If you are using a printed copy of this procedure, and not the on-screen version, then you MUST make sure the dates at the bottom of the printed copy and the on-screen version match.
The on-screen version of the Collider-Accelerator Department Procedure is the Official Version.
Hard copies of all signed, official, C-A Operating Procedures are kept on file in the C-A ESHQ Training Office, Bldg. 911A.

C-A OPERATIONS PROCEDURES MANUAL

9.5.2 ALARA Design Review

Text Pages 2 through 6

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Approved: _____***Signature on File***_____ _____
Collider-Accelerator Department Chairman Date

D. Ryan

9.5.2 ALARA Design Review

1. Purpose

1.1 The As Low As Reasonably Achievable (ALARA) design review will address how the design of new equipment, such as experimental beam-line and accelerator components, or objects intentionally placed in or near the beam path has included the goal of keeping radiation exposure to personnel ALARA over the lifetime of the equipment.

1.2 The ALARA design goal is to reduce the amount of time an individual will spend in a radiation area working on the equipment, to reduce the potential for contamination, and/or to reduce the ambient radiation level while working on the equipment.

1.3 For the purposes of this procedure, objects intentionally placed in the beam path include targets, target baths, target cooling systems, target holders, target containment vessels, target foils, collimators, devices to reduce beam halo, helium-filled vessels, vacuum vessels, or any other device struck by primary beam or significant amounts of secondary hadrons such that dispersible contamination is a potential hazard.

2. Responsibilities

2.1 The C-A scientific and engineering staffs are responsible for carrying out this procedure. The cognizant project leader or project engineer must identify the radiation exposure hazards and design the equipment to reduce the hazard. At both the preliminary and final design review, they shall prepare for and present ALARA design considerations that explain the potential hazards and the steps taken to reduce them.

2.2 The C-A Chief Mechanical Engineer (CME) and Chief Electrical Engineer (CEE) are responsible for ensuring monitoring that ALARA principles are used in the design and that a formal design review takes place on all equipment whose installation, operation, maintenance, repair, and/or disposal, can result in radiation exposure to personnel.

2.3 The C-A CME and CEE shall determine if a formal ALARA review is necessary. The CME or CEE shall have the project leader or project engineer contact the Chairman of the ALARA Committee. In all cases of new targets or other objects that are to be intentionally hit by beam, or near a source of radiation, the CEE or CME must consult directly with the ALARA Committee Chair regarding the need for an ALARA design review. If it is determined by the Chairman of the ALARA Committee that an ALARA Committee review is not required, the project leader

must inform the CME and CEE, as appropriate (or Department Chairman) in writing to that effect.

2.4 The following guidelines (Reference 7.1) will be followed by project leaders and the ALARA Committee, to determine when an ALARA Committee review is necessary:

2.4.1 Installation of a new accelerator system, experiment, or beam-line component, is expected to result in > 0.75 person-rem collective exposure.

Note:
This procedure relates to systems that are at the design stage. The following shall invoke the ALARA procedure in C-A-OPM 9.5.5 rather than this procedure:

A non-routine maintenance or repair project in C-A facilities, results in > 0.75 person-rem collective exposure.

2.4.2 Operation of a beam-line component, experiment or accelerator system during its lifetime, results in > 0.75 person-rem/year averaged over a two-year period.

2.4.3 Future routine maintenance of a new beam-line component, experiment or accelerator system will result in > 0.75 person-rem/year averaged over a two-year period.

2.4.4 Replacement, removal or rebuilding an existing beam-line component or accelerator system, results in > 0.75 person-rem/upgrade.

2.5 The Chairman of the ALARA Committee (or designee) shall determine if a separate ALARA review is to be presented to the ALARA Committee, or if the review can be held in conjunction with other ES&H reviews with designated ALARA committee members present. If a distinct ALARA Committee review is required, it shall be scheduled, and the ALARA Committee shall send out meeting notices. If ALARA is covered in other ES&H reviews, it shall be scheduled in accordance with the applicable procedures (e.g., References 7.2 and 7.3).

2.6 The ALARA Committee may determine a threshold level of potential dispersible contamination and use that threshold to require a Committee review.

