SUPERCONDUCTING
SUPER
COLLIDER

MATERIAL SPECIFICATION

NO. SSC-MAG-M-402

TITLE: NbTi SUPERCONDUCTOR CABLE
FOR SSC DIPOLE MAGNETS

ISSUE DATE 6-9-87
REV. NO. 1
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- PREPARED BY _____
R. Scanlan - LBL Supercon Material Development

- APPROVED BY _____
V. N. Karpenko - SSC Division Head, Magnet Division

REVISION RECORD

REVISION NO.	DATE	PAGE	SUBJECT	APPROVAL
1	8/17/87	2	Cable mid-thickness .0574 instead of .0584.	
		8	Add Fig. 1; change prior Fig.1 to Fig. 1a - see Appendix	
		8	Change pg.8 to pg. 9	
		2	Strand twist pitch in cable is 1.7 twists/inch	
		3	Maximum R_{295} for Outer Layer = 29.0	
		3	Maximum R_{10} for Inner Layer = 0.40 and for Outer Layer = 0.41	

1. Scope:

This specification establishes the requirements for the fabrication, inspection, test, identification and delivery of superconducting NbTi cable using SSC-MAG-M-401 superconducting wire.

1.1 Cable Definition

The final assembled cable is a flat (Rutherford) cable. It is composed of either 23 or 30 superconducting wires which are twisted around a hollow core during the cabling operation and then pressed into a keystoned shape. Each wire is a multifilamentary conductor with requirements described in an accompanying specification. Cable types are classified as follows:

Type 402 I - 23 wires (Inner)
Type 402 O - 30 wires (Outer)

2. Applicable Documents

The following documents of the issue in effect on the date of invitation for bids form a part of this specification to the extent specified herein:

SSC-MAG-M-401	-	Specification NbTi Superconducting Wire for SSC Dipole Magnets.
SSC-TBD	-	Wire and Cable Data System
TBD	-	Ebanol
TBD	-	Cleaning Solvent
MIL-C-12000	-	Packaging for Shipment

3. Requirements

3.1 Received SSC 401 Wire

3.1.1 Direct Shipment - SSC 401 wire shipped directly from the wire manufacturer to the cable fabricator shall be inspected and tested upon receipt by the fabricator for the following SSC-MAG-M-401 Table I characteristics.

Ref. SSC-MAG-M-401 - Table I

Examination or Test

1. Critical current
3. Copper to noncopper ratio
4. Wire Diameter
6. Surface condition
7. Sharp bend test
8. Springback test
9. Twist pitch
10. Annealing

3.1.2 Buyer Furnished SSC 401 Wire - Buyer furnished wire shall be checked for damage, condition, and identification before release for cable fabrication.

3.1.3 Material Handling - Wire awaiting cable fabrication shall be identified, protected, and handled in a manner to prevent degradation or damage.

3.2 Technical Requirements

3.2.1 Cable Dimensional Requirements - Cable dimension requirements are defined in Table I.

Table I - Cable Dimensional Requirements

Requirement	Inner	Outer
Cable mid-thickness	.0574 ± .00025"	.0459 ± .00025"
Cable width	.366 ± .001"	.383 ± .001"
Keystone angle	1.6 ± .1°	1.2 ± .1°
Cable lay pitch	3.1 ± .2"	2.9 ± .2"
Cable lay direction	Left	Left
Strand twist pitch in cable	1.7 twists/inch	1.7 twists/inch

3.2.2 Cable Electrical Requirements - Cable electrical properties are defined in Table II.

Table II - Cable Electrical Requirements

Requirement	Inner Layer	Outer Layer
Minimum Critical Current at 5.6 T[1]	N.A.	7860 A
Minimum Critical Current at 7 T[1]	7167 A	N.A.
Maximum R (295K) (micro-ohms/cm)[2] of finished cable	26.5	26.0
Maximum R (10K) (micro-ohms/cm)[2] of finished cable	0.40	0.41

(1) The minimum critical current is measured with applied magnetic field perpendicular to wide surface of the cable (measured at 4.222 K and 1×10^{-14} ohm m effective resistivity across the entire cross section.

(2) The RRR for finished cable is defined by the values of R_{295} and R_{10} given in Table I. The target values for RRR as given there are greater than 66 for the inner and 70 outer layer cables.

3.3 Processing Requirements

3.3.1 Identification - Each piece of wire (strand) and cable in the cable fabrication process shall be identified by a unique code number. Wire identification shall be traceable to the wire manufacturer's lot number as defined in SSC-QA-4. In process wire identification shall be traceable to the final cable serial number. All cable fabrication material, processing, inspection, tests, and delivery records shall be retrievable to either wire or cable code numbers.

a) Strand Map: The seller shall supply a strand map giving the serial numbers of the strands used in the cable manufacturing and the locations of any cold welds (Ref. #3.5.2). The minimum acceptable lengths of cable are 2210 ft. for outer layer cable and 1775 ft. for inner layer cable. A maximum of two lengths may be placed on each spool.

b) Tracer Wire: A tracer wire will be used in fabricating the cable. This wire shall be the same as the other superconductor wires used in the fabrication of the cable, but will be coated with Ebanol or Stabrite solder in accordance with its manufacturer's instruction for identification traceability to wire/billet sources.

