational risk classification.
6. If the USI process determination is that the discovery or planned change will impact credited controls, existing MCIs, create new MCIs or cause an increase in risk classification as per the SAD risk table, it is a USI. Forward the USI analysis and proposed revisions to the ASE (if applicable) to the Laboratory Environment, Safety and Health Committee (LESHC) for review.
   Note: Any activity, such as a facility modification, resulting from a USI with a positive determination requires prior DOE approval.
7. The LESHC reviews the documents and provides any comments or recommendation to the organization. Upon satisfactory resolution of any comments or recommendations, the LESHC recommends to the Assistant Laboratory Director, Environment, Safety & Health (ALD ES&H) that the USI and revised ASE (if applicable) are forwarded to BHSO for approval.
8. The ALD ES&H acts upon the recommendation of the LESHC and forwards the USI and revised ASE (if applicable) to BHSO for approval.
9. BHSO sends the approval letter for the activity and ASE (if applicable) to the ALD ES&H.
10. The ALD ES&H notifies the organization on the response from BHSO.
11. The Secretary of the LESHC posts a copy of the USI and revised ASE (if applicable) to the institutional listing of Accelerator Facilities at BNL.
12. The organization appends a copy of the approved USI to the SAD.
13. The organization updates their USI process to assess the changes or additions to the credited controls from the updated SAD and/or ASE, as appropriate.
14. The organization incorporates the USIs into the SAD when the SAD is updated following subsection 2.2 Developing the Safety Assessment Document (SAD) in this subject area.

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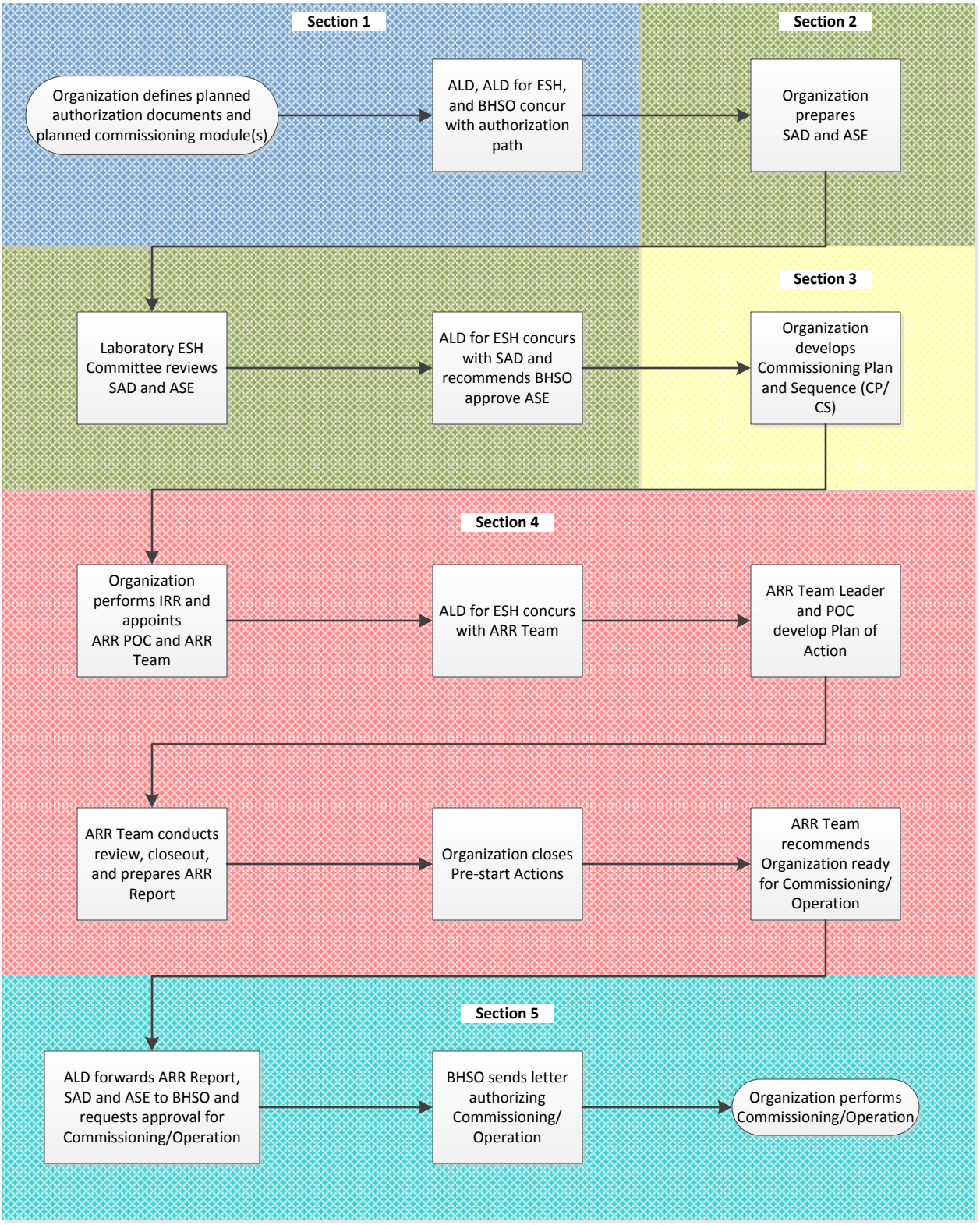
Accelerator Commissioning and Operation Authorization Path



Introduction

An ARR report should be prepared as soon as possible after the completion of the review. The ARR team leader should obtain input from all team members, and the team should reach consensus on the readiness of the facility to commence the activity for which the ARR was performed.

The conclusions reached by each team member are the principal end product of the ARR. They should be carefully drawn so that they unambiguously reflect the true intent of the team member, and they should be supported just as carefully. Suggestions of the types of information that will help support the conclusions include methodology used in pursuing the review, personnel contacted and their positions, documents reviewed, operations witnessed, and spaces visited.

A conclusion drawn as a result of the ARR effort may lead to one or more findings and/or observations. Findings are more serious and require documented closure. Findings reported by the team should be categorized as Pre-start or Post-start Findings. A Pre-start Finding is one, which, in the Team's opinion, must be corrected before an activity can be started. A Post-start Finding can be corrected after the start of the activity under review.

The final ARR report should be directed to the Deputy Director of Operations (DDO), with an information copy to the appropriate Facility Manager. Each member of the team should also receive a copy of the ARR Report. The DDO will be responsible for any further distribution of the report to the Brookhaven Group Office (BHG).

ARR REPORT TEMPLATE

1. Title/Cover Page

State the subject and date of the ARR

2. Signature Page

Include the signatures of all team members, signifying their agreement with the report and its conclusions. If a signature cannot be obtained for logistical reasons, the ARR Team Leader should obtain concurrence verbally or by facsimile and sign for the member.

3. Table of Contents

Identify all sections (including page numbers), subsections, illustrations, tables, charts, and appendices.

4. Executive Summary

Provide a summary of the review, findings and facility readiness. Suggested considerations include

- Brief synopsis of review;
- A determination as to readiness of the facility to undertake the activity;
- A statement regarding the adequacy of management systems to oversee the activity;
- A synopsis of the significant problems and strengths found by the ARR;
- A brief summary of the findings, including numbers of pre-start or post-start findings.

5. Introduction

Provide background information regarding the activity under review. This should include

- Purpose, scope, and objectives of the ARR;
- Review process and methodologies;
- Composition of the ARR Team;
- Definitions applicable to the ARR.

6. Conclusions

Address each subject identified in the scope and discuss the facility's readiness in each area. State each finding succinctly and unequivocally, and characterize as pre-start or post-start. Provide the basis for each finding.

7. Observations

Identify those items that, in the opinion of the ARR team, do not require action by the facility but would likely enhance the ESH status of the facility.

8. **Readiness Determination**

Provide an overall recommendation as to the readiness of the facility to commission, restart, or routinely operate.

9. Appendices

Append data/documents to support the report. These should include

- Review criteria and approach;
- Team roster with relevant qualifications of each member;
- Differing opinions (when applicable);
- Plan of Action.

Accelerator Safety Analysis Template for Exempt Accelerators

The purpose of the Safety Analysis for exempt accelerators is to show the hazards for the facility under review can be can safely managed under the provisions of Title 10, Code of Federal Regulations (CFR), Part 835 and Part 851, are not complex in nature, and are only capable of producing local work area impacts. That is, exempt accelerator facilities can control all local work area hazards by meeting the requirements in the RADCON Manual for ionizing radiation control, and by complying with the BNL Worker Safety & Health Program.

A Safety Analysis for an exempt accelerator must

- identify hazards and associated impacts to workers, the public, and the environment from the facility for both normal operations and credible accidents;
- contain sufficient descriptive information and analytical results pertaining to specific hazards to provide an understanding of risks presented by the proposed operations;
- provide appropriate documentation and detailed descriptions of engineered controls (e.g., interlocks and physical barriers) to eliminate, control, or mitigate routine and accidental radiation exposure.
- include or reference a description of facility function, location, and management organization;
- be prepared as a single document addressing the hazards of the entire accelerator facility; and
- be maintained current and consistent with the administrative control measures and physical configuration of the facility and major safety features and equipment.

Cover Page: As a minimum the cover page must include

Title of Facility
Building Number

Date of Initial Safety Analysis
Subsequent Revision Dates

Signature of Preparer(s)
Signature of Department Chair/ Division Manager
Signature of Appropriate Associate Laboratory Director
Signature of ALD for ESH

Section 1: Introduction

In this section, give a basic understanding of the facility's function and the local work area hazards.

Section 2: Summary/Conclusions

The summary gives an overview of the results and conclusions of the analysis contained within the Safety Analysis. Address the comprehensiveness of the safety analysis and appropriateness of the controls under Title 10, Code of Federal Regulations (CFR), Part 835 and Part 851.

Section 3: Details of the Safety Analysis

This section documents the analysis used for identifying and mitigating potential hazards. It should identify, characterize, and quantify hazardous materials, (i.e., chemicals, compressed gasses, explosives) and energy sources, (i.e., air, pressure, steam, hydraulic, flammable/combustible materials, lasers, RF, microwave). It should demonstrate there are NO off-site impacts due to air and liquid emissions at the facility, including radiological hazards.

The level of detail necessary will depend largely upon the complexity of the facility and magnitude of the local area work hazards. The purpose of the Safety Analysis is not only to detail the hazards identified, but also to demonstrate that a rigorous study of the activity has been completed and that all significant hazards have been identified and controlled in compliance with the RADCON Manual and the Worker Safety & Health Program.

Credible maximum bounding accident scenarios for the accelerator and experiments must demonstrate that emergency plans or site assistance agreements are not necessary. Each hazard identified must also show how the requirements of Title 10, Code of Federal Regulations (CFR), Parts 835 and Part 851, as implemented via the RADCON Manual and the Worker Safety & Health Program, can adequately control the hazard.

Exempt accelerator owners must reference all applicable OSH MS Job and Facility Risk Assessments to the Safety Analysis in order to demonstrate safety and health risks were addressed. Additionally, exempt accelerator owners must reference the EMS Process Assessment for the accelerator in order to demonstrate environmental risks were addressed.

Accelerator Safety Assessment Document (SAD) Template

Per DOE O 420.2C Contractor Requirements Document (CRD), Safety Assessment Document (SAD), a 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;
- 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;
- provide detailed descriptions of engineered controls (e.g., interlocks and physical barriers) and administrative measures (e.g., training) taken to eliminate, control, or mitigate risks of operation; and
- include or reference a description of facility function, location, and management organization in addition to details of major facility components and their operation;

Additionally, the Order states that the SAD is to represent the technical basis for the ASE and is to be maintained current. This template provides guidance detailing an acceptable approach to meeting the Order requirements for the SAD.

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. However, the organization must meet the DOE Order 420.2C requirements for the SAD.

Cover Page: As a minimum the cover page must include

Title of Facility
Building Number

Date of Initial SAD
Subsequent Revision Dates

Signature of Preparer(s)
Signature of Department Chair/ Division Manager
Signature of Associate Laboratory Director
Signature of BNL ALD for ESH

Chapter 1: Introduction

Give a basic understanding of the facility's function and the protection afforded the public, workers (health and safety), and the environment. Address the scope of the document and include an overview 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 used to establish acceptable safety for workers and the public may be listed or referenced here, or elsewhere in the document.

