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ENGINEERING SPECIFICATION
INTERNAL CRYOSTAT COAX CABLE

APPROVALS

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TABLE OF CONTENTS

1. Introduction 1
    1.1 List Of Assemblies 1
        1.1.1 Immediate Purchase 1
        1.1.2 Option To Purchase In FY 1988 1
        1.1.3 Option To Purchase In FY 1989 1
        1.1.4 Option To Purchase In FY 1989 2
    1.2 Environmental 3
2. Cable 3
    2.1 Type Of Cable 3
    2.2 Conductor 4
    2.3 Primary Insulation 4
    2.4 Shield 4
    2.5 Cable size 4
    2.6 Jacket 4
    2.7 Ribbon Construction 4
    2.8 Material Traceability 5
3. Termination 5
    3.1 Connectors 5
    3.2 Soldering 6
    3.3 Strain Relief 6
    3.4 Labelling 7
4. Testing 7
    4.1 Electrical 7
        4.1.1 Electrical characteristics 7
        4.1.2 Electrical Tests 8
    4.2 Mechanical 8
        4.2.1 Mechanical Tests 8
    4.3 Environmental 9
        4.3.1 Temperature Cycling Tests 9
5. Approval Of Production Samples 10
Appendix 1 - Problem Materials For Argon Purity 11
Appendix 2 - Additional soldering specifications Based on MIL-S-45743E 12
    A2.1 Certification Of Personnel 12
        A2.1.1 Inspector 12
        A2.1.2 Operator 12
    A2.2 Tools And Equipment 12
        A2.2.1 Holding Tools 12
    A2.3 Workmanship 12
    A2.4 Quality Conformance Inspection 12
        A2.4.1 One Hundred Inspection 12
    A2.5 Inspection Methods 13
        A2.5.1 Visual Inspection 13

1. INTRODUCTION

Fermilab wishes to purchase 2934 coax cable assemblies as listed below and detailed in the enclosed drawings # 3740.543-MB-255016 to 3740.543-MB-255018. Only part of the listed assemblies are for immediate delivery, the remainder being the subject of an option to purchase during FY1988 and FY1989. The lengths are not known but the average lengths are given and the bid should be quoted as a price per ft plus a price per termination.

1.1 List Of Assemblies

The assemblies are of two types. The first have single identical sockets on each end, while the second type consists of a socket on one end and two on the other. The split of cables between the two connectors occurs in two ways. Firstly for the 25 coax cable a split of cables 1-12 to one connector and 13-25 to the other and secondly for the 20 and 30 coax cables odd to one connector and even to the other.

The numbers in sections 1.1.1 and 1.1.2 include an allowance for spares and the destructive tests. Fermilab will detail the spare assemblies and those to be destructively tested prior to manufacture but an additional 6% has been added to the numbers. The appraisal of the bid prices will not include this 6%.

There will be a large variation in lengths for the cables listed below and the manufacturer should expect to fabricate to a detailed list to be issued prior to manufacture. The tolerance on lengths will be ± 0.5".

1.1.1 Immediate Purchase

Cable (Unit)	Connector End 1 (pins)	Connector End 2 (pins)		Number	Average Length (feet)
10	20	20		32	32
15	30	30		6	32
17	34	34		3	32
20	40	40		3	32
25	50	50		49	32
25	50	50		512	20
30	60	60		83	32
20	40	2*20	split odd-even	32	32
25	50	2*26	split 12-13	8	32
25	50	2*26	split 12-13	256	20
30	60	2*30	split odd-even	6	32
TOTAL				990	
+6%				1,049	

1.1.2 Option To Purchase In FY 1988

Cable (unit)	Connector End 1 (pins)	Connector End 2 (pins)		Number	Average Length (feet)
10	20	20		32	32
25	50	50		50	32
30	60	60		80	32
20	40	2*20	split odd-even	32	32
25	50	2*25	split 12-13	8	32
TOTAL				205	
+6%				217	

If taken up this option will be ordered at the same time as the cables for immediate purchase listed in the previous section.