3.3.2 Cable Welds - The seller may use cold welds during the manufacture of the cable. No single strand can have two cold welds within a distance of 100 ft., and there will not be any welds in the cable closer than 100 ft.

3.3.3 Cable Surface Condition - The cable surface must be thoroughly clean and free from oil, metallic particles or residue. Cleaning solvents shall be in accordance with cable drawing requirements. The cable must be free of roughness, sharp edges or burrs. The cable surface shall be uniform to within 25% of a single wire diameter. This measure refers to a cable laying on a flat surface without tension applied to the cable. There can be no crossovers of strands in the cable. The cable shall not have excessive twist. The twist is measured by suspending a 30 lb. weight from a 3 ft. length of cable. The maximum twist under these conditions is 90° in the direction of the cable lay and 0° in the direction opposite to the cable lay.

3.4 Inspection and Test Requirements - The seller is responsible for the performance of the inspections and tests defined in Table III and the preparation and maintenance of resultant data. A copy of applicable test results shall accompany each shipment identifiable to the cable serial number.

3.4.1 Nonconforming Material - Finished cable failing to meet the requirements of Table III shall be identified by condition and segregated from conforming material. Material shall remain on hold pending buyer notification and disposition.

Table III - Finished Cable Acceptance Inspection/Test

Characteristic	Requirement Value(3)	Test Specimen Sample(1)	Frequency	Test Method(1)
1. Cable Thickness	Table I	TM-402-1(2)(4)	Each 100 ft.	TM-402-1
2. Cable Width	Table I	TM-402-1(4)	Each 100 ft.	TM-402-1
3. Keystone Angle	Table I	TM-402-1(4)	Each 100 ft.	TM-402-1
4. Cable Lay Pitch	Table I	TM-402-2	Beginning/end of each cable length	TM-402-2

(continued)

Table III - (continued)
Finished Cable Acceptance Inspection/Test

Characteristic	Requirement Value	Test Specimen Sample(1)	Frequency	Test Method(1)
5. Cable Lay Direction	Table I	TM-402-3	Beginning/end of each cable length	TM-402-3
6. Cable Strand Twist Pitch	Table I	Etched 3" piece	Beginning/end of each cable length	TM-402-4
7. Bend Strength	No visible cracks	TM-402-5	Beginning and end of each continuous length	TM-402-5
8. Insulation Damage Test	No visible damage	TM-402-6	Beginning and end of each continuous length	TM-402-6
9. Weld Tensile Strength	50% of wire tensile strength	TM 402-7	Proof test 1 weld per length	TM-402-7
10. Surface Condition	#3.5.3	100%	100%	Visual

(1) Test methods are included in Appendix A.

(2) Refer to #5.4 for location, size, and identification of test specimens to be submitted for buyer inspection and test.

(3) Reference Figure 1.

(4) The cable measuring machine shall be used as described in TM-402-1 for the noted tests. Acquistion or use of the CMM shall be as specified in the applicable P.O. or contract.

4. Quality Assurance Provisions

4.1 Quality Plan - The seller shall provide the buyer, within 30 days of receipt of an order referencing this specification, a documented description of the quality controls to be implemented to assure compliance with the requirements of this specification and the P.O. The sellers quality plan shall be considered acceptable until disapproved in writing by the buyer.

4.2 Sampling - Where the seller proposes to use sampling in lieu of 100% inspection or test, it shall be in accordance with the requirements of MIL-STD-105.

4.3 Certificate of Compliance - The seller shall provide a written statement certifying compliance with the requirements of the applicable P.O. and this specification with each product shipment, together with a completed copy of test result data.

5. Preparation for Delivery

5.1 Packaging - Spool of cable shall be packaged in accordance with the requirements of MIL-C-12000 appropriate to assure adequate protection during shipment.

5.2 Reels/Spools - The cable must be spooled with a radius larger than or equal to 12 inches. The spools must be constructed to prevent damage to the cable during spooling and unspooling. The spools shall be boxed or strapped to a pallet to prevent damage in shipment. They should be stacked and shipped with the spool flanges maintained in a vertical orientation in order to prevent the cable from settling on the spool.