Chapter 2: Summary/Conclusions

The summary gives an overview of the results and conclusions of the safety analysis contained within the SAD. Address the comprehensiveness of the safety analysis and appropriateness of the proposed Accelerator Safety Envelope.

Authorized variances from SBMS requirements (such as subject areas and manuals) used to implement DOE accepted codes, standards, and regulations should be identified, and justification for the deviations should be provided in the SAD.

The analysis for an operation that involves only hazards that are routinely encountered by the public may be replaced by a simple, formal statement of that fact.

If applicable to portions of the accelerator facility, identify exemptions and / or equivalencies that have been previously reviewed and approved.

Chapter 3: Description of Site, Facility and Operations

Show accurately the environment within which the facility will be constructed (or modified), those facility characteristics that are safety-related, and the methods to be used in operating the accelerator and associated equipment.

The SAD may be prepared as a single document addressing the hazards of the entire accelerator facility, or as a set of separate SADs for discrete modules of the facility, such as injectors, targets, experiments, experimental halls, or any other type module (such as commissioning modules vs. routine operations modules).

Address the following items in this chapter:

- The location of the accelerator site should be characterized, including any special site requirements or unusual design criteria. Data typically address site geography, seismology, meteorology, hydrology, demography, and adjacent facilities that may impact or be impacted by the accelerator facility.

- Detail design criteria and as-built characteristics for the accelerator, its supporting systems, and components with safety-related functions. Particular attention should be given to those design features that minimize the presence of hazardous environments, and ensure that chemical and radiation exposures are kept ALARA during operation, maintenance, and facility modification.

- Address the Department/Division work planning and control program for that work that could impact the safety of the accelerator facility.

- Describe the maintenance, performance testing, inspection and surveillance activities required to maintain the inherent reliability of safety-related systems (e.g., interlock tests).

- Similarly, also identify training and certification required to maintain the facility within the analyzed safety envelope.

- Describe experiments that will be conducted in the accelerator facility, including design criteria and characteristics of the experimental equipment, systems, and components having safety-related functions. The Work Planning and Control for Experiments should be described or referenced.

- Describe the functioning of administrative measures important to safety; a non-exhaustive list of examples includes:
  - Essential procedures required to prevent or mitigate accidents
  - Calibration and testing of safety related equipment
  - Radiation, ODH, environmental or non-standard hazard-control guidelines for the facility (e.g. facility worker, non-facility worker, member of public, groundwater activation, airborne emissions, etc)
  - Process for ensuring guidelines are met

- Configuration management related to accelerator safety (e.g. credited controls, facility shielding, initial/periodic shielding verification, USI Process, as-built drawings, and change control process)

- Administrative controls that serve to limit the intensity of the maximum beam loss and/or its duration

- Records management for operations, health, safety and quality records

Chapter 4: Safety Analysis

Document the analysis, including any systematic methodology (i.e., Failure Mode and Effects Analysis, Fault Trees) used for identifying and mitigating potential hazards and Maximum Credible Incident (MCI) scenarios. It also identifies, characterizes, and quantifies hazardous materials, (i.e., chemicals, compressed gasses, explosives) energy sources, (i.e., air, pressure, steam, hydraulic, flammable/combustible materials, lasers, RF, microwave) and potential sources of environmental pollution (i.e., air and liquid emissions) at the facility, including radiological hazards (contamination, activation, criticality*)*.

The purpose of the SAD is not only to detail the hazards identified, but also to demonstrate that a rigorous study of the activity has been completed and that all significant hazards have been identified.

Coupled with identifying hazards should be a description of the controls that will be used for their mitigation. In this description, include a discussion of credible challenges and estimates of consequences in the event of failure. Analysis of estimated consequences and likelihood of occurrence may signify the need for additional or more reliable controls. Credible maximum bounding accident scenarios for the accelerator and experiments may be described to indicate the need for and extent of emergency plans or site assistance agreements.

Where appropriate, address the residual risk to workers, the public and environment in the risk assessment. However, a separate effort beyond that of the safety analysis is typically not necessary for residual risk estimation, since requirements, codes, and consensus standards establish acceptable risk.

Risk assessment, i.e., the predicted severity of consequences and the probability of occurrence for all hazards, may be expressed qualitatively or quantitatively.
Base the risk assessment on experience with similar equipment, data from other laboratories, industry experience, and the best judgment of the analyst. The following risk assessment matrix should be used and tailored to the consequences and frequency of events anticipated for the facility. Implement controls on consequences and frequency of events such that the risks are low to medium.

Table 1
Risk Assessment Matrix

	Hazard Probability				
Hazard Severity	**Frequent**	**Probable**	**Occasional**	**Remote**	**Improbable**

Catastrophic	High	High	Serious	Medium	Low
Critical	High	High	Serious	Medium	Low
Marginal	Serious	Serious	Medium	Medium	Low
Neglible	Medium	Medium	Low	Low	Low

Hazard Severity definitions:

Catastrophic –

Can a radiological or chemical hazard cause multiple deaths or serious injury, off-site evacuation, >1 rem off-site, >100 rem to an individual on-site, greater than ERPG-1 off-site, or have a public impact that closes the Department buildings or a User Facility?

Critical –

Can a radiological or chemical hazard cause a death or serious injury, 0.1 to <1 rem off-site, >5 rem to an individual on-site, greater than ERPG-2 or have a public impact that closes down 'an experiment or program?

Marginal –

Can a radiological or chemical hazard cause multiple moderate injuries, local evacuation, > 2 rem to an individual, greater than ERPG-3, or have a public impact that brings the experiment to the attention of the community and activist groups?

Neglible –

Can a radiological or chemical hazard cause minor injuries, no on-site or off-site evacuation, >100 mrem unplanned to an individual, or have a public impact that is below public perception?

Hazard Probability definitions:

Frequent – Likely to occur repeatedly during the lifetime of the accelerator
Probable – Likely to occur several times during the lifetime of the accelerator
Occasional – Likely to occur sometime during the lifetime of the accelerator
Remote – Not likely to occur during the lifetime of the accelerator
Improbable – Very unlikely – unrealistically perceivable

Management Decision Levels for Risk:

High – Operation not permissible
Serious – High priority remedial action
Medium – Take remedial action at appropriate time
Low – Risk Acceptable; Remedial action discretionary

The following lists the overall process to follow in designating Credited Controls for inclusion in the ASE:

- Identify the hazards present at the facility, and determine if they need further analysis
- Distinguish the maximum credible incidents (MCIs) caused by these hazards
    - Ascertain the initiating event and its likelihood
    - Delineate methods of detecting the event
    - Recognize the hazards from the initiating event

    - Assess the consequences and risk from the event
    - Determine engineered and administrative features that reduce risk to acceptable levels
    - Determine need for Credited Controls to ensure actual consequences and risk are bounded by the analysis
- Select the Credited Controls
- Protect the Credited Controls
- Manage the Credited Controls' operability and specify surveillance requirements via the ASE

The process driving the determination of Credited Controls should evaluate the following:

- Internal events
    - These include credible internally initiated operational accidents, such as process upsets, beam misalignments, spills, equipment failures, unauthorized work, fires, and gas releases. In evaluating all types of scenarios, base determinations of credible internal events on consensus and operational experience, and exclude as not credible easily justified internal events based on physics or other bounding logic. Examples of initiators of credible internal events are events resulting from equipment failures and human errors.
- Natural phenomena
    - These encompass seismic events, extreme wind, hurricanes, and flooding. Consider these events against applicable building codes under which the facility was constructed.
- External events initiated by humans
    - These include explosions or vehicular crashes that either cause releases or have a major impact on the facility's operations. The frequency for their credibility should be an event with a frequency greater than once every 10,000 years.

The safety analyses must consider the consequences to workers inside the accelerator or the accelerator facility. To assure the proper controls, the analyses must cover all credible on-site and off-site locations, including appropriate occupancy. Adopt an informed approach to selecting the Credited Controls that combines expert opinion, and cautious assumptions and calculations to generate a conservative understanding of the risk.

Chapter 5: Basis for Accelerator Safety Envelope (ASE)

The ASE formally establishes Credited Controls and the limits on operations within which one operates the accelerator facilities. It ensures that the Credited Controls are reliably in place.

Credited Controls are essential controls critical to protecting the public, workers, and the environment from the more severe postulated events involving non-standard industrial hazards. The ASE ensures that additional quality controls, design margins, and operational attention is given to these essential controls.

Credited Controls are a limited subset of the total number of controls an accelerator facility employs for overall facility safety and operation. In most cases, specific Credited Controls protect against significant exposure to ionizing radiation from accelerator beams, airborne releases of radioactive material, and in some cases oxygen-deficiency hazards involving liquid-

helium releases. Controls that are not Credited Controls offer additional significant reductions in risks. However, they should not be included in the ASE unless they directly support a Credited Control.

Determining Credited Controls based on risk is not an exact science but an art that people master with experience. For example, an extremely low consequence event that does not entail a major injury or occupational illness, or does not significantly affect the environment might be activation of local soil. Some communities greatly value their groundwater and gaining the trust of the public and the regulators may require a Credited Control such as a rainwater-impermeable caps over activated soils. As such, the accelerator facility must assure additional quality control, design margin, and operational attention to maintaining the impermeable cap. Thus, selecting Credited Controls is more of a judgment-based process (an art) than a standardized one (science) since the choice may depend on economic- and social-factors, rather than just regulations or risk.

The following criteria are suggested for the number of Credited Controls for each off-normal/accident event evaluated in Chapter 4.

Table 2
Example of Consequences, and Minimum Number of Credited Controls

Consequence	Minimum Number of Credited Controls
High: The radiation dose could exceed 1 rem to an offsite receptor	At least two Credited Controls; the controls may be similar but common-mode failure should be considered
Medium: The radiation dose could exceed between 0.1 to 1 rem to an offsite receptor	At least one Credited Control
Medium: The offsite airborne toxic-chemical-vapor concentrations could exceed ERPG-2	At least one Credited Control
High: The radiation dose to a worker could exceed 50 rem, or exposure to airborne chemical concentrations above the defined ERPG-3 level	At least two Credited Controls; the controls may be similar but common-mode failure should be considered
Medium: The unmitigated radiation dose to a worker could exceed 5 rem, or exposure to airborne chemical concentrations above the defined ERPG-2 level	At least one Credited Control
Medium: Each unmitigated event that could cause a worker to breath air with an oxygen concentration below 14% by volume	At least one Credited Control

The following assumptions were used in constructing Table 1:

- Radiation dose criteria are for the total equivalent dose, including both the internal and external doses resulting from an event
- Toxic chemical hazards are evaluated against the appropriate criteria of the Emergency Response Procedure Guidelines (ERPGs) associated with that chemical

- Incidents that could impact the public outside accelerator facilities are assessed in areas immediately outside the site boundary
- Incidents that could impact nearby non-accelerator workers outside the accelerator facility boundary are assessed in uncontrolled areas inside site's boundary
- Incidents that result in an airborne release of radiological- or toxic-material are assessed by an appropriately conservative meteorological model
- Incidents that affect workers locally are assessed at the shield boundary, or within an accessible enclosure

For credible events that require one Credited Control to protect personnel, consider designating an additional Credited Control to afford significant additional mitigation so to help ensure the minimal possible risk to workers. Example credible situations to consider are

- An event initiated by, or involving an explosion or large fire that could breach a confinement barrier for inert gas or radioactive material
- The Credited Control depends on correct human actions undertaken within a limited time
- The Credited Control depends on a complex device for which a documented reliability analysis is unavailable

Once the need for a Credited Control is identified, follow a reasoned process to select the specific Credited Engineered Control or Credited Administrative Control required to accomplish the required safety function.

When selecting Credited Engineered Controls, identify any dependencies for each system considered. For example, if a given Credited Engineered Control depends on another system to enable its required function, then at least some aspect of that other system becomes an essential Support to the Credited Engineered Control (e.g., area-radiation monitors support the Access Control System). Follow the selection criteria listed below to the greatest extent practicable when designating Credited Controls and their essential Supports:

- When either an active or a passive device could be a Credited Control to ensure the safety function, select the latter. Passive devices, such as configuration-controlled shielding, inherently exhibit higher reliability than active devices, such as interlocking radiation monitors.
- If either an engineered control or an administrative control could perform the needed safety function, then select the former. Engineered controls generally have higher reliability than human actions. For example, interlocking radiation monitors that remove the beam are preferred to procedures that require manually stopping the beam, or expecting personnel leave an area when radiation alarms annunciate.
- When there is a choice between a non-credited control that would prevent an event and a Credited Control that would mitigate the consequences of the event, then select the non-credited control. Prevent events rather than mitigate their effects if it is practicable. For example, if the supply of helium could be limited to prevent an oxygen level below 18% compared to installing a Credited emergency-ventilation system, then the supply of helium should be controlled.

