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Jnited States Government **Department of Energy**

memorandum

Oak Ridge Operations

DATE: February 23, 2000

EPLY TO
ATTN OF: LM-14:Wilfert

SUBJECT: **SUPPLEMENT ANALYSIS OF THE PROPOSED SUPERCONDUCTING CAVITY CHANGE FOR THE SPALLATION NEUTRON SOURCE, (DOE/EIS-0247/SA1)**

TO: Edward G. Cumesty, Assistant Manager for Laboratories, LM-10

We have reviewed the subject analysis for the proposed superconducting cavity change for the Spallation Neutron Source (SNS) facility. Based on the findings in the Supplement Analysis (SA), the recommendation of the Oak Ridge Operations National Environmental Policy Act (NEPA) Compliance Officer, and after consultation with the Office of Chief Counsel, I have determined that the proposed action does not constitute a significant change relevant to environmental concerns pursuant to 40 CFR 1502.9 and 10 CFR 1021.314; therefore, no additional review under NEPA is required.

Please note that your office is responsible for making the SA available to the public and issuing a public Notice of Availability for this document in accordance with 40 CFR 1506.6(b), 10 CFR 1021.314, and DOE Order 451.1A (5)(e)(5). A copy of the analysis should be attached to DOE/EIS-0247 as part of the NEPA record for this project.

If you have questions on the ORO NEPA process, please contact David R. Allen, ORO NEPA Compliance Officer at (865) 576-0411.

G Leah Dever

G. Leah Dever
Manager

Attachment

cc w/attachment:
C. M. Borgstrom, EH-42, HQ/FORS
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SUPPLEMENT ANALYSIS

PROPOSED CHANGE TO SUPERCONDUCTING LINEAR ACCELERATOR AT THE SPALLATION NEUTRON SOURCE OAK RIDGE, TENNESSEE

FEBRUARY 2000

INTRODUCTION

A superconducting linear accelerator (linac) is proposed as a replacement for a portion of the ambient-temperature linac currently in the Project Baseline. This Supplement Analysis is conducted to evaluate the environmental impacts associated with the proposed modification in comparison with the environmental impacts analyzed in the SNS Final Environmental Impacts Statement (FEIS) (ref.1). In keeping with the material presented in the FEIS, a brief description of the superconducting option will be provided, and the environmental impacts associated with the proposed alternative will be analyzed. This Supplement Analysis will then duplicate the comparison of alternatives contained in Table 3.5-1 of the FEIS to ensure consistency of the issues identified and analyzed. Finally, the major impact categories identified in the SNS Mitigation Action Plan (ref. 2) will be examined for the superconducting alternative as compared to the current baseline.

DESCRIPTION OF THE PROPOSED OPTION

The warm temperature linac from 194.3 MeV to 1GeV would be replaced by a superconducting linac operating at 2 degrees above absolute zero (2 K) (ref. 3). At this very low temperature, cavities made of niobium exhibit extremely low resistance to electricity, allowing for higher electric fields than the room temperature linac. These higher electric fields allow for more efficient beam acceleration, requiring on the order of 30% less distance to reach the same beam energy. The baseline design is depicted in Figure 1, and the superconducting option is shown in Figure 2. Beam from the superconducting linac would be transported by a room-temperature HEBT to the ring as in the current baseline. A cryogenic (supercold) facility would supply liquid helium to the superconducting linac cavities.

By providing very efficient transmission of energy, a superconducting linac puts more energy into the beam with fewer losses due to resistance. Superconducting cavities operate at high accelerating gradients, so the beam is accelerated to the desired velocity in less length. The electric fields in cavities must overcome resistance in the room temperature linac resulting in higher resistance losses needing higher input power. In the superconducting option essentially no power is lost due to resistance in the cavity walls, so virtually all of the input power goes into the beam, requiring less total power than in the room temperature design.

The proposed superconducting linac, including all associated facilities, would use approximately 12 megawatts less electricity over the course of a year than the baseline design. Peak power requirements would drop even more, but the cryogenic facility would be operated year-round to maintain the cavities. The superconducting linac also produces about 6 MW less heat than the baseline warm linac section, resulting in less heat rejected by the cooling towers to the atmosphere. The superconducting linac would have better beam control, resulting in less beam loss, lower activation of linac components, less exposure to workers performing maintenance on linac components, and less activated material over the life of the project.