5.3 Winding Requirements - The cable must be wound so there are no crossovers of the cable windings. A sheet of plastic or paper will be placed between cable layers to prevent penetration of one layer into another. Filler cord shall be used at the edges of the cable layers as required so the cable will lie flat. The cable will be wound onto a spool in the following manner, with the observer looking down onto the spool and with the cable being wound in the horizontal plane:

5.3.1 The spool rotation direction for winding the cable onto the spool shall be counterclockwise.

5.3.2 The cable top or thick keystone edge will be up (facing the observer looking down).

5.3.3 A maximum of two lengths may be placed on each spool.

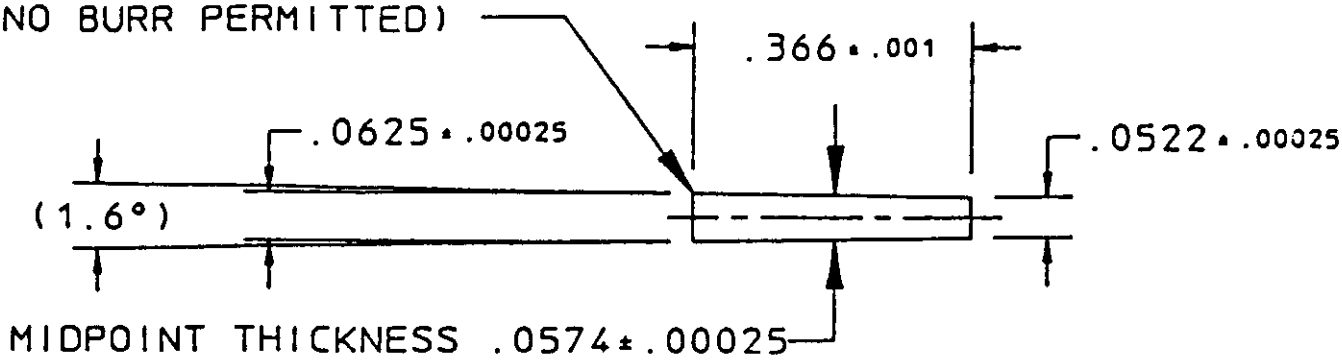
5.4 Preshipment Test Specimen Submittal - The vendor shall deliver to the buyer 15 ft. long samples of cable from one end of every continuous length of cable. Each sample must be adjacent to one used by the vendor to measure the cable mechanical properties. Sample identification shall include "preshipment test specimen" and the data required by #5.5. These samples shall be marked with their serial numbers and delivered to the buyer soon after the manufacture of the cable and ahead of the regular cable shipment. The cable samples will be accompanied by results of mechanical measurements

made during the cabling operation and by a strand map described in #3.5.1a. They will be shipped to the buyer in a condition so they will not be damaged. These samples will be used by the buyer to verify the mechanical and electrical requirements of the cable.

5.5 Marking/Identification Requirement - Spools and exterior packaging shall be identified with the following information in the order shown:

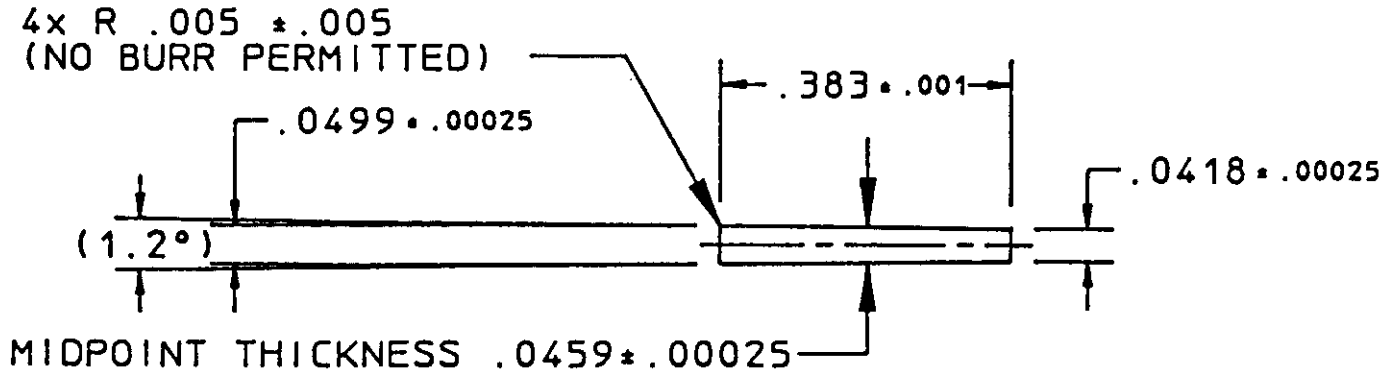
"Superconducting Cable"
Specification SSC-MAG-M-402 Type __.
Buyer P.O. No. _____.
Billet No. _____
Length _____ feet.
Weight _____ pounds.
Strand Map No. _____.
Date of Manufacture _____.
Name of Manfacturer _____.

Fig. 1.