It is preferable to use Credited Controls that, in some cases, protect against multiple events. An example is using the Access Control System to prevent access to both a radiation hazard and a

potential oxygen-deficiency hazard. Working against this preference is the desire to make protection systems simple and efficient for testing and annual re-certification.

Authorized Alternatives may be listed in the ASE. Authorized Alternatives are pre-approved compensatory actions that, when implemented as specified in the ASE, prevent ASE violations and reduce unnecessary impact on operations. Base the Authorized Alternatives on detailed risk analyses, previous experience, or informed engineering judgment. Recognize that equipment is not 100% reliable, and indicate time in the Authorized Alternative to allow restoration of full operability of Credited Controls. Implementing an Authorized Alternative should not affect risk. The time to allow restoration of full operability must be supported by engineering analysis or judgment.

Describe the bases for each Credited Control listed in this Chapter. For example;

> **Credited Control**: Radiological shielding and barriers must undergo visual inspection before operations to ensure that they are in place and functional (ASE).
> **Bases:** This interval coincides with the annual running period at the accelerator, and the inspection is part of the facility startup. The accelerator operators use procedures for this task, and document all shielding using a checklist. Once operational, periodic radiation-dose-rate surveys ensure the radiation barriers remain in place and are effective.

The reason for indicating the bases of a Credited Control is to ensure operators, engineers or others do not change the bases without considering the impact on the Credited Control.

Chapter 6: Quality Assurance

Describe the Quality Assurance (QA) Program applied to the accelerator facility, focusing upon those activities that impact protection of the worker, public, or environment. Contact your Departmental Quality Representative for assistance.

Chapter 7: Considerations for Decommissioning and Decontamination (D&D) or Post-Operations Planning

Describe the structural and internal features that would facilitate D&D of the accelerator facility. Discuss waste management of radiological and hazardous material generation from the D&D operation within the context of DOE requirements. Consideration of long-term records management to facilitate post-operations activities should be included.

Chapter 8: References/Glossary/Acronyms

RISK ASSESSMENT

FACILITY NAME:_____ NUMBER: _____

SYSTEM:_____
SUB-SYSTEM:_____

HAZARD:_____

Event Possible Consequences & Hazards: Potential Initiators:	

Risk Assessment Prior to Mitigation					
Severity:	I ☐ Catastrophic	II ☐ Critical	III ☐ Marginal	IV ☐ Negligible	
Probability:	A ☐ Frequent	B ☐ Probable	C ☐ Occasional	D ☐ Remote	E ☐ Extremely Remote
Risk Category:	1 ☐ High	2 ☐ Serious	3 ☐ Medium	4 ☐ Low	

Hazard Mitigation	

Risk Assessment Following Mitigation					
Severity:	I ☐ Catastrophic	II ☐ Critical	III ☐ Marginal	IV ☐ Negligible	
Probability:	A ☐ Frequent	B ☐ Probable	C ☐ Occasional	D ☐ Remote	E ☐ Extremely Remote
Risk Category:	1 ☐ High	2 ☐ Serious	3 ☐ Medium	4 ☐ Low	

Is the mitigated hazard adequately controlled by existing laboratory policies? Y/N _____ If No, roll up the required credited controls into ASE.

Accelerator Safety Envelope (ASE)

Title of Facility:

Date of Initial ASE:

Subsequent Revision Dates:

Signature of Preparer(s):

_____

Signature of Department Chair:

_____

Signature of Associate Laboratory Director:

_____

Signature of BNL ALD for ESH:

_____

Section 1. Introduction

This ASE defines the Credited Controls that are unique to accelerators necessary to ensure safe operations and minimize the potential accelerator-related risks to the public, workers and environment.

1.1. A variation away from the Credited Controls and their Supports, which are described in Sections 2, 3, and 4 of this ASE, must be treated as a violation of the ASE and must be treated as a reportable occurrence, as defined by the BNL SBMS Subject Area on Occurrence Reporting. A violation is not satisfying a Credited Control, its Supports or its Authorized Alternative.

1.2. If a Credited Control or its Supports are not satisfied and the Control has a specific Authorized Alternative, then take immediate actions to implement the Authorized Alternative or stop the activity that uses the affected equipment as soon as practicable.

1.3. If a Credited Control or its Supports are not satisfied have no specific Authorized Alternative, then stop the activity that uses the affected Credited Control as soon as practicable.

1.4. Emergency actions may be taken that depart from Credited Control or its Supports when no actions consistent with the Credited Control are immediately apparent and when these actions are needed to protect the public, worker and environmental safety. These emergency actions must be approved prior to implementation by the person in charge of facility safety, as defined in the operating procedures, when the emergency occurs and must be reported to accelerator facility management within 2-hours.

Section 2: Credited Controls for Maximum Credible Incident (MCI)

This section contains the Credited Controls that limit accelerator operations in order to protect the environment, workers, and the public.

Credited Controls for Beam Energy and Beam Intensity

The following limits are the maximum beam energy and number of particles or beam intensity that are under configuration management. These Credited Controls cannot be exceeded without changing the beam-producing and/or -controlling elements of the accelerator. Changing these systems requires authorization by accelerator management and a documented evaluation for an Unreviewed Safety Issue..

2.1. The maximum number of particles or beam current must not exceed the XXX at XX eV.

Credited Control for Radiation Hazard Due to Access (if applicable)

2.2. During operations with beam, the relevant access controls system must prevent access to the accelerator enclosure.

Credited Control for Oxygen Deficiency Hazard (ODH) (if applicable)

2.3. Engineered systems (interlocks and alarms) must be in place and operational to minimize the likelihood of injury/illness from a release of inert gas.

Credited Controls for Fire Hazards (if applicable)

2.4. Manually initiated exhaust fans to exhaust smoke from the enclosure must be operational during occupancy.

2.5. Flammable gas detection must be operational during running periods with flammable gases present in ….

Section 3: Credited Control Supports

This section identifies the measurable limitations on Supports for Credited Controls that ensure that accelerator operations do not exceed the Credited Controls in Section 2. These Credited Control Supports are derived from the safety analyses described in the approved SAD. They are:

Credited Control Supports to Protect against Radiation (if applicable)

3.1. In order to protect groundwater, if the annual activity concentration of sodium-22 in leachate is calculated to exceed 25% or tritium in leachate is calculated to exceed 5% of the Drinking Water Standard, then a cap must be used unless BNL Management waives the requirement.[1]

Example Authorized Alternative: If an installed cap is discovered to be breached, alternative equivalent protection approved by management must be in place within XX days of discovery. Permanent repair to the cap must be initiated as soon as possible.

3.2. Before beam or other radiation producing operations (e.g., RF testing), beam line enclosures must have all shielding (e.g., berms, shield blocks, fences, etc.) properly in place and configuration controlled.

3.3. During operations with beam, the Access Controls System (ACS) must be functional. This means that the portions of the ACS preventing exposure to beam radiation or to RF generated x-rays inside enclosures must remove beam or turn off RF when excessive beam loss or x-ray dose occurs.

3.4. During beam or RF operations, area radiation monitors interfaced with the ACS to remove beam when excessive beam loss is sensed or turn off RF when excessive x-rays are produced must be within their calibration date.

3.5. During operations with beam or RF cavities, the locations of area radiation monitors interfaced with the ACS are to be configuration controlled.

[1] BNL SBMS Accelerator Safety Subject Area, Design Practice for Known Beam Loss Locations

Credited Control Supports to Protect against an ODH (if applicable)

3.6. When a potential ODH is possible:

3.6.1. At least XX ODH exhaust fans in YY must be operational, and

3.6.2. The ODH portion of the Access Controls System must be operable.

Example Authorized Alternative: If less than XX ODH fans are operable in YY or the ODH portion of the Access Controls System is out of service, then entry is allowed if each entrant has their own 5-minute escape pack (or a self-contained breathing apparatus) and a portable oxygen monitor.

Credited Control Support to Protect against Smoke Inhalation (if applicable)

3.7. Personnel may occupy the accelerator enclosure if the exhaust fans in the occupied area, required for personnel protection during an emergency, can be manually activated.

Example Authorized Alternative: If exhaust fans in an occupied area are inoperable, take immediate actions to empty the affected area of all personnel, within XX hours. Prevent occupancy until operability is restored; however, workers may enter the affected area using PPE as required by work planning to restore fan operability.

Credited Control Supports to Protect against Flammable Gas Hazards (if applicable)

3.8. The following are required whenever flammable gas is in use at YY:

3.8.1. Flammable gas detection systems must be operational.

3.8.2. Emergency exhaust fans must be operable.

3.8.3. A minimum of XX ft^3 of inert purge gas must be available to dilute the flammable gas volumes below 25% of the Lower Explosive Limit.

Section 4: Calibration, Testing, Maintenance and Inspection that maintains Credited Controls (if applicable)

The calibration, testing, maintenance or inspections needed to maintain Credited Controls are:

4.1. The ACS must be functionally tested in accordance with requirements in Chapter 3, Appendix 3A of the BNL Radiation Control Manual.

4.2. ODH ventilation fans and air inlet louvers that are signaled by the ACS must be functionally tested annually or before the running period.

4.3. High Sensitivity Smoke Detection (HSSD) systems must undergo annual testing (not to exceed XX months).

4.4. Flammable gas detection systems must undergo annual testing (not to exceed XX months).

4.5. Emergency exhaust fans must undergo annual testing (not to exceed XX months).

4.6. High capacity ventilation systems must undergo annual testing (not to exceed XX months).

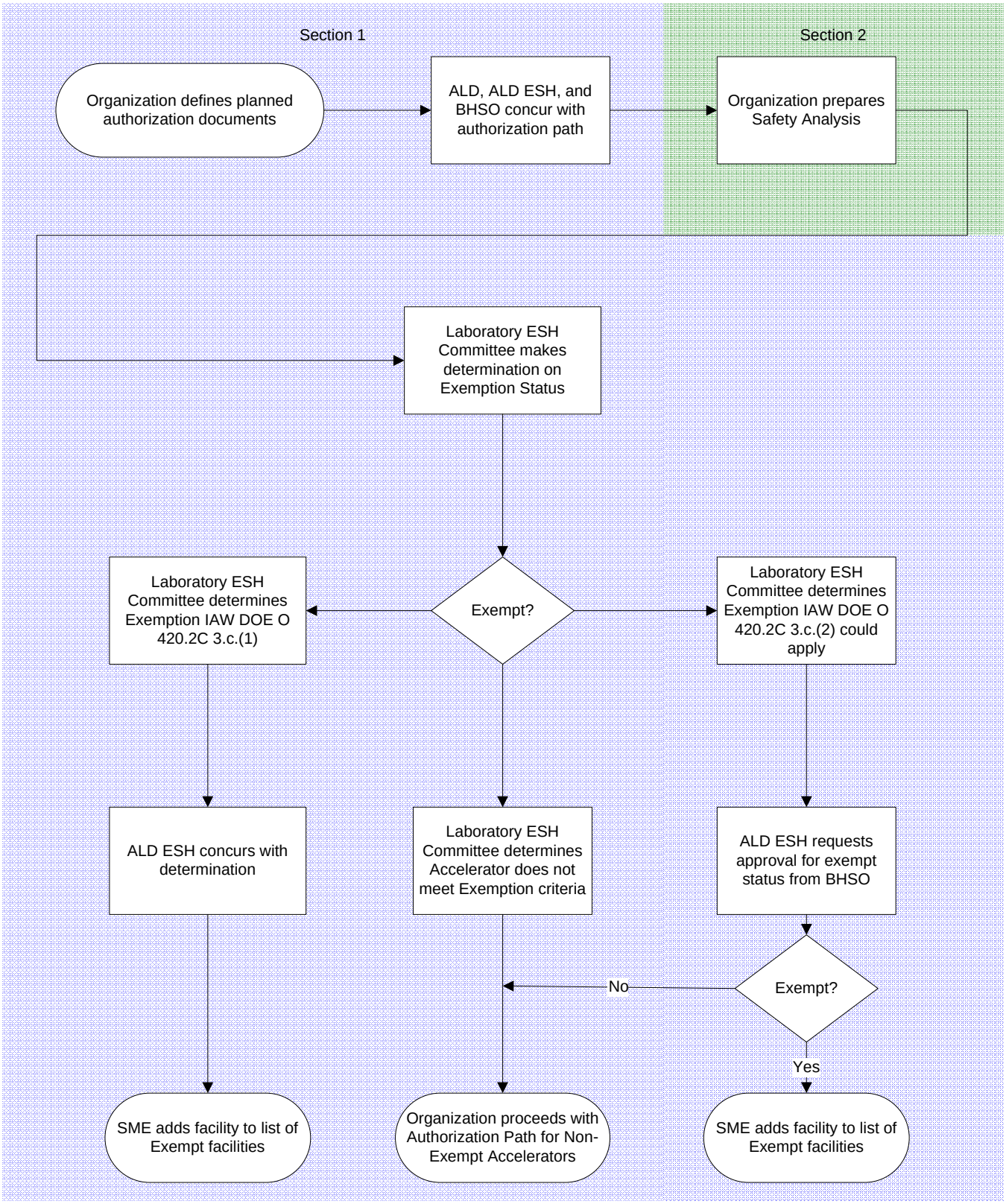
4.7. Electronics racks interlocks must undergo annual testing (not to exceed XX months).

