LONG REMOVABLE CRYOGENIC TRANSFER LINES*

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Summary

Easily removable cryogenic transfer lines of lengths up to 63 feet have been successfully constructed and operated at the National Superconducting Cyclotron Laboratory. For the initial testing phase of the K-800 superconducting magnet, temporary lines which span a rather long distance between coil cryostat and a helium refrigerator were built. Eventually, a low heat load cryogenic distribution system will be constructed. The differential contraction between the cold inner pipe and ambient temperature outside vacuum jacket presents design problems for stainless steel bayonet transfer lines. The traditional solution to the contraction problems, contraction loops or bellows, usually results in a fixed line. Using the alloy Invar 36, which has a contraction coefficient ~ 1/8 of stainless steel, simple bayonet type transfer lines have been built. A lifting fixture is used for line installation.

Introduction

The various technological problems concerning the transport of liquid helium over long distances is now well known[1]. One of the problems is the thermal contraction of the inside piping of the transfer lines. For example, a liquid helium transfer line made of stainless steel, a material of common choice, has an approximate contraction of 1 inch per 30 foot of line length. The engineering solution to this contraction problem is loops or bellows and this usually results in a fixed line. Recently short transfer lines made of an iron-nickel alloy, Invar 36, have become commercially available[2]. The Invar 36[3] has a contraction coefficient approximately 1/8 of stainless steel and thereby allows the building of long length transfer lines before encountering severe contraction problems.

At Michigan State University, a large superconducting cyclotron[4] (K800) is now under construction and the need to temporarily connect the superconducting magnet coil to the liquid helium refrigerator required the construction of three long transfer lines (~60 ft.). In the following section the construction and operation of these easily removable Invar 36 transfer lines is reported.

Transfer Line Design and Construction

A schematic drawing of the liquid helium transfer line is shown in Fig. 1. The line is a simple "U" tube design and the standard methods of cryogenic construction techniques were used. The inside pipe is Invar 36, and the outside vacuum jacket is stainless steel. Standard stainless steel fittings were used at the 90° elbows, valves and bayonet ends. The high carbon content of Invar relative to stainless steel necessitated special precautions during welding. The steps of making short welds and continuous flow of argon gas passing over the weld area help maintain the temperature below the point where carbon would precipitate out of the steel and make the weld area brittle. Invar filler rod was used in both Invar to Invar and Invar to stainless steel weld joints. Failed joints, in general, could only be repaired by replacing the entire weld. The liquid helium carrying inner tube is wrapped with super insulation and at approximately 4 ft. intervals is supported with G10 spacers that make point contact with the outer room temperature vacuum jacket pipe. The spacing at the corners of the line provide room for the required thermal contraction of the inner line. The Invar 36 tube was constructed by seam welding rolled strips. One 20 ft. section out of ten leaked, thereby necessitating a pretesting program on the tubing.

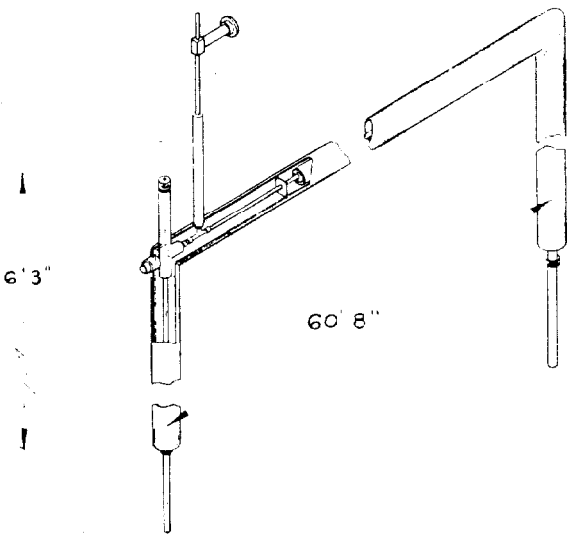

Fig. 1 A schematic drawing of a liquid helium transfer line is shown. The inner pipe diameter is 1/2 inch. The line length is ~ 60 feet and its weight is ~ 500 lbs. This line used standard "U" tube cryogenic line technology in its construction.

To avoid a large thermal pulse into the magnet cryostat, when first cooling the liquid helium transfer line, a bleed valve was added at the cryostat end. The gas from the transfer line is then initially returned through the bleed-line until liquid condensates from the surrounding air forms on it.

Line Installation

Figure 2 is a picture of the liquid helium transfer line as it is being installed. A special aluminum I beam lifting fixture was designed to pick up the 500 lb. line. It provides multiple support points to avoid stresses on the line due to its own weight. The line is easily installed in less than 15 minutes, where several people at each bayonet guide the line into position and purge the line with helium gas before completing the bayonet connection. The installed line is supported at two intermediate points. The line and the lifting fixture can be stored on racks attached to the experimental high bay wall.

Conclusion

We have found that the Invar 36 transfer lines

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satisfactorily solved the thermal contraction problem and make excellent long transfer lines. We plan to incorporate Invar 36 extensively in the cryogen distribution system designed for the Michigan State University Superconducting Cyclotron.

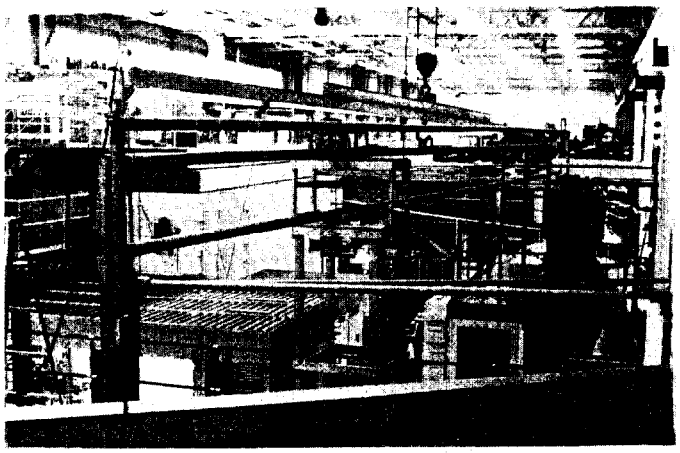

Fig. 2 A photograph showing the three Invar 36 transfer lines and the aluminium I beam lifting fixture (upper photo). The lines can be installed in approximately 15 minutes. The lines are stored on racks attached to the experimental high bay wall (far upper right).

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References

1. P.D. Brindza, D.E. Richied, and C.H. Rode; IEEE Trans. Nucl. Sci.,NS-26,No.3,4102(1979).
2. Design News,22(1982).
3. Carpenter Technology Corporation, Carpenter Steel Division, Invar 36 Technical Data.
4. P.S. Miller, Tenth International Conf. on Cyclotrons and their Application, IEEE Conf. Notes,11(1984).