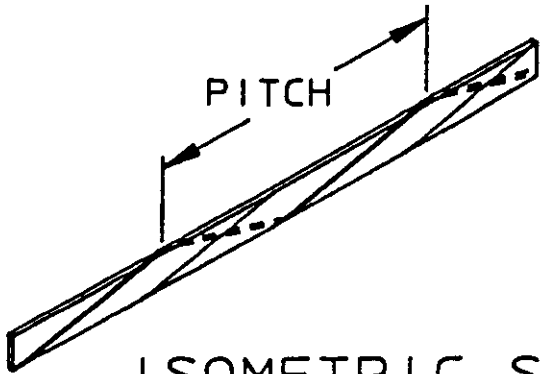
INNER CABLE

23 STRANDS OF NbTi WIRE
WIRE DIA. = .03180 +/-.0001
CABLE TO BE LEFT LAY
(SAME AS LEFT HAND SCREW THREAD)
WITH A PITCH OF 3.125



OUTER CABLE

30 STRANDS OF NbTi WIRE
WIRE DIA. = .0255 +/-.0001
CABLE TO BE LEFT LAY
(SAME AS LEFT HAND SCREW THREAD)
WITH A PITCH OF 2.900



ISOMETRIC SKETCH

PITCH

INNER CABLE	3.125
OUTER CABLE	2.900

LAWRENCE BERKELEY LABORATORY UNIVERSITY OF CALIFORNIA-BERKELEY			
HFS-SSC			
SSC MAGNETS			
CABLE SPECIFICATIONS			
PAT CLEAR	DWG TYPE SKETCH	SHOWN IN	SCALE: NONE
MODIFIED	4540-50	40-11-01	21M9151 REV

Appendix A - SSC Cable Test Methods

Test Methods	Title
No. 402-1	Cable measuring machine methods for determining SSC cable thickness, width and keystone angle.
No. 402-2	Cable lay pitch
No. 402-3	Cable lay direction
No. 402-4	Cable strand twist pitch
No. 402-5	Cable bend strength
No. 402-6	Cable insulation damage test
No. 402-7	Weld tensile test

Test Method 402-1 - Cable Thickness, Width and Keystone Angle

The Cable Measuring Machine (CMM) is a tool which measures and records the SSC type cable dimensions in a nondestructive fashion. It is used in-line with the superconductor cable as it is being made and can be used off-line for ckecking dimensions. The CMM is intended to be used as a standard method of measuring by the various manufacturers involved in the SSC cable process. (See Fig. 1.)

Method of Operation

The CMM is driven by a mechanical and electrical system. The mechanical function of the CMM is operated by an air actuated hydraulic system. This system controls the pressure applied to the measuring head. The measuring head clamps the cable in two directions and travels with the cable flow when taking measurements. First, an edge load of 30 psi centers the cable. Second, a load of 5,000 psi compresses the cable thickness.* The cable is held at these pressures for a specified time, typically 3 to 5 seconds, allowing the dimensions to stabilize.

The measuring head is measured by the electronic system. Three LVDT's are used to measure the position of the measuring head when clamped on the cable. (See Fig. 2.)

The LVDT output, hydraulic pressure, and cable footage measurements are then sent to the computer for processing. Recorded measurements and calculated dimensions are displayed on the CRT, kept on disk, and printed on paper. (See Appendix C, D, and E.)

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* These are actual pressures on conductors, not the system pressure required to achieve these pressures.

LIST OF POSSIBLE COMPUTER COMMANDS

Q	=>	Quit
GO	=>	Start taking data
ST	=>	Stop taking data
RX	=>	Take RelaXation curve for single cycle
WT	=>	choose Wire Type
D	=>	Display system status
SU	=>	Set Up TAURUS cable counter (also change relaxation time and measurement #)
PD	=>	Print last 100 lines of Data on line printer
PR	=>	Print last Relaxation data run on line printer
OD	=>	Open new Data file (closes any existing file)
CM	=>	Add CoMment to data file
CC	=>	Check or change Calibration of measuring head
LE	=>	List TAURUS Error codes
HELP	=>	list HELP file (this file)

shift - PrtSc prints current display screen)

Enter new command line

Prerequisites to Operation

The CMM must only be operated by persons specifically trained in its use, as damage to the cable and the LVDT's may result.

- The cable must be clean, no chips or oil, and be free from defects such as broken strands, fractured edges or cross overs.
- The take-up spool or level winder must be capable of supplying approximately 40 lbs. of constant tension.
- The cabling machine and the CMM must be set up to allow the cable to enter the CMM in the correct orientation. The direction of cable travel (right to left or left to right), and front-to-back orientation of the major edge must be determined for each individual CMM.

The LBL CMM cable travels from left to right and the major edge faces the operator.

Set Up and Operation Procedures

1. Complete routine maintenance
   A. Keep measuring head free of dust and chips.
   B. Inspect all moving parts for proper lubrication and adjustment.
   C. Inspect hydraulic, pneumatic, and electrical lines for leaks or wear.
   D. Refill printer with paper, as needed.