4.8. Area radiation monitors must undergo annual calibration (not to exceed XX months) (See Chapter 3, Appendix 3A in the BNL Radiation Control Manual).

4.9. Radiological shielding and barriers (berms, shield blocks, fencing, etc.) must undergo visual inspection prior to operations to ensure that they are in place and functional.

4.10. Rainwater barriers for activated soil must undergo annual visual inspection to ensure that they are in place and functional.

Authorization Path for Exempt/Equivalent Accelerators



Commissioning Plan

The Commissioning Plan needs to contain the following elements:

I Introduction

Provide the background and context for the planned commissioning activities, e.g., "This plan outlines the activities that need to be undertaken to safely commission this accelerator facility (or beam line)."

II Facility Description

Example: "The Energy Recovery Linac is designed to operate at electron beam energies of 20 MeV and beam powers up to 1 MW. It is designed to test concepts relevant for high-energy coherent electron cooling and electron-ion colliders. One of the goals is to demonstrate an electron beam with charge per bunch (~ 5 nC) and low normalized emittance (~ 5 mm-mrad) at an energy of 20 MeV. The ERL facility contains several major components: cryogenic system, super-conducting RF (SRF) Gun, SRF Linac, laser, beam instrumentation, vacuum system, magnets and magnet-power supplies, and a control system.

III Scope

Briefly identify which aspects of the accelerator or beam line are to be readied for verification by the IRR/ARR. For example,

1. Engineered safety systems and accelerator-associated experimental facilities,
2. Specific facilities, sub-systems, and operations modes,
3. Procedures, administrative controls, and personnel training and qualification for routine operations at full-intensity

Also, identify by date and revision number the Safety Assessment Document (SAD) and Accelerator Safety Envelope (ASE) for the accelerator or beam line applicable to commissioning or routine operation.

IV Safety Considerations

Briefly describe the mitigations that are in place to protect staff from the routine hazards of operating the accelerator facility or beam line. This should include the accelerator credited controls and routine radiological and/or industrial hygiene monitoring programs.

V Responsible Persons/Authorizations

Briefly, describe the following:

1. The operating organization,
2. To whom problems encountered during commissioning are reported:
   2a. operational,
   2b. safety,
   2c. scheduling problems
3. Who makes the necessary notifications or arrangements for operations or authorizations, and
4. Where the required authorizations are documented.

List all aspects of commissioning/operating activities requiring authorization. For example:

1. Delegating authority,
2. Satisfying Hold Points,
3. Proceeding to successive operating modules,
4. Changing operating modes,
5. Implementing authorized alternatives to credited controls,
6. Starting-up or restarting systems,
7. Review and approval of fault studies,
8. Performing maintenance on systems,
9. Approving temporary procedures,
10. Approving changes to operating procedures.

VI Preparations for the IRR

Briefly describe the preparations that are necessary to conduct the IRR. This would include selection of IRR Team members, development of lines of inquiry (LOIs) to be used by the IRR Team, and the IRR schedule.

VII Preparations for the ARR

Briefly describe the preparations and schedule for achieving readiness for the ARR. This would include selection and concurrenece by ESH ALD of ARR Team members, development of lines of inquiry (LOIs) to be used by the ARR Team, close out of IRR pre-start actions, and the ARR schedule.

VIII Provisions for Managing Documentation Needed for the IRR/ARR

Describe the process for making documentation available to IRR/ARR Teams for their review. In some cases, documents should be made available electronically via a SharePoint site or other electronic document control system to facilitate access and review as early as possible. It is also useful to plan to have paper copies of key operating documents available on site during the review.

IX Commissioning and Operations Modules

Assemble the commissioning/operations activities into convenient modules. For each module, tabulate a schedule, briefly describe the commissioning module objective, and list the operating prerequisites that must be met. For example,

Module for Accelerator Operations, Scheduled Readiness Date

SCHEDULE: Accelerator beam operations commences or or about February 15, 2015.
OBJECTIVE: The accelerator will spiral and accelerate particles at low beam energy by February 22, 2015.
OPERATING PREREQUISITES 1. Prior IRR and/or ARR items are closed out 2. Critical devices, beam-current monitors and reach-backs for radiation protection have been established 3. The access-control system is operational and tested 4. Emergency procedures are complete 5. Operations procedures are complete 6. Fault Study Plan approved 7. Safety Check-Off List(s) prepared 8. Safety Review Committee issues closed out 9. Sweep procedures are complete 10. Training records for round-the-clock operations staff are complete

X Transitioning to Operations

Briefly describe the process for transitioning from commissioning to routine operations/production once all commissioning objectives have been met. In most cases, commissioning is performed at beam powers which are a small fraction of the maximum beam power, so the transition may include ramping up beam power over several months or years and evaluating performance of key operating systems. For a large accelerator with multiple beam lines, the process may also involve implementing an IRR in lieu of an ARR

for each beam line as it is built out and commissioned. For smaller facilities with only one or a few beam lines, the ARR may have been scoped to address both commissioning and routine operations, so the transition may involve testing beam lines with different types of end-station target materials.

Commissioning Sequence

The Commissioning Sequence needs to contain the following elements:

I Purpose and Scope

Example: "The purpose of this procedure is for commissioners and their support personnel to provide the sequence of activities during the NSLS-II Storage Ring commissioning. This document outlines the operating conditions of the SR at each step of commissioning. It is not intended to absolutely define the specific commissioning tasks that should be performed at each step, but rather provide a guideline for the commissioning sequence process. This document also provides radiological safety guidance and establishes hold points for safety reviews prior to progression to the next commissioning step."

II Acronymns

Examples:

As Low as Reasonably Achievable (ALARA)
Integrating Current Transformer (ICT)
Machine Protection System (MPS)

III Definitions

Examples:

ICT: Devices which measure the total charge in the electron beam
MPS: A system that protects accelerator components from damage from beam parameters that are beyond their normal operating boundaries

IV Responsibilities

Provide responsibilities for key operating and support staff; for example, a minimum list of personnel should include:

Accelerator Manager: Responsible for delivering beam of sufficient quality

Departmental Manager: Approves progression from each step in the commissioning sequence and overall schedule

Departmental ESH Manager: Assures authorization basis and ASE requirements are in place to perform commissioning sequence

Facility Support Representative: Provide radiological support services to meet commissioning objectives

V Prerequisites

Provide the prerequisites that are necessary prior to commissioning; for example,

1. Receipt of authorization/approval from DOE-BHSO to initiate commissioning
2. The System Readiness Checklist/Beam Authorization Form is complete
3. Access control system is operational
4. All Operators are trained and qualified, and staffing is adequate for the commissioning sequence

VI Precautions and Limitations

Examples:

1. Beam current limit
2. Beam energy limit
3. Access to areas contiguous to the accelerator are controlled during fault studies

VII Procedure and Hold Points

Provide a sequence of commissioning steps and hold points for safety that relate to the commissioning modules in the Commissioning Plan, for example:

1. Once beam is controlled, seek permission to commence fault studies
    a. Hold Point: Initial fault study plan is acceptable and planned initial beam power is ALARA and is reviewed and approved by the accelerator manager or designee
2. Once initial fault studies are competed, seek a review of the radiological results
    a. Hold Point: Fault study results are reviewed by accelerator manager or designee and appropriate radiological controls are in place
3. Once low power fault studies are completed and approved, seek permission to increase beam power
    a. Hold Point: Higher power level approved by accelerator manager or designee

    Note: The above steps emphasize the key safety procedure steps, however, machine performance steps can be interwoven with the above hold points in a commissioning sequence procedure

VIII References

References include internal operating documents that support commissioning, for example, start up and shut down procedures, fault study plans, Lock Out-Tag Out procedures, alarm response procedures, etc.

IX Attachments

Provide attachments that are needed as part of the Commissioning Sequence. In many cases, attachments are not needed to impement the Commissioning Sequence.

X Documentation

Identify the documentation that is expected to be produced as a result of implementing the Commissioning Sequence. Archive fault study records such that they are easily retrievable.

Considerations for the Selection of Accelerator Readiness Review (ARR) Team Members

The ARR Team must be comprised of individuals representing disciplines as necessary to cover the identified scope of the ARR and are selected based upon their expertise in the functional areas being reviewed (e.g., accelerator operations, conduct of operations, radiological control, access control systems, USI Process, etc.).

When selecting potential ARR Team Members it is important to obtain a commitment from their management allowing them to fully support the ARR process for the expected time needed. Without such a commitment the team member may be unable to effectively support the ARR process and provide the level of review required.

Individuals serving on an ARR Team should be independent from the accelerator facility being reviewed. Independent persons are persons who did not participate in the concept phase, design phase, or construction phase of the accelerator, and do not have any direct responsibility for commissioning or operations.

I. Team Leader

A. The Team Leader needs to have prior experience leading an ARR team, or equivalent, and possess technical familiarity with the functional areas being reviewed.

B. The Team Leader should have demonstrated leadership and managerial skills, including seniority in relation to the members of the ARR Team, necessary to guide the Team.

II. Team Members

A. The number of team members should very based upon the complexity and breadth of the accelerator. Smaller, less complex accelerators should not require as many team members as larger more complex accelerators.

B. Team members are expected to possess technical knowledge of the area assigned for evaluation. The knowledge should include experience working in the technical area.

C. Team members should possess experience in performance-based assessment processes and methods. This knowledge may be gained through experience as a qualified auditor or inspector or through training.

Design Practice for Known Beam-Loss Locations (BLLs)

Introduction 1
Standardized Calculation of Soil Activation in the Vadose Zone 3
Standardized Calculation of Radioactivity Concentration in Leachate 3
Beam Tuning To Minimize Beam Loss 7
Standard for Prevention of Rainwater Infiltration 7
Direct Activation of Groundwater 8
Acceptable BLL Capping Materials 9
Validating the As-Built Cap 9
Stormwater Management 11
Preventive Maintenance Schedule and Reporting 11
Preoperational Environmental Monitoring (Baseline) 12
Verification of Controls by using Environmental Monitoring 12
Verification of Beam Loss Estimates by Soil Sampling 14
Incorporate Lessons Learned 14
Internal and External Approvals 14

Introduction

High-energy accelerators (greater than 1 GeV) accelerate charged particle, such as protons and heavy ions. If these particles leave the vacuum confines of an accelerator, they encounter various materials along the flight path. These materials are various metals such as aluminum, copper and steel, as well as air, water, concrete and soil. Energy loss for high-energy particles is uniform; the higher the energy, the deeper the particles travel into the material.

High-energy electron accelerators greater than 10 MeV produce photons with energy up to the maximum electron energy whenever the electron decelerates or changes direction. Energy loss for high-energy photons is not uniform; however, because photons are uncharged they can travel deep into materials.

