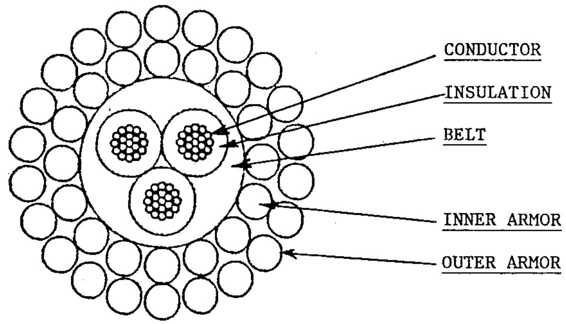
the ROCHESTER corporation

POST OFFICE BOX 312
CULPEPER, VIRGINIA 22701 U.S.A.

TELEPHONE 703/825-2111
TWX 710-839-3439

DATALINE



CONDUCTORS - 3	
#19 AWG 19/.008" Bare Copper	.039"
INSULATION - 3	
.016" Wall Polypropylene Colors: 2 Natural, 1 Black	.071"
CABLED	
3 conductors, no fillers	.153"
BELT:	
.015" Wall HDPE	.183"
INNER ARMOR	
16/.0375" SGXXIPS	.247"
OUTER ARMOR	
22/.0375" SGXXIPS	.322"

NOTE: Sequential marker tape in meters included in cable.

the ROCHESTER corporation
P.O. BOX 312
CULPEPER, VIRGINIA 22701

TITLE: 3-CONDUCTOR CABLE
CODE: I 3 Ø Ø 3 Ø 1 5 2 P O Ø Ø

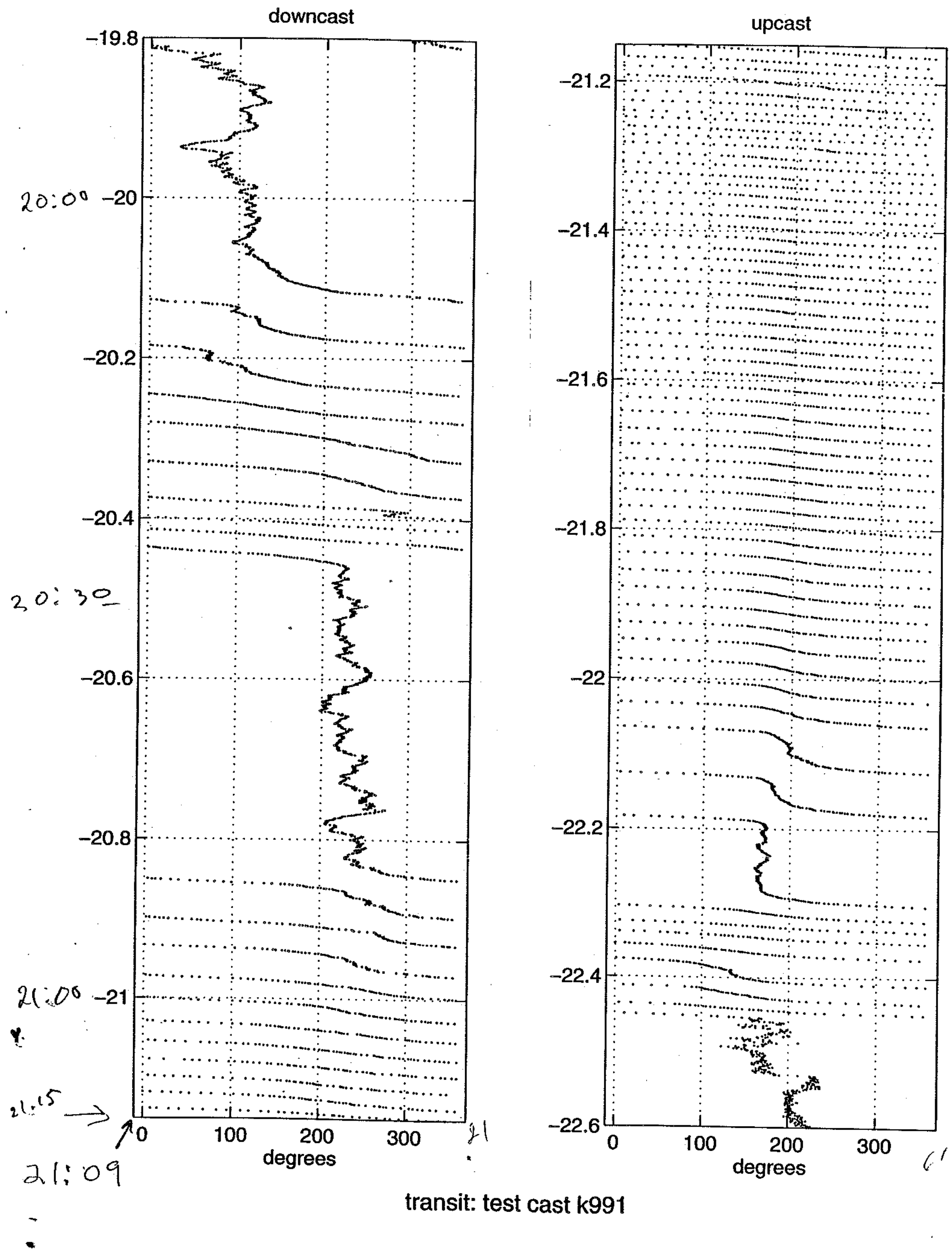
DATE	SHEET	REVISION	NUMBER
05/05/86	1		01592

CABLE CHARACTERISTICS	METRIC	ENGLISH
(Nominal Values @ 20°C)		
PHYSICAL		
Wt. in Air		174 lb/kft
Wt. in Seawater		141 lb/kft
Overall Diameter		.322" ±.004"
MECHANICAL		
Breaking Strength		≧ 11,600 lbf
Maximum Working Load		≦ 5,000 lbf
Recommended Bend Radius		6 in
Torque, Rotation, and Elongation (See Attached Printouts and Graphs)		
ELECTRICAL		
Voltage Rating		600 volts
Insulation Resistance		≧ 10,000 MΩ/kft
dc Resistance		
cdr		≦ 9.4 Ω/kft
armor		2.4 Ω/kft
Capacitance (cdr-armor)		35 pF/ft

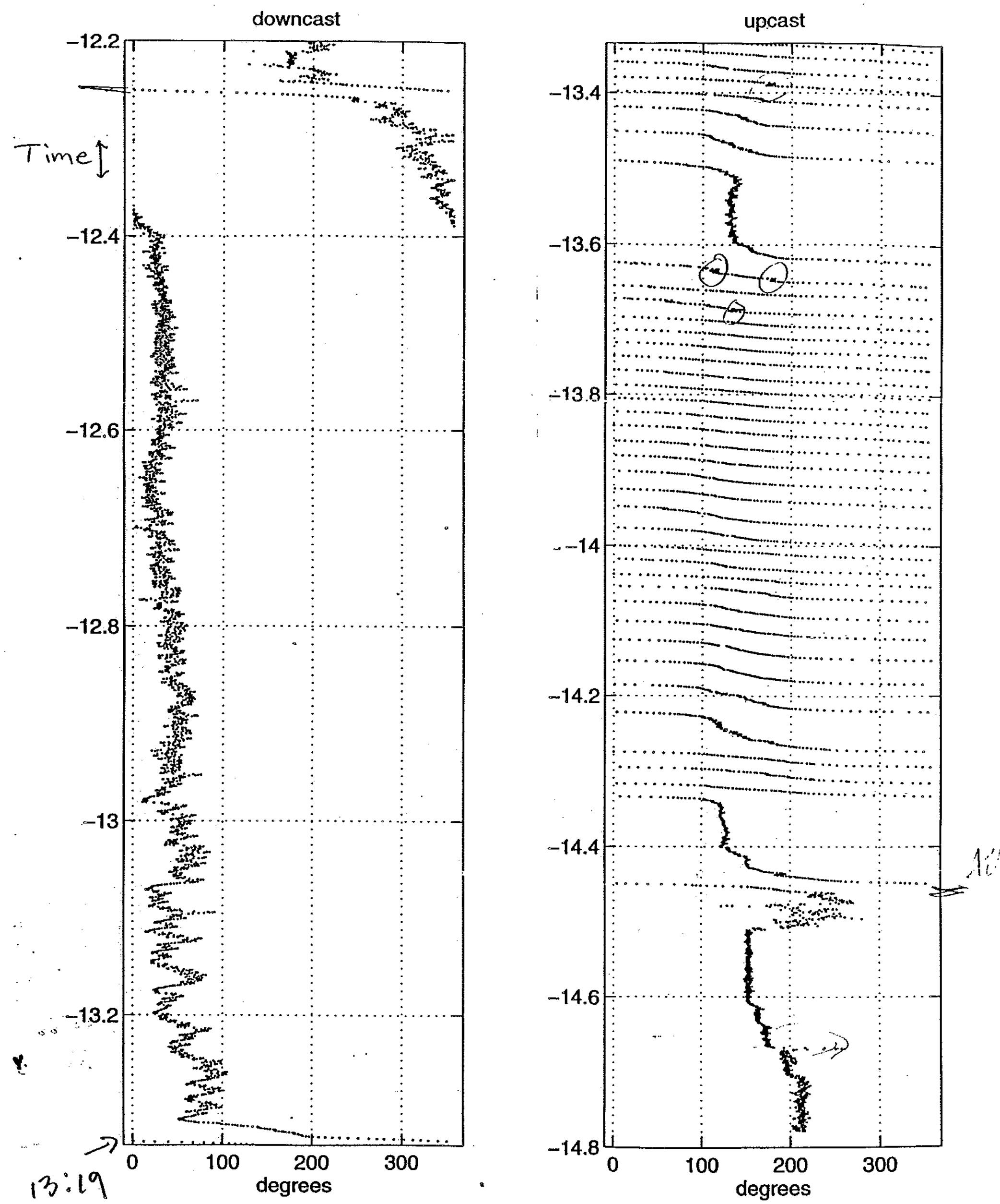
the ROCHESTER corporation
P. O. BOX 312
CULPEPER, VIRGINIA 22701