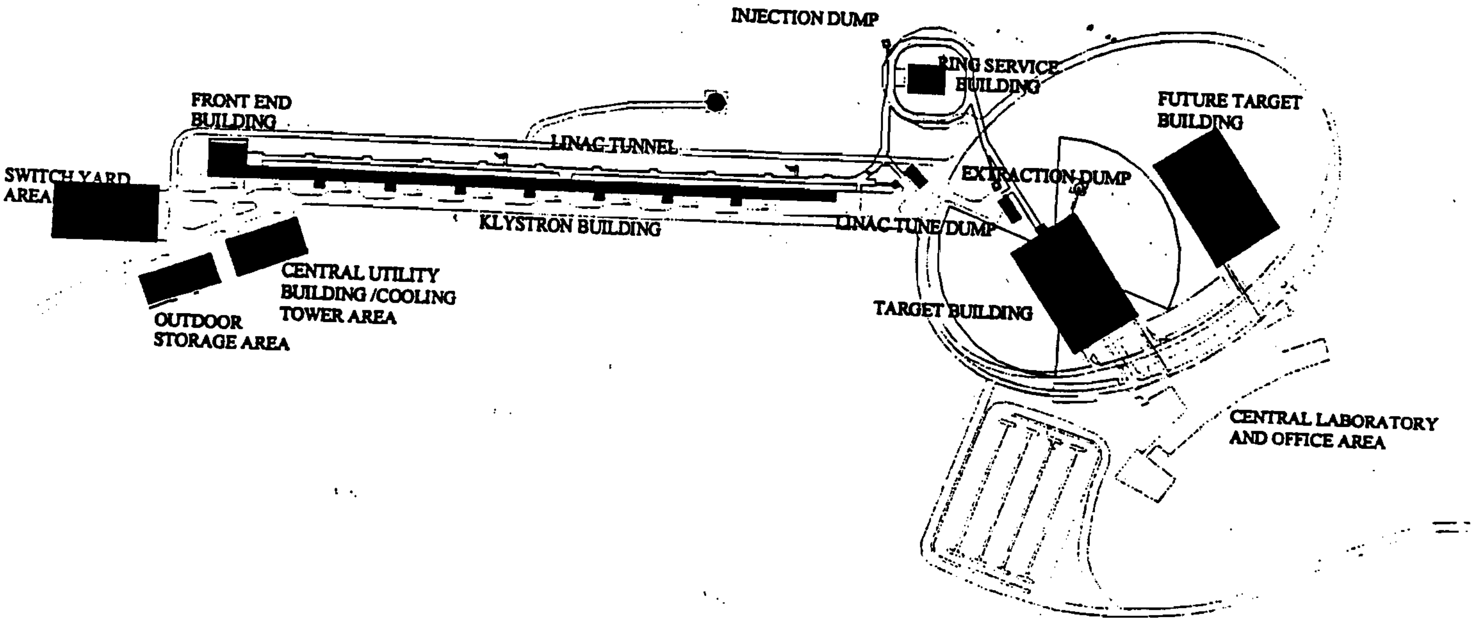

Figure 1 Baseline configuration with warm linac. Linac tunnel length is approximately 460 m.

