DØ SOLENOID UPGRADE PROJECT

DØ Solenoid Current Leads

D-ZERO ENGINEERING NOTE # 3823.111 EN-350

Oct. 4, 1993

Russ Rucinski
RD/D-Zero Mechanical Group

INTRODUCTION

This engineering note documents information gathered and design decisions made regarding the vapor cooled current leads for the D-Zero Solenoid.

GENERAL

The decision was made during design group meetings that the D-Zero Solenoid, rated at 4825 amps, should use vapor cooled current leads rated at 6000 amps. CDF uses 6000 amp leads from American Magnetics Inc. (AMI) and has two spares in their storage lockers. Because of the spares situation and AMI's reputation, AMI would be the natural choice of vendor.

A quotation from AMI (4/20/93) put the cost of a pair of the leads at \$3550.00.

HELIUM CONSUMPTION

The manufacturer's listed helium consumption is 19.2 liters/hr. From experience with these types of leads, more stable operation is achieved at an increased gas flow. See attached E-Mail message from RLS. We have decided to list the design flow rate at 28.8 liquid liters/hr in the design report. This corresponds to CDF's operating point.

A question was raised regarding how long the current leads could last at full current should the vapor cooling flow was stopped. This issue was discussed with Scott Smith from AMI. See the attached E-Mail message from Rucinski for the answer. We do not feel that there is a problem for this failure scenario.

PENETRATION THRU CONTROL DEWAR

The penetration of the leads out the top of the control dewar is planned to be the same design as the Fermilab Tevatron leads box. A copy of a portion of the drawing (1650-ME-167080 sht. 1 of 3) showing this area is attached. A full set of detail prints can be arrived at by referencing this drawing and the "SAVER CRYOGENICS SYSTEM GROUP PARTS LIST" for the this assembly drawing.

Early in the design an open neck penetration was considered. It was put aside because the saver sleeved type penetration was felt to have less heat leak. For archive purposes only, a sketch of that arrangement (with 5000 amp lead size) and a quote from AMI for this type of penetration is attached to this note.

AMERICAN MAGNETICS, INC.

P.O. Box 2509, 112 Flint Road, Oak Ridge, TN 37831-2509
Phone: (615) 482-1056 Fax: (615) 482-5472 Telex: 557-592

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QUOTATION

Address: Fermi National Laboratory
PO Box 500
Mail Stop 357
Batavia, IL 60510

Date: April 20, 1993

Quotation No.: 930420-10552

Reference:

Attention: Dr. Russ Rucinski

Page: 1 of 1

ITEM	QUAN.	DESCRIPTION	UNIT PRICE	TOTAL
1	1 Pr.	L-6000 Amp Vapor Cooled Current Lead Assembly	\$3,550.00	\$3,550.00

AMI 6,000 amp. vapor cooled current leads transfer current from a 300K room temperature environment to 4.2K helium. The heat capacity of helium vapor is used in these counterflow leads to minimize the liquid helium consumption. The 6,000 amp current leads will be provided with a 19.5 inch active cooling length and a 0.5 inch diameter stainless steel tube fittings for helium gas recovery.

Warranty

All products manufactured by AMI are warranted to be free of defects in materials and workmanship and to perform as specified for a period of one year from date of shipment. In the event of failure occurring during normal use, AMI, at its option, will repair or replace all products or components that fail under warranty, and such repair or replacement shall constitute a fulfillment of all AMI liabilities with respect to its products. Since, however, AMI does not have control over the installation conditions or the use to which its products are put, no warranty can be made of fitness for a particular purpose, and AMI cannot be liable for special or consequential damages. All warranty repairs are F.O.B. Oak Ridge, Tennessee, USA.

Prices offered are firm for a period of 60 days from this date 04/20/93

Delivery: 30 days after receipt of order.

Terms: Net 30 days

FOB: Oak Ridge, TN

Very truly yours,

AMERICAN MAGNETICS, INC.

Scott T. Smith - Director, Marketing and Sales

Vapor Cooled Current Leads

Vapor Cooled Current Lead and Bus

AMI vapor cooled current leads are the industry standard for introducing high currents into liquid helium. State-of-the-art techniques provide the most efficient way to transfer high currents from 300K to 4.2K. Standard and custom designs from 25 amperes to 75,000 amperes have been built and used.

The heat capacity of helium vapor is used in these counterflow leads to minimize the liquid helium consumption for a specified operating current. Leads of this type have been shown to evaporate 2.8×10^{-3} liters per hour per ampere for each lead pair when operated at the design current* (40% less at zero current). AMI leads are expected to provide this performance under normal conditions, however a more conservative value of 3.2×10^{-3} liters per hour per ampere is recommended for system design calculations. A voltage drop of less than 0.2 volts per lead pair at the rated current is typical. A pressure difference of approximately 2 mm of mercury (0.03 psi) is developed through the leads at the rated current.