TITLE: 3-CONDUCTOR CABLE
CODE: I 3 Ø Ø 3 Ø 1 5 2 P O Ø Ø

DATE	SHEET	REVISION	NUMBER
05/05/86	2		01592



transit: test cast k991

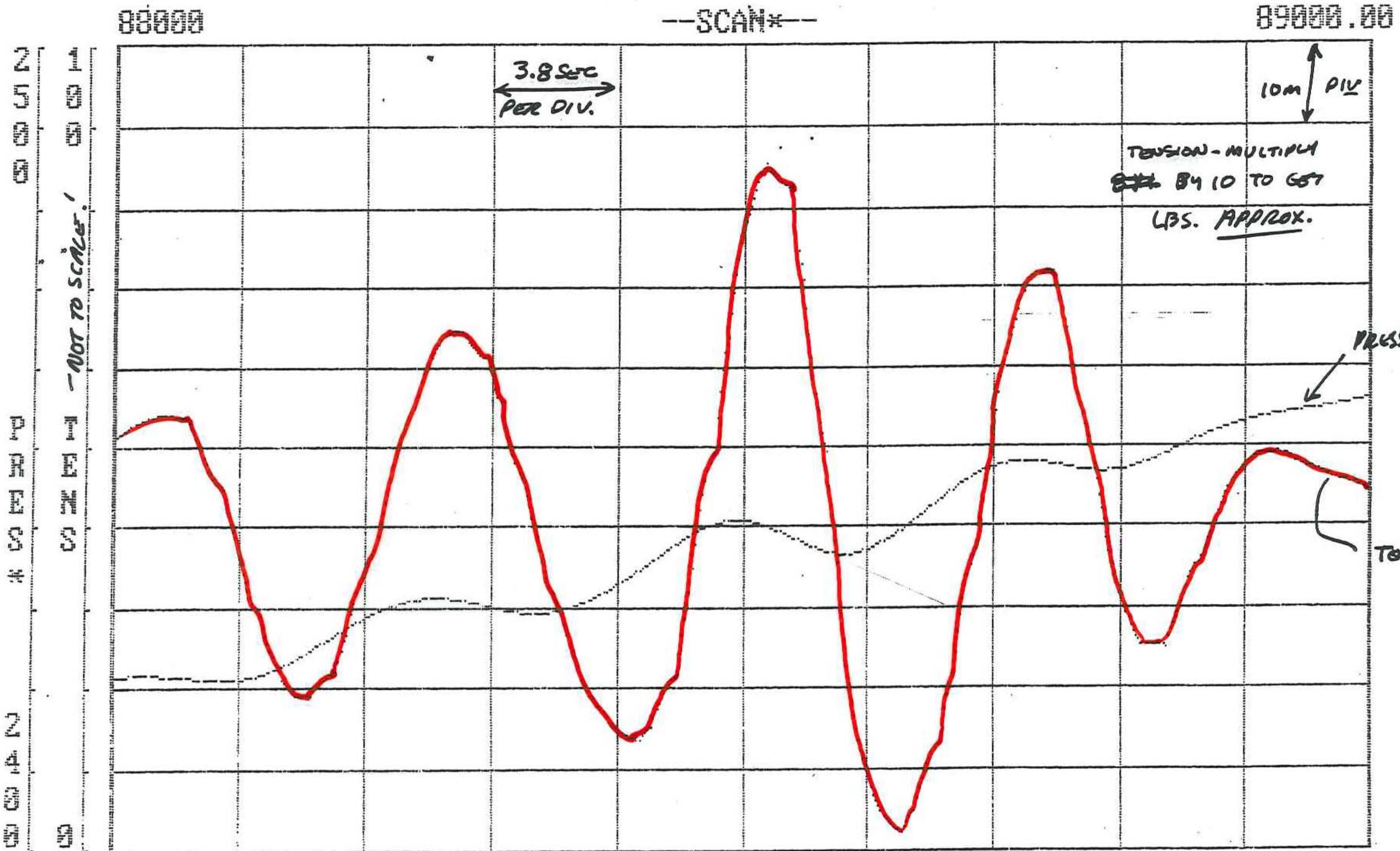


transit: test cast k992

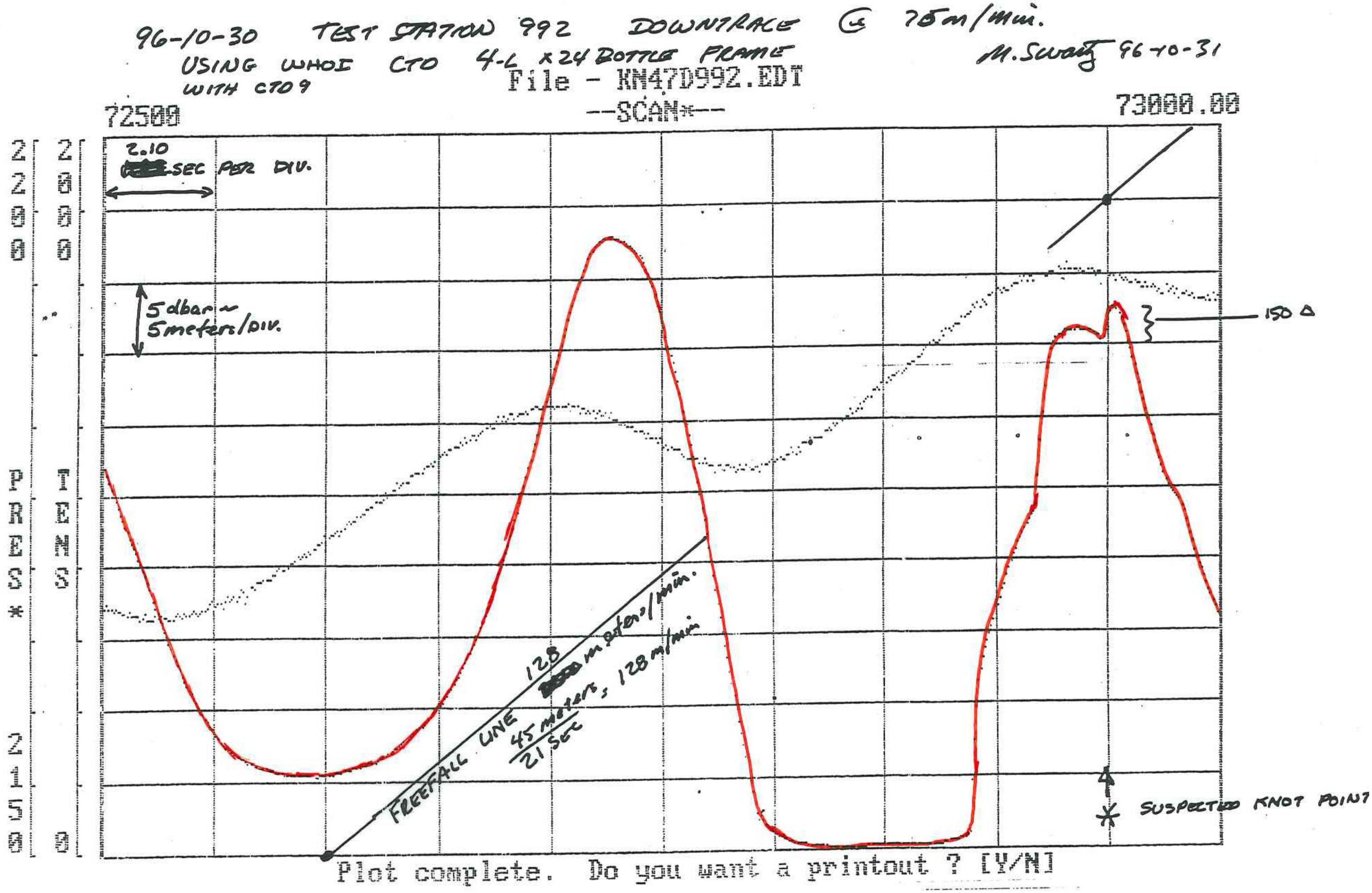
Kinky

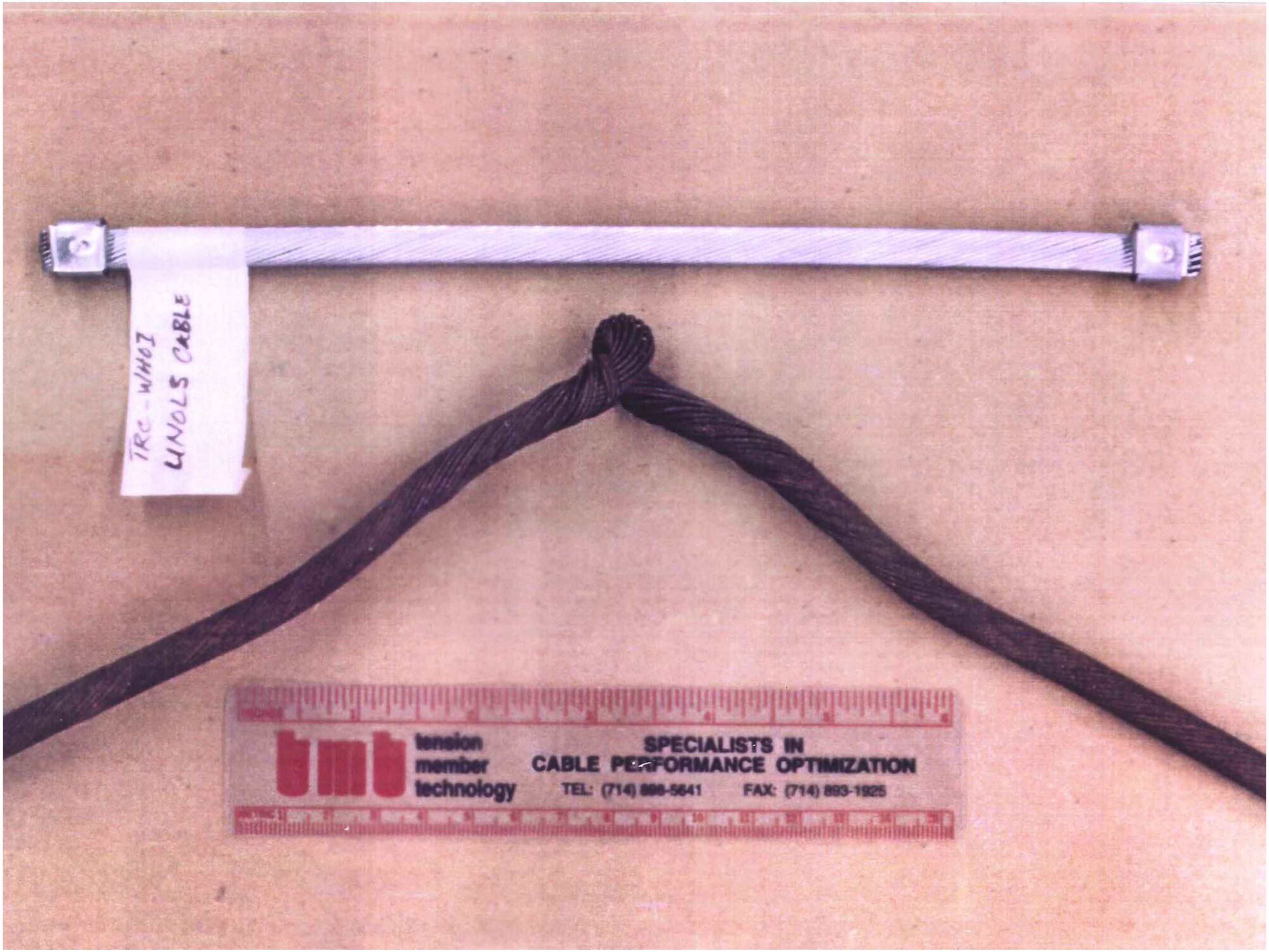
TEST CAST #3 10/30/96 60m/min
4L FRAME CTD 38 ADDED 240 LBS TO FRAME.

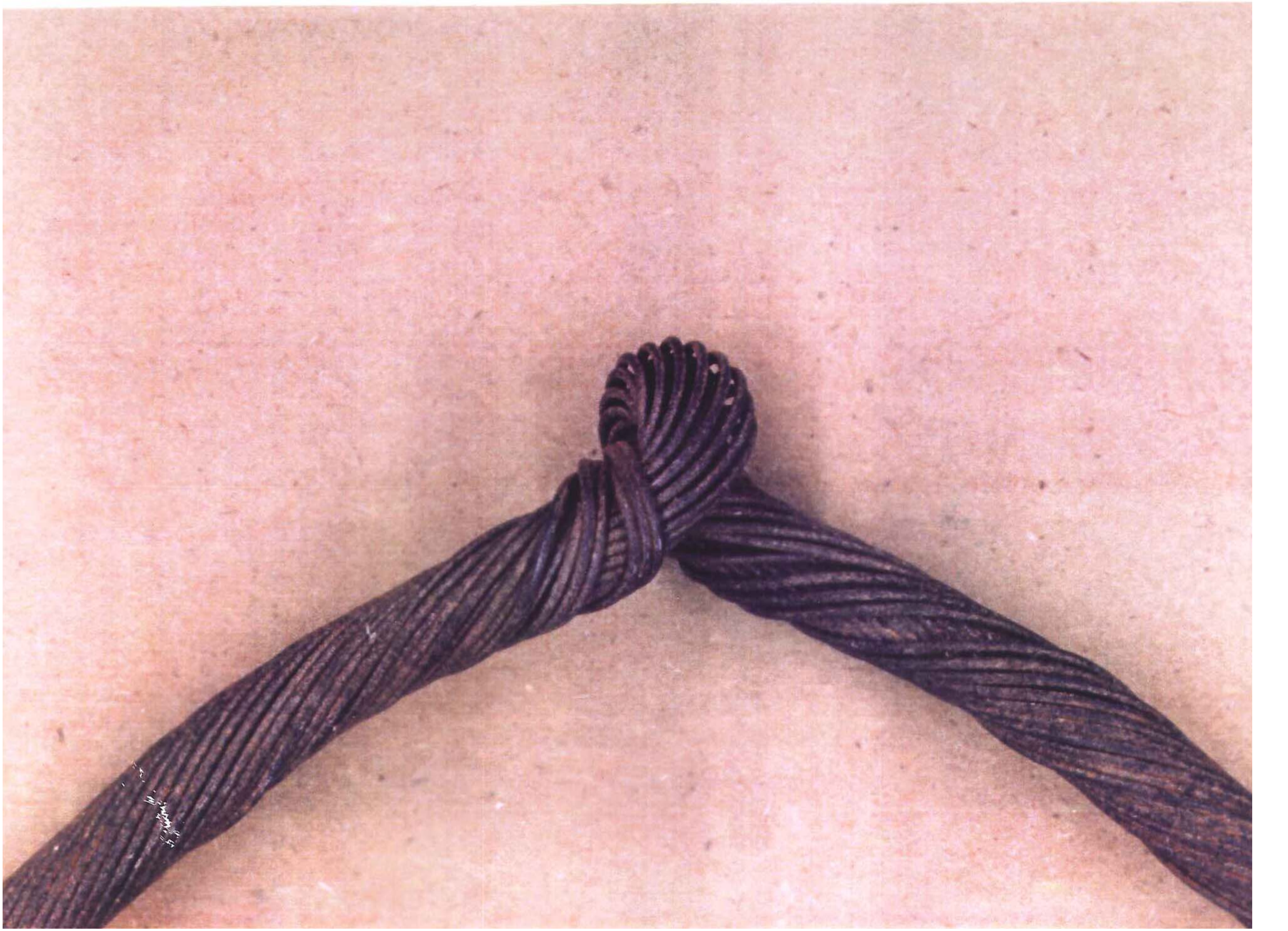
File - KN47D993.EDT



Plot complete. Do you want a printout ? [Y/N]


96-10-30 TEST STATION 992 DOWNTRACE @ 75 m/min.
USING WHOI CTD 4-L x24 BOTTLE FRAME
WITH CTD9
M. Swartz 96-10-31
File - KN47D992.EDT
--SCAN*--
72500
73000.00
2200
2000
2.10 SEC PER DIV.
5 dbar ~ 5 meters/DIV.
150 Δ
PRES*
TENS
FREEFALL LINE
128 meters/min.
45 meters / 21 sec, 128 m/min
SUSPECTED KNOT POINT
2150
0
Plot complete. Do you want a printout ? [Y/N]


TRC - WHOI
UNOLS CABLE
tmt
tension
member
technology
SPECIALISTS IN
CABLE PERFORMANCE OPTIMIZATION
FAX: (714) 893-1925



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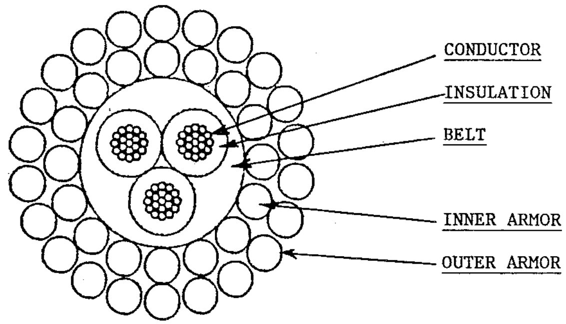
DATALINE



CONDUCTORS - 3

#19 AWG 19/.008" Bare Copper .039"

INSULATION - 3

.016" Wall Polypropylene .071"
Colors: 2 Natural, 1 Black

CABLED

3 conductors, no fillers .153"

BELT:

.015" Wall HDPE .183"

INNER ARMOR

16/.0375" SGXXIPS .247"

OUTER ARMOR

22/.0375" SGXXIPS .322"

NOTE: Sequential marker tape in meters included in cable.

the ROCHESTER corporation
P.O. BOX 312
CULPEPER. VIRGINIA 22701

TITLE:	3-CONDUCTOR CABLE CODE: I 3 Ø Ø 3 Ø 1 5 2 P O Ø Ø		
DATE	SHEET	REVISION	NUMBER
05/05/86	1		01592

CABLE CHARACTERISTICS	METRIC	ENGLISH
(Nominal Values @ 20°C)		
PHYSICAL		
Wt. in Air		174 lb/kft
Wt. in Seawater		141 lb/kft
Overall Diameter		.322" ±.004"
MECHANICAL		
Breaking Strength		≥ 11,600 lbf
Maximum Working Load		≤ 5,000 lbf
Recommended Bend Radius		6 in
Torque, Rotation, and Elongation (See Attached Printouts and Graphs)		
ELECTRICAL		
Voltage Rating		600 volts
Insulation Resistance		≥ 10,000 MΩ/kft
dc Resistance		
cdr		≤ 9.4 Ω/kft
armor		2.4 Ω/kft
Capacitance (cdr-armor)		35 pF/ft

the ROCHESTER corporation P. O. BOX 312 CULPEPER, VIRGINIA 22701	TITLE: 3-CONDUCTOR CABLE CODE: I 3 Ø Ø 3 Ø 1 5 2 P O Ø Ø