Particles such as neutrons, protons and other nuclear fragments may be produced along the path of the initial high-energy particle or photon as it slows down in the material. That happens when a nucleus is struck by a high-energy particle or photon; it may be broken into smaller pieces. At high-energy accelerator energies, tens to hundreds of nuclei may be broken-up by these "spallation reactions" when dissipating the energy carried by a single high-energy particle. The kinds and quantities of fragments produced depend upon various factors such as the type and energy of the incident particles, the composition of the material struck, the species and energy spectrum of the fragments arising out of the collision and the production probability of the fragment concerned.

Most materials at accelerators are not pure elements; that is, there are of many different elements that make up magnets, cooling water pipes, electrical systems, concrete and earth. While many types of fragments are produced in these structures, the fragments are radioactive and they decay back to stable elements within minutes. Only a few types of fragments have long half-lives.

A commonly produced fragment in most spallation reactions is a nucleus with two neutrons and a proton, which is the radionuclide known as 12.3-year tritium (^{3}H). The amount of tritium radioactivity present at any given time will depend upon tritium's half-life and the time since production of the tritium has ceased, the flux of high-energy particles or photons and the actions taken to reduce the tritium concentration in the irradiated material (e.g., drain and refill of activated water systems). There are other radioactive spallation fragments; however, most are very short lived, minutes to days. A few longer-lived radionuclides are produced but most are immobile, with the exception of tritium and 2.6 year sodium-22 (^{22}Na). When one considers the problem of activation of soil and subsequent groundwater contamination, not only half-life but also mobility and transit time of a given radionuclide from its production point to the water table are key parameters.

The term “activation” refers to the process of creating radionuclides in materials such as concrete or soil-shields via the spallation reaction. Soil shields used near beam stops and targets are termed "activated soil" because they contain ^{22}Na and tritium. At high-energy accelerators, the activation of soil may extend many tens of feet into the soil-shield. However, the production rate of tritium and other radioactive atoms generally falls off by a factor of ten due to attenuation of high-energy particles for every 4 feet of soil traveled by the slowing high energy particles. Actual falloff is greater when one accounts for geometric spreading of the high-energy particles from the source.

If rainwater percolates through activated soil in the vadose zone, it can leach tritium and ^{22}Na into the groundwater. By preventing the leaching of tritium and ^{22}Na via rainwater infiltration, the introduction of radionuclides into the water table is prevented. Reducing the amount of soil activation by using other types of material for shielding or by using engineering controls to reduce beam loss are additional pollution-prevention opportunities. At BNL, soil is an ideal radiation shield for human protection. It is dense, conforms to desired shapes, does not deteriorate and is inexpensive.

The objectives of the following design practices are 1) operate within regulatory requirements, and 2) integrate pollution prevention and waste minimization into the decision process that results in minimal beam loss in soil. Mitigation of leachate from activated soil is the minimum requirement, and it is to be carried out by capping activated soil when tritium or ^{22}Na concentrations may exceed the BNL established thresholds described below.

Evaluation of pollution prevention opportunities leads to the following design practices

- Determine beforehand via calculations the amount of residual ^{22}Na and tritium created in the soil
- Determine beforehand whether new activated soil locations will be fully protected from water infiltration by existing building structures and stormwater systems
- Determine beforehand via calculations the concentration of radionuclides in any potential rainwater leachate from an uncapped region of activated soil
- Minimize the amount of residual radioactivity in soil using iron and concrete shielding
- Eliminate potential radioactive effluent from known activated soil locations by capping the soil with effective, maintained water impermeable barriers

- Determine whether it is desirable to implement a removable soil sample program to verify beam loss calculations after beam line operations have started[1] Monitor the effectiveness of the design practices

Standardized Calculation of Soil Activation in the Vadose Zone

The following standardized model for soil activation in the vadose zone may be used; however, more advanced models may be used if they are documented and a qualified independent professional engineer reviews results. Documented organizational peer review is also acceptable.

The vadose zone, also termed the unsaturated zone, is the portion of earth between the land surface and the zone of saturation ("vadose" is Latin for "shallow"). It extends from the top of the ground surface to the water table. Water in the vadose zone has a pressure head less than atmospheric pressure, and is retained by a combination of adhesion, and capillary action. If the vadose zone envelops soil, the water contained therein is termed soil moisture.

Of the radionuclides that may be found in activated vadose-zone soil, only tritium and ^{22}Na need be considered for potential impacts to groundwater quality because of their longer half-lives, ability to be leached from activated soils, and their mobility in groundwater.

As part of the evaluation, annual activity concentrations in soil moisture are to be estimated. This requires an estimate of beam loss in a year, the density of hadron interactions due to proton or heavy ion accelerator operation or photon interactions due to electron accelerator operations as a function of position in soil near the beam loss point(s), and the production probability of tritium and ^{22}Na per interaction. Additionally, parameters for rainfall must be known.

The density of hadron interactions is estimated by Monte Carlo codes such as CASIM and MCNPX. The density of photon interactions is calculated using code systems for Monte Carlo simulation of electron and photon transport such as PENELOPE2011. The tritium or ^{22}Na nuclide production may be estimated by Monte Carlo code either directly or indirectly.

Once the tritium and ^{22}Na activity concentrations in soil are determined, either by calculation of by soil sampling, the maximum annual activity concentration in soil moisture due to direct radionuclide production in vadose-zone soil must be estimated. This should be taken to be 10 times the activity concentration in vadose-zone soil multiplied by the leachable fraction, which is 1.0 for tritium and 0.075 for ^{22}Na. A factor of 10 increase in concentration from soil to moisture is used because it is assumed 10% of the vadose-zone is free space that may at some time be occupied by rainwater.

Standardized Calculation of Radioactivity Concentration in Leachate

[1] Removable soil samples are typically plastic liter bottles filled with soil and placed inside the accelerator enclosure to simulate soil just outside the enclosure wall. Samples are placed near known beam loss areas such as beam dumps or beam scrapers. Samples are retrieved after months of operating the accelerator, and then analyzed in a laboratory for tritium and ^{22}Na radioactivity content.

Assuming the maximum annual activity concentration in soil is above the water table, the maximum activity in water at the water table due to leaching by a normal amount of annual rainfall for Long Island should be estimated using the model of Lessard[2]. In the example model (see Tables 1 and 2), 3.7×10^8 atoms tritium/cc in one year (soil) results in the drinking water limit of 20,000 pCi/L (water) and 2.1×10^7 atoms ^{22}Na/cc in one year (soil) results in the drinking water limit of 400 pCi/L (water). In these expressions, the soil radionuclide-concentrations are evaluated at the position of maximum soil radionuclide concentration.

[2] E. J. Bleser, "Shielding for the AGS J10 Scraper, AGS/AD/Tech. Note No. 444, Accelerator Division, Alternating Gradient Synchrotron Department, Brookhaven National Laboratory, Upton, New York 11973, September 13, 1996.

TABLE 1

Quantity	Value	Units
^{22}Na Atoms per unit volume of soil in one year	2.13E+07	atoms/cc_{soil}
Available atoms per unit volume of soil since 7.5% of ^{22}Na is leachable	1.60E+06	atoms/cc_{soil}
Fraction of vadose-zone soil that is moisture	0.1	
Concentration factor since 1 unit volume of moisture can leach nuclides from 10 unit volumes of soil	10	
Dilution factor:		
a. Radioactive atoms are essentially contained in a 1/e thickness of irradiated soil	60	cm
b. fraction of soil that is moisture	0.1	
c. height of moisture column in 1/e thickness of soil	6	cm
d. annual rainfall that percolates down to groundwater	55	cm
e. dilution per year = 55/6	9	
Overall concentration factor of leachable atoms from soil to soil moisture	1.1	
Annual average ^{22}Na atom concentration in leachate	1.76E+06	atoms/cc_{water}
Half-life of ^{22}Na	2.60E+00	year
Annual average ^{22}Na activity concentration in leachate	4.01E+02	pCi/L

TABLE 2

Quantity	Value	Units
^{3}H Atoms per unit volume of vadose-zone soil in one year	3.75E+08	$atoms/cc_{soil}$
Available atoms per unit volume of soil since 100% of ^{3}H is leachable	3.75E+08	$atoms/cc_{soil}$
Fraction of vadose-zone soil that is moisture	0.1	
Concentration factor since 1 unit volume of moisture can leach nuclides out of 10 unit volumes of soil	10	
Dilution factor:		
a. Radioactive atoms are essentially contained in a 1/e thickness of irradiated soil	60	cm
b. fraction of soil that is moisture	0.1	
c. height of moisture column in 1/e thickness of soil	6	cm
d. annual rainfall that percolates down to groundwater	55	cm
e. dilution per year = 55/6	9	
Overall concentration factor of leachable atoms from soil to soil moisture	1.1	
^{3}H atom concentration in leachate	4.13E+08	$atoms/cc_{water}$
Half-life of ^{3}H	1.24E+01	year
Annual average ^{3}H activity concentration in leachate	1.98E+04	pCi/L

Beam Tuning To Minimize Beam Loss

The accelerator management must design beam loss to soil such that levels are below regulatory requirements. Additionally, uncapped activated soil activity concentrations must be as low as reasonably achievable with operational, economic and community factors taken into account. As a minimum, the accelerator management must meet the following requirements:

- Responsibility for determining acceleration, extraction and transport loss limits for setting threshold values to activate alarms must be formally assigned by the management of the accelerator
- Changing acceleration, extraction and transport loss limits as operations evolve must be done via a formal approval mechanism
- Accelerator management must assign responsibility for determining appropriate instrumentation for measurement of the losses, and for ensuring measurements are reviewed at appropriate intervals in order to validate loss assumptions
- Accelerator management must ensure that alarm threshold values used by operations personnel are incorporated into the appropriate computerized controls programs

Management must ensure that operations procedures contain loss limits. Response by operators to alarms must be clearly written in procedures. Loss problems must be corrected within minutes, otherwise operators must reduce the beam intensity to the affected area. Accelerator operations staff must determine whether there will be a negative impact on the environment, safety or health of workers, a negative impact on the physics program, or a negative impact on accelerator equipment if prolonged high-loss operation is permitted. Authorization for prolonged high-loss operation, with an alarm present, must come from the highest-level manager of the accelerator and be documented.

Management must ensure that the responsibility for maintaining loss-monitor systems is assigned. Beam current transformers and loss monitors used to determine operating efficiencies and losses must undergo verification by the operations staff in the control room at start-up of a running period.

Residual radiation surveys on new elements or new beam lines must be made after the first operational running period in order to confirm loss assumptions. Accelerator management must also determine whether a removable soil sample program is needed to verify beam loss assumptions.

Standard for Prevention of Rainwater Infiltration

The accelerator management must prevent leachate from activated soil due to rainwater or stormwater such that levels are as low as reasonably achievable with operational, economic, regulatory and community factors taken into account. As a minimum, the accelerator management must meet the following requirements

- Annual activity concentration in leachate should be prevented if it is calculated to be measurable in rainwater leachate

- If activated soil is not adequately protected by an existing building structure, an engineered impermeable cap should be constructed over the activated soil area to eliminate exposure to rainwater
- If the annual activity concentration in leachate is calculated to exceed 0.05 (5%) of the drinking water standard for tritium or 0.25 (25%) of the drinking water standard for ^{22}Na, then a cap must be used unless an exemption is approved by BNL management; that is, impermeable caps must be required for soil activation areas where the predicted annual average activity concentration in leachate that may be created by infiltration of rainwater or stormwater runoff through activated soils exceeds 1,000 pCi/L for tritium or 100 pCi/L for ^{22}Na

The moisture of interest for the activity-concentration calculation is leachate from the vadose-zone soil. It is not the concentration in groundwater at the "point of assessment." It is noted that leachate concentrations at 0.05 (5% for tritium) or 0.25 (25% for ^{22}Na) of the drinking water standard are not anticipated to be measurable at the "point of assessment." See Verification by Monitoring for further discussion of "point of assessment."