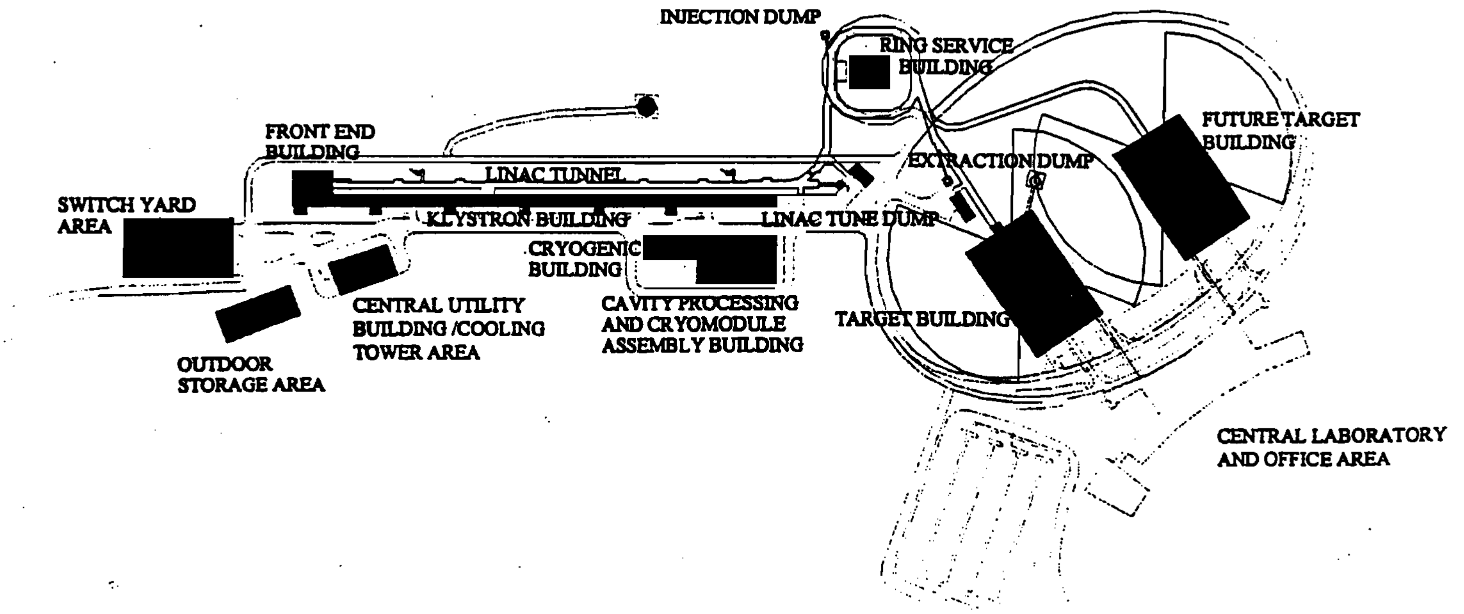

Figure 2. Superconducting configuration. Linac tunnel length is approximately 320 m.

Because of enhanced beam acceleration, the superconducting accelerator requires less linac length to achieve the same beam energy. The linac tunnel and adjacent klystron gallery would be reduced from approximately 460 m to about 320 m, a reduction on the order of 140m, as can be seen in a comparison between Figures 1 and 2. These reduction results in a smaller area disturbed by construction, less material consumed in construction, and smaller areas to maintain. Approximately 30% less excavation, on the order of 80,000 cubic yards, and backfill would be required for the superconducting linac.

As previously described, the niobium superconducting cavities require operating temperatures of 2 K. In the proposed superconducting option, the modules that maintain the superconducting temperature of the niobium cavities are cooled by liquid helium. A cryogenic facility, capable of producing liquid helium at the design temperature, uses electrical refrigerator units and liquid nitrogen. The cryogenic facility would be on the order of 6,000 square feet, with an adjacent 15,000 square foot facility for cavity processing and assembly. The facility would consume an average of 5000 gallons of liquid nitrogen each day (ref. 4). To maintain the cavities, the cryogenic facility would operate year-round and is not dependent upon linac operation. Liquid nitrogen is provided by air separation facilities, and the liquid nitrogen use of the proposed superconducting linac is far too small to economically support a stand-alone air separation facility. Therefore, the liquid nitrogen used to cool the helium will be returned to the atmosphere. The cryogenic facility and cavity conditioning building will be located adjacent to the klystron gallery, and land disturbed during tunnel excavation and other site work.

IMPACTS OF THE PROPOSED OPTION

The superconducting option fits within a reduced footprint of the current baseline, requiring a smaller linac and klystron gallery. The cryogenic facility would be constructed adjacent to the klystron gallery within the SNS footprint, so no additional land would be disturbed. Traffic would be limited to the planned SNS access roads, with no additional roads required to support the alternative. The environmental impacts associated with the superconducting option are generally limited to releases of nitrogen from the cryogenic facility, very small releases of helium from leaks in piping, and acid wastes generated in the cavity conditioning process.

Releases of nitrogen are predicted to be on the order of 5,000 gallons per day. Since nitrogen is the principal constituent of air, releases of this magnitude would increase the concentration of nitrogen in the atmosphere by fraction of a percent offsite. These changes are anticipated to have no adverse impacts on SNS staff or the environment.