1.1.3 Option To Purchase In FY 1989

Cable (unit)	Connector End 1 (pins)	Connector End 2 (pins)		Number	Average Length (feet)
10	20	20		128	26
15	30	30		128	26
17	34	34		64	26
20	40	40		128	26
25	50	50		320	26
30	60	60		448	26
20	40	2*20	split odd-even	128	26
30	60	2*30	split odd-even	128	26
Total				1,472	
+6%				1,560	

The vendor should give the cost and details of any improvement in delivery gained by ordering the materials for this option immediately.

1.1.4 Option To Purchase In FY 1989

Due to the large number of cable types Fermilab also wishes to obtain an option to purchase additional spares of a yet undefined length as detailed below. The vendor should quote a delivery for those spares from receipt of firm order and an indication of the minimum size of acceptable order.

Cable (Unit)	Connector End 1 (pins)	Connector End 2 (pins)		Number	Average Length (feet)
10	20	20		12	30
15	30	30		12	30
17	34	34		12	30
20	40	40		12	30
25	50	50		12	26
30	60	60		12	30
20	40	2*20	split odd-even	12	30
26	50	2*26	split 12-13	12	26
30	60	2*30	split odd-even	12	30
Total				108	

The vendor should give the cost and details of any improvement in delivery gained by ordering the materials for this option immediately.

1.2 Environmental

These cables will be used in the D0 Calorimeter under construction at Fermi National Accelerator Laboratory. The application is a moderately high radiation environment (10^6 Rads) and immersed in liquid Argon at a temperature of -183° Celsius (-297° Fahrenheit). During commissioning the cryostat will be raised to a temperature of 93° Celsius (200° Fahrenheit).

Argon purity is of paramount of importance. Appendix I lists chemicals that should be avoided in the manufacture of this cable. If in doubt, any chemicals used should be brought to the attention of Fermi National Accelerator Laboratory for approval. The prototype cables will be tested by Fermilab for any adverse effect on purity.

These assemblies will also be used in a cryostat that will be welded closed and only accessible with a minimum experimental downtime of 5 months therefore the reliability of these units is of prime importance.

2. CABLE

2.1 Type Of Cable

Ribbon cable consisting of 10, 15, 17, 20, 25 and 30 coax units. The design should reflect this wide range of cable widths and one option may be to make use of a woven cable.

2.2 Conductor

The central conductor must be tin or silver plated. The performance under flex at the termination is of prime importance so a AWG 28 or larger solid copper-chromium-cadmium alloy such as PD-135 may be advisable.

2.3 Primary insulation

The primary insulation must be TefZel or any other suitable radiation resistant polymer with good mechanical properties such as flexibility and not becoming brittle at the operating temperature. Foam insulation can not be used as the cables cannot then be effectively evacuated and behaves as an indefinite leak in the cryostat.

2.4 Shield

Tin or silver plated copper wire. The coverage should be 90% or more. A foil and drain wire shield is unacceptable due to its reduced effectiveness at high frequencies. A spiral wrap may be preferred due to the ease of termination.

2.5 Cable size

The maximum overall ribbon dimension for a 25 coax cable including any weave fiber, if used, is shown below in inches. The size should be scaled for the alternate cable widths.

2.6 Jacket

TefZel or any other suitable radiation resistant polymer with good mechanical properties such as flexibility, abrasion resistance and not becoming brittle at the operating temperature.

The ribbon cable must be color coded to identify coax cable number one. This color coding may be included in the weave.

2.7 Ribbon Construction

Should a woven approach be used the fibre must be man made and thought should be given to the issue of Argon purity.

2.8 Material Traceability

A document must accompany each delivered assembly detailing the material batches used in its construction. Details of the process operators, process stations and quality inspectors is desirable.

A simple visual inspection of the material should be carried out prior to use. One example is to visually inspect the quality of the shield and detect the presence of a spiral gap. This is made possible due to the transparent nature of Teflon. If in doubt a short sample of the material should be sent to Fermilab for approval.

3. TERMINATION

3.1 Connectors

The assemblies are of two types. The first have single identical sockets on each end, while the second type consists of a socket on one end and two on the other. The split of cables between the two connectors occurs in two ways.