Break-away vapor cooled current leads are available for a majority of amperage ratings and represent a popular configuration for persistent magnet operation. Break-away leads are supplied in two sections so that the upper section can be detached from the lower section during persistent magnet operation. Helium consumption is significantly reduced because current lead thermal paths are eliminated. Automatic lead retractors can be incorporated for automation and control of the break-away lead configuration.

AMI can provide custom vapor cooled current leads for many combinations of current ratings, sizes, lengths, and mounting configurations. An AMI Technical Sales Representative is available to help you define your current lead requirements.

Measured Performance*

*Ref: K.R. Efferson, *Rev. Sci. Instr.* 38, 1776 (1967).

Vapor Cooled Current Leads

Model Number		L-50	L-75	L-100	L-150	L-200	L-250	L-500	L-1000	L-2000	L-3000	L-5000	L-10000
Amperes		50	75	100	150	200	250	500	1000	2000	3000	5000	10000
~ Helium consumption, liters/hr. (pair of leads)		0.16	0.24	0.32	0.48	0.64	0.80	1.6	3.2	6.4	9.6	16.0	32.0
Type (see figures above)		A	A	A	A	A	A	A	B	B	B	B	B
Dimensions (inches)	A	1/4	1/4	1/4	1/4	3/8	3/8	1/2	1/2	1/2	1/2	3/4	3/4
	B	1-1/2	1-1/2	1-1/2	1-1/2	2	2	3	3	3	3-3/4	4-1/2	7
	C	1	1	1	1	1-1/4	1-1/4	1-1/2	2	2-1/2	3	3	3-1/2
	D								1	1	1-1/2	1-1/2	2
	E	9/32	9/32	9/32	9/32	9/32	9/32	9/16	9/32	7/16	7/16	7/16	7/16
	F	3/8	3/8	3/8	3/8	1/2	1/2	3/4	3/4	3/4	1	1	1 & 3
	G	3/8	3/8	3/8	3/8	1/2	1/2	1/2	7/8	1-1/8	1-1/4	1-1/2	2-1/2
	H	1/4	1/4	1/4	1/4	3/8	3/8	1/2	1/2	3/4	1	1	1-3/4
	I								2-1/4	2-1/2	2-5/8	3	3-3/4
	J								1-3/4	2	2-1/8	2-1/4	3-1/4
	K	1/4NPT	1/4NPT	1/4NPT	1/4NPT	3/8NPT	3/8NPT	1/2NPT	1	1-1/4	1-3/8	1-5/8	—
	L	7/8	7/8	7/8	7/8	1	1	1-3/16	5/8	5/8	5/8	5/8	3/8
	M	9/16	9/16	9/16	9/16	9/16	9/16	3/4	3/8	3/8	3/8	3/8	—
	N								9/32	9/32	9/32	9/32	9/32
	O	1/4	1/4	1/4	1/4	3/8	3/8	1/2	3/4	1	1-1/8	1-3/8	2-1/8
	P					0.201	0.201	0.201	9/32	13/32	17/32	17/32	3/8
	R	1	1	1	1	1	1	1	1-1/2	1-1/2	1-1/2	1-1/2	4
	S	1/18	1/16	1/16	1/16	1/8	1/8	1/8	1/4	1/4	1/4	1/4	3/8
	T					1/4	1/4	1/4	1/2	1/2	1/2	1/2	1 & 2-1/2
	U	16-5/8	16-5/8	16-5/8	16-5/8	16-5/8	16-5/8	17-1/2	19-1/2	19-1/2	19-1/2	19-1/2	26
	V	Adjust.	Adj.	Adj.	Adj.	Adj.	Adj.	Adj.	1-1/2	1-1/2	1-1/2	1-1/2	2-1/8
	W	1/4	1/4	1/4	1/4	3/8	3/8	1/2	3/4	1	1-1/8	1-3/8	2-1/8
	X												

DIMENSIONS SUBJECT TO CHANGE

AMERICAN MAGNETICS, INC.
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PROPRIETARY INFORMATION

HELIUM CONSUMPTION

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From: FNAL::RLS "RICH SCHMITT, X4849, P-467, MS-219" 5-MAR-1993 10:43:11.81
To: KREMPETZ, RPSMITH, FAST, RUCINSKI, SQUIRES, STEFANIK, SANDERS, CRYOENGINEER
CC: RLS
Subj: Power lead cooling measurements

For the 6000 amp leads used at CDF and CVM, AMI said they required 0.0014 liquid liters per amp-hour-lead. That was expected, not gaurenteed.

McInturff said these leads were marginally stable at 10.6 liters/hour at 5000 amps, compared to 7.0 expected.

At CVM the magnet current was 5000 amps and the total lead flow was 275 standard liters per minute. This converts to 23.6 liquid liters per hour for both. We marginal with refrigerator capacity at that location and ran the lead flow as low as we felt we could.