A hydraulic barrier layer or cap is to be designed to prevent or minimize rainwater infiltration into the activated soil areas. The cap must be designed to incorporate the following criteria as a minimum

- The peak rainwater infiltration rate is less than or equal to the infiltration rate in 18 inches of low permeability soil (hydraulic conductivity less that $1x10^{-5}$ cm/sec) with one inch of ponded water above the cap; this equates to an allowable peak infiltration rate of approximately 1 cm/day; this is approximately 0.3% of the infiltration rate for natural soils at BNL
- The long-term average infiltration rate, as estimated with the Hydrologic Evaluation Landfill Performance (HELP) Model, Version 3.07 or newer,[3] is less than 0.12 cm/year (0.047 inches/year); this is approximately 0.2% of the natural groundwater recharge rate at BNL

Direct Activation of Groundwater

The accelerator management must prevent direct activation of groundwater to the extent practicable. Management must use appropriate beam line operation protocols and shielding designs to ensure that radioactivity levels are as low as reasonably achievable with operational, economic and community factors taken into account. As a minimum, the accelerator management must meet the following requirements:

- The highest level of the water table must be determined based on archival water-table information for the BLL site
- The shield thickness or alternatively the thickness of soil in the vadose zone must minimize direct activation of groundwater

[3] USEPA, "The Hydrologic Evaluation of Landfill Performance (HELP) Model," Version 3.07. EPA Office of Research & Development, 1995

- For direct activation of groundwater, if the estimate of annual radioactivity concentration produced directly in the groundwater at its highest level exceeds 0.05 (5%) of the drinking water standard for tritium or 0.25 (25%) of the drinking water standard for ^{22}Na, then the physical configuration is not acceptable; planned losses must be reduced, the distance to the water table must be increased or the shielding between the BLL and the groundwater must be increased

Acceptable BLL Capping Materials

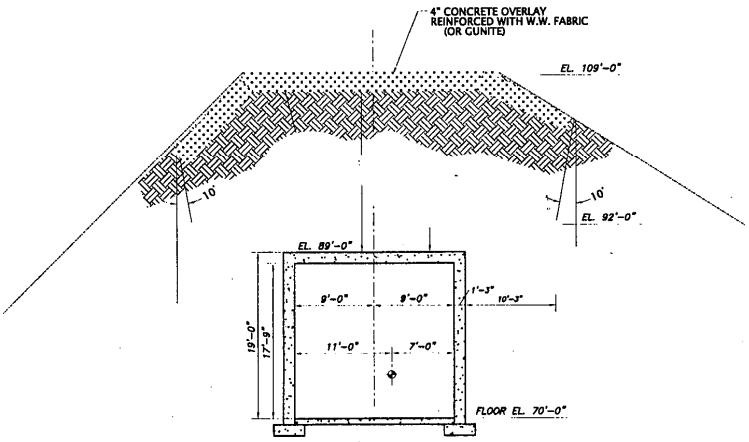
- Concrete or Gunite Overlay (Conventional)
    - The cap must be placed directly over the area to be protected, reinforced with welded wire fabric and meet the American Concrete Institute code. The cap must be sealed to existing structures using flexible sealants or grouts
- Geomembrane Covers (Conventional)
    - Standard landfill geomembranes and construction techniques may be used. The geomembrane cap must meet the general requirements of 6NYCRR, Part 360, 2.13, R
- Low Permeability Soil Covers (Conventional)
    - A minimum 18-inch thickness of low-permeability, properly pre-planned barrier soil, meeting the general requirements of 6NYCRR, Part 360, 2.13, J and Q, may be used
- Metal or EPDM Roofing (Alternative)
    - Standard roofing technique may be used if they meet the building code and the manufacturer's recommended instructions. The roofing must be sealed to existing structures using flashing and sealants

Innovative or alternative capping systems such as metal roofing, rubber membranes such as EPDM or paving may be used if it is demonstrated that the infiltration-rate design-criteria will not be exceeded (see Standard for Prevention of Rainwater Infiltration). This demonstration must be made using the HELP model analysis[2] or moisture monitoring from beneath the capping system using lysimeters or equivalent.

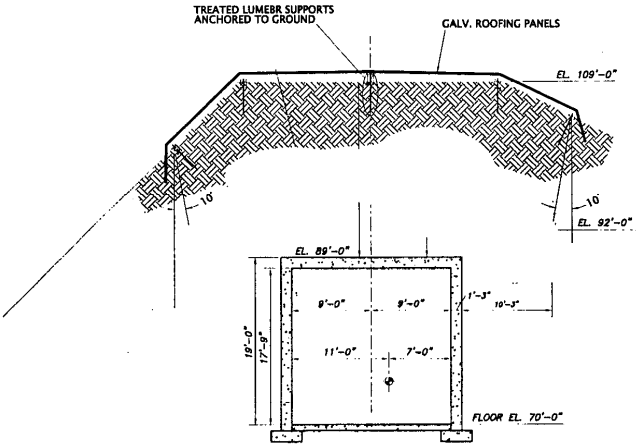
Validating the As-Built Cap

The project engineer in charge of installing the cap must validate the as-built structure against the design drawings, and update the drawings according to internal change procedures. See Internal and External Approvals. The project engineer must ensure that:

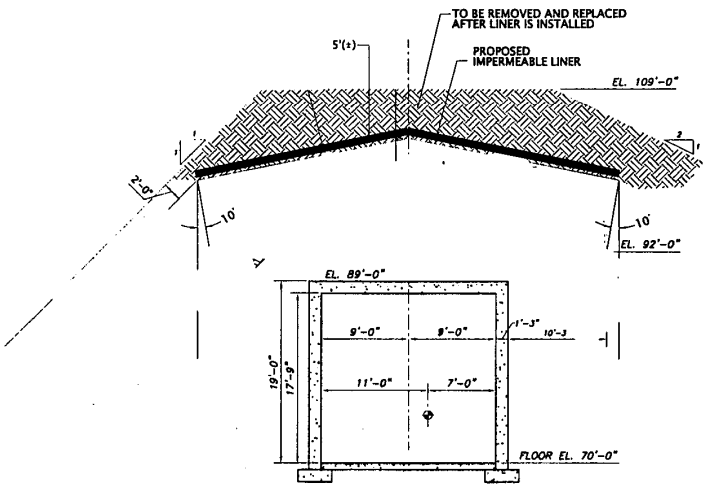
- The as-built cap structure is inspected and validated against design drawings
- The as-built cap structure extends beyond the protected activated soil zone by at least 10 degrees as shown in the following illustrations



CONCRETE OVERLAY OR GUNNITE METHOD Conventional



METAL ROOFING METHOD Alternative



LINER METHOD Conventional

Stormwater Management

Stormwater runoff from capped beam-loss areas must be collected and conveyed to the BNL stormwater collection system, when practicable. If the BNL stormwater system is not convenient, then stormwater runoff must be collected and discharged to an area outside the area of beam loss influence. The following design considerations must be reviewed during design of loss areas

- Stormwater run-on from adjacent areas must be prevented
- The design must not allow a direct pathway from the stormwater piping or recharge system through a beam-loss location
- Drywells, if necessary must be located at least 100 feet outside the beam-loss areas; all drywells must be approved by the BNL manager who has that authority
- Rooftop drainage from adjacent structures must be conveyed away from beam-loss areas
- Storm, sanitary and domestic water piping must not be located within beam-loss area

Preventive Maintenance Schedule and Reporting

Engineered activated soil caps must be inspected at the start-up and conclusion of each running period, which is typically twice per year. In no case must inspection of all caps be less frequent than annually. Sufficient time should be allowed before operations to allow for repairs. A written procedure must be used to conduct inspections. A record of inspection must be maintained in accordance with internal operating procedures.

Note: Cap inspections are not required for permanent, maintained building structures that protect engineered BLLs (i.e., targets, beam stops and collimators) in the same manner as engineered activated soil caps, assuming that these structures meet the Standard for Prevention of Rainwater Infiltration, describe above. The building roof structures, concrete floors, stormwater drainage systems, and preventative maintenance programs provide defense in depth.

Engineered activated soil caps must be inspected as follows and the inspection procedures must be maintained according to the Document Control Subject Area in SBMS:

- Check for penetrations such as cracks in concrete or Gunite caps
- Check sealed areas such as penetrations or fence posts or sheet piling
- Check for holes, cracks or tears in waterproof membranes such as EPDM rubber roofing membrane
- Check for excessive ponding of rainwater
- For above-grade, below-grade caps and paved areas, check for trees and woody shrubs whose roots can damage the cap
- For below-grade caps, check for soil erosion that can expose the membrane and for signs of excessive animal burrowing

Preoperational Environmental Monitoring (Baseline)

Groundwater surveillance wells must be installed and sampled before the operation of the facility to obtain DOE required pre-operational monitoring data. It is recommended that two sampling events in two separate calendar quarters should be conducted. See Establishing Environmental Monitoring Programs Subject Area.

As necessary, soil samples can be collected to determine baseline radionuclide levels in the area of a planned activated soil location before new operations are conducted. Baseline soil samples can provide useful information on current radioactivity levels because beamlines are often re-used for new experiments, and because modes of accelerator operation evolve over time (i.e., beam energies may increase). A sufficiently representative number of soil samples are recommended. Accelerator management must decide the number and location of soil samples based on planned beam-loss locations, former beam-loss locations, soil locations not planned to be activated, and energy and type of particles accelerated.

Verification of Controls by using Environmental Monitoring

BNL has a comprehensive environmental monitoring program that includes monitoring the air, drinking water, surface water, groundwater, soil, sediment, flora and fauna. Guidance for the evaluation of environmental monitoring requirements at BNL is provided in the Environmental Monitoring Subject Area. This program is designed to provide early warning of potential environmental releases, monitor potential pathways for exposure to the public and the environment, monitor the effectiveness or environmental remediation systems, measure the potential impact BNL operations may have on the environment, and provide data to demonstrate compliance with applicable laws, regulations, and permit limits. It includes planning, implementation and reporting activities associated with the collection and analysis of samples, or

the direct measurement of environmental media, including liquid effluent monitoring, air emissions monitoring, and environmental surveillance.

Groundwater monitoring is a means of verifying that administrative and engineered controls at BLLs are effective in protecting groundwater quality. Verification of groundwater quality is based on actual measurements at the groundwater "point of assessment." A hydrogeologist along with other Subject Matter Experts must determine the "point of assessment" (see Environmental Monitoring Subject Area).

When establishing a groundwater-monitoring program:

- Groundwater monitoring programs must be established in soil activation areas that are capped. A staff hydrogeologist must evaluate the geology and hydrology of the potential soil activation area
- The wells must be positioned as close as reasonably achievable to known or potential soil activation
- The number of wells required for a monitoring program must be based upon the size of the potential soil activation area, and take into account potential variations in groundwater flow directions due to natural or synthetic effects (i.e., pumping and recharge effects)
- Typically, two downgradient wells must be used to monitor small activation areas
- Upgradient wells may be required if other known or potential soil activation sources may influence measurements at the "point of assessment"
- All monitoring wells must be installed according to BNL requirements (see Environmental Monitoring Subject Area)
- Depth of the wells and location of the screened sections must be based upon depth to groundwater and complexity of potential contaminant migration pathways
- Groundwater modeling may be used to assess contaminant migration pathways and rates
- Typically for wells located close to a potential soil activation area, the well's screened section should be 20 feet in length, and installed across (i.e., straddling) the water table to accommodate fluctuations in water table position
- A groundwater sampling and analysis plan must be developed, and incorporated into the annual BNL Environmental Monitoring Plan as per relevant DOE Order. Factors to consider when defining the frequency of sampling (i.e., annual, semi-annual, or quarterly) should be: archival and current water quality data; the potential for a contaminant release; distance from the soil activation area to the well(s) and groundwater flow velocity; and the proximity of the soil activation area to active potable water supply wells
- All monitoring wells must be sampled according to BNL requirements (see Environmental Monitoring Subject Area)
- Groundwater samples must be analyzed for tritium and Na^{22} by certified analytical laboratories using methods acceptable to the EPA
- All groundwater data should be stored in, and be accessible through, the BNL Environmental Information Management System (EIMS)
- All new groundwater-monitoring results must be reviewed on a routine basis, generally within 90 days of receipt of the results from the analytical laboratory. Appropriate response actions must be taken if unusual or unexpected levels of tritium or ^{22}Na are detected in the groundwater samples

- If groundwater monitoring indicates that the sources pose a continuing threat to groundwater quality (i.e., concentrations at the point of assessment exceed stated thresholds), then the need for additional protective measures must be evaluated
- The continued adequacy of the monitoring program should be periodically verified Additional wells may be required if significant changes groundwater flow directions are observed

Verification of Beam Loss Estimates by Soil Sampling

Direct measurement of soil activation must be incorporated, where practicable, into the conduct of operations. A direct soil-sampling program must:

- Provide a baseline, see Preoperational Monitoring (Baseline)
- Verify/benchmark soil-activity calculations by:
    - Establish soil shielding sampling access ports at beam height, where practicable, which is likely the location of maximum soil-activity concentration
    - Establish Removable Soil Sample (RSS) locations at beam height, where practicable, which is likely the location of maximum soil-activity concentration
- Meet sample Volume and Container Requirements
- Comply with relevant BNL Radiological Control Procedures

Incorporate Lessons Learned

There are two elements to incorporating Lessons Learned: (1) conform to the SBMS Lessons Learned Subject Area, which will track off-normal performance of these engineered controls and (2) track and trend results from inspections of cap systems and results from maintenance requirements. Nonconformance must be reported in accord with SBMS requirements.