DATE	SHEET	REVISION	NUMBER
05/05/86	2		01592

DESIGN: UNOLS-1
DESCRIPTION: 0.322-inch Diameter 3-Conductor Cable

LAYER 4 Outer Armor

LAYER DESIGNATION	-> ARMOR
NUMBER OF WIRES	= 22
WIRE DIA. (in)	= 0.0375
LAYER O.D. (in)	= 0.3250
LAY LENGTH (in)	= 2.685
LAY DIRECTION	-> LEFT
TENSILE MODULUS (Mpsi)	= 28.000
ULTIMATE STRESS (kpsi)	= 300.0
YIELD STRESS (kpsi)	= 265.0
POISSON'S RATIO	= 0.30
THERMAL EXPANSION COEF (10^-6/deg F)	= 6.0
SPECIFIC GRAVITY	= 7.80

CORE Belt Over Power Conductors

INITIAL CORE I.D. (in)	= 0
INITIAL CORE O.D. (in)	= 0.1800
BULK MODULUS (kpsi)	= 100.0
VOID VOLUME (%)	= 0
SPECIFIC GRAVITY OF VOID FILLER	= 0
THERMAL EXPANSION COEF (10^-6/deg F)	= 0

MAXIMUM CUSP FILL (%)	= 90
CUSP FILL PRESSURE PARAMETER (psi)	= 1000
HERMETIC CABLE JACKET	-> NO

CABLE SOLVER 1 V4.09 CS1000 11-07-1996

DESIGN: UNOLS-1
DESCRIPTION: 0.322-inch Diameter 3-Conductor Cable

LAYER	DESCRIPTION
LAYER 1	#19 AWG Conductors
LAYER 2	Core Jacket
LAYER 3	Inner Armor
LAYER 4	Outer Armor
CORE	Belt Over Power Conductors

CABLE SOLVER 1 V4.09 CS1000 11-07-1996

DESIGN: UNOLS-1
DESCRIPTION: 0.322-inch Diameter 3-Conductor Cable

MATERIAL PROPERTIES TABLE

LAYER NUMBER	1	2	3	4
LAYER DESIGNATION	COND	NHL	ARMOR	ARMOR
TENSILE MOD (Mpsi)	15.000	0.100	28.000	28.000
ULTIMATE (kpsi)	40.0	5.0	300.0	300.0
YIELD (kpsi)	30.0	3.0	265.0	265.0
SHEAR MOD (Mpsi)	5.639	0.034	10.769	10.769
POISSON'S RATIO	0.33	0.45	0.30	0.30
TEC (10^-6/deg F)	9.0	70.0	6.0	6.0
SPECIFIC GRAVITY	8.90	0.96	7.80	7.80
SG OF INSULATION	0.90	n/a	n/a	n/a

CABLE SOLVER 1 V4.09 CS1000 11-07-1996

DESIGN: UNOLS-1
DESCRIPTION: 0.322-inch Diameter 3-Conductor Cable

TENSION (lb)	= 4000
END CONDITION	-> FIXED (NO ROTATION)
COMPRESSIBLE CORE MODEL	
TENSION DEPENDENT CUSP FILL	
NO BIAS	
CORE: INITIAL CORE I.D. (in)	= 0
INITIAL CORE O.D. (in)	= 0.1800
EFFECTIVE CORE O.D. (in)	= 0.1749
DELTA CORE O.D. (in)	= -0.0051
BULK MODULUS (kpsi)	= 100.0
VOID VOLUME (%)	= 0
SPECIFIC GRAVITY OF VOID FILLER	= 0
MASS OF VOID FILLER (lbm/ft)	= 0
LAYER OVER CORE	= LAYER 3
INITIAL CUSP FILL (%)	= 74
MAXIMUM CUSP FILL (%)	= 90
CUSP FILL PRESSURE PARAMETER (psi)	= 1000
CUSP FILL (%)	= 90
NO HERMETIC CABLE JACKET	

(4.6)

CONFIGURATION TABLE

LAYER NUMBER	1	2	3	4
LAYER DESIGNATION	COND	NHL	ARMOR	ARMOR
NO. OF ELEMENTS	3	1	16	22
ELMNT DIA. (in)	0.0349	n/a	0.0375	0.0375
INSLTN DIA. (in)	0.0710	n/a	n/a	n/a
LAYER I.D. (in)	0.0107	0.1263	0.1694	0.2444
LAYER P.D. (in)	0.0797	0.1506	0.2069	0.2819
LAYER O.D. (in)	0.1487	0.1749	0.2444	0.3194
DELTA O.D. (in)	-0.0043	-0.0051	-0.0056	-0.0056
DIA. BIAS (in)	0	0	0	0
LAY LENGTH (in)	1.309	n/a	1.607	2.704
LAY ANGLE (deg)	10.83	0	22.02	18.14
LAY DIRECTION	Left	n/a	Right	Left
R OF CURV (in)	1.1	n/a	0.7	1.5
COVERAGE (%)	101.4	n/a	100.0	98.3
STRENGTH (lb)	110	60	4890	6910
MASS (lbm/ft)	0.01	0.01	0.06	0.09

STRAIN (%)	= 0.71	CORE PRESSURE (psi)	= 4870
TENSION (lb)	= 4000	TENSILE STRENGTH SUM (lb)	= 11970
TORQUE (lb-in)	= 91	MASS SUMMATION (lbm/ft)	= 0.17
ROTATION (deg/ft)	= 0		

CABLE SOLVER 1 V4.09 CS1000 11-07-1996

DESIGN: UNOLS-1
DESCRIPTION: 0.322-inch Diameter 3-Conductor Cable

TENSION (lb)	= 4000
END CONDITION	-> FIXED (NO ROTATION)
COMPRESSIBLE CORE MODEL	
TENSION DEPENDENT CUSP FILL	
NO BIAS	

CORE: INITIAL CORE I.D. (in)	= 0
INITIAL CORE O.D. (in)	= 0.1800
EFFECTIVE CORE O.D. (in)	= 0.1749
DELTA CORE O.D. (in)	= -0.0051
BULK MODULUS (kpsi)	= 100.0
VOID VOLUME (%)	= 0
SPECIFIC GRAVITY OF VOID FILLER	= 0
MASS OF VOID FILLER (lbm/ft)	= 0

(4.6)

LAYER OVER CORE	= LAYER 3
INITIAL CUSP FILL (%)	= 74
MAXIMUM CUSP FILL (%)	= 90
CUSP FILL PRESSURE PARAMETER (psi)	= 1000
CUSP FILL (%)	= 90
NO HERMETIC CABLE JACKET	

STRESS/STRAIN TABLE

LAYER NUMBER	1	2	3	4
LAYER DESIGNATION	COND	NHL	ARMOR	ARMOR
TEN STRESS (kpsi)	39.7	0.7	61.6	124.2
TEN STRAIN (%)	0.58	0.71	0.22	0.44
SHR STRESS (kpsi)	0	0	0.4	0.1
SHR STRAIN (%)	0	0	0	0
MXTOR STRESS (kpsi)	2.0	0	1.8	0.8
MXTOR STRAIN (%)	0.04	0	0.02	0.01
MXBEN STRESS (kpsi)	*0*	0	22.5	10.4
MXBEN STRAIN (%)	*0*	0	0.08	0.04
MXEFF STRESS (kpsi)	39.8	0.7	84.1	134.6
TENSION (lb)	110	10	1010	2870
TORQUE (lb-in)	1	0	-41	132
RAD FORCE (lb/in)	100	0	1570	2180
RAD PRESS (psi)	410	0	2420	2460

LAYER(S) 1 MXEFF STRESS ABOVE YIELD.

STRAIN (%)	= 0.71	CORE PRESSURE (psi)	= 4870
TENSION (lb)	= 4000	TENSILE STRENGTH SUM (lb)	= 11970
TORQUE (lb-in)	= 91		
ROTATION (deg/ft)	= 0		

CABLE SOLVER 1 V4.09 CS1000 11-07-1996

DESIGN: UNOLS-1
DESCRIPTION: 0.322-inch Diameter 3-Conductor Cable

TENSION (lb)	= 4000
END CONDITION	-> FREE TO ROTATE
COMPRESSIBLE CORE MODEL	
TENSION DEPENDENT CUSP FILL	
NO BIAS	

CORE: INITIAL CORE I.D. (in)	= 0
INITIAL CORE O.D. (in)	= 0.1800
EFFECTIVE CORE O.D. (in)	= 0.1734
DELTA CORE O.D. (in)	= -0.0066
BULK MODULUS (kpsi)	= 100.0
VOID VOLUME (%)	= 0
SPECIFIC GRAVITY OF VOID FILLER	= 0
MASS OF VOID FILLER (lbm/ft)	= 0

(4.6)

LAYER OVER CORE	= LAYER 3
INITIAL CUSP FILL (%)	= 74
MAXIMUM CUSP FILL (%)	= 90
CUSP FILL PRESSURE PARAMETER (psi)	= 1000
CUSP FILL (%)	= 90
NO HERMETIC CABLE JACKET	

CONFIGURATION TABLE

LAYER NUMBER	1	2	3	4
LAYER DESIGNATION	COND	NHL	ARMOR	ARMOR
NO. OF ELEMENTS	3	1	16	22
ELMNT DIA. (in)	0.0349	n/a	0.0375	0.0375
INSLTN DIA. (in)	0.0710	n/a	n/a	n/a
LAYER I.D. (in)	0.0106	0.1252	0.1681	0.2431
LAYER P.D. (in)	0.0790	0.1493	0.2056	0.2806
LAYER O.D. (in)	0.1474	0.1734	0.2431	0.3181
DELTA O.D. (in)	-0.0056	-0.0066	-0.0069	-0.0069
DIA. BIAS (in)	0	0	0	0
LAY LENGTH (in)	1.325	n/a	1.588	2.771
LAY ANGLE (deg)	10.61	0	22.13	17.65
LAY DIRECTION	Left	n/a	Right	Left
R OF CURV (in)	1.2	n/a	0.7	1.5
COVERAGE (%)	101.5	n/a	100.7	98.5
STRENGTH (lb)	110	60	4890	6910
MASS (lbm/ft)	0.01	0.01	0.06	0.09

STRAIN (%)	= 0.84	CORE PRESSURE (psi)	= 6410
TENSION (lb)	= 4000	TENSILE STRENGTH SUM (lb)	= 11970
TORQUE (lb-in)	= 0	MASS SUMMATION (lbm/ft)	= 0.17
ROTATION (deg/ft)	= 36.6		

CABLE SOLVER 1 V4.09 CS1000 11-07-1996

DESIGN: UNOLS-1
DESCRIPTION: 0.322-inch Diameter 3-Conductor Cable

TENSION (lb)	= 4000
END CONDITION	-> FREE TO ROTATE
COMPRESSIBLE CORE MODEL	
TENSION DEPENDENT CUSP FILL	
NO BIAS	

CORE: INITIAL CORE I.D. (in)	= 0
INITIAL CORE O.D. (in)	= 0.1800
EFFECTIVE CORE O.D. (in)	= 0.1734
DELTA CORE O.D. (in)	= -0.0066
BULK MODULUS (kpsi)	= 100.0
VOID VOLUME (%)	= 0
SPECIFIC GRAVITY OF VOID FILLER	= 0
MASS OF VOID FILLER (lbm/ft)	= 0

(4.6)

LAYER OVER CORE	= LAYER 3
INITIAL CUSP FILL (%)	= 74
MAXIMUM CUSP FILL (%)	= 90
CUSP FILL PRESSURE PARAMETER (psi)	= 1000
CUSP FILL (%)	= 90
NO HERMETIC CABLE JACKET	

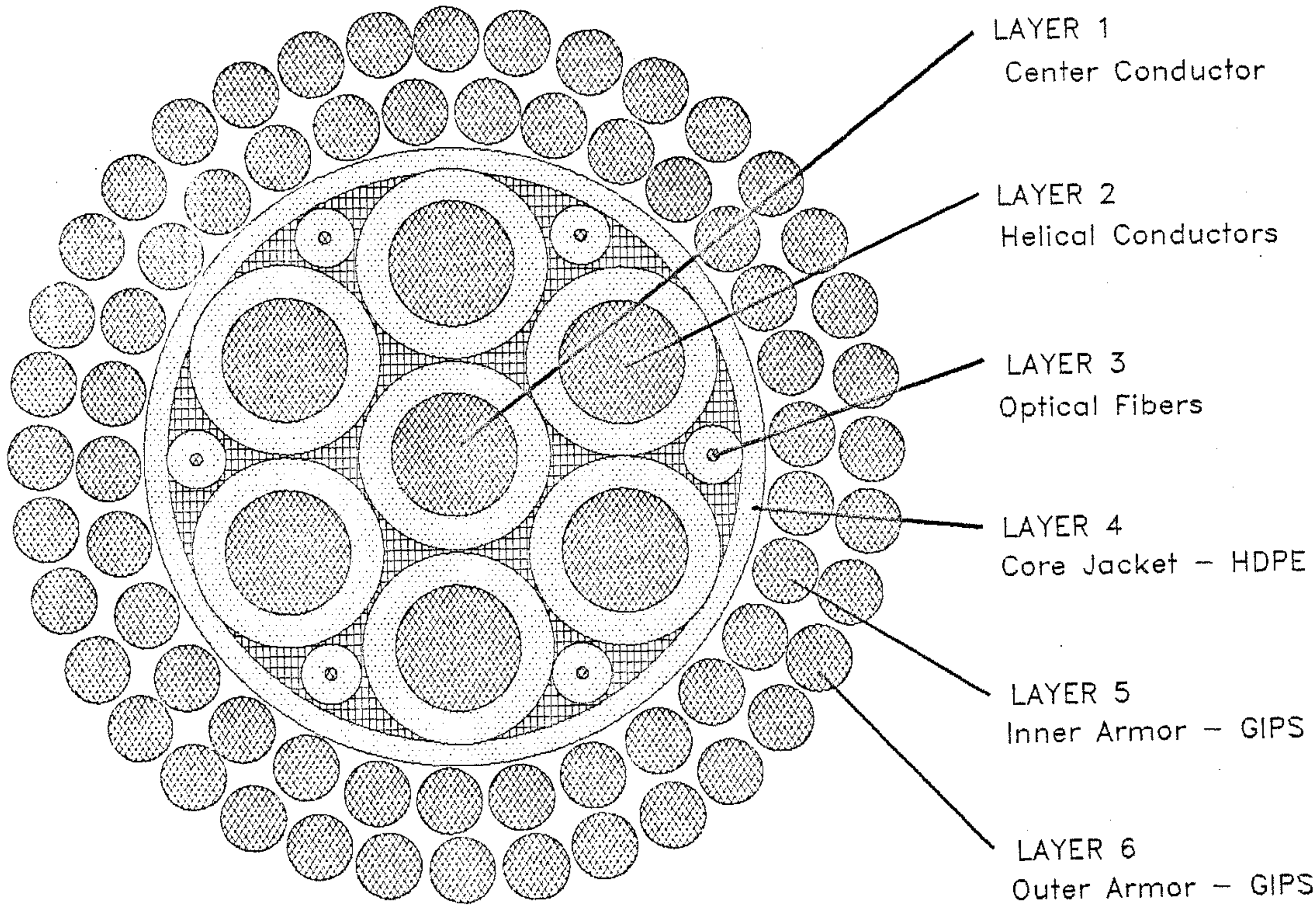
STRESS/STRAIN TABLE

LAYER NUMBER	1	2	3	4
LAYER DESIGNATION	COND	NHL	ARMOR	ARMOR
TEN STRESS (kpsi)	39.8	0.8	119.7	82.7
TEN STRAIN (%)	0.63	0.84	0.43	0.30
SHR STRESS (kpsi)	0.1	0	0.3	0.2
SHR STRAIN (%)	0	0	0	0
MXTOR STRESS (kpsi)	7.0	0.2	9.0	8.6
MXTOR STRAIN (%)	0.12	0.46	0.08	0.08
MXBEN STRESS (kpsi)	*0*	0	10.8	27.3
MXBEN STRAIN (%)	*0*	0	0.04	0.10
MXEFF STRESS (kpsi)	41.6	0.9	131.5	111.0
TENSION (lb)	110	10	1960	1920
TORQUE (lb-in)	1	0	-82	82
RAD FORCE (lb/in)	100	0	3130	1370
RAD PRESS (psi)	400	0	4850	1550

