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WATER-COOLED BEAM LINE COMPONENTS AT LAMPF*

D. L. Grisham and J. E. Lambert
Los Alamos National Laboratory, Los Alamos, NM 87545

Summary

The beam line components that comprise the main experimental line at the Clinton P. Anderson Meson Physics Facility (LAMPF) have been operating since February 1976. This paper will define the functions of the primary water-cooled elements, their design evolution, and our operating experience to the present time.

Introduction

The proper operation of a high-power experimental facility, such as Line A at LAMPF, depends on suitable design of the many components that comprise that system. Line A consists of water-cooled target boxes, collimators, and either water-cooled or radiatively cooled targets in three target stations. In addition, a water-cooled vacuum window at the end of the line and a water-cooled beam stop are also required. This paper will deal with the design and operating experience of these water-cooled components. The targets are addressed in separate papers.[1,2]

Beam Stop

The Line A beam stop (Fig. 1) consists of an Inconel 718 front window followed by 29 OFHC copper plates with water-cooling passages between each plate. The copper plates are contained in a stainless steel tube that contains water distribution manifolds. The thickness of the copper plates was determined by limiting the maximum copper temperature to 475 K. The maximum heating rate at ~0.1 m from the front face is ~2000 kW/m.[3] The original beam stop was in use from February 1976 to November 1980, at which time it was replaced by one of an identical design. The original stop received 4.67×10^6 μA-h without obvious damage or loss of function.

Beam Line Windows

Originally, the beam line end window upstream of the beam stop (Fig. 2) consisted of two 0.0038-m-thick stainless steel foils with helium passing between them for cooling. Although the foil window could be used up to about 0.5 mA, as shown in Fig. 3, LAMPF chose to replace it late in 1976 with the water-cooled design shown in Fig. 4. As a result of an undetected manufacturing defect, the original window was replaced by a more carefully manufactured version in late 1977. It was just replaced (early 1981) as a preventative maintenance measure. The temperatures at 0.75 mA are moderate (Fig. 5).

Beam Line Collimators

A water-cooled collimator is installed at LAMPF downstream of each target to limit the beam diameter and to protect the downstream components from both excessive heat deposition and activation. Figure 6 illustrates the construction of typical water-cooled collimators. The original collimators of this design have been in service since early 1976, with no failures to date.

Water-Cooled Vacuum Chambers

Table I illustrates the evolution of vacuum chambers in Line A from 1972 to the present time. The maximum heat depositions and the temperature range were calculated for a 0.0127-m-thick plate with cooling tubes on 0.0508-m centers, minimum water flows, and with the maximum temperature limited to 475 K. Since heating rates in the Line A chambers range up to $\sim 2 \times 10^6$ W/m^2, thinner plates, maximum water flows, and higher allowable temperatures are all required.

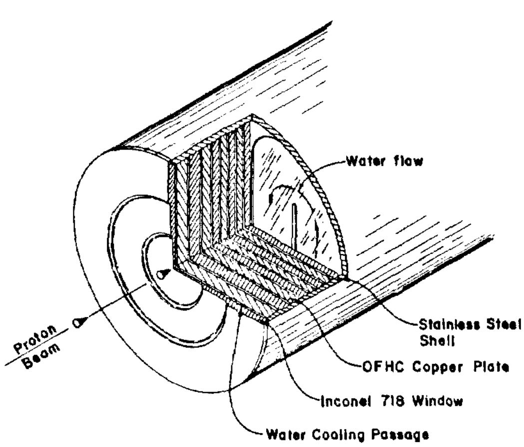

Fig. 1. Beam stop.

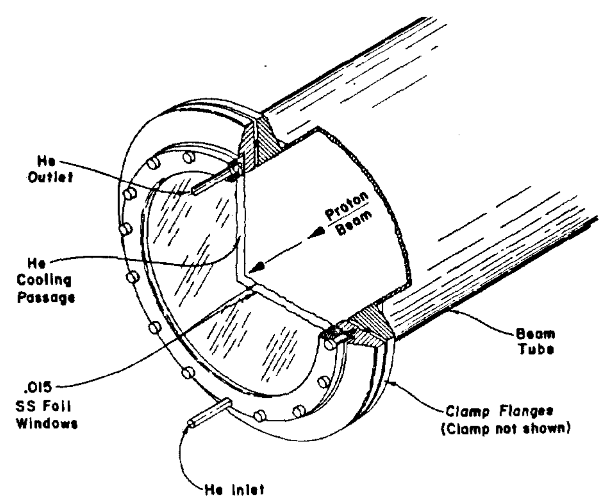

Fig. 2. Beam line foil window.