Split Cables:-

25 coax cable.	A split of cables 1-12 to one connector and 13-25 to the other.
20 and 30 coax cables.	Odd to one connector and even to the other.

The cable is to be terminated at both ends by 0.1 inch center spacing sockets compatible with Mil-C-83503/7 and with the following specification:-

No polarization

Beryllium Copper contacts.

Gold plated ≥0.000030 inches over ≥0.000030 nickel or gold flash over ≥0.000007 inches Nickel Palladium.

To mate with 0.025"±.002" square or round pins

Current rating 1 Amp.

Insulation resistance ≥ 1×10^9 Ω at 500 vDC.

Connector insulation material glass reinforced thermoplastic, UL flammability rating 94 V-0.

Temperature rating -55 C to +105 C.

Details of the mating connectors will be given prior to manufacture and the vendor will be expected to ensure a correct mate to those units.

The connections must be soldered as tests show that unsoldered IDC terminations fail in the severe temperature environment.

3.2 Soldering

Signal(center) conductors must be soldered to odd pins.

Ground(outer) conductors soldered to even pins.

In a small number of the assemblies the above connections would be reversed. This will be detailed in drawings to be issued prior to manufacture.

Flux or flux remover on pin and socket connections leads to failures at low temperatures and great care must be used during any cleanup operations to avoid getting flux remover or devolved flux onto the sockets. The vendors attention is drawn to the issue of Argon purity and the list of problem chemicals given in Appendix 1. One suitable solvent for flux removal is Ethyl Alcohol.

The soldering operation should be carried out to MIL-STD-454 Req 5 with the additional requirements drawn from MIL-S-45743 as listed in Appendix 2.

Cable must exit the connector shell at the outer corner on the ODD-PIN side, making an angle of 25° ± 5° from perpendicular to pins (see Drawing # 3740.543-MB-255017). The cable order will require a small fraction of the cables with even-pin side exit.

Shell dimensions must match standard long (ie "strain-relief") lock-eject mechanism on the matching header (eg Amphenol 842-816-xx21-435, Ansley 612-xx43 or MIL-C-83503/21-xx). The maximum connector dimensions are 5/8 inch by 1/4 inch by 2-11/16 inch as shown in Drawing # 3740.543-MB-255017, but the primary concern is the correct mate to the specified header.

3.3 Strain Relief

The use of strain relief to meet the stringent flexibility requirements is believed to be essential. Vendors will be asked to illustrate their approach to this problem in their technical proposal and will be expected to produce physical samples at the time of any vendor visit.

Strain relief to pass the test as described in MIL-C-83503A Section 4.7.5 and 4.7.6. Due to the inflexible nature of coaxial cables it may be necessary to make use of epoxy potting or injection moulding to provide strain relief. The use of this type of connector for shielded cables may also necessitate the potting or injection moulding approach to prevent shorts between shields. The 25 exit angle is critical and must be 'jig' enforced during any potting operations.

Great care must be taken to prevent any potting or moulding compounds migrating into the sockets. A 100 % visual inspection of this is required.

3.4 Labelling

Each assembly should be given a unique identifier embossed on to the surface opposing the mating face of both connectors. No ink should be used in this process. This identifier will be 10 characters long and follow the format listed below:-

The details to be forwarded prior to manufacture.

Fermilab will also provide adhesive barcode labels for temporary attachment to the assemblies. The test results for each assembly and the material batch information should be referenced to this number.

4. TESTING

4.1 Electrical

4.1.1 Electrical characteristics

The cable should have a mean characteristic impedance of 30 ± 3Ω. The standard deviation across all cables should be less than 3% .

The velocity of propagation should be greater than 55% the speed of light. The standard deviation across all cables should be less than 5%.

The attenuation should be better than 2.2 dB / 100 ft at 1 MHz. The standard deviation across all cables should be less than 2% .

The capacitance per foot should not exceed 60 pF and a reduced figure would be advantageous. The standard deviation across all cables should be less than 2% .

The crosstalk between any two cables within an assembly with both cables terminated in their characteristic impedance must be suppressed by at least 60dB from 0 to 1 MHz and by at least 40dB from 1 to 10 MHz.