3. Prerequisites

3.1 Prior to the ALARA design review, the following items should be considered in the design and be prepared for presentation during the design review by the project leader, or designee:

3.1.1 An estimate of the cumulative radiation to which the equipment will be exposed. Emphasis should be placed on the location and types of materials that are susceptible to radiation damage, the dose that they will receive, the probability they will be damaged in the equipment's life time, and the doses to repair or replace those items.

3.1.2 A list of items on the equipment that will require maintenance, adjustment, and repair during its lifetime, and the dose required to work on those items. For example, are the replacement parts standardized, or must parts be measured and then "filed to fit" or surveyed into position? That time must be included in the dose estimate.

3.1.3 A list of materials used in the equipment such as heavy metals, alloys or compounds containing heavy metals, oils, etc., that will be activated when the equipment is installed and operating. These items will become mixed waste when the C-A equipment is decommissioned. The ease with which these items can be removed from the rest of the equipment for separate disposal must be considered.

3.1.4 Identification of potential sources of radioactive contamination; e.g., components which can decompose in operation, rust, or require machining for removal or repair after they have become activated.

3.1.5 Identification of potential for dispersible contamination due to overheating by beam or due to gas emanations from any object intentionally placed in or near the beam path (e.g., targets or collimators) .

3.2 For ingestion and inhalation, the ALARA design guidelines are:

3.2.1 Beam stops or beam loss points will be capped to prevent rainwater infiltration of activated soil. Caps shall be employed wherever there is potential for groundwater contamination greater than 5% of the Drinking Water Standard.

3.2.2 Off-site and on-site drinking water concentrations of ^{3}H and ^{22}Na shall not exceed 2E+4 pCi per liter and 400 pCi per liter respectively. These concentrations correspond to 1 mrem/yr (^{3}H) and 4 mrem/yr (^{22}Na) to persons drinking from water supplies contaminated at these levels.

3.2.3 The ^{3}H concentration of sanitary sewer liquid effluents at the Sewage Treatment Plant from C-A discharge shall be no greater than 5E+3 pCi per liter.

3.2.4 Exposure of personnel to airborne radioactivity is to be avoided during normal operations. This shall be accomplished by appropriately designed beam vacuum systems, confinement, delay time and ventilation.

3.2.5 For airborne emissions because of operations, release concentrations contributing to potential site boundary exposure are controlled so that cumulative annual emissions contribute less than 0.1 mrem/yr. to the Maximum Exposed Individual (MEI) offsite.

3.3 For new and significantly modified equipment or facilities, an ALARA Design Review Document shall be written for the project and it should:

- Document the dose assessment.
- Document the potential internal dose from an accidental release of airborne radioactivity from any object intentionally placed in or near the beam path.
- Document the review of radiological conditions against the trigger levels in Section 2. That is, describe all new radiation sources or an increase in the dose rates from an existing source. Include increased operations, maintenance, production, research, inspection or decommissioning requirements in radiological controlled areas; document your review for any projected expenditure of a collective dose greater than 0.75 person-rem per year or 0.75 person-rem during installation. Use approved optimization methods in C-A OPM 9.5.6 for evaluating the various ALARA considerations where applicable. For example, the cost of shielding versus the cost of dose avoided.
- Identify applicable radiological design criteria.
- Document a review of previous similar jobs, designs and processes that have similar hazards. Do this in order to assist in the selection of design alternatives.
- Document the design features used to reduce dose and the spread of radioactive materials.
- List all post-construction reviews that will determine the effectiveness of engineering features to reduce dose and the spread of radioactive materials.
- An example ALARA Design Document may be found at http://www.rhichome.bnl.gov/AGS/Accel/SND/SAD/C-ASADAppendix1.pdf

4. Precautions

4.1 The ALARA design review is not to be substituted for a radiation-protection design review by the Radiation Safety Committee.

4.2 The ALARA design review shall occur before a significant commitment has been made in the design through engineering and designer time, and the purchase or

manufacture of parts. Design change suggestions should not have to be turned away because the drawings are finalized or the parts have already been purchased.