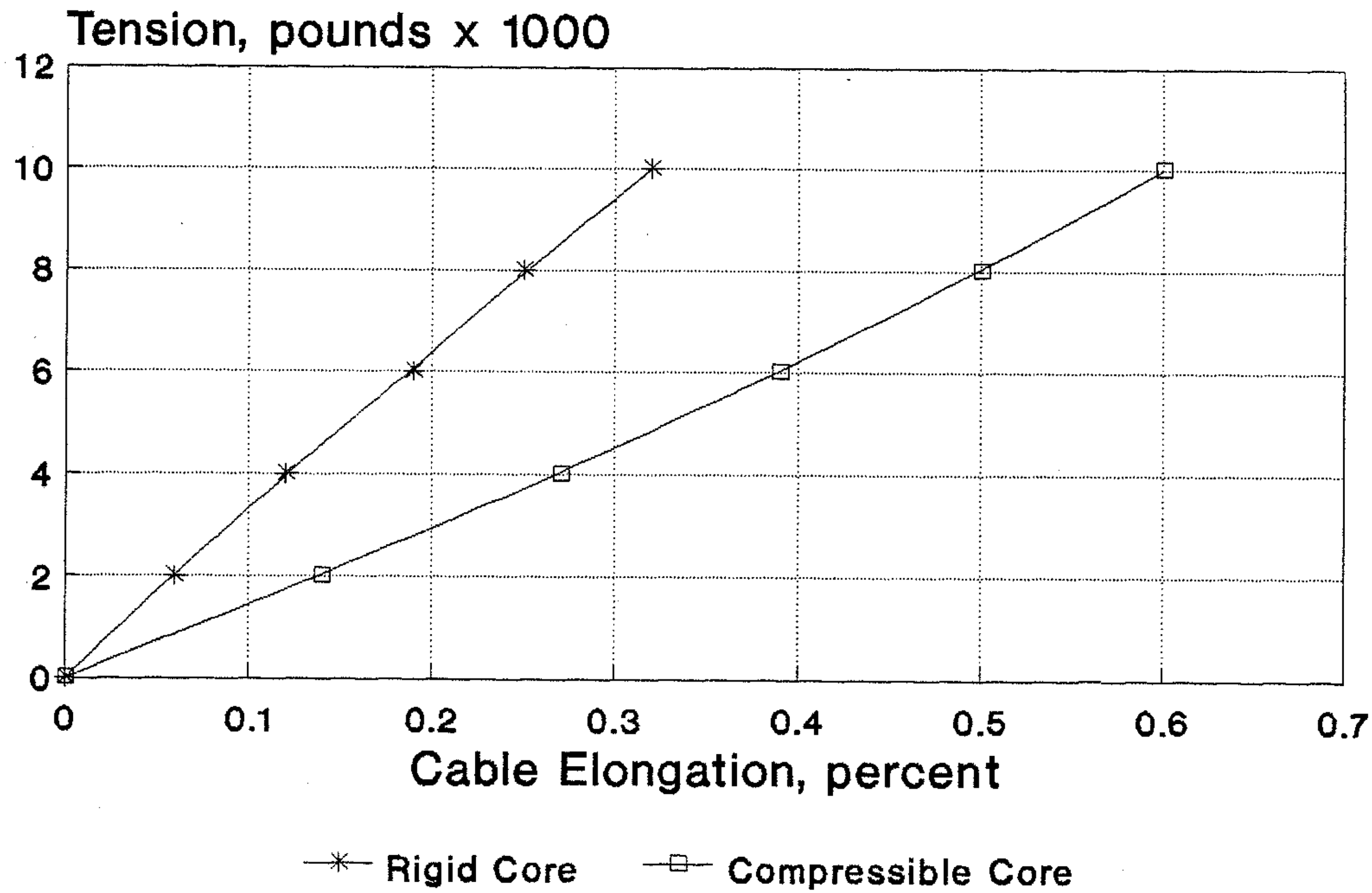
LAYER(S) 1 MXEFF STRESS ABOVE YIELD.

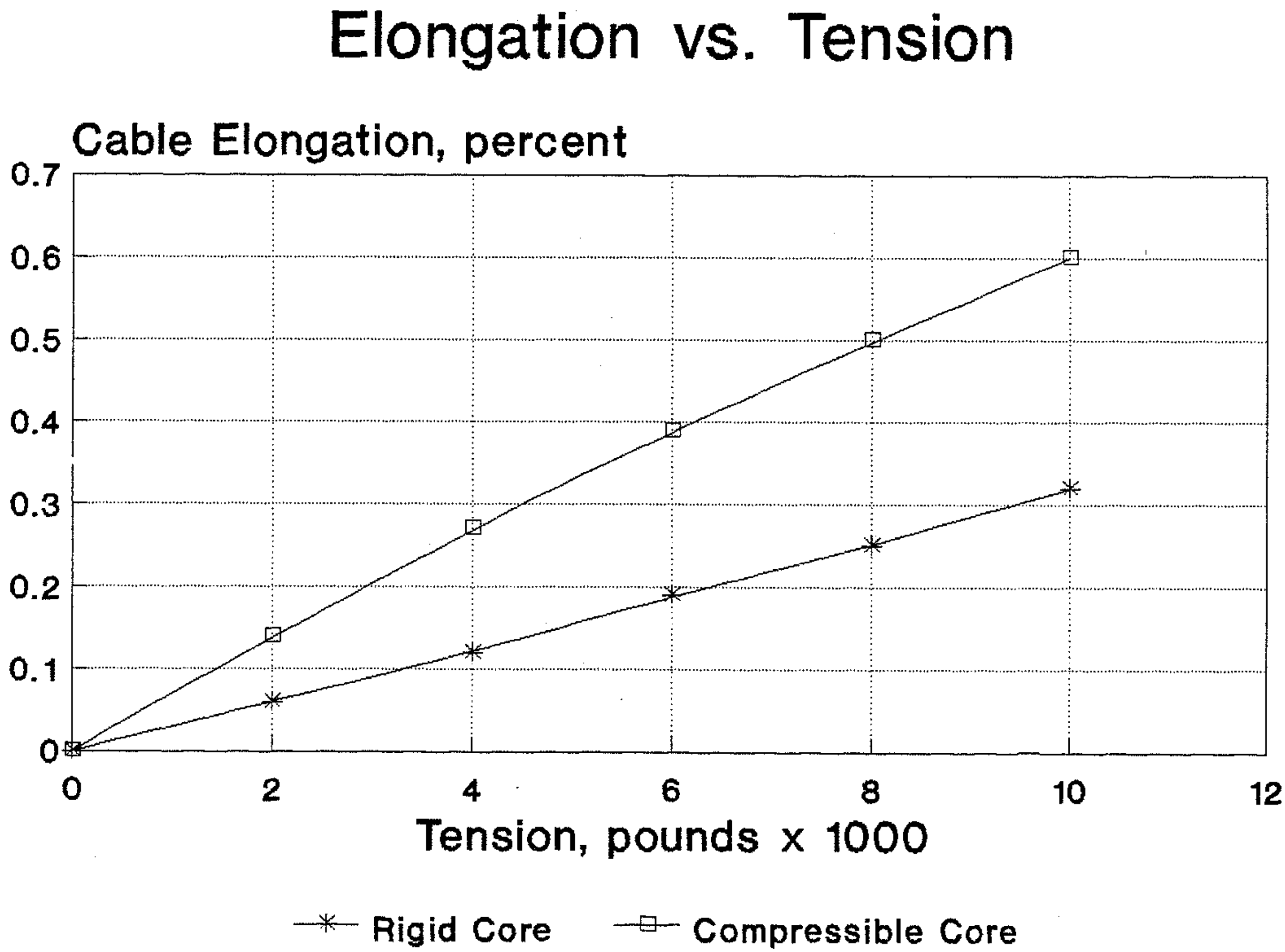
STRAIN (%)	= 0.84	CORE PRESSURE (psi)	= 6410
TENSION (lb)	= 4000	TENSILE STRENGTH SUM (lb)	= 11970
TORQUE (lb-in)	= 0		
ROTATION (deg/ft)	= 36.6		

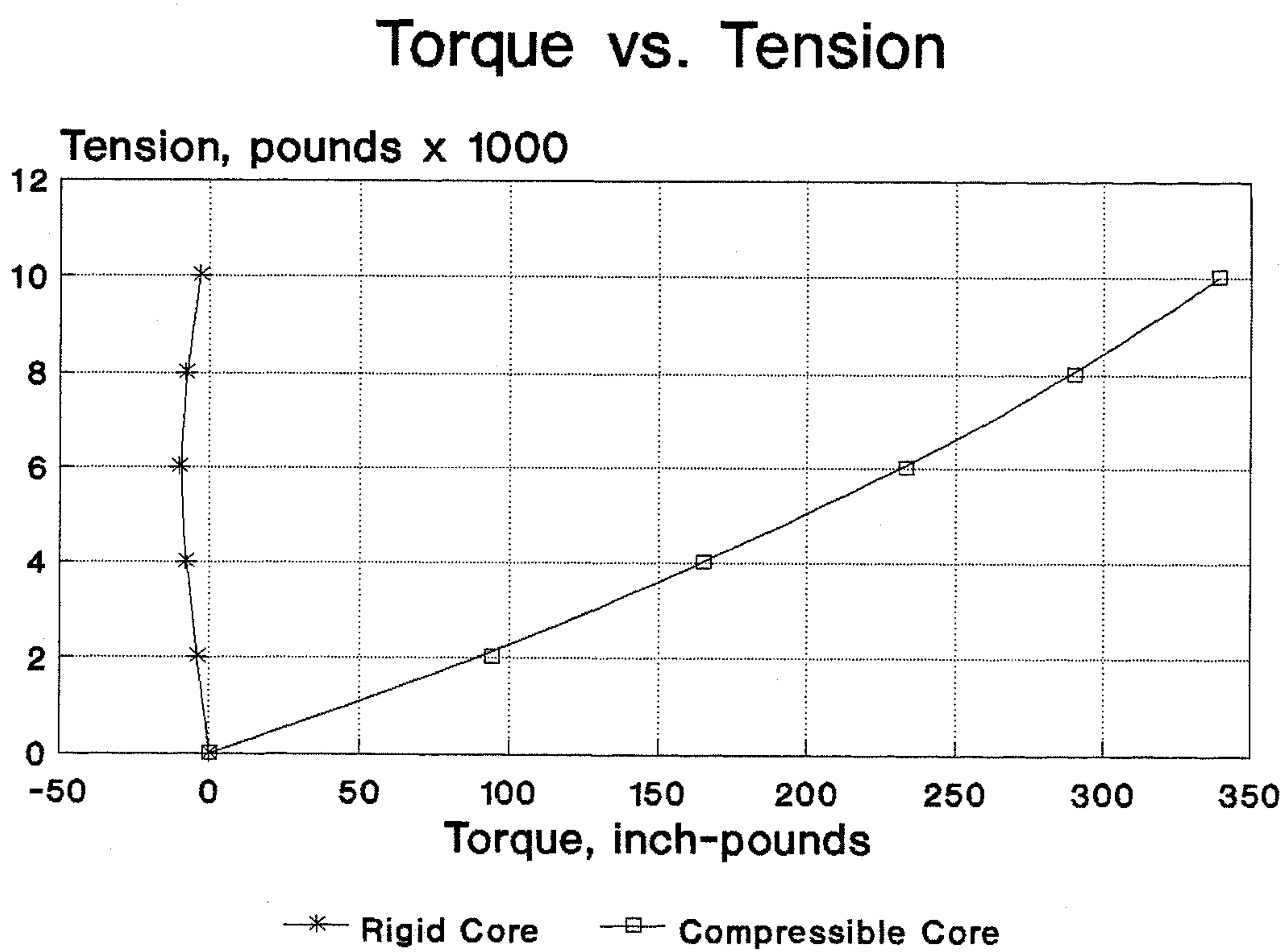
CABLE SOLVER 1 V4.09 CS1000 11-07-1996


LAYER 1
Center Conductor
LAYER 2
Helical Conductors
LAYER 3
Optical Fibers
LAYER 4
Core Jacket - HDPE
LAYER 5
Inner Armor - GIPS
LAYER 6
Outer Armor - GIPS