The D.C. resistance of the central conductor should not exceed 100Ω / 1000 feet. The shield resistance should be less than 30Ω / 1000 feet. The standard deviation across all cables should be less than 2% .

4.1.2 Electrical Tests

The vendor will carry out the following electrical tests on a 20ft ± 3in sample of each batch of single coaxial cable manufactured and every 10th reel received within a given batch. The batch will be considered to have changed with every change in central conductor, polymer or shield wire. A divergence of more than 2 standard deviations from the nominal should be cause to reject the batch. The samples should be sent to Fermi National Accelerator Laboratory with the results following the tests.

Characteristic Impedance

Velocity of propagation

Attenuation

The following test should be carried out on a random 5 adjacent coax pairs on a random 5% sample of the cable assemblies. The distribution of the lengths of the samples should match that of the order or be weighted towards the longer cables.

Crosstalk

4.2 Mechanical

4.2.1 Mechanical Tests

The following physical tests should be carried out on 1 % of the assemblies and the documented results and tested samples sent to Fermilab. Fermilab will identify the samples to be tested. All these tests to be carried out at ambient temperature.

The cable must pass the above electrical tests with a 150 Lb crushing load applied for a short duration to 3 inches of the cable assembly.

The cable must sustain at least 100 sharp bends (180° bend with 0.25 inch bend radius) in any location . The cable must pass the above electrical tests following this flex cycling.

The cable will be stressed in use so we require the cable to withstand 50 pounds linear stress for a short duration without loss of performance during or after the force is applied. The cable must pass the above electrical tests with this stress applied.

The termination must pass the following two Mil. Spec. tests:-

MIL-C-83503A 4.7.5 Cable Retention

MIL-C-83503A 4.7.10 Connector-Cable Flexing

The angle over which the cable is flexed should be 70° in both directions from the 25° exit angle of the cable.

4.3 Environmental

4.3.1 Temperature Cycling Tests

The vendor may provide separate pricing for the building of a facility to carry out the following test and should provide a price per cable to carry out that test. Fermi National Accelerator Laboratory can provide limited assistance with the design of the implementation of this procedure. The vendor may subcontract this test to a third party.

All cable terminations should be cycled 5 times between cooler than -190° Celsius (-321° Fahrenheit) and hotter than 93° Celsius (200° Fahrenheit). Liquid nitrogen is suggested as the means of providing the low temperature. The continuity and shorts test outlined below should be carried out each time the assemblies have reached both the low and high temperature equilibria.

Continuity and shorts to all other connectors. The continuity test to be carried out at greater than 10 V DC or greater than 500 mA and ensure the resistance is below 4 Ω for the signal path and 2 Ω for the return. The short test to be carried out at a minimum of 500 V DC and to test for an insulation resistance of greater than 1 MΩ.

5. APPROVAL OF PRODUCTION SAMPLES

Fermi National Accelerator Laboratory is prepared to test a single sample of the coax cable prior to weaving (if used) and termination. This will allow approval of the cable at an early stage.

Six weeks after the acceptance of the bid the vendor will provide two samples for Fermi National Accelerator Laboratory to test against the specification. Production of the remainder of the order should not continue until approval has been given, which will be done within 15 working days. Further samples will be provided for test if the first do not meet specifications and the vendor may include in the bid a price for these samples.

Two weeks after the above approval the vendor will provide Fermi National Accelerator Laboratory with the first 10 production assemblies for tests which will be completed within 30 working days. These will form part of the order quantity. Approval represents an acceptance of the cable and termination design.

Two weeks after each of the options for production has been taken up the vendor will provide Fermi National Accelerator Laboratory with the first 10 production assemblies for tests which will be completed within 30 working days. These will form part of the order quantity. Approval represents an acceptance of the cable and termination design.