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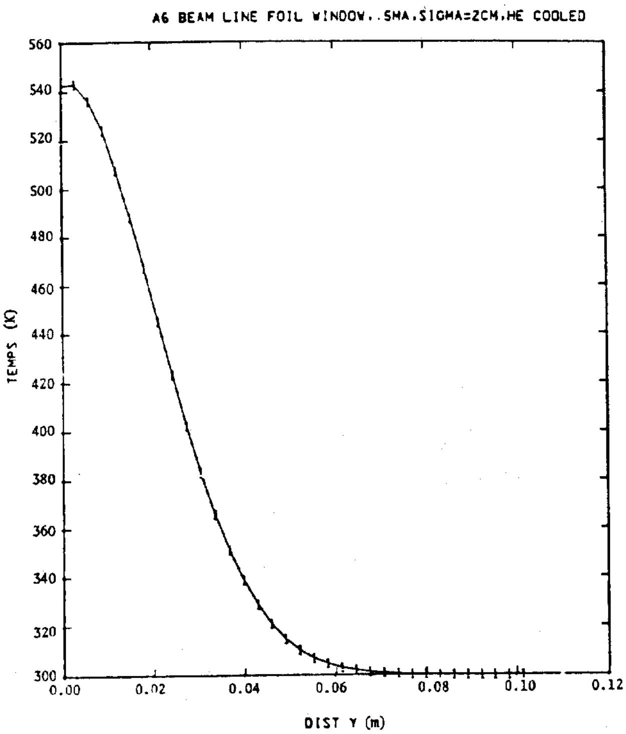


Fig. 3. Temperature distribution of helium-cooled foil window.

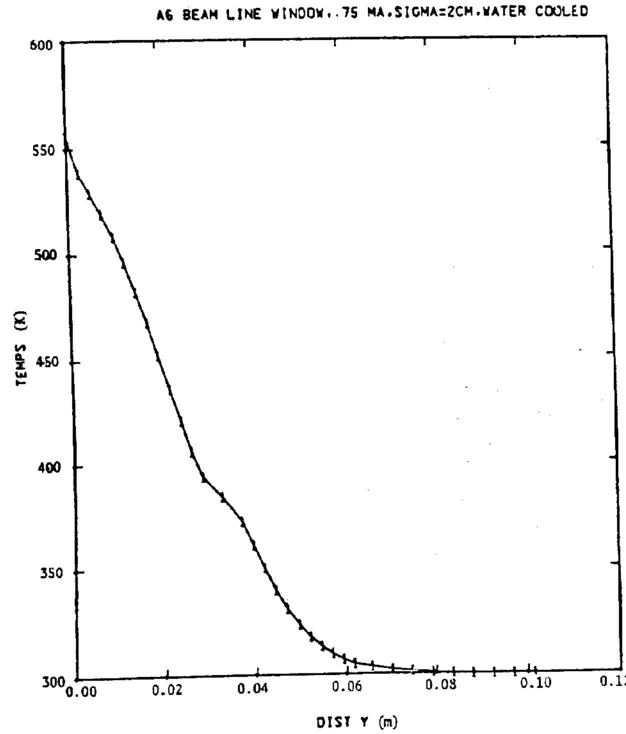


Fig. 5. Temperature distribution of water-cooled beam line window.

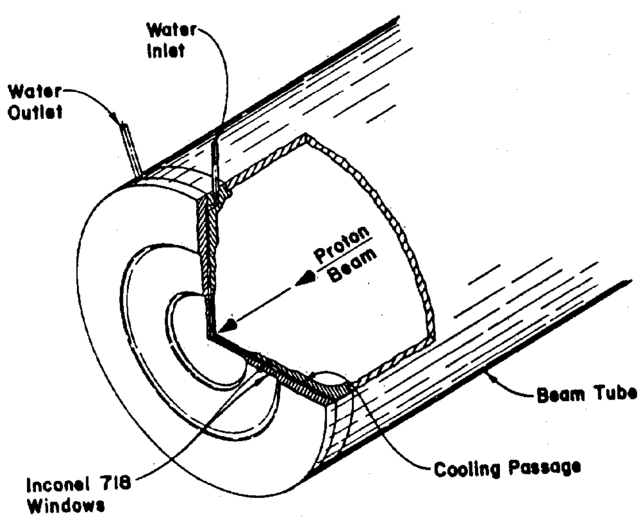


Fig. 4. Water-cooled beam line window.