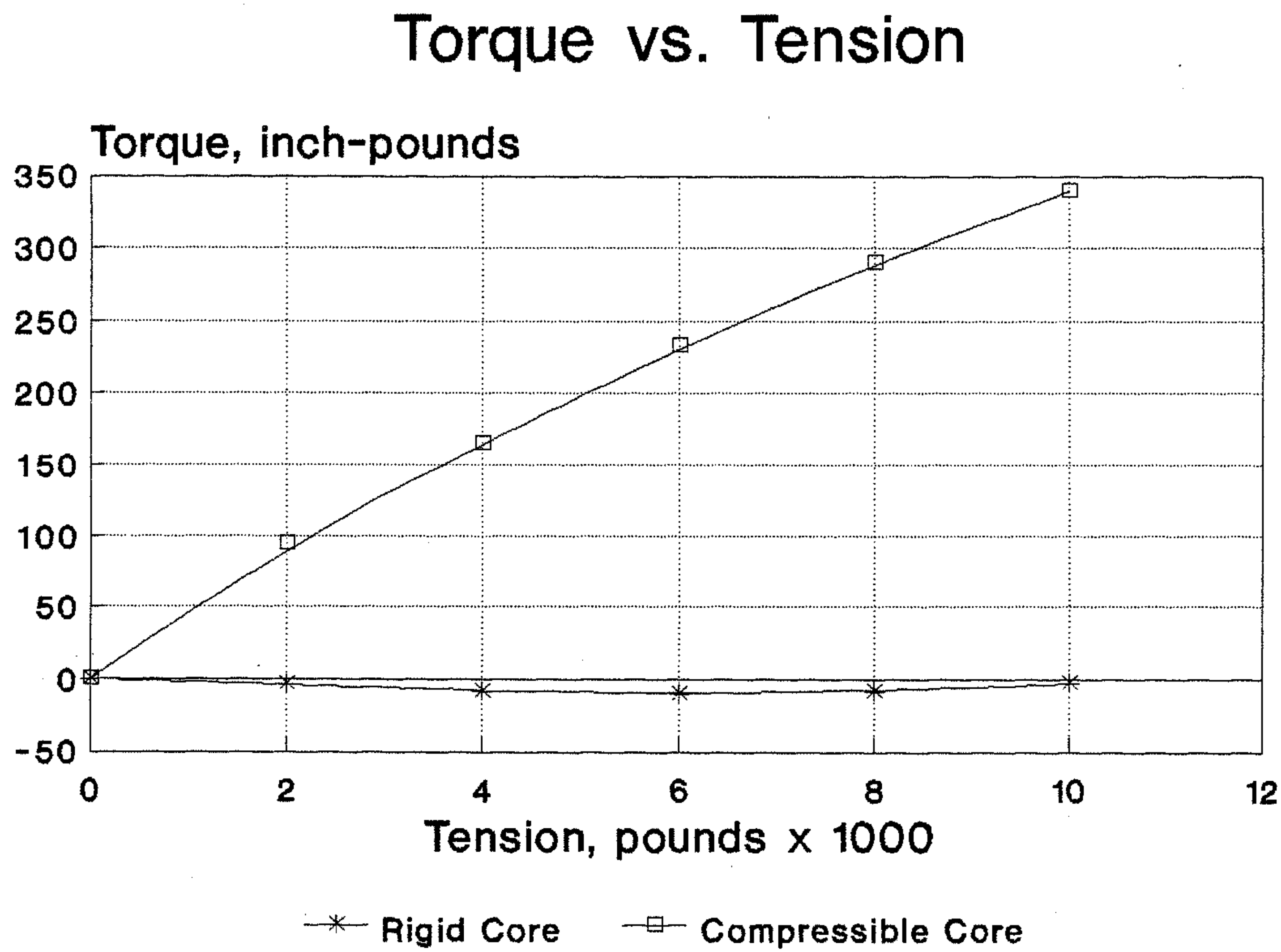
Elongation vs. Tension

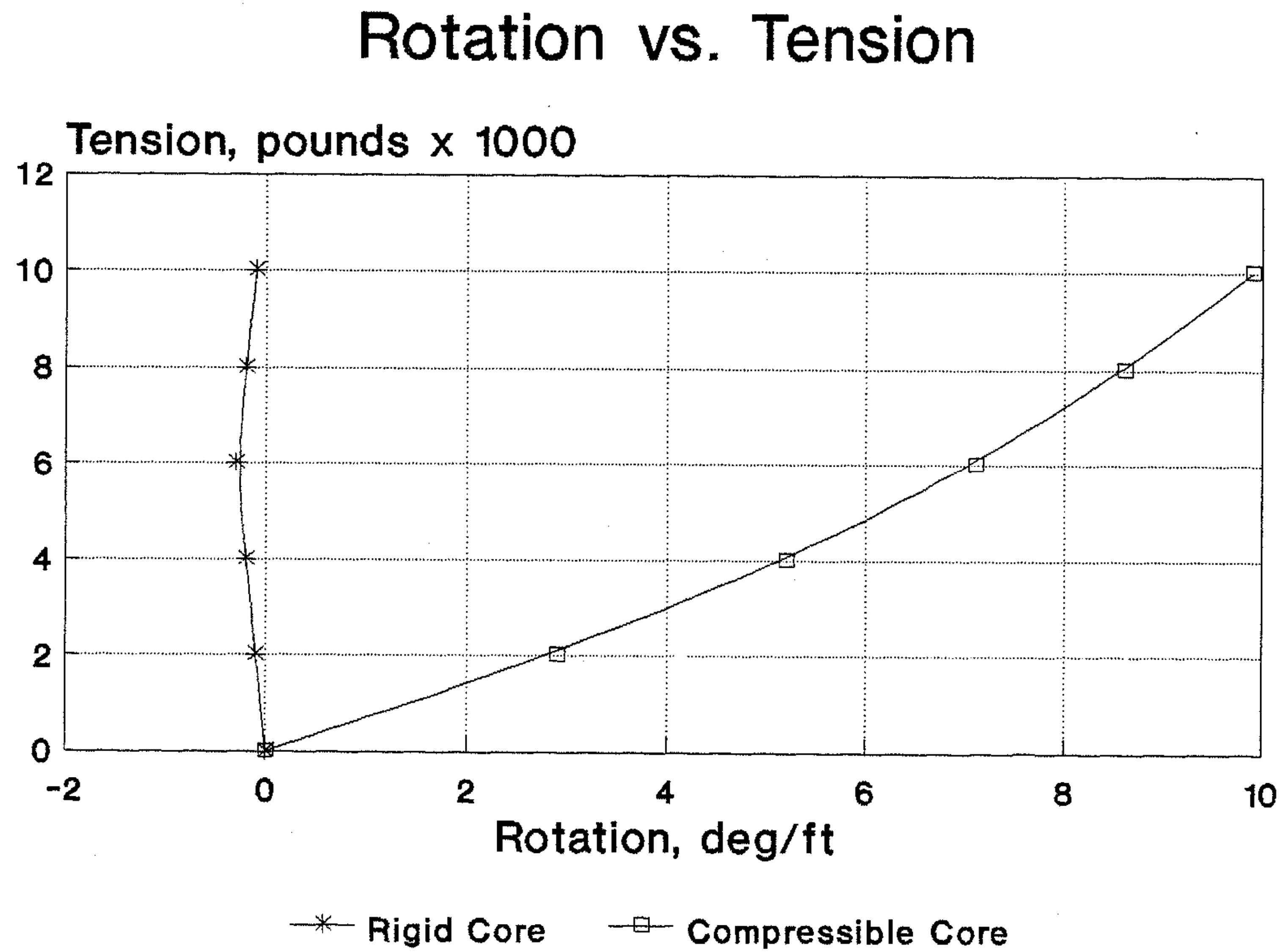



Elongation vs. Tension
Cable Elongation, percent
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
Tension, pounds x 1000
Rigid Core
Compressible Core

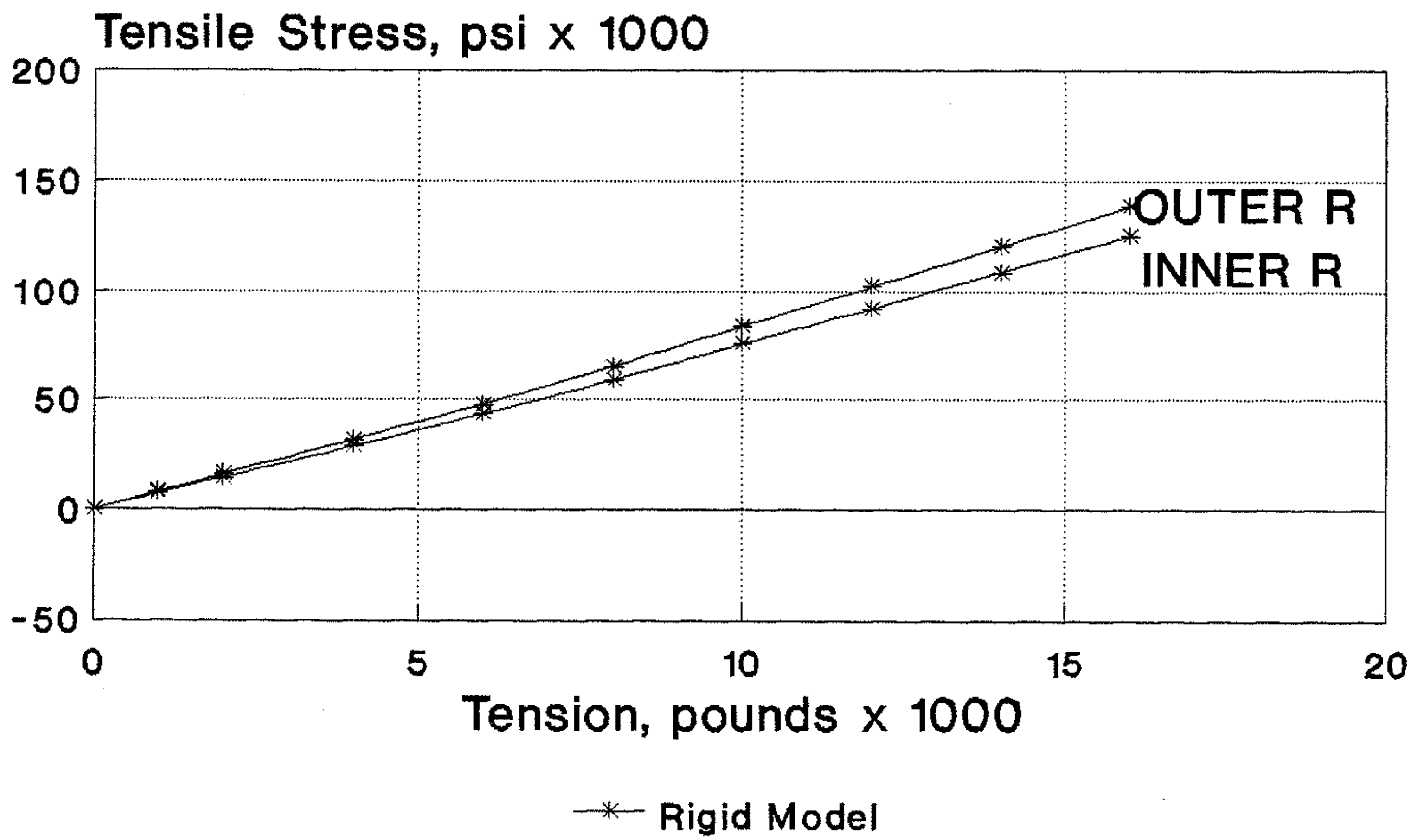


Torque vs. Tension
Tension, pounds x 1000
12
10
8
6
4
2
0
-50
0
50
100
150
200
250
300
350
Torque, inch-pounds
Rigid Core
Compressible Core

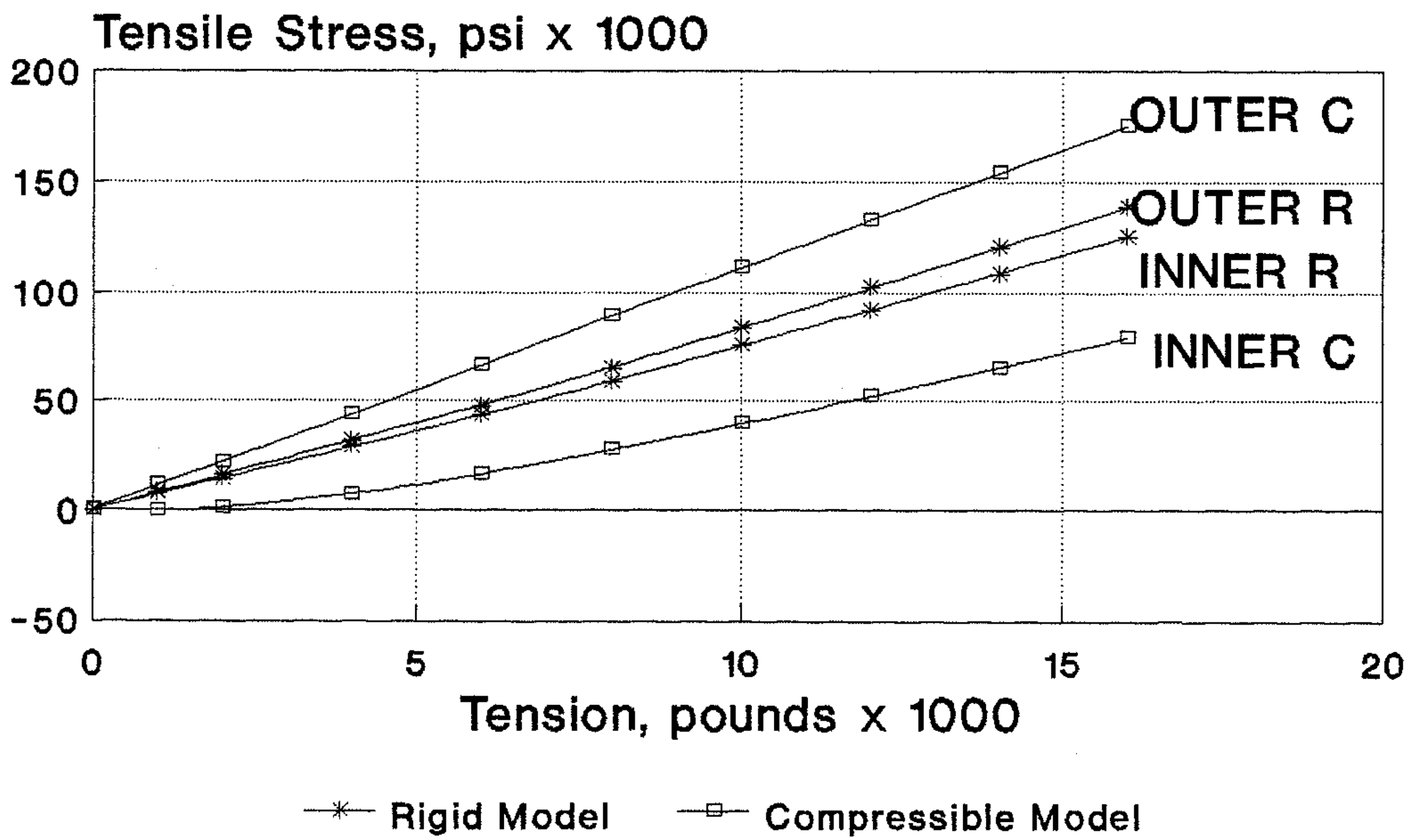

Torque vs. Tension
Torque, inch-pounds
350
300
250
200
150
100
50
0
-50
0
2
4
6
8
10
12
Tension, pounds x 1000
Rigid Core
Compressible Core