APPENDIX 1 - PROBLEM MATERIALS FOR ARGON PURITY

Chlorinated and Fluorinated Solvents
Specifically 1,1,1-trichloroethane and
tetrachloroethylene as listed in MIL-STD-454
Fire retardant
Foamed materials
Freon
Kerosene
Natural Fibers
Silicon Rubber potting compounds (e.g. RTV)

APPENDIX 2 - ADDITIONAL SOLDERING SPECIFICATIONS BASED ON MIL-S-45743E

A2.1 Certification Of Personnel

A2.1.1 Inspector

Inspection to be carried out by Category D or better qualified personnel. The certification of Category D personnel to be carried out as detailed in the above Specification.

A2.1.2 Operator

Soldering operations to be carried out by Category E or better qualified personnel . The certification of Category E personnel to be carried out as detailed in the above Specification.

A2.2 Tools And Equipment

A2.2.1 Holding Tools

Tools, fixtures and materials used to hold or restrain wires and components shall be of a type which will not damage or deform wires, leads, wire insulation or components. If toothed clips are utilized, the jaws of the clips shall be plastic covered.

A2.3 Workmanship

The workmanship, utilized in accomplishment of the processes specified herein, shall be of a level of quality adequate to assure that the processed products shall meet the performance requirements of the applicable product drawings and specifications, relative to these processes. The solder connections shall have a smooth, bright appearance with metallic luster and shall not have a chalky, gritty or irregular surface, nor exhibit points (peaks), pits, scars, fractures, trapped flux, foreign materials or have holes which expose base metal (where the bottom is not visible, exposed metal will be assumed). The connections shall be completely covered by solder to the extent that no base metal is visible, including the copper ends of cut wire or leads. Solder spatter shall not exist on adjacent components or surfaces.

A2.4 Quality Conformance Inspection

A2.4.1 One Hundred Inspection

Each soldered connection and its associated wiring or leads shall be visually inspected to determine conformance to the requirements specified herein. Listed below are defects of particular interest.

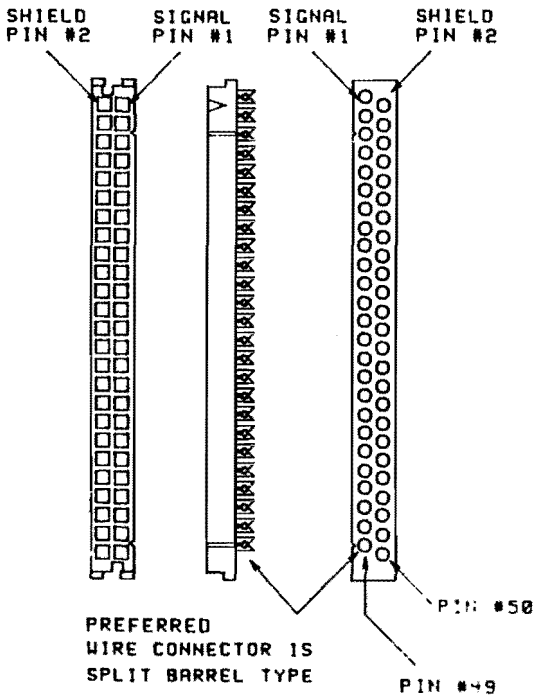
Solder spatter
Cold solder joint (This is of particular importance as cold soldered joints fail when temperature cycled)
Rosin joint
Incorrect insulation clearance
Damaged insulation
Damaged conductor
Excessive wicking
Solder points
Pits, scars or holes
Fractured solder connections
Insufficient solder
Dewetting

A2.5 Inspection Methods

A2.5.1 Visual Inspection

Visual inspection shall be performed using a minimum of 4 times magnification. Lighting shall equal or exceed 100 foot-candles (1077 lm/m^2).

