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LAMEAR-0001 Mechanical Engineering of the
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LAMEAR- 001 Mechanical Engineering of the Linac for the Spallation Neutron Source*

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The linac for the Spallation Neutron Source (SNS) Project will accelerate an average current of 1 mA of H⁻ ions from 20 MeV to 1 GeV for injection into an accumulator ring. The linac will be an intense source of H⁻ ions and as such requires advanced design techniques to meet project technical goals as well as to minimize costs. The DTL, CCDTL and CCL are 466m long and operate at 805 MHz with a maximum H⁻ input current of 28 mA and 7% rf duty factor. The Drift Tube Linac is a copper-plated steel structure using permanent magnet quadrupoles. The Coupled-Cavity portions are brazed copper structures and use electromagnetic quads. RF losses in the copper are 80 MW, with total rf power supplied by 52 klystrons. Additionally, the linac is to be upgraded to the 2- and 4-MW beam power levels with no increase in duty factor. We give an overview of the linac mechanical engineering effort and discuss the special challenges and status of the effort.

* Work supported by the Office of Energy Research, Basic Energy Sciences, of the U.S. Department of Energy; and the Oak Ridge National Laboratory.

MECHANICAL ENGINEERING OF A LINAC FOR THE SPALLATION NEUTRON SOURCE*

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Abstract

The linac for the Spallation Neutron Source (SNS) Project will accelerate an average current of 1 mA of H^- ions from 20 MeV to 1 GeV for injection into an accumulator ring. The linac will be an intense source of H^- ions and as such requires advanced design techniques to meet project technical goals as well as to minimize costs. The DTL, CCDTL and CCL are 466m long and operate at 805 MHz with a maximum H^- input current of 28 mA and 7% rf duty factor. The Drift Tube Linac is a copper-plated steel structure using permanent magnet quadrupoles. The Coupled-Cavity portions are brazed copper structures and use electromagnetic quads. RF losses in the copper are 80 MW, with total rf power supplied by 52 klystrons. Additionally, the linac is to be upgraded to the 2- and 4-MW beam power levels with no increase in duty factor. We give an overview of the linac mechanical engineering effort and discuss the special challenges and status of the effort.

1 INTRODUCTION

Los Alamos will design, build and install the 1-MW H^- linac for the SNS facility. A summary of the overall design is available in the on-line design manual¹. The linac accepts a 2.5-MeV H^- beam from the Front-End System being built by Lawrence Berkeley Lab. The linac is then comprised of three major structure types: a Drift Tube Linac that accelerates the beam to 20 MeV, a Coupled Cavity Drift Tube Linac that accelerates the beam to 86 MeV, and a Coupled Cavity Linac that completes the acceleration to 1 GeV and delivers the beam to the Brookhaven-designed High Energy beam transport line that leads to the accumulator ring. The CCL is comprised of an 8-cell per segment section and a 10-cell per segment section. The DTL runs at 402.5 MHz while all the coupled cavity structures run at 805 MHz.

2 DESIGN REQUIREMENTS

Selected requirements and overall design parameters are listed in Table 1.

Table 1. Overall linac requirements and parameters

Input H^- Energy	2.5 MeV
Output H^- Energy	1001 MeV
Average Beam Current	1.04 mA
Average Beam Power	1.04 MW
Macropulse Repetition Rate	60 Hz
Macropulse Length	0.974 ms
RF Duty Factor	7.02%
Average Accelerating Gradient, E0T	2.7 MV/m
Avg Energy Gain/Real Estate Meter	2.02 MeV/m
Peak Structure Power Losses	80.7 MW
Peak RF Power	98.7 MW

Overall, the design of the SNS linac is similar to the LANSCE linac. The primary difference is that the accelerating gradient is twice as high, allowing a much shorter linac with higher RF power. The design must be capable of being upgraded to the 2 MW level by doubling the current and the 4 MW level by funneling at 20 MeV. To prepare the structure for these upgrades, each accelerating module, driven by 2 2.5 MW klystrons at the 1 MW level, is designed with a terminated drive port to accept a third klystron. The linac vacuum requirement of $<1 \times 10^{-7}$ torr is based on less than 1 nA/m beam loss at 1 GeV. Beam loss also drives the linac aperture which varies from XXX to XXX. The aperture is generally set to 10 times the rms beam size at higher energies. Additional linac design parameters are listed in Table 2.