2. Turn on computer and run program.
3. Maintain log book. Log book entries should include:
   A. Date and operator's initials.
   B. "Run Title" or Cable No., Disk No., File No., and number of bytes free on data disk.

C. Steps taken by operator. For example, change in cable type, calibration of measuring head, relaxation time, adjustment of system pressures, routine maintenance, and operator observations. (See Appendix A-F.)

4. Calibrate measuring head. (See Appendix A-A, A-B, and A-C.)
5. String cable through the CMM to the take-up spool.
6. Take relaxation time measurements. (See Appendix A-D.)
7. Run CMM and collect data. (See Appendix A-E.)

APPENDIX A-A

SET UP INSTRUCTIONS FOR FIXED GUIDE SLIDE:

1. Make sure machine is switched off, and run light is not lit.
2. Loosen hold down screws for fixed guide slide. (The two inner shoulder screws are guide pins. They should be left alone.)
3. Pull fixed guide slide as far back as possible. (Move moving guide slide back by backing off LVDT No. 2 and then backing out over travel stops.)
4. Select the displayed calibration gage and the appropriate calibration slot blocks that match wire size. Each calibration gage is identified with a serial number. The individual calibration gages are not to be interchanged.
5. Wipe as clean as possible all gaging surfaces, blocks, gages, and fingers (of guide slides). Make sure no grit is visible in gage head opening. Blow out with compressed air.
6. Place slot blocks in their appropriate 'V' notch, and slide flat calibration gage through slot blocks and measuring head.
7. Making sure all gages stay flat and seated in position, push fixed guide slide against gage and clamp securely in place with hold down screws.
8. Fixed guide slide is now set for specific wire type.
9. Remove calibration slot blocks and return to their protective case.

APPENDIX A-B

SET UP INSTRUCTIONS FOR LVDT's

1. Loosen set screws on adjustable indicator bases for all three LVDT's, and back them clear of moving parts.
2. clamp measuring head on selected calibration gage. (Make sure all surfaces are clean. (See set up for fixed guide slide, #4.)
3. Set each LVDT to the position displayed on the computer screen. Lock securely in place with set screws on indicator bases.
4. Tighten the three over travel stops until they make contact. (One on top, two on the side.)
5. Unclamp head. Overtravel stops should hold head in place. Back stops out until they leave sufficient clearance for wire, but do not allow pressure on the LVDTs. **DO NOT ALLOW HEAD TO BOTTOM OUT ON LVDTs.** Lock over travel stops into place.
6. Clamp and unclamp head several times to insure LVDT readings' fall within tolerance range.
7. LVDTs are now set for specific wire type.

APPENDIX A-C

CALIBRATION

Note: In this case, the LVDT's are too unstable to read. This means the procedure must be run again, or the LVDT's are not adjusted properly.

Reel ID= 1 Relaxation time 5 sec. Current cal. block serial number 2366011

POINT	FEET	L0-MILS	L1-MILS	L2-MILS	PRS-PSI	ANGLE	WIDTH	THICK
+1	+0.0	-85.30	+88.49	+0.21	+2651	-0.004	+.3662	+.0575
+2	+0.0	-85.20	+88.39	+0.18	+2651	-0.002	+.3661	+.0575
+3	+0.0	-85.25	+88.44	+0.15	+2656	-0.003	+.3661	+.0575
+4	+0.0	-85.25	+88.49	+0.18	+2656	-0.004	+.3661	+.0575
+5	+0.0	-85.20	+88.39	+0.15	+2656	-0.002	+.3661	+.0575
+6	+0.0	-85.25	+88.44	+0.15	+2661	-0.003	+.3661	+.0575
+7	+0.0	-85.25	+88.44	+0.18	+2666	-0.003	+.3661	+.0575
+8	+0.0	-85.25	+88.44	+0.15	+2666	-0.003	+.3661	+.0575
+9	+0.0	-85.25	+88.39	+0.15	+2671	-0.003	+.3661	+.0575
+10	+0.0	-85.25	+88.44	+0.15	+2671	-0.003	+.3661	+.0575

Finished taking points. Now checking offsets.

LVDTS are too unstable to read offsets!

LVDT #	TOLERANCE	DIFFERENCE
0	0.16	0.20
2	0.16	2.70

Start again (Y or N)?Y

APPENDIX A-D

RELAXATION TIME

Note: The second column indicates elapsed time. LVDT's 0, 1 and 2 are reasonably stable at 2.91 seconds. The minimum RX time would be the next even number of seconds after the LVDT's have stablized.