4.3 ALARA considerations for any new equipment should begin when the project begins and the basic specifications and layouts are developed for the equipment. The request for the design review should be made after the design specifications and the initial drawing layouts are complete, so that the design, purpose and principle of operation of the equipment can be clearly presented during the ALARA review.

4.4 The need for procuring radioactive material (including accountable sealed-sources) should be identified in the ALARA design review. Procurement shall be in accordance with HP-SOP-026, Procurement of and Approval to use Radioactive Material, (reference 7.7).

4.5 Ozone-type water treatment systems should be used in lieu of chemical water treatment systems where feasible.

4.6 All cooling water systems expected to contain tritium (^{3}H) or other water activation products shall be designed such that all piping is above ground and indoors. There must be no nearby sanitary or storm system drains. Lined sumps should be used and should have alarm capability.

4.6.1 Cooling water for power supplies should be isolated from cooling water used for magnets if the magnet cooling water can become activated.

4.6.2 Consider placement of an impermeable barrier under all piping and reservoirs, which contain activated water, even though the system is fully enclosed within a structure containing concrete flooring.

5. Procedure

5.1 The project leader shall request an ALARA review, from the Chairman of the ALARA Committee.

5.2 The Chairman will schedule the review or arrange to have it included with another safety review, determine who shall attend, and send out the meeting notices.

Note:
The ALARA design review can be a part of the equipment design review or other safety review (e.g., Reference 7.2, and 7.3) since ALARA is a major design consideration. Even if the equipment does not meet the minimum requirements for a formal review, ALARA goals must be considered in any new equipment.

5.3 The ALARA Committee and the project leader shall review:
- 5.3.1 installation location and ambient radiation level,
- 5.3.2 amount of activation anticipated,
- 5.3.3 reliability and maintainability,
- 5.3.4 materials used,
- 5.3.5 temporary and permanent shielding,
- 5.3.6 potential for contamination,
- 5.3.7 for objects intentionally placed in or near the beams path:
  - 5.3.7.1 containment design
  - 5.3.7.2 handling, dispersible contamination and PPE
  - 5.3.7.3 heat transfer
  - 5.3.7.4 radioactivity inventory and confidence in calculations
  - 5.3.7.5 potential for gaseous or airborne particulate emanations
- 5.3.8 decommissioning and disposal

5.4 The ALARA Design Review Document described in Section 3.3 will be presented by the project leader or designee.

5.5 The Chairman of the ALARA Committee (or designee) will take the minutes and publish them in a memorandum.

5.6 Any ALARA action items in the ALARA Committee minutes, or ALARA action items in the minutes of other reviews, must be acted upon by the project leader.

5.7 When the action items are completed, the project leader shall note this fact by memorandum to the Chairman of the ALARA Committee. The project leader shall forward copies of this memorandum to the appropriate Chief Engineer and other affected personnel.

6. Documentation

6.1 The ALARA Committee meeting minutes, related minutes of other reviews, the ALARA Design Review Document and the responses to the minutes if applicable are the documentation. The ALARA Committee Chairman will maintain the minutes and the responses to the minutes, or cause them to be maintained, for archive storage.

7. References

7.1 Proposed Man-Rem Triggers for an ALARA Design Review, AGS Department Memorandum, Brookhaven National Laboratory, E. T. Lessard, June 18, 1991

7.2 C-A OPM 9.2.1, Procedure for Reviewing Conventional Safety Aspects of an Experiment

7.3 C-A OPM 9.3.1, Procedure for Reviewing Conventional Safety Aspects of an Accelerator System

7.4 C-A-OPM 9.5.5, ALARA Job Review
7.5 C-A-OPM 9.5.6, ALARA Optimization and Cost Benefit Procedure
7.6 C-A OPM 9.1.1, Procedure for Obtaining a Review by the C-A Radiation Safety Committee BNL Procedure HP-SOP-026, Procurement of and Approval to use Radioactive Material
7.7 BNL Procedure HP-SOP-020, ALARA Program
7.8 10CFR835 § 835.1002 (d), Code of Federal Regulations, Part 835 -Occupational Radiation Protection
7.9 Accelerator Safety Subject Area, BNL Standards Based Management System
7.10 ALARA Program Subject Area, BNL Standards Based Management System

8. Attachments

None