REV.	DESCRIPTION	DRAWN / APPD.	DATE / DATE



50 POSITION
IDC CONNECTOR

ITEM	PART NUMBER	DESCRIPTION OR SIZE	QTY
PARTS LIST			

UNLESS OTHERWISE SPEC.	ORIGINATOR	M. JOHNSON	3/24/88
	DRAWN BY	W.R. SOUTH	3/31/88
	CHECKED BY		
	APPROVED BY		
	USED ON -		
	MATERIAL -		

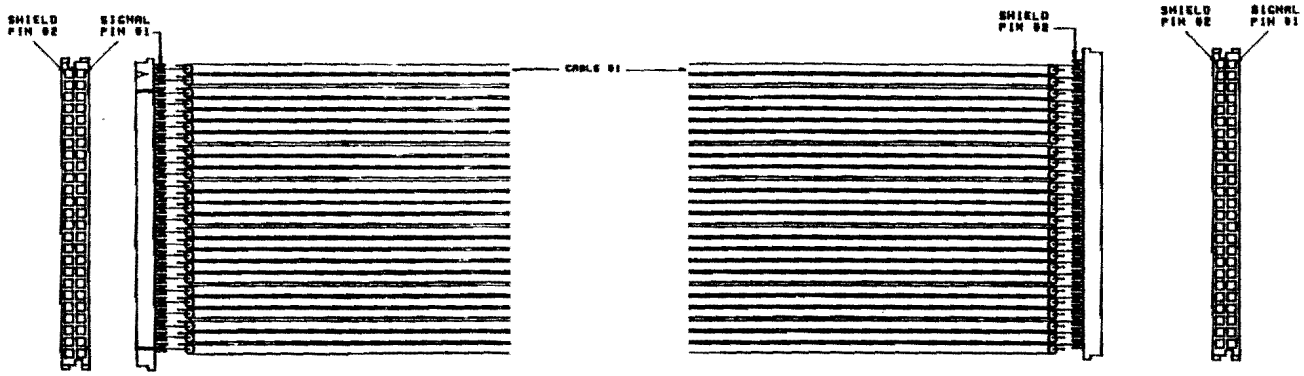
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

D0 EXPERIMENT

50 POSITION IDC CONNECTOR

SCALE	FILMED	DRAWING NUMBER	REV.
		3740.543-MB-255016	

REV.	DESCRIPTION	DRAWN	DATE
		APPD.	DATE



50 POSITION
IDC CONNECTOR

50 POSITION
IDC CONNECTOR

CABLE - DESIG.

CABLE NO.	SIGNAL PIN	GROUND PIN	SIGNAL CHANNEL
1	1	2	CH. 0
2	3	4	CH. 1
3	5	6	CH. 2
4	7	8	CH. 3
5	9	10	CH. 4
6	11	12	CH. 5
7	13	14	CH. 6
8	15	16	CH. 7
9	17	18	CH. 8
10	19	20	CH. 9
11	21	22	CH. 10
12	23	24	CH. 11
13	25	26	CH. 12
14	27	28	CH. 13
15	29	30	CH. 14
16	31	32	CH. 15
17	33	34	CH. 16
18	35	36	CH. 17
19	37	38	CH. 18
20	39	40	CH. 19
21	41	42	CH. 20
22	43	44	CH. 21
23	45	46	CH. 22
24	47	48	CH. 23
25	49	50	CH. 24

NOTES:

1. CABLE CHARACTERISTICS :
   CABLE O.D. 0.95 IN.
   IMPEDANCE 50 OHMS (NOM.)
   VEL. OF PROP. 0.82 (NOM)
2. CABLE 01 IS IDENTIFIED BY EITHER BY COLOR OR BY A COLORED WEAVE

ITEM	PART NUMBER	DESCRIPTION OR SIZE	QTY

PARTS LIST

UNLESS OTHERWISE SPEC.	ORIGINATOR	H. JOHNSON	4/04/88
FRACTIONS / DECIMALS / ANGLES	DRAWN BY	H.A. SOUTH	4/06/88
	CHECKED BY		
	APPROVED BY		
	USES ON -		
	MATERIAL -		

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

D0 EXPERIMENT

INTERNAL CRYOSTAT COAXIAL CABLES

SCALE	FILMED	DRAWING NUMBER	REV.
		3740.543-MB-25501B	

EXHIBIT C

Fermilab Subcontract General Provisions
(FL-1)

with

Addendum I to FL-1
(FL-30)

Clean Air and Water
(FL-24)

Sub-Subcontracting Plan Submitted in Accordance
with Public Law 95-507
(FL-54)

and

Small Business and Small Disadvantaged Business
Sub-Subcontracting Plan
(FL-55)