.366 Bare Cable SSC Design "D" Inner Coil 04-10-1987 10:11:05
RELAXATION DATA
S/C #356 , 23 ST.
Reel ID = 1 Relaxation time 10 sec. Cable counter = 2 FEET

POINT	TIME (sec)	L0 (MILS)	L1 (MILS)	L2 (MILS)	PRS (PSI)
1	+0.17	+15.20	-10.62	+3.05	+102.5
2	+0.88	+13.30	-10.67	+3.29	+2304.7
3	+1.54	+13.15	-10.76	+3.32	+2651.4
4	+2.25	+13.15	-10.71	+3.29	+2661.1
5	+2.91	+13.15	-10.71	+3.32	+2661.1
6	+3.63	+13.15	-10.71	+3.29	+2661.1
7	+4.29	+13.15	-10.71	+3.32	+2666.0
8	+5.00	+13.15	-10.71	+3.32	+2666.0
9	+5.66	+13.15	-10.71	+3.32	+2666.0
10	+6.37	+13.10	-10.71	+3.32	+2666.0
11	+7.03	+13.10	-10.71	+3.32	+2666.0
12	+7.75	+13.10	-10.71	+3.32	+2670.9
13	+8.41	+13.10	-10.71	+3.32	+2670.9
14	+9.12	+13.10	-10.71	+3.29	+2670.9
15	+9.78	+13.10	-10.71	+3.32	+2670.9

Enter new command line

APPENDIX A-E

EXAMPLE OF CABLE DATA

CABLE OR CALIBRATION BLOCK DATA
.366 Bare Cable SSC Design "D" Inner Coil 04-08-1987 10:10
FURUKAWA LOT # SG-6215 , 23 ST. , 100 M , NET. WT. 9.4 KG.
Reel ID = 1 , Relaxation time 4 sec.
FURUKAWA FIRST 100 POINTS

POINT	FEET	LO-MILS	L1-MILS	L2-MILS	PRS-PSI	ANGLE	WIDTH	THIC
+1	+1.0	+2.83	-0.68	+0.15	+2671	+1.640	+.3655	+.056
+2	+1.0	+3.26	-1.02	+0.12	+2676	+1.647	+.3654	+.056
+3	+1.0	+4.29	-1.95	+0.09	+2681	+1.665	+.3654	+.056
+4	+1.0	+4.09	-1.90	+0.21	+2681	+1.663	+.3655	+.056
+5	+1.0	+3.60	-1.41	+0.09	+2686	+1.654	+.3654	+.056
+6	+1.0	+3.70	-1.46	+0.15	+2686	+1.655	+.3655	+.056
+7	+1.0	+4.09	-1.85	+0.26	+2686	+1.662	+.3656	+.056
+8	+1.0	+3.17	-0.88	+0.29	+2686	+1.645	+.3656	+.056
+9	+1.0	+3.46	-1.22	+0.09	+2686	+1.651	+.3654	+.056
+10	+1.0	+4.38	-2.09	+0.12	+2686	+1.667	+.3654	+.056
+11	+1.0	+4.68	-2.39	+0.15	+2686	+1.673	+.3655	+.056
+12	+1.0	+4.34	-2.05	+0.12	+2681	+1.666	+.3654	+.056
+13	+1.0	+3.99	-1.80	+0.09	+2686	+1.661	+.3654	+.056
+14	+1.0	+4.09	-1.80	+0.09	+2681	+1.662	+.3654	+.056
+15	+1.0	+3.31	-1.07	+0.06	+2686	+1.648	+.3654	+.056
+16	+19.0	+3.90	-1.61	+0.21	+2681	+1.658	+.3655	+.056
+17	+20.0	+3.90	-1.61	+0.23	+2686	+1.658	+.3655	+.056
+18	+20.0	+3.65	-1.41	+0.29	+2681	+1.654	+.3656	+.056
+19	+21.0	+3.51	-1.22	+0.21	+2681	+1.651	+.3655	+.056
+20	+21.0	+2.63	-0.34	+0.29	+2686	+1.635	+.3656	+.056
+21	+22.0	+3.36	-1.07	+0.35	+2681	+1.648	+.3657	+.056
+22	+22.0	+2.92	-0.68	+0.32	+2686	+1.641	+.3656	+.056
+23	+23.0	+4.29	-1.95	+0.32	+2686	+1.665	+.3656	+.056
+24	+23.0	+4.09	-1.75	+0.26	+2686	+1.661	+.3656	+.056
+25	+24.0	+3.60	-1.27	+0.32	+2681	+1.652	+.3656	+.056
+26	+24.0	+3.31	-1.07	+0.23	+2686	+1.648	+.3656	+.056
+27	+25.0	+3.31	-1.02	+0.26	+2686	+1.648	+.3656	+.056
+28	+25.0	+3.41	-1.12	+0.35	+2686	+1.649	+.3657	+.056
+29	+25.0	+4.14	-1.80	+0.21	+2681	+1.662	+.3655	+.056
+30	+26.0	+3.70	-1.31	+0.21	+2681	+1.654	+.3655	+.056

APPENDIX A-F

EXAMPLE OF LOG SHEET

4/8/87 H.H.

IGC Lot 5155, 23 st., 4,000 ft.
Disk #0, File #17, 233 K bytes free
Relaxation time 4 sec.