Rotation vs. Tension
Tension, pounds x 1000
12
10
8
6
4
2
0
-2
0
2
4
6
8
10
Rotation, deg/ft
Rigid Core
Compressible Core

Effect of Compressibility on Stress Balance

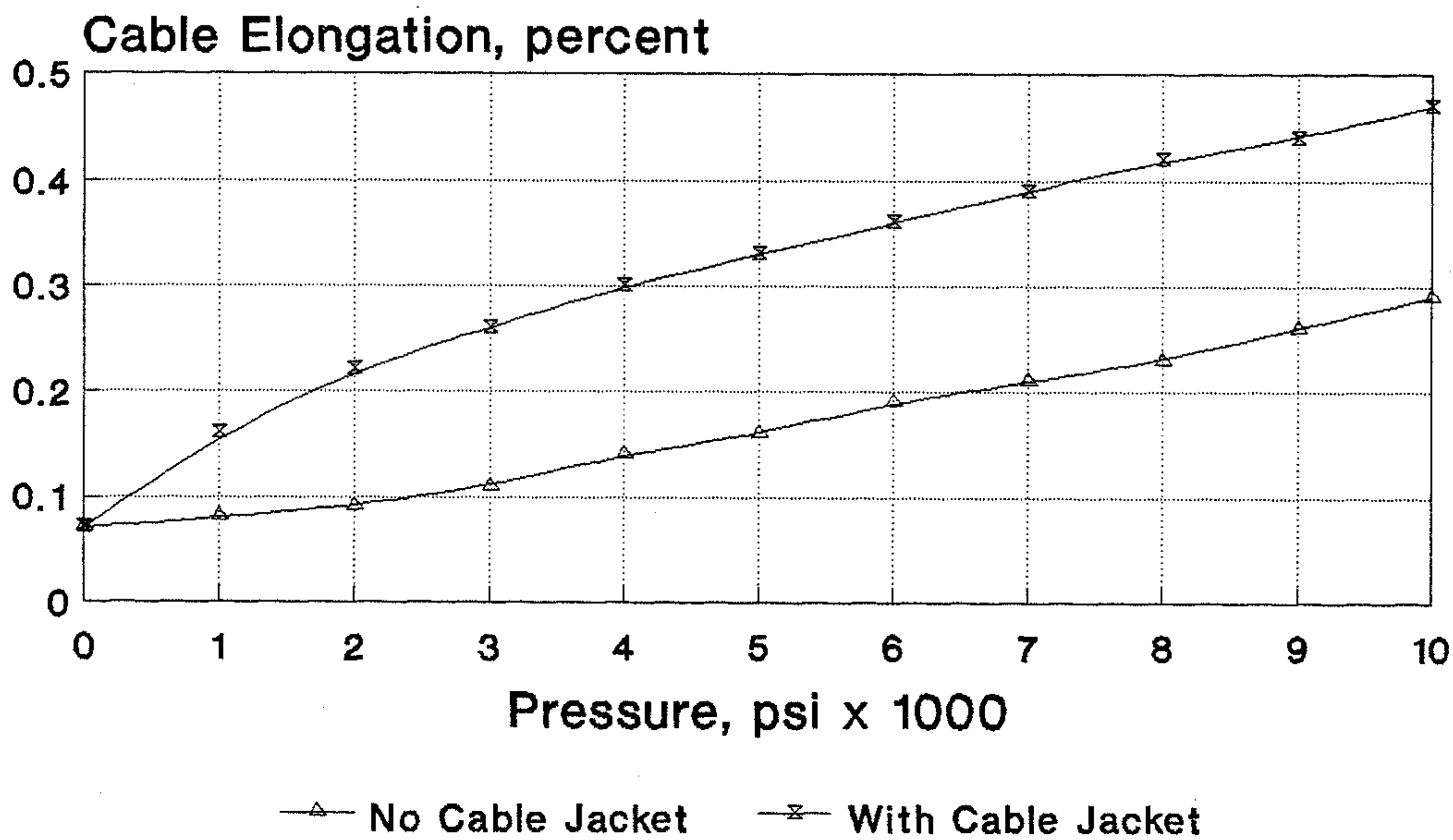


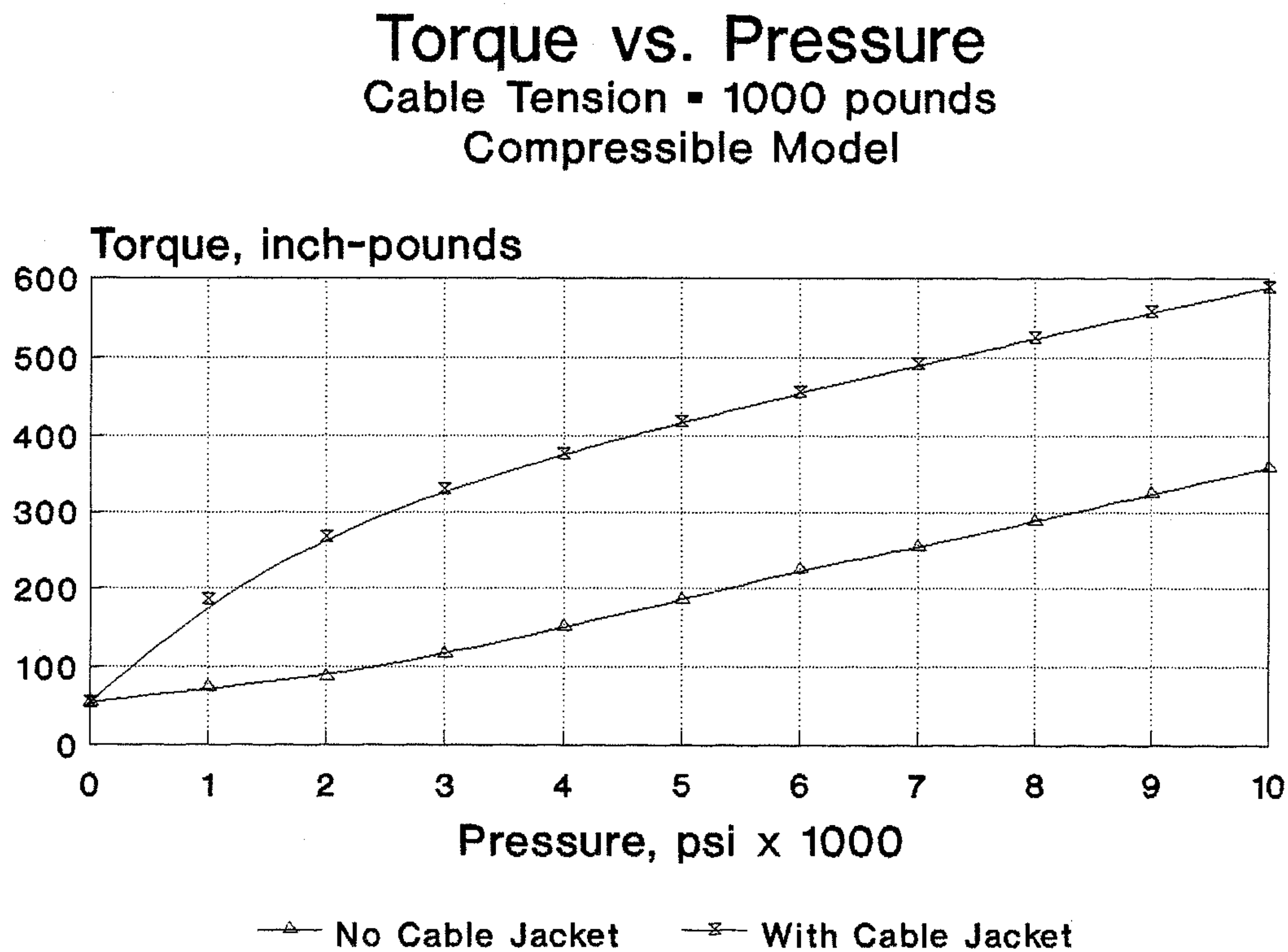
Effect of Compressibility on Stress Balance



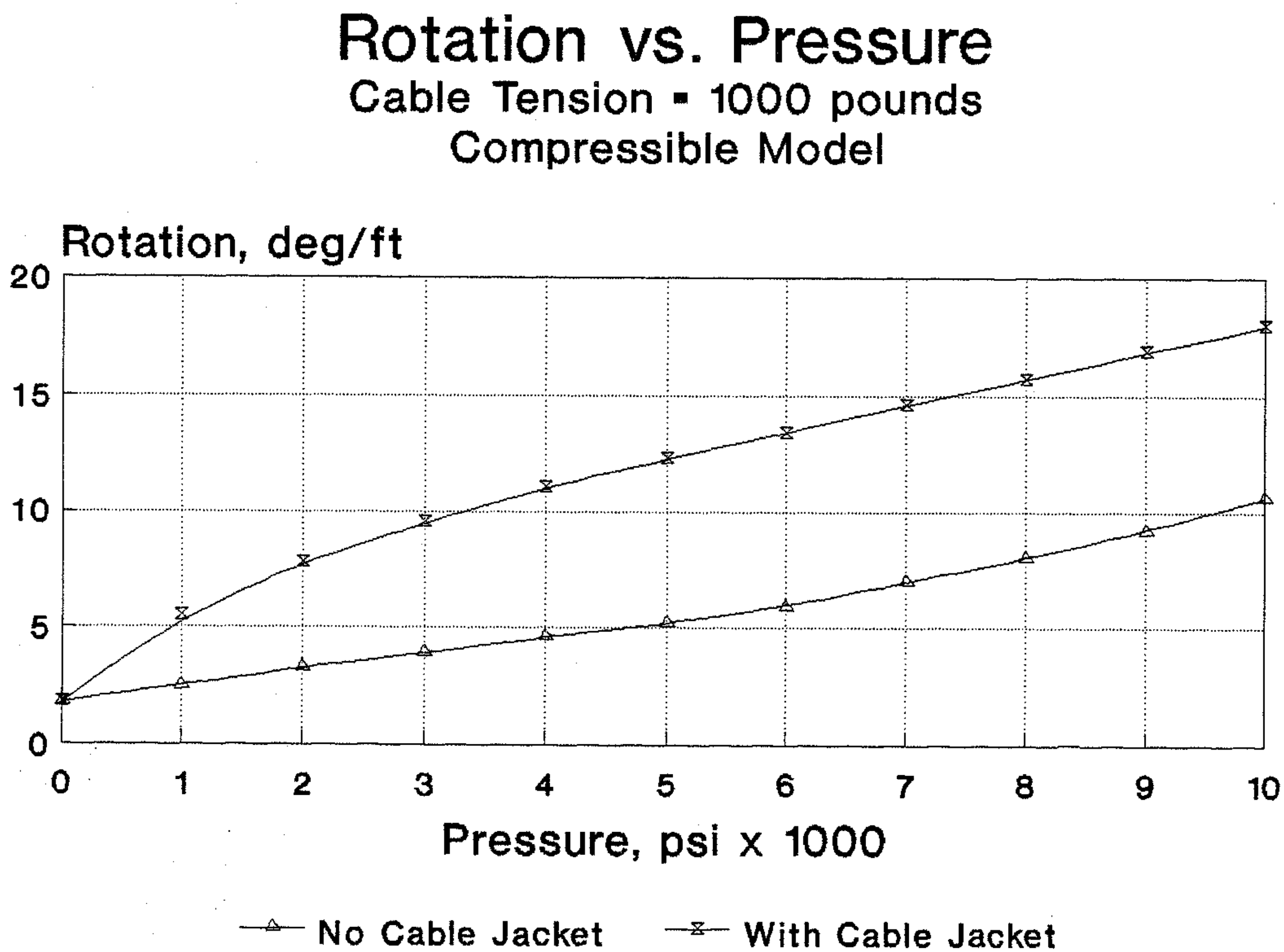
Elongation vs Pressure

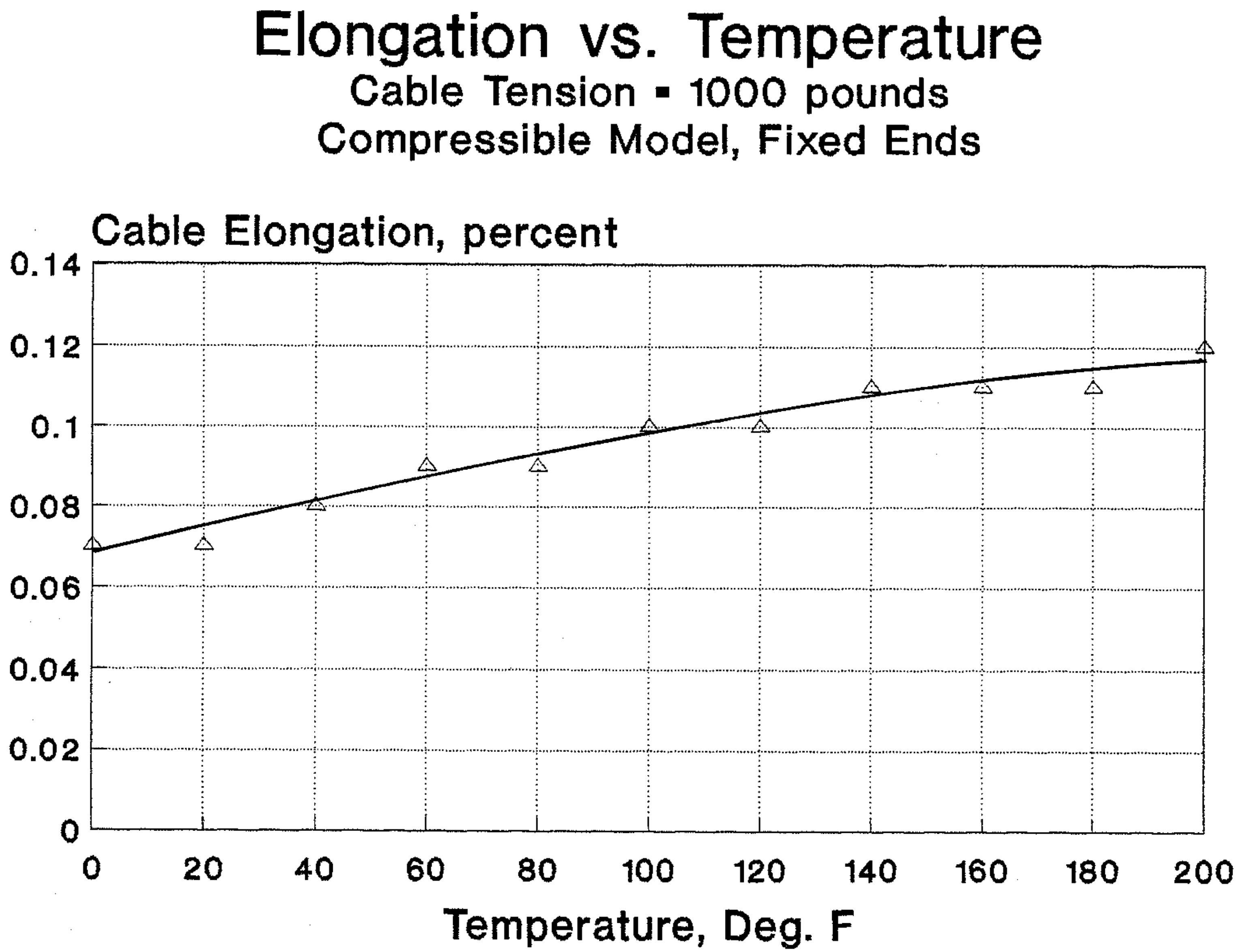
Cable Tension = 1000 pounds
Compressible Model, Fixed Ends