CDF is running at lower current now, but has the lead flow set up for 5000 amps. The lead flow is not directly controlled there, and Bruce reports that it runs about 1 gram/second, or 28.8 liquid liters/hour total.

From: FNALV::RUCINSKI 27-JUL-1993 16:04:24.93
To: RPSMITH
CC: RUCINSKI
Subj: AMI lead, no flow

Per Scott Smith from AMI,

If their 6000 amp lead carrying 6000 amps had flow stopped, There would be an average temperature rise in the lead of 100 K after 12 to 15 seconds. There would be an average temperature rise of 200 K in 20 seconds.

The average temperature rise of 200 K is close to where you begin to reach a critical temperature where damage could result (ie. solder melting etc.).

He said that running with less than the design current (4825 amps in our case) really extends the time it takes for the associated 200 K temperature rise.

Hopefully based on the above information you can conclude whether a slow or fast dump is required on sensing a no flow condition. I believe that we would know that there was a no flow condition very quickly <2 seconds. The response time on a typical flowmeter we might use (Matheson) is 0.50 seconds to 98% of full scale range. That signal would be read by the PLC and integrated for say 3 read passes at about 200 to 300 ms/pass after which time an action could be taken via output of the PLC.

Sincerely,

Russ

CC: Krempetz
Markley

VAPOR-COOLED LEAD

COPIED FROM 165D-ME-167080-
SHEET 1 of 3

FERMILAB +
ENGINEERING NOTE

SECTION +
RD/D-ZERO

PROJECT
DR. SOLENOID
UPGRADE

3823.111

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SUBJECT

CONTROL DEWAR

NAME

RUSS RUCINSKI

DATE

2/23/93

REVISION DATE

OLD VERSION

5/6/93 RAR

ARCHIVE
PURPOSES
ONLY.

RAR
10/18/93

APPROX VOLUME = 14 LITERS

* VENDOR TO DEFINE

ARCHIVE PURPOSES
ONLY.
RAR 10/16/93

AMERICAN MAGNETICS, INC.
DESCRIPTION	
		L-5000 Vapor Cooled Lead Assembly For Fermi Lab	
DATE	DRAWN BY	VERIFIED	
2-26-93	S. Smith		
SCALE	SIZE	DRAWING NO.	
NTS		Inq. No. 920226-10552	

AMERICAN MAGNETICS, INC.

P.O. Box 2509, 112 Flint Road, Oak Ridge, TN 37831-2509
 Phone: (615) 482-1056 Fax: (615) 482-5472 Telex: 557-592

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QUOTATION

Address: Fermi National Laboratory
 PO Box 500
 Mail Stop 357
 Batavia, IL 60510

Date: February 26, 1993

Quotation No.: 930226-10552

Attention: Dr. Russ Rucinski

Reference:

Page: 1 of 1

ITEM	QUAN.	DESCRIPTION	UNIT PRICE	TOTAL
1	1	L-5000 Amp Vapor Cooled Current Lead Assembly	\$4,960.00	\$4,960.00

AMI L-5,000 amp. vapor cooled current leads transfer current from a 300K room temperature environment to 4.2K helium. The heat capacity of helium vapor is used in these counterflow leads to minimize the liquid helium consumption. The 5,000 amp current leads will be provided with a 19.5 inch active cooling length and a 2.75 inch diameter knife edge flange fittings for helium gas recovery.

The leads will be mounted in a support assembly designed to reduce heat transferred to the liquid helium environment. The 8.5 inch diameter top assembly insulating plate is manufactured of 3/4 inch thick G-10 fiberglass with a bolt circle pattern designed to mate with the helium vessel. Copper radiation baffles with outside diameters of 6.375 inches, are attached to the vapor cooled leads to minimize thermal conduction and radiation heat transfer into the liquid helium. An electrical connector is provided for helium level sensor and instrumentation hook-up. Two helium level sensors are included with the assembly.

Warranty

All products manufactured by AMI are warranted to be free of defects in materials and workmanship and to perform as specified for a period of one year from date of shipment. In the event of failure occurring during normal use, AMI, at its option, will repair or replace all products or components that fail under warranty, and such repair or replacement shall constitute a fulfillment of all AMI liabilities with respect to its products. Since, however, AMI does not have control over the installation conditions or the use to which its products are put, no warranty can be made of fitness for a particular purpose, and AMI cannot be liable for special or consequential damages. All warranty repairs are F.O.B. Oak Ridge, Tennessee, USA.

ARCHIVE PURPOSE
ONLY.

RAR 10/18/93

Prices offered are firm for a period of 60 days from this date 02/26/93

Delivery: 30 days after receipt of order.

Terms: Net 30 days

FOB: Oak Ridge, TN

Very truly yours,

AMERICAN MAGNETICS, INC.

Scott T. Smith - Technical Sales Engineer