Table 2 Linac Design Parameters

Average RF Power to Linac	6.74 MW
No. 1.25 MW 402.5 MHz Klystrons	2
No. of 2.5 MW 805 MHz Klystrons	56
Physical Length of Linac	466 m
Linac Vacuum	$<1 \times 10^{-7}$ torr
Linac Tunnel, Width x Height	14 x 10 ft
Beam-Floor Distance	5 ft

3 DTL

The lattice period for the DTL is 4 bl at 402.5 MHz (8bl equivalent at 805 MHz). The design has recently been changed to a single tank design with 82 drift tubes rather than a 2 tank design. This eliminates the complexity of hardware design in the 1bl intertank region that would have included 2 end walls and beam diagnostics. The single tank shown in Figure 1 will be built up from 4 tank sections bolted together to make the 8.5 m long structure. The tanks are thick-walled copper plated steel tubes in which the drift tube supports are integrated into the walls rather than relying on a separate girder support.

The drift tubes are brazed and electron beam welded structures with stainless steel stems, copper bodies and samarium-cobalt permanent magnet quadrupoles. Post couplers are used to stabilize and tune the longitudinal field distribution.

RF power will be coupled to the tank via 2 drive loops. The peak RF structure power loss is 0.994 MW. The DTL will be water cooled and tuned by adjusting the coolant temperature according to feedback from the RF frequency measurement. The structures will be aligned one tank section at a time using a pulsed taut wire system. Each tank section will be aligned to the next section by aligning the first drift tube only, then removing the upstream tank and aligning the remaining drift tubes in the downstream tank to the first. The DTL is in it's preliminary design phase with the PDR scheduled for the end of FY '99. Prototype tanks sections are being machined and plated, prototype magnets are being built and prototype drift tubes will be built during the Summer of '99.

Figure 1 - DTL Layout

4 CCDTL

The CCDTL consists of 2 cells per segment, where a segment refers to a continuous brazed section of accelerating cavities between two quadrupole focusing magnets. Each cavity contains a drift tube. The lattice period for both the CCDTL and the CCL is 12 bl. The CCDTL layout is shown in Figure 2. An electromagnetic quadrupole singlet is located between the segments of RF structure. Beam diagnostic elements are also located in these intersegment spaces as necessary. These intersegment spaces are $6bl/2$ in length and are spanned by 3-cell coupling cavities. The CCDTL consists of XXX segments arranged into 2 RF modules and has a total length of XXX m. The peak structure power loss is 5.85 MW. Each module is driven by 2 RF klystrons coupled to the structure with waveguide irises.

Figure 2 CCDTL Layout

5 CCL

The bulk of the acceleration, 86MeV to 1 GeV, takes place in the CCL. The low energy portion has 8 cells per segment while the high energy portion has 10 cells per segment. The intersegment spaces are 2bl in the 8-cell CCL and 1bl in the 10 cell CCL. This provides sufficient space for electromagnetic quadrupoles and diagnostics at all energies. All the coupled cavity structures use an even number of cells per segment so that all the coupling cells will be on the same side of the structure in order to simplify the mechanical design. Similarly, all intersegment spacings are even multiples of $bl/2$ so that the major coupling cavities are on-axis to simplify the mechanical design. Peak structure power loss in the CCL is 73.9 MW. The longest RF module in the linac is XXX m.

The preferred site for the SNS linac is the Chestnut Ridge site at ORNL. Due to the geology of the area, settlement of the building site has been a concern.

* Work supported by the Office of Science¹, Basic Energy Sciences, of the U.S. Department of Energy; and the Oak Ridge National Laboratory.

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¹ Design Manual for the Spallation Neutron Source Project, draft June 1998,
<http://www.ornl.gov/~nsns/ProjectInformation/DesignManual/DesignManual.html>