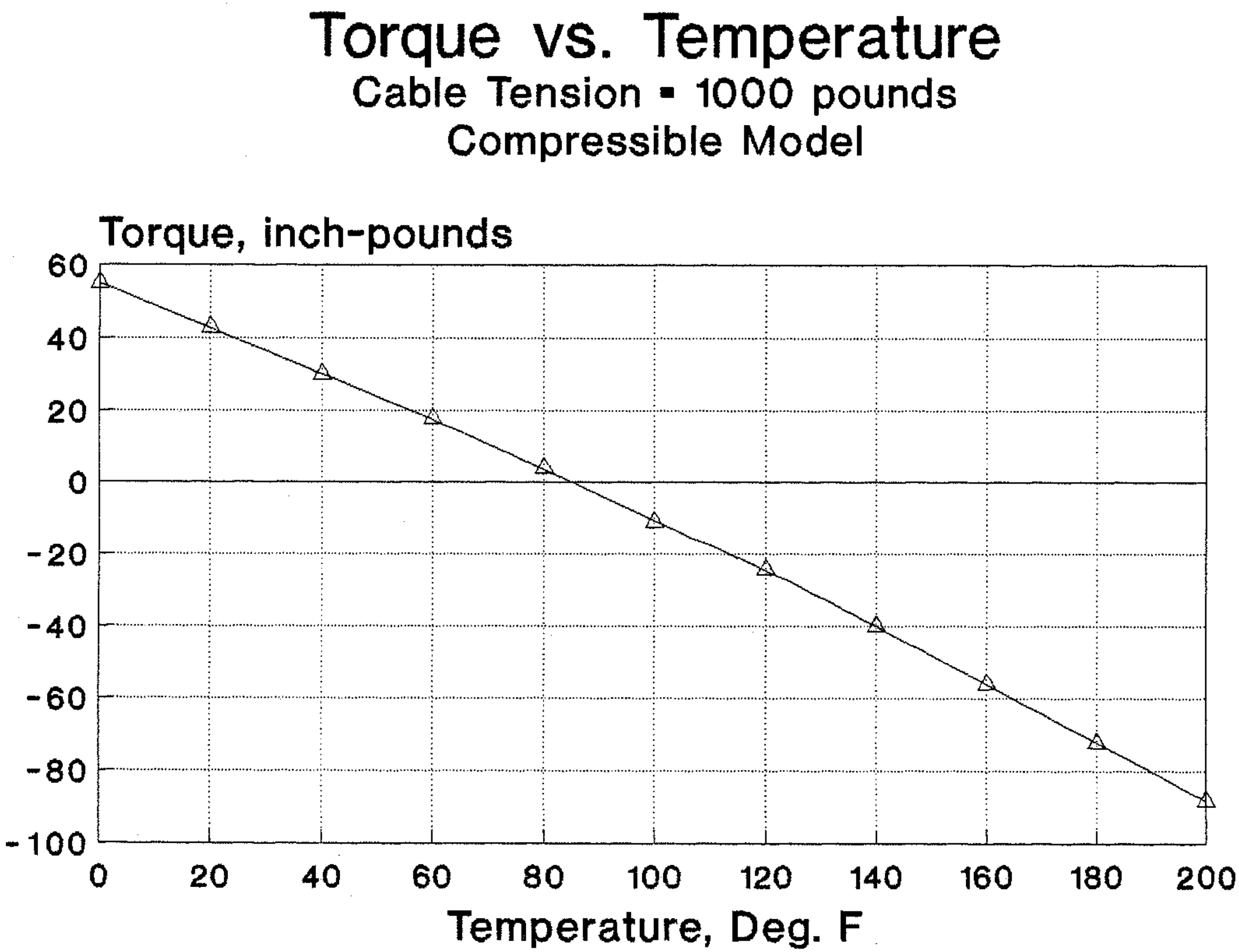


Torque vs. Pressure
Cable Tension = 1000 pounds
Compressible Model
Torque, inch-pounds
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
Pressure, psi x 1000
No Cable Jacket
With Cable Jacket


Rotation vs. Pressure
Cable Tension = 1000 pounds
Compressible Model
Rotation, deg/ft
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
Pressure, psi x 1000
No Cable Jacket
With Cable Jacket

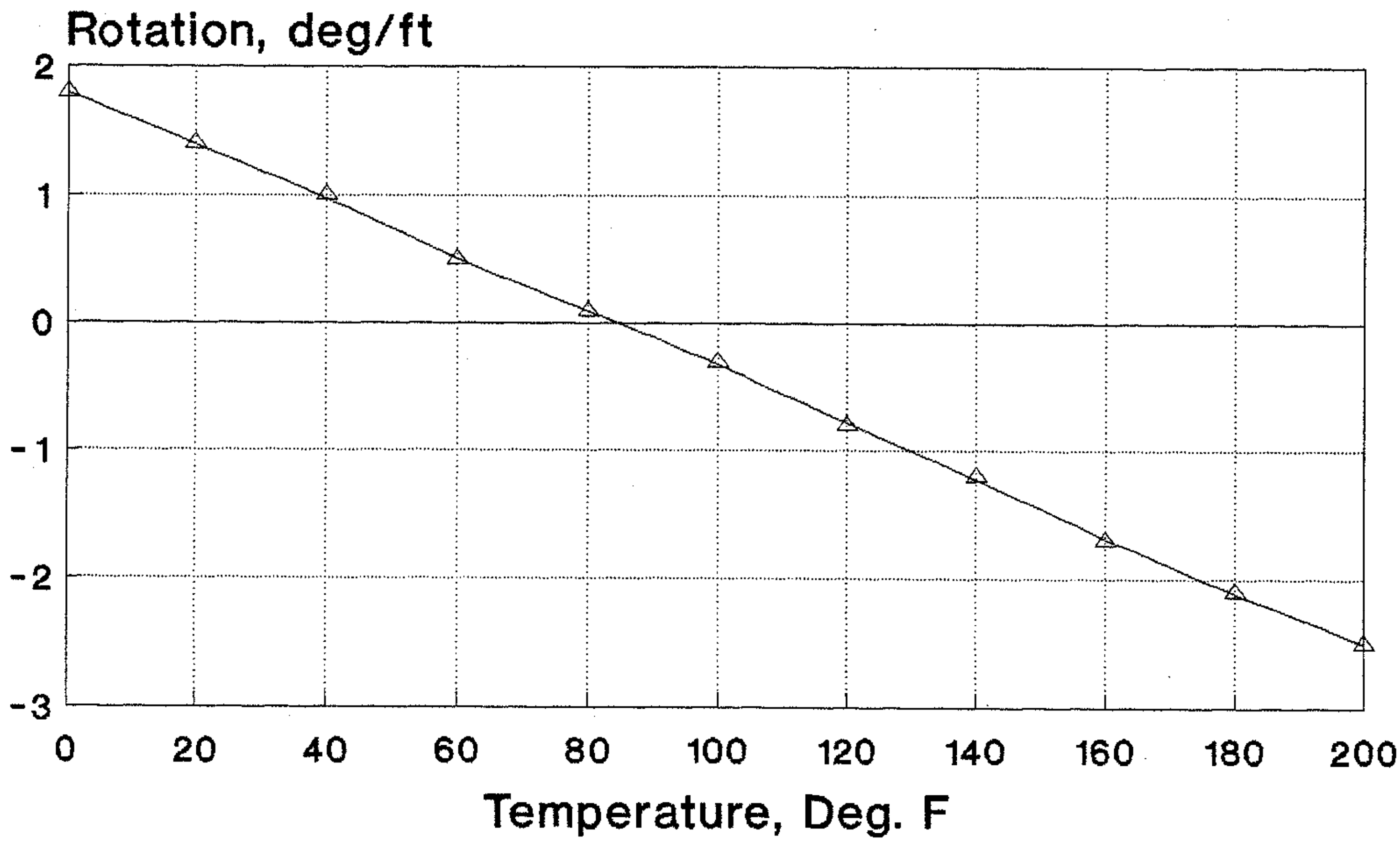


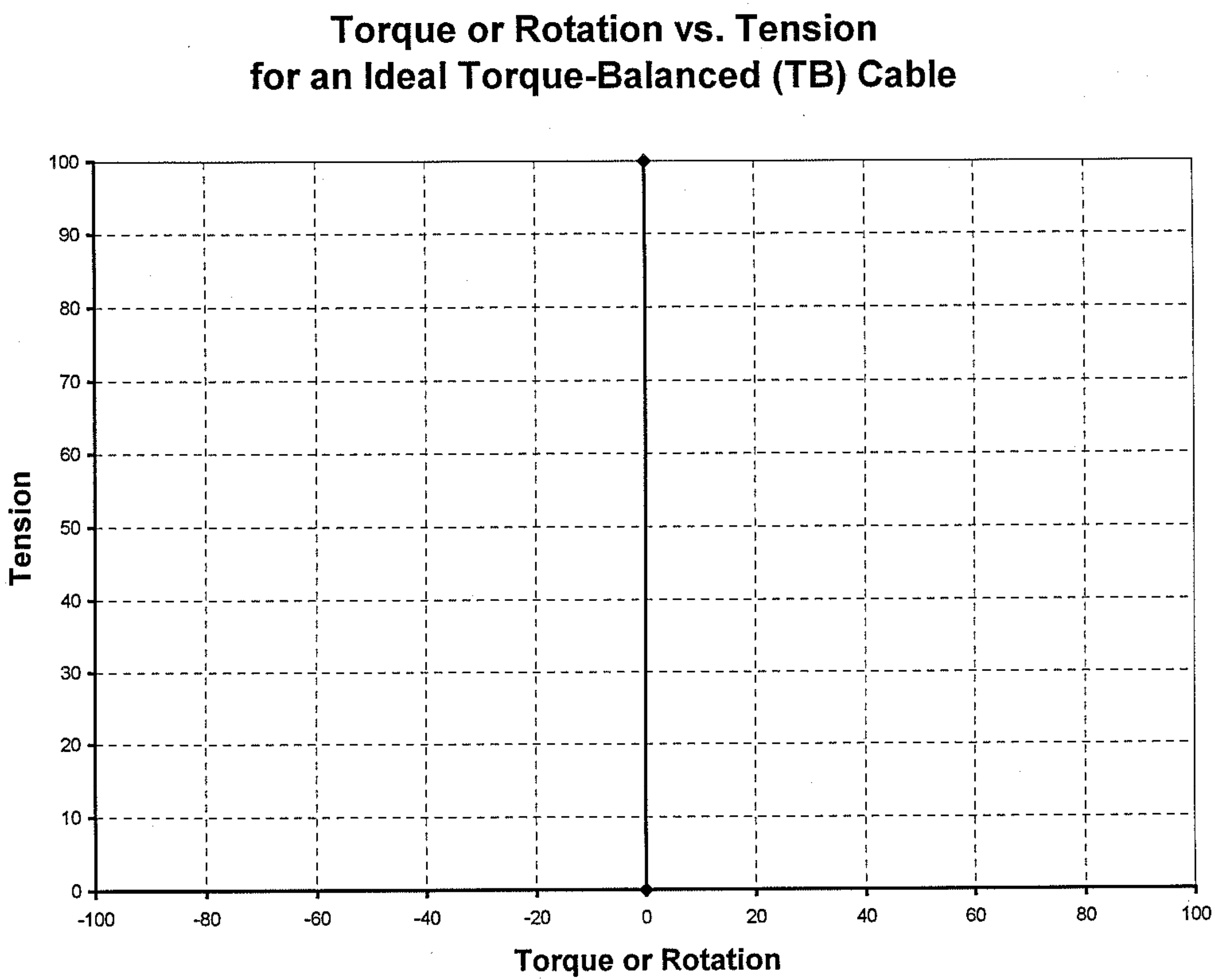
Elongation vs. Temperature
Cable Tension ▪ 1000 pounds
Compressible Model, Fixed Ends
Cable Elongation, percent
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
20
40
60
80
100
120
140
160
180
200
Temperature, Deg. F


Torque vs. Temperature
Cable Tension = 1000 pounds
Compressible Model
Torque, inch-pounds
60
40
20
0
-20
-40
-60
-80
-100
0
20
40
60
80
100
120
140
160
180
200
Temperature, Deg. F