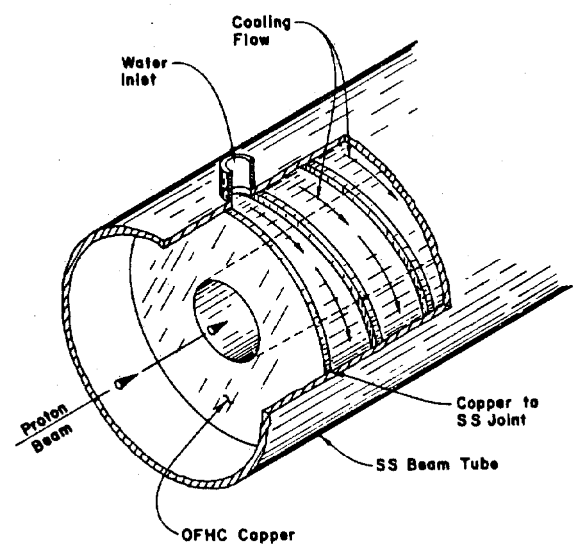
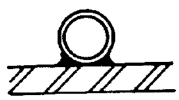
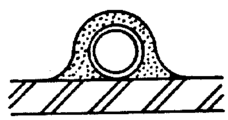
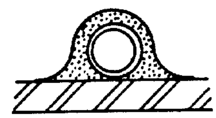
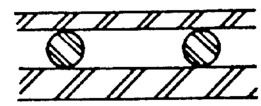


Fig. 6. Beam line collimator.

TABLE I

EVOLUTION OF WATER-COOLED VACUUM CHAMBERS

Basic Fabrication Method	Copper tubes brazed (furnace or torch) to stainless steel chambers.	Copper tubes Tungsten Inert Gas/Heliarc (TIG) welded to stainless steel chambers, flame sprayed with copper.	Stainless steel tubes TIG welded to stainless steel chambers, flame sprayed with copper.	Water-cooled double-wall stainless steel chambers.
Illustration				
Maximum Heat Deposition	6×10^4 W/m^2	1×10^5 W/m^2	1×10^5 W/m^2	3×10^5 W/m^2
Temperature Distribution	420-480 K	415-480 K	415-480 K	Uniform at 470 K.
Advantages	-Low cost.	-Medium cost (~2 X Method 1). -Welding and flame spraying easier technique than torch brazing.	-Medium cost (~2 X Method 1). -Welding less skilled than Method 2. -Erosion and corrosion problems essentially eliminated.	-Optimizes heat transfer to coolant. -Erosion and corrosion problems eliminated.
Disadvantages	-Small heat transfer area (~1/2 tube diameter). -Requires large furnace for large chambers. -Requires high operator skill for torch brazing.	-Cracks in area of TIG weld cause water leaks. -Erosion and corrosion problems with copper tubes and joint brazing. -Increased heat transfer area (1 to 1-1/2 tube diameters.	-Heat transfer only equivalent to Method 2.	-Highest cost (3 to 7 X Method 1), depending on geometry.
Era	1972-1973	1974-1976	1978	1980-1981

Conclusion

The designs of LAMPF's water-cooled components have gone through a period of evolution since the first designs in 1972. We are now confident that the present designs are adequate for long life and reliable operation at the LAMPF design levels.

References

1. L. Agnew, T. S. Baldwin, D. L. Grisham, R. C. Holmberg, J. E. Lambert, L. O. Lindquist, R. D. Reiswig, and L. L. Thorn, "Graphite Targets for Use in High Intensity Beams at LAMPF," Particle Accelerator Conference, Accelerator Engineering and Technology, San Francisco, CA (March 1979).

2. R. D. Brown and D. L. Grisham, "Design and Operation, Water-Cooled Pyrolytic Graphite Targets at LAMPF," 1981 Particle Accelerator Conference, Accelerator Engineering and Technology, Washington, D. C. (March 1981).

3. J. B. Donahue, "Power Deposition of LAMPF Proton Beam in Various Materials," Los Alamos National Laboratory Group MP-7 technical note MP-7-TN-14 (August 1980).