Accelerator management must demonstrate that these sources of information have been incorporated into their formal conduct-of-operations procedures.

Internal and External Approvals

The following must be approved or documented by the accelerator manager/department chair or designee according to internal formal conduct-of-operations procedures

- As-built drawings for caps and membranes
- Locations for loss monitors
- Procedures for cap maintenance
- Procedures for response to loss monitor alarms
- Benchmark soil-activity calculations

The following must be approved or documented by the appropriate BNL environmental Subject Matter Expert

- A design review according to requirements in SBMS or according to requirements in accelerator department procedures
- Type, number and location of monitoring wells and sampling protocols
- Groundwater surveillance results
- Transmittal of DOE or regulatory agency required cap inspection reports

Lines of Inquiry (LOIs) from Previous Photon Science and Collider-Accelerator Reviews

[**Note:** The listed Lines of Inquiry that follow are examples of General LOIs for a large facility. Specific LOIs should be developed in conjunction with the review team leader for each project readiness review taking advantage of professional judgment].

Safety Assessment Document (SAD)

1. Interview selected management /staff involved in SAD development
2. Verify that the SAD has been internally approved and that the ASE has been approved by DOE-BHSO
2. Determine adequacy of safety analysis performed to support SAD
3. Determine if SAD meets DOE O 420.2C requirements
4. Determine if SAD provides adequate technical basis for ASE
5. Determine adequacy of process to review and approve SAD
6. Interview selected management /staff to determine knowledge of SAD requirements
7. Verify completion of select Laboratory ESH Committee (LESHC) recommendations and actions for their SAD review
8. Determine adequacy of SAD to support commissioning

Accelerator Safety Envelope (ASE)

1. Interview selected management/staff involved in ASE preparation
2. Determine if ASE addresses required controls and operating limits
3. Determine if ASE meets DOE O 420.2C requirements
4. Determine adequacy of process to review and approve ASE
5. Interview selected management/operational staff
6. Verify completion of select Laboratory ESH Committee (LESHC) recommendations and actions for their ASE review
7. Determine adequacy of ASE to support commissioning

Unreviewed Safety Issues (USI)

1.	Determine if USI process meets DOE O 420.2C requirements
2.	Interview those involved in USI process development and management
3.	Determine if USI process will be adequately linked to Configuration Management program
4.	Determine adequacy of USI process to support commissioning

Contractor Assurance System (CAS)

1.	Determine if CAS provides a comprehensive internal assessment and action tracking process
2.	Determine if the CAS Program uses external assessment: employs peer reviews and assessments that include accelerator subject matter experts from other accelerator facilities
3.	Determine CAS program adequacy to support commissioning

Safety Configuration Management (CM)

1.	Determine if the configuration of Credited Controls are properly managed during accelerator operation and maintenance
2.	Determine if the accelerator controls system is protected against un-authorized access
3.	Determine if configuration management is applied to defense-in-depth controls on a graded approach
4.	Determine if the configuration management program is adequate to support commissioning

Commissioning Plan & Commissioning Sequence

1.	Commissioning Plan fully describes roles, responsibilities, accountabilities, and authorities that establish the expectations and duties of managers, supervisors, and operators for carrying out the commissioning/ operations and any related documented authorizations
2.	Commissioning Plan addresses staffing schedules, authority and reporting chain for operational, safety, and scheduling issues procedures (normal and emergency/contingency), administrative controls, and personnel training
3.	Commissioning Plan identifies or properly references engineered safety systems that will be operable for the accelerator
4.	Commissioning Plan identifies the operational characteristics for specific modes of commissioning needed to support the safety case for progressively higher power commissioning
5.	The Commissioning Sequence provides a logical sequence of facility activities for commissioning or routine operations and hold points to support the safety case for progressively higher beam current commissioning
6.	Determine the process for communicating fault study results to the operations group

7. Determine adequacy of Commissioning Plan, Commissioning Sequence, and fault studies to support commissioning

Credited Controls (CC)

1. Verify that Credited Passive, Active, and Administrative Controls in the ASE are installed and their operability tested/verified
2. Verify that defense-in-depth controls also have Configuration Management applied on a graded approach
3. Verify that appropriate procedures are in place to ensure ASE Credited Controls and their Supports are properly managed during operations and maintenance
4. Determine adequacy of Credited Controls to support commissioning

Accelerator Operator Training and Qualification Program

1. Review training program documentation and procedures
2. Interview training manager regarding program
3. Interview selected personnel regarding training
4. Observe selected job assignments and compare with job-specific training
5. Determine adequacy of training program to support commissioning
6. Verify Job Training Assessments (JTAs) have been completed and are adequate to allow personnel to carry out their roles and responsibilities

Accelerator Commissioning Procedures

1. Review procedure program documentation
2. Interview staff responsible for assuring implementation of the procedure program
3. Interview selected management/staff on their role in the procedure program
4. Review selected operating procedures controlling approval for startup, beam authorization, and safety significant controls
5. Review procedures required for commissioning readiness
6. Interview staff on emergency response procedures
7. Observe selected job assignments with job-specific procedures
8. Determine adequacy of procedure program to support commissioning

Work Planning and Control Related to Accelerator Safety

1. Review work control program documentation
2. Interview selected management/staff on their role in the work control program
3. Observe selected job assignments with job-specific work controls
4. Determine adequacy of the work planning and control program to support commissioning

Accelerator Controls/Cyber Security

1. There is a plan that addresses cyber security on a site-wide basis and specifically for accelerator controls
2. The cyber security risk assessment for accelerator controls adequately identifies threats and vulnerabilities specific to the operating environment
3. The cyber-risk assessment for accelerator controls adequately identified risks and counter measures to reduce risks to an acceptance level
4. There is an authority to operate the system used to control accelerator functions within acceptance risks
5. The cyber-security plan incorporates the following recommended practices and protocols: a. defense-in-depth by layering b. physical security c. network segmentation and isolation d. Internal/ external fire-walling e. mitigation of insecure processes and protocols f. access control from on and off-site g. authentication management h. user auditing i. configuration management including patches j. monitoring and use analysis k. vulnerability scanning and periodic l. Incident Response/Contingency Planning m. Control of external media devices n. Remote access
6. There are adequate personnel resources to maintain the cyber-security program and processes: a. personnel are trained and authorized
7. There are adequate fiscal resources to maintain the cyber-security program equipment through near-term software and hardware upgrades
8. There is adequate infrastructure to maintain and support cyber-security for accelerator controls
9. Determine if the accelerator controls system is protected against unauthorized access
10. Verify the process for managing configuration of computer software controls

Software QA

1. The development of accelerator controls and safety system software is governed by applicable standards
2. The applicable standards require, at a minimum: a) written requirements or specifications b) software version management c) documentation
3. Accelerator controls and safety system software have accurate configuration information from users/system owners for device control and data translation
4. There are resources that allow controls and safety system software to be tested before implementation.
5. The interface for programmers needing information or analysis data is controlled
6. Software users are adequately trained and authorized depending on the level of control afforded by accelerator and/or safety system software before being allowed access
7. There is an adequate user feedback mechanism to resolve software issues
8. Accelerator controls and safety system software are configuration managed
9. There are adequate personnel resources to maintain the accelerator controls and safety system software applications; personnel are trained and authorized
10. There is adequate infrastructure to maintain and support accelerator controls and safety system software applications
11. Software QA supports activities related to commissioning

Radiological Protection Program

1. Does the program provide for the detection and measurement of expected accelerator radiological hazards (e.g., prompt ionizing radiation, activated materials, etc.)?
2. Verify that there are a sufficient number of trained and qualified Radiological Control Technicians to support commissioning or routine operations
3. Is a hierarchy of controls effectively implemented including engineering and administrative controls?
4. Is the organization's Radcon Support Staff effectively integrated with accelerator operations and other safety and health disciplines?
5. Is the organization's Radcon Support Staff effectively integrated with the work planning and control process?
6. Is the BNL RPP providing adequate support to upgrade activities?
7. Determine adequacy of the organization's radiation protection program to support commissioning or routine operations

Industrial Safety Systems

1.	Are the industrial hazards of the system well understood?
2.	Were the hazards of the system considered during the design phase?
3.	Does the system design, where possible, use engineered safeguards to minimize industrial hazards during operation?
4.	Is the system design documented?
5.	Does the system interface to other industrial systems and is that interface documented?
6.	Does the system interface to the Personnel Protection System (PPS)?
7.	Are the documents available to staff that work on the system?
8.	Was the system checked to ensure it performed according to design when it arrived at the lab (or at the point of assembly)?
9.	Are there further operational checks needed before it is placed in service?
10.	Are there system integration checks needed before the systems are placed in service?
11.	Are the hazards of working on (installing, trouble-shooting, repairing, maintaining) the installed system mitigated on the basis of a laboratory industrial safety program?
12.	Are the hazards of working on the system mitigated as part of an integrated laboratory work planning and control process?
13.	Are the staff that work on the system qualified, and are they authorized to conduct work on the system?
14.	Are there lessons learned from previous operational experience with this system? Have they been implemented?
15.	Are industrial systems ready to support commissioning?

Emergency Management Program

1.	Site has an emergency management program (EMP) supported by documentation and procedures
2.	EMP includes a technical basis document and an emergency management program plan
3.	EMP includes procedures relevant to accelerator operations
4.	EMP addresses onsite and offsite hazards (if applicable) and associated impacts for both normal operations and credible accidents
5.	BNL EMP benefits from programmatic lessons learned
6.	BNL effectively utilizes mutual aid relationships
7.	Accelerator Operations personnel have an effective understanding of EM
8.	Accelerator Operations personnel have an effective understanding of the application of programmatic lessons learned
9.	Observe function of site-wide notification system
10.	Determine adequacy of emergency response program to support commissioning

Lessons Learned Program

1.	Review lessons learned program procedures and documents to verify coordinated site-wide program
2.	Verify that the program identifies routine and non-routine occurrences that elevate to the level of lessons learned
3.	Verify that the program identifies and evaluates lessons learned at other DOE and non-DOE facilities
4.	Verify that there is a program to effectively disseminate lessons learned to those best suited to use the information
5.	Verify that recent external accelerator-based lessons learned have been effectively evaluated and incorporated into current Accelerator Readiness Review
6.	Lessons learned processes effectively support commissioning

Conduct of Operations

1.	Interview management and staff involved in the development and implementation of the Conduct of Operations program
2.	Review Conduct of Operations procedures to determine overall adequacy of program
3.	Is the Conduct of Operations Matrix, if required, approved, and are implementing procedures cited in the Matrix prepared and approved?
4.	Has an Operations/Commissioning Organization been established consistent with the organization described in the Conduct of Operations?
5.	Determine if Conduct of Operations program is adequately implemented
6.	Interview staff to assess knowledge of and implementation of Conduct of Operations program
7.	Determine adequacy of the Conduct of Operations program to support commissioning
8.	Verify that there are a sufficient number of trained and qualified operators to support commissioning or routine operations
9.	Verify that the basis for ASE Credited Controls and Credited Control Supports are understood by Operators

Records Management

1.	Key records are identified
2.	Records custodians for key records are identified
3.	Records are managed and stored properly
4.	Record management effectively support commissioning

Radiological Shielding

1. **Verify that shield design drawings and related Engineering Change Notices (ECNs) have been approved and are under configuration management**
2. **Verify whether shielding calculations have been independently reviewed and verified**
3. **Verify that shielding design assumptions are configuration managed**
4. **Verify that organizational Radiation Safety Committee (RSC) recommendations or requirements have been formally addressed**

Area Radiation Monitors (ARMs)

1. V erify that the area radiation monitors (ARMs) are capable of detecting the facility source terms and at the levels needed
2. Verify that all of the ARMs are calibrated and configuration controlled
3. Verify the organization has a formal process for setting and changing ARM Alarm and Interlock set points
4. Verify the process used to functionally check the ARMs as part of the facility start-up process
5. **Verify the availability of an ARM Alarm response procedure**
6. **Verify the availability of ARM dose rate displays in the Control Room**
7. **Do the ARMs audibly alarm in the Control Room alerting operators to take appropriate action?**
8. **Has the facility validated that the dose rates displayed in the Control Room are correct?**

Template for the Accelerator Readiness Review (ARR) Plan of Action

The ARR Plan of Action (POA) is a document developed by the ARR Team. The POA is intended to be a short and concise document that establishes the path forward for the ARR. The POA summarizes the proposed methodology for the ARR. This will assure that the appropriate scope and depth of the review is established.