To ensure effective operation of the cavities, releases of helium would be tightly restricted. Specifications for compressors and related piping systems would limit helium releases to less than 15 standard cubic feet per hour. Helium is a non-toxic, non-reactive gas, and releases of this scale would have no adverse environmental impacts.

On an annual basis, the superconducting option, including operating the cryogenic facility throughout the year, would use approximately 12MW of electricity less than the ambient-temperature linac. These reductions would be associated with smaller releases of pollutants from electricity generating facilities, resulting in less adverse impacts to the environment in the vicinity of the electrical generating facility. The superconducting option would reduce cooling loads and therefore emissions from the SNS cooling towers by approximately 20%. Less water would be consumed and released as either water vapor to the atmosphere or discharged into White Oak Creek. Water vapor and heat impacts from the cooling towers on the Walker Branch Watershed research area would be slightly reduced.

Superconducting cavities are cleaned in a buffered chemical polish to enhance performance. This material is an equimolar solution of nitric acid, phosphoric acid, and hydrofluoric acid. These cleaning operations would occur in closed systems with no worker contact. The number of cavities cleaned in this system would determine the amount of these wastes generated. Based on waste generation rates at Thomas Jefferson National Accelerator Facility (ref. 5) which would produce the cavities for the SNS superconducting linac, projected activities of cleaning on the order of five cavities per year would result in less than 50 gallons of waste being generated from cavity cleaning activities. This material would be treated or recycled at a licensed hazardous waste facility. These wastes would not be radioactive, and numerous commercial sites are licensed to treat the solutions

The superconducting linac tunnel would have the potential to become oxygen-deficient in the event of a release of cryogenic fluids. At other superconducting facilities, releases of cryogenic fluids are not common, and no injuries have been recorded. Impacts of these releases would be confined to the tunnel, which is a controlled access area. Oxygen monitors would be located in the tunnel, and access controls used at other superconducting accelerators would be employed. No releases from the superconducting linac or associated facilities can adversely affect the public or the environment.

The superconducting linac would have better beam control, and less activation of linac components. Less soil in berm would be activated from beam losses as well. Accidental beam misalignment defined in the worst-case accident in the FEIS (Section 5.2.9.3.2) to an individual in an uncontrolled area would be limited to 1 rem, and for a worker in a controlled area would be limited to 25 rem. Because beam misalignment causes a cavity to heat up, no longer be superconducting, thus shutting the beam off, the superconducting section of the linac would not challenge these limits.

COMPARISON OF IMPACTS

Table 3.5-1 in the SNS FEIS is a comparison of the impacts between the alternative locations analyzed. Those same impacts are compared for the room temperature and superconducting alternative at the SNS site.

1a. Impacts on geology and soils (construction)

> Same for either option, but the superconducting option disturbs less area

1b. Impacts on geology and soils (operations)

> The soil in the berm used to shield the linac would be subject to neutron activation in either option, with slightly less activation for the superconducting option due to reduced beam loss. Worst-case accidents for beam misalignment would be reduced for the superconducting option.

2a. Impacts on water resources (construction)

> Same for either option.

2b. Impacts on water resources (operation)

> Less impact for superconducting option due to smaller cooling loads, less water use, and less water discharged to White Oak Creek

3a. Impacts on climate and nonradiological air quality (construction)

> Same for either option

3b. Impacts on climate and nonradiological air quality (operation)

> Slight increase in nitrogen in superconducting option, with small decrease in air pollutants associated with reduced electricity consumption and less water vapor released due to reduced cooling loads

4a. Impacts on noise levels (construction)

> Same for either option.

4b. Impacts on noise levels (operation)

> Slight additional noise associated with the cryogenic facility compressors, which would meet standards for occupational noise and not be audible offsite

5a. Impacts on ecological resources (construction)

Same for either option

5b. Impacts on ecological resources (operation)

Same for either option

6a. Impacts on socioeconomics (construction)

Same for either option

6b. Impacts on socioeconomics (operation)

Same for either option

7a. Impacts on cultural resources (construction)

Same for either option

7b. Impacts on cultural resources (operation)

Same for either option

8a. Impacts on land use (construction)

The superconducting option would require a shorter linac and klystron gallery, reducing the footprint of the facility as shown in a comparison of Figures 1 and 2.