- changed wire type to 23 st.
- calibrated measuring head
- adjusted pressure to 2686 psi.

Run O.K.

4/27/87 H.H.

S/C 356, 30 st., 700'
Disk #0, File #18, 198 K bytes free
Relaxation time 5 sec.

- changed wire type to 30 st.
- calibrated measuring head
- adjusted pressure to 2750 psi.

Minor difficulty calibrating measuring head, stopped run at 97 feet, readjusted. Rest of run O.K.

Fig. 1a.

This figure illustrates the measuring machine installed in the cable insulation line.

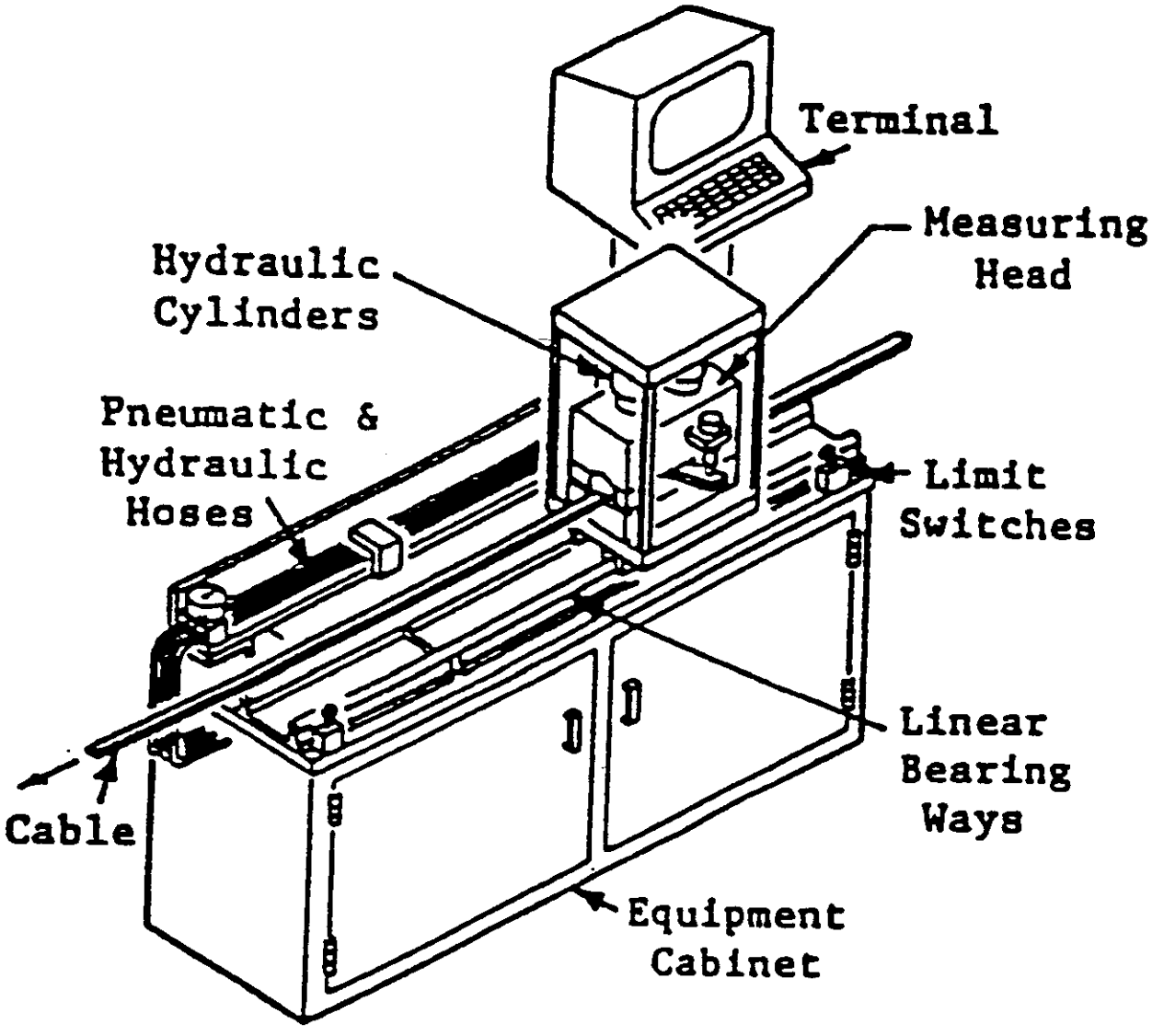
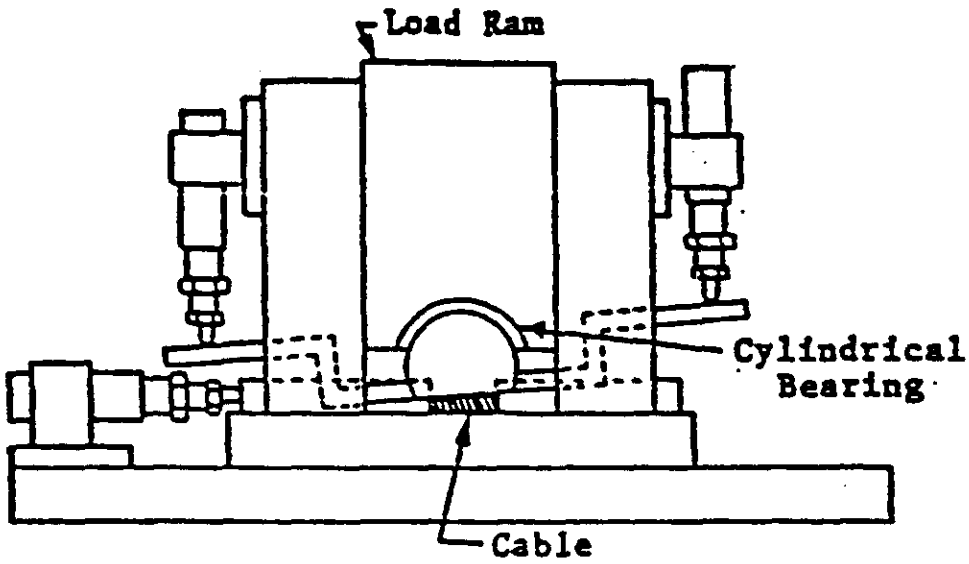
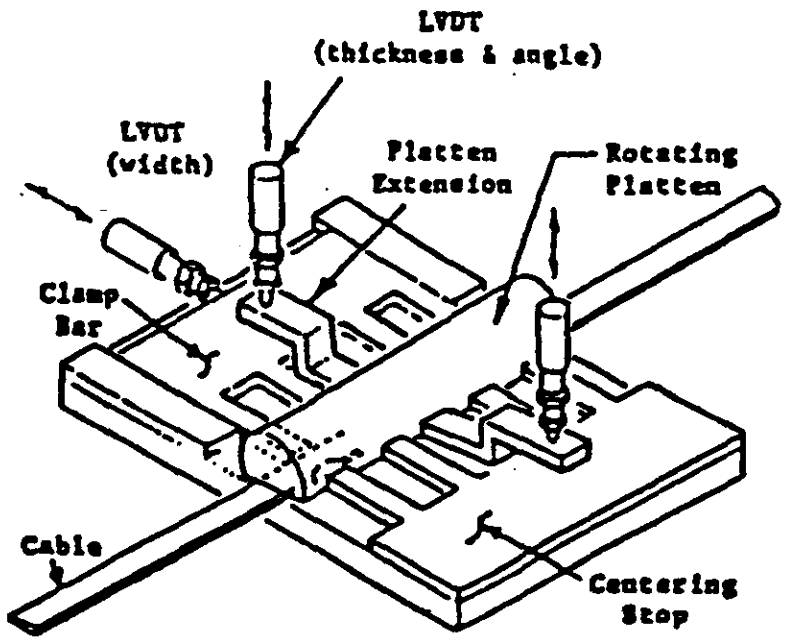