The purpose of an ARR is to verify that the facility's personnel, hardware, and procedures are ready to permit the activity to be undertaken in a safe and environmentally sound manner. An ARR is not a method for achieving readiness but for verifying it. The facility's line management is responsible for ensuring and declaring readiness.

ARRs are required before commissioning and before routine operations. In commissioning, the ARR should confirm that construction is sufficiently complete; required safety-related systems are installed; operations and relevant procedures have been approved; and appropriate personnel have been assigned and adequately trained. The purpose of a routine operation ARR is to confirm that the facility is fully ready for routine operations, including that construction is complete, systems are fully tested and operational, procedures are established and operationally verified, staffing is complete, and personnel are fully trained.

Depending on the complexity of the facility, a POA may be established for each phase of the ARR or be combined into one POA for both phases. To the extent possible, documentation reviews and accelerator system presentations should occur prior to the on-site verification to ensure the best use of ARR Team members' time and expertise while at BNL.

[Template]
Accelerator Readiness Review
Plan of Action

[Click here and type Facility Name]

1. Objective/Scope

To ensure that (commissioning or operation) of the [Click here and type Facility Name] Facility, located at [Click here and type location] can be performed in a safe and environmentally safe manner. The ARR process shall verify that all facility conditions and operations with the potential to affect worker or public safety and health, or to have a negative impact on the environment, have been evaluated with appropriate safeguards established, and that the requirements of DOE Order 420.2C, SBMS Accelerator Safety Subject Area, and other associated directives, requirements, and procedures are met.

The ARR will verify that:

- An acceptable Safety Assessment Document (SAD) has been properly developed in accordance with DOE O 420.2C requirements, and has been reviewed and approved in accordance with the BNL internal safety review system.
- An adequate Accelerator Safety Envelope (ASE) has been developed, is supported by the SAD, and approved in accordance with BNL and Brookhaven DOE site office (BHSO) requirements.
- 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 activities are controlled.
- Equipment and systems having safety importance meet criteria established in the SAD and have been appropriately tested.
- Personnel training and qualification programs relevant to safe facility operation have been established.
- Staffing requirements specified in the ASE are met.

2. Methodology

Review methodologies include those aspects of each requirement that the ARR Team r plans to address by some combination of evaluating procedures and/or other documentation, conducting interviews and performing first hand observations or inspections. Include a description of how each Team member reports on their area. Findings reported by the team should be categorized as Pre-start or Post-start findings. A Pre-start finding must be corrected before an activity can be started. A Post-start finding can be corrected after the start of the activity under review. A description of the anticipated duration of the ARR Team on-site, description of the ARR Report, and a time frame for its issuance should be discussed.

3. ARR Team Members and Assignments:

Name	Affiliation	Primary Responsibility	ASO/Guide/SBMS Requirement	Phone/ E-mail

4. BNL Personnel Contact Information:

Name	Responsibility	Phone/E-mail

Topics to Guide the Accelerator Readiness Review (ARR) Team

The purpose of an ARR is to verify that the facility personnel, hardware and procedures are ready to permit the activity to be undertaken in a safe and environmentally sound manner. An ARR is not a method for achieving readiness but for verifying it. The facilities line management is responsible for declaring and ensuring readiness.

I. Documentation Readiness

A. Accelerator Safety Envelope

The ARR should verify that:

1. The ASE has been approved by BHSO or the DOE PSO

B. Safety Assessment Document

The ARR should verify that:

1. A Safety Assessment Document (SAD) exists, has been reviewed by the BNL ES&H Committee as an independent safety review, the comments and recommendations resulting from that review have been adequately addressed by the organization, and has been approved by the ALD ESH.

C. Procedures

The ARR should verify that:

1. Procedures necessary for safe commissioning or operation of the activity have been developed, reviewed, verified (by performance where applicable), and approved;
2. A document control system has been established, which defines the processes for document preparation, review, approval, verification distribution and training, and processes are kept current;
3. Maintenance, inspection & testing involving the safety aspects of the activity being reviewed has been identified and maintenance, inspection & testing procedures for these activities have been developed, reviewed, verified, and approved;
4. Procedures to deal with off-normal and emergency situations have been prepared, reviewed and verified, and are approved for use.
5. The procedures addressing the ASE-required equipment and systems specify the minimum necessary system components and monitoring devices to allow operation. If these minimums are not met, authorized alternate controls or other actions are specified.

D. Compliance with DOE ES&H Requirements

The ARR should verify that

1. Facility management has required a review to be made of the activity's conformance to applicable ES&H requirements;
2. Non-conformances have been identified and schedules and resources for achieving compliance have been established and approved by the appropriate level of management;
3. There is a process for reviewing changes to the proposed activity for impacts on credited controls and unreviewed safety issues;
4. Processes exist for evaluating the readiness of radiological control measures and other credited controls applicable to the proposed activity.

E. Resolution of Findings and Observations

The ARR should verify that:

1. Previous findings made by internal and external oversight and audit groups, including prior Accelerator Readiness Reviews or System/Component Readiness Reviews of the accelerator, which are relevant to the activity under review, and BORE/ORE Pre-start findings have been satisfactorily completed.

F. Configuration Management

1. A configuration management system for authorization documents, procedures, drawings, hardware associated with engineered safety systems and Credited Controls;

G. Quality Assurance

1. A Quality Assurance Program in compliance with SBMS is in place;

II. Hardware Readiness

A. Hardware

The ARR should verify that:

1. Equipment and systems having safety importance meet criteria described in the SAD and have been appropriately maintained, inspected and tested. This includes:
    a. Shielding
    b. Electrical systems
    c. Protection against credible fires
    d. Protection from oxygen deficient environments
    e. Storage, transfer, and use of cryogens
    f. Beam transport
    g. High power beam dumps
    h. Personnel protection systems, including secured area interlock system
    i. Fixed and portable radiation monitoring equipment
    j. Other instrumentation for monitoring safety and health conditions
    k. Systems for controlling environmental, safety, and health parameters
    l. Magnets
    m. RFs
    n. Lasers
    o. Radiation sources
    p. Ventilation systems
2. The results of testing conducted to confirm the readiness of hardware to undertake the activity safely have been documented, evaluated to ensure adequacy, and meet quality assurance requirements.

B. Hardware Operability

The ARR should verify that:

1. A program is in place to periodically confirm the status and operability of hardware systems that have safety importance.

2. The performance of the Credited Controls, have been verified, and records of appropriate system, tests, and calibrations exist and are current.

III. Personnel Readiness

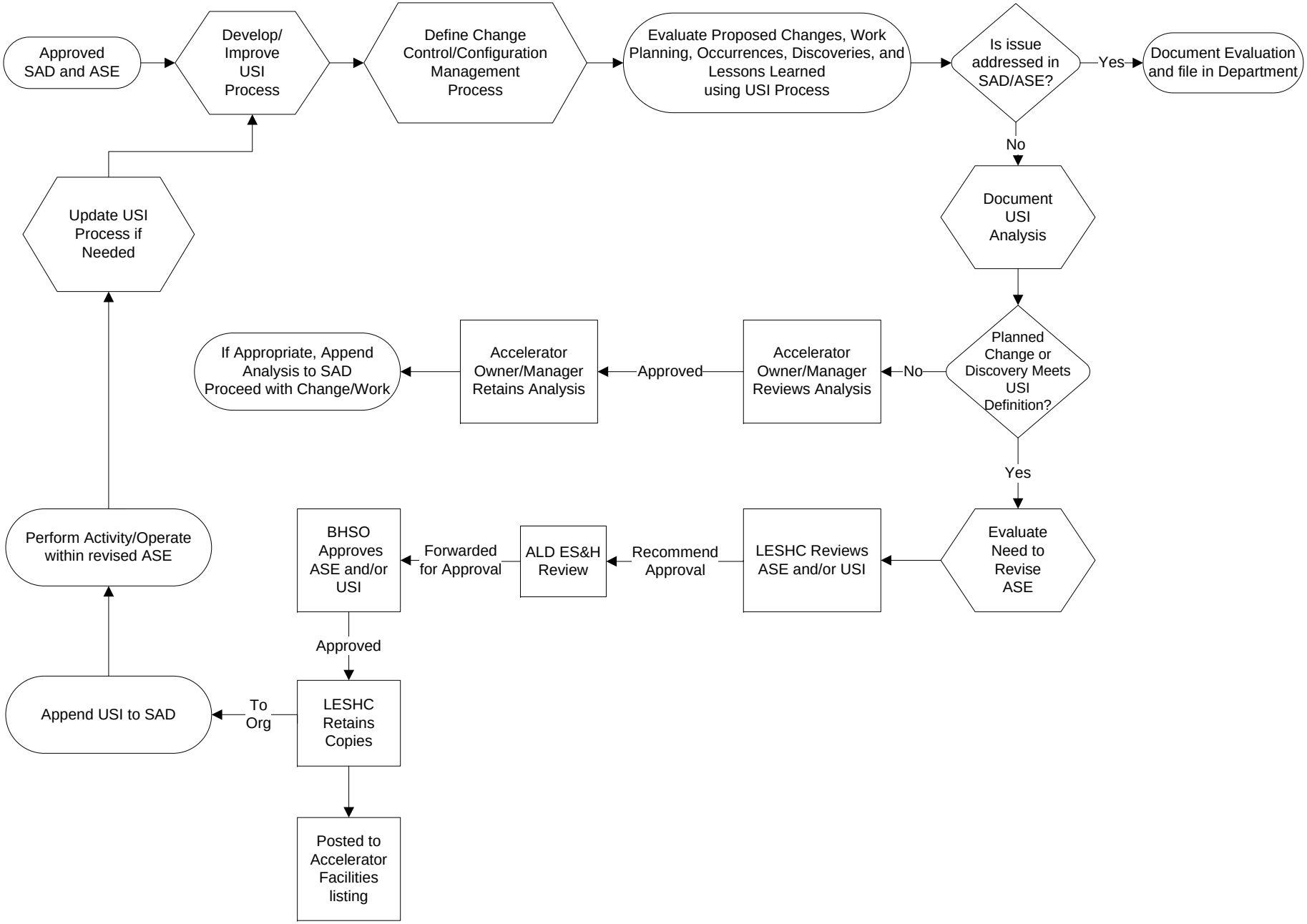
A. Training Program

The ARR should verify that:

1. Training and qualification programs have been established for general safety orientation, accelerator operations personnel, maintenance and support personnel, experimenters using the facility, and emergency responders. These programs are documented and encompass the range of duties required to be performed in accordance with the SAD
2. A process to periodically evaluate training program effectiveness has been established and documented and specifically includes the following considerations:
    a. Instruction method(s) are appropriate for the facility and the audience, and facility management periodically evaluates instructor performance;
    b. A systematic evaluation of training program effectiveness, including feedback from job performance, is used to ensure the training program conveys all the required skills and knowledge.
    c. The personnel protection training program is specific to the facility's hazards and provides the knowledge and skills necessary of individuals to perform their assigned job functions while avoiding exposure to specific facility hazards, such as high voltage-, cryogen-, and oxygen- deficient environments, and minimizing their exposure to radiation and chemicals;
    d. All required training and qualification of personnel has been achieved.

B. Qualified Personnel

The ARR should verify that:

1. A process is in place to ensure all required training is completed prior to workers engaging in activities at the accelerator facility.
2. The numbers of trained and qualified operations, maintenance and support personnel meet SAD requirements.
3. Individual assignments, responsibilities, authorities, and reporting relationships are defined, documented, and included in training.
4. Qualifications or exceptions to specified areas of training based upon education or experience have been granted and documented.

Unreviewed Safety Issue (USI) Process Flowchart