8b. Impacts on land use (operation)

Slight reduction in water vapor impacts on Walker Branch Watershed research areas. Other impacts are the same for either option

9a. Impacts on human health (construction)

Same for either option

9b. Impacts on human health (operation)

Same for either option

10a. Impacts on support facilities and infrastructure (construction)

Same for either option

10b. Impacts on support facilities and infrastructure (operation)

The superconducting option would require approximately one liquid nitrogen tube-truck per day. Currently, ORNL requires approximately 35 trucks of liquid nitrogen per year, and the Y-12 Plant requires approximately 300 trucks of liquid nitrogen per year (ref. 6). Overall, SNS is anticipated to require three service trucks of various sizes plus one additional nitrogen truck per day, compared with the ORNL traffic of 7,810 vehicle trips per day. The superconducting option would have less worker dose due to reduced beam loss, and reduced consequences of the maximum beam loss accident. Offsite radiation doses would be the same for either option.

11a. Impacts of waste management (construction and operations)

The superconducting option would generate small quantities, expected to be 50 gallons per year of acidic wastes associated with cavity cleaning. Licensed commercial vendors would recycle or dispose of these wastes.

12a. Impacts on long-term productivity of the environment

Same for either option

13a. Cumulative impacts (construction and operation)

The superconducting option would use less electricity and generate smaller releases from the cooling towers, and would require a smaller linac and klystron gallery. The superconducting option would use approximately one tube-truck of liquid nitrogen per day, resulting in slight increases of nitrogen in the vicinity of the cryogenic facility. Other impacts would be similar for either option.

COMPLIANCE WITH THE MITIGATION ACTION PLAN

Groundwater. No changes in groundwater are anticipated with either option. The monitoring data collected will be appropriate for either option.

Surface water. The superconducting option would require lower cooling loads, slightly reducing the flow from the cooling towers to the retention basis. The mitigation will be appropriate for either option.

Terrestrial Wildlife. No change.

Surface and Groundwater Monitoring. No change.

Wetlands. No change.

Protected Species. No change.

Cultural Resources. No change.

Transportation infrastructure (construction): No change

Transportation infrastructure (operation): The superconducting option will require approximately 1 additional liquid nitrogen tube-truck per day, or essentially no change.

Research projects: The superconducting option will result in smaller cooling loads, and less impact from cooling towers. The release of liquid nitrogen could have slight impacts on certain research activities. Siting an additional monitoring tower away from the SNS will effectively mitigate the effects from either option.

SUMMARY

The major concerns raised by the public and commenting agencies were (1) radiation contamination of groundwater, (2) selection of the site on the Oak Ridge Reservation, (3) effects on Walker Branch research, (4) mitigation actions, and (5) waste management. Addressing these primary areas identifies advantages to selecting the superconducting option. The superconducting linac would result in less radiation contamination of groundwater due to better beam control. The proposed change is located within the footprint selected for the SNS, with a reduction in the area disturbed by construction. The superconducting linac would release less heat and water vapor, reducing impacts to the Walker Branch Watershed. The MAP would be followed, and all impacts associated with a change to the superconducting option would continue to be addressed by the MAP. Waste management issues associated with the superconducting option are the generation of an additional 50 gallons of acid waste per year, but fewer activated components would be created due to improved beam control.

The environmental impacts associated with a superconducting linac are similar to or less than the impacts associated with the room temperature linac analyzed in the SNS FEIS. The impacts associated with the superconducting linac are within the limits analyzed in the FEIS, and the mitigation proposed for the baseline design would further reduce the slight impacts associated with the superconducting option.

References:

1. Final Environmental Impact Statement, Construction and Operation of the Spallation Neutron Source. DOE/EIS-0247, April 1999.

2. Mitigation Action Plan for the Spallation Neutron Source. MAP for the DOE/EIS-0247. October 1999.

3. Preliminary Design Report, Superconducting Radio Frequency Linac for the Spallation Neutron Source. November 1999.

4. Personal Communication, F. Kornegay (SNS) with W. Chronis (Thomas Jefferson National Accelerator Facility). February 2000.

5. Personal Communication, S. Trotter (SNS) with S. Prior (Thomas Jefferson National Accelerator Facility). February 2000.

6. Personal Communication, F. Kornegay with J. Lyles, Oak Ridge Procurement. February 2000.