Fig. 2.



An end view of cable head showing cable during measurement.



Isometric illustration of the measuring head with the load ram and guides removed for clarity.

Test Method 402-2 - Cable Lay Pitch

Purpose: To determine conformance to cable lay pitch requirement.

Method: Using a suitable cable specimen mark a strand to allow accurate identification and measure lay pitch parallel to the cable axis as shown in Figure I using a metal scale.

Test Method 402-3 - Cable Lay Direction

Purpose: To determine the direction of cable rotation.

Method: Visually examine the cable rotation to verify that it conforms to the rotation of a left hand screw thread.

Test Method 402-4 - Cable Strand Twist Pitch

Purpose: To determine the twist pitch of cable strands.

Method: Using a 50/50 nitric acid water solution, etch a 3" cable specimen with tape secured ends until filaments are visible in the copper matrix. Under the magnification of a 20xx binocular microscope measure the visible 1/4 twist pitch and multiply by four.

Test Method 402-5 - Cable Bend Strength

Purpose: To determine cable resistance to bend induced cracks and fractures.

Method: Bend a cable specimen over a 1/2" diam. mandrel while applying a tensile load of 40 lbs. Visually examine cable edges in bend area for cracks.

Test Method 402-6 - Insulation Damage Test

Purpose: To determine the suitability of cable source conditions for the application of insulating materials.

Method: Visually examine the sample cable edges and surfaces to assure the absence of burrs, nicks, slivers or other defects that could damage insulation material.

Test Method 402-7 - Weld Tensile Test

Purpose: To proof test cold weld tensile strength.

Method: On a cold weld joint in a deliverable length of production cable, using a buyer furnished tool (ref. applicable P.O.) grip wire on each side of weld and apply the designated load. Weld shall not exhibit fractures cracks or other damage.