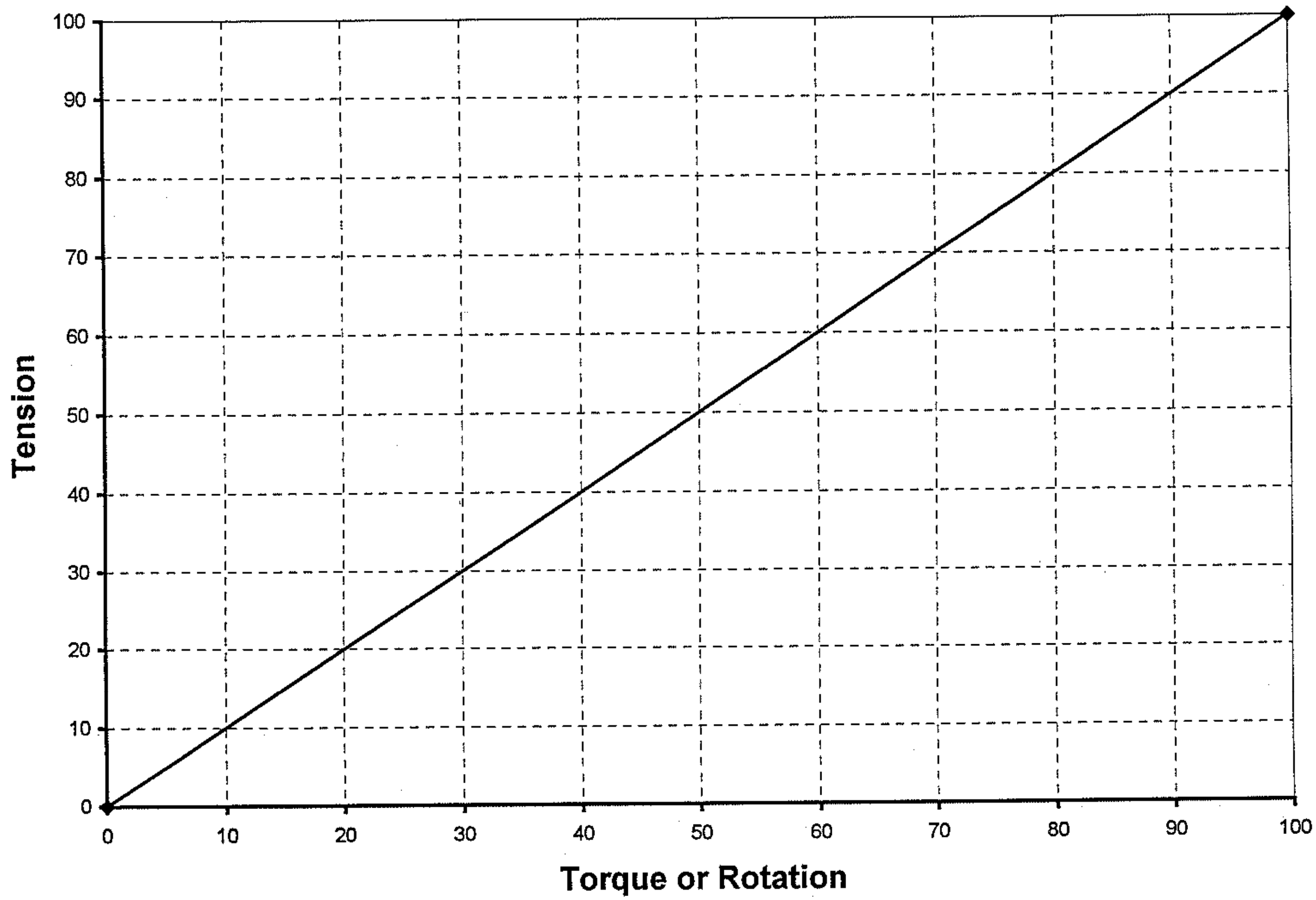
Rotation vs. Temperature

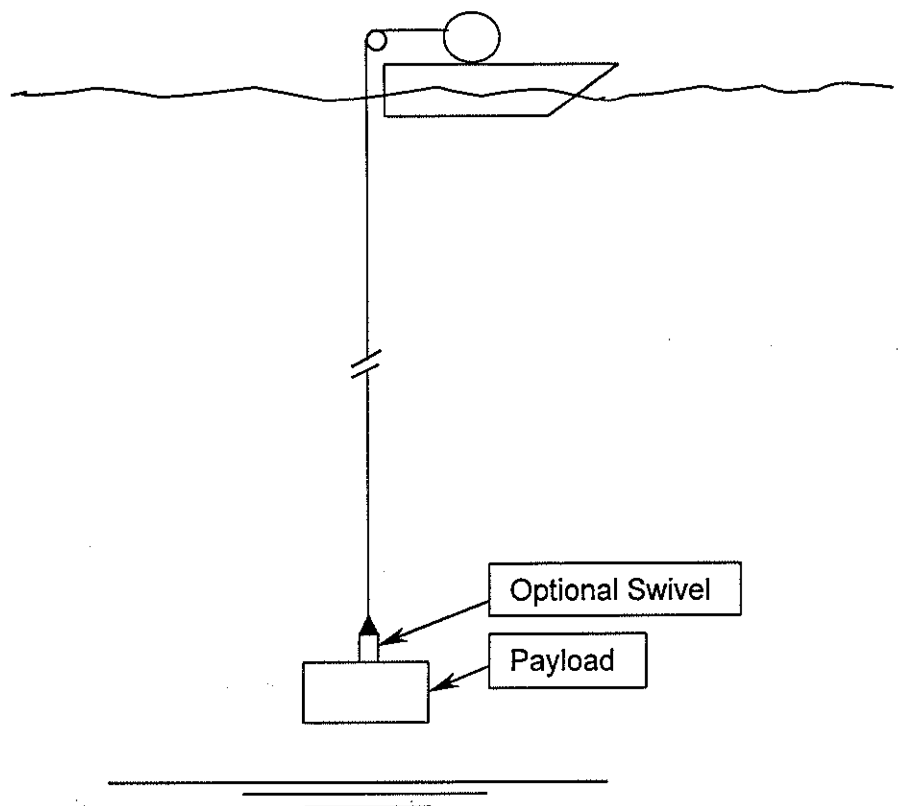
Cable Tension = 1000 pounds
Compressible Model

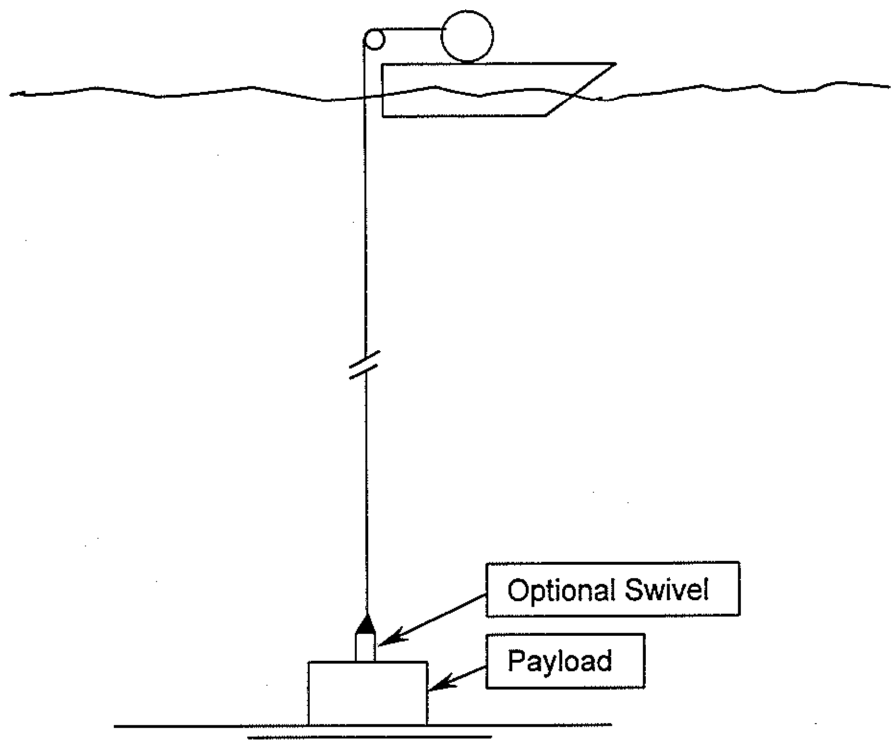


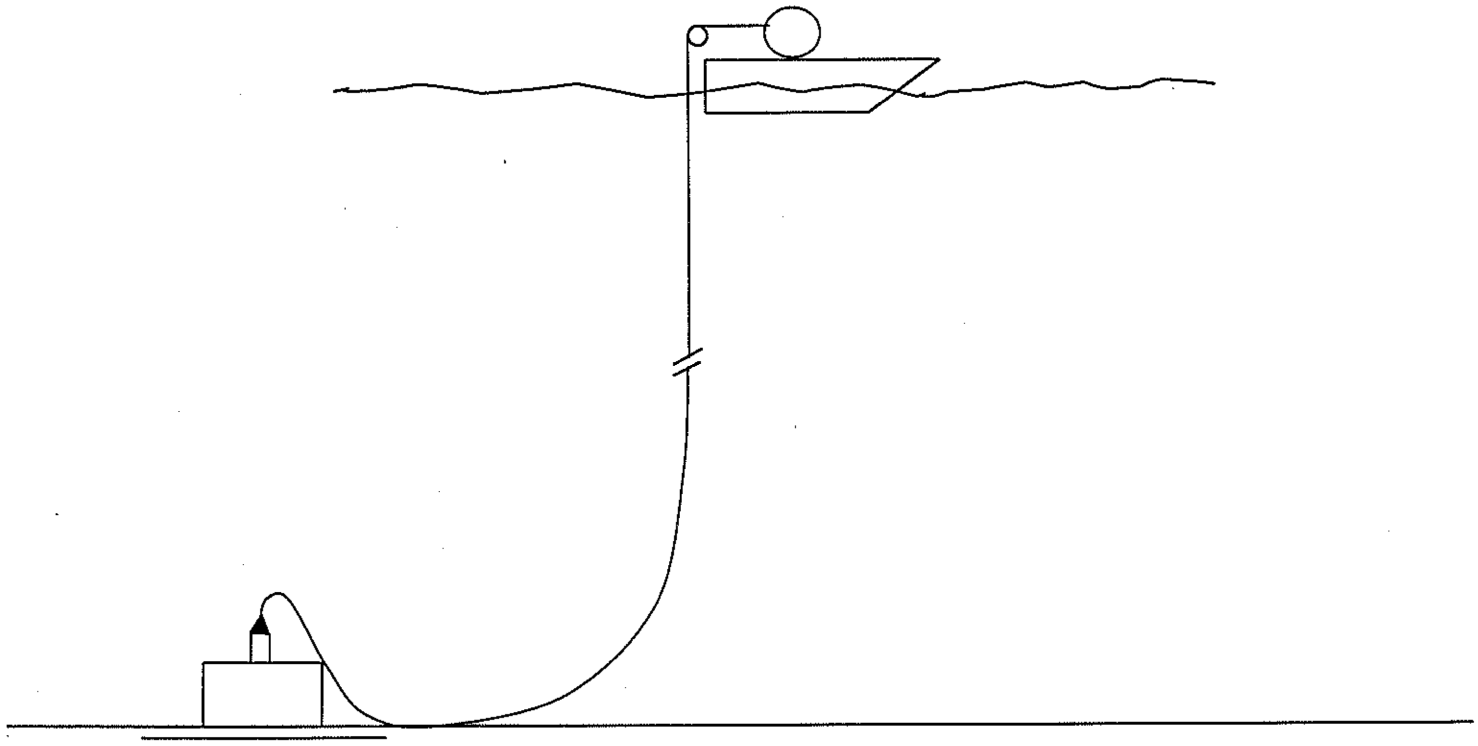

Torque or Rotation vs. Tension
for an Ideal Torque-Balanced (TB) Cable
Tension
100
90
80
70
60
50
40
30
20
10
0
-100
-80
-60
-40
-20
0
20
40
60
80
100
Torque or Rotation

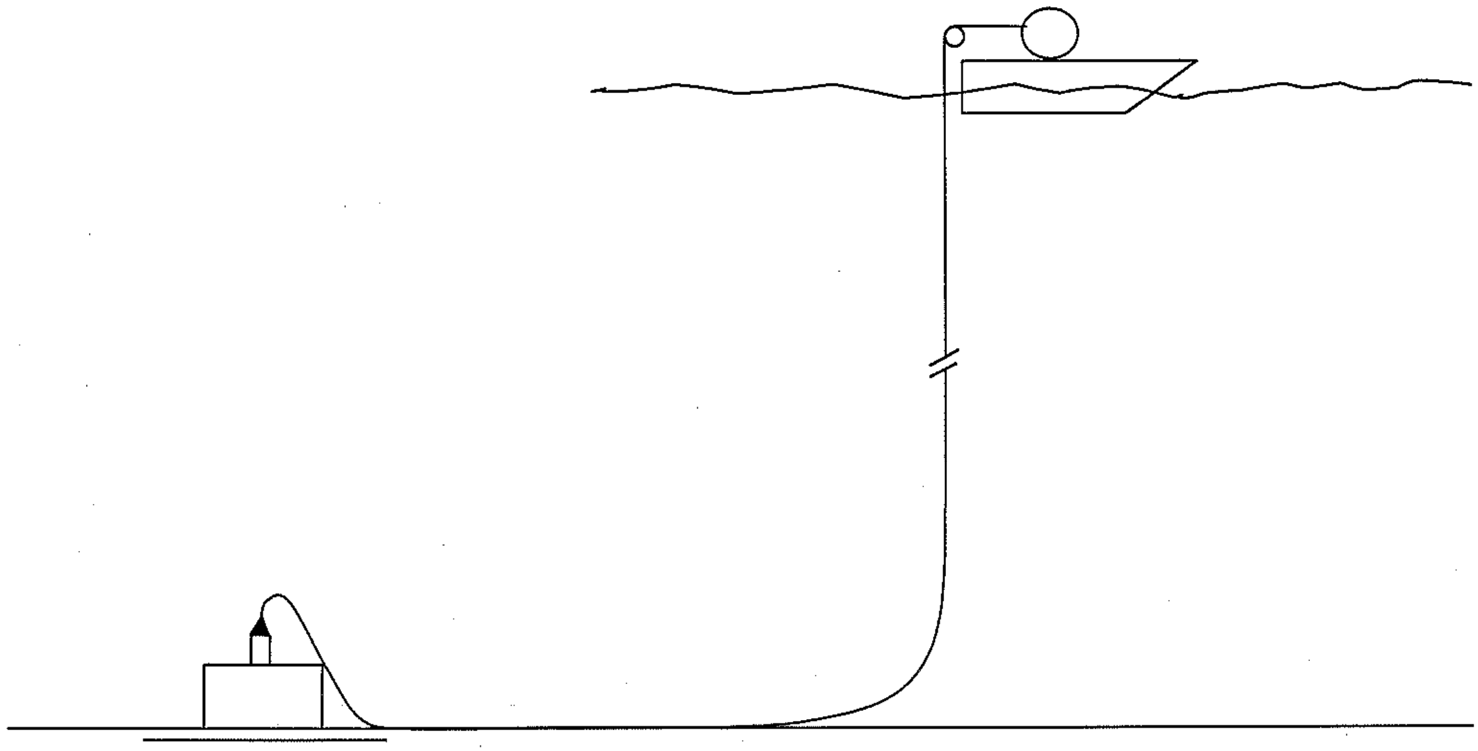
Torque or Rotation vs. Tension for a Non-Torque-Balanced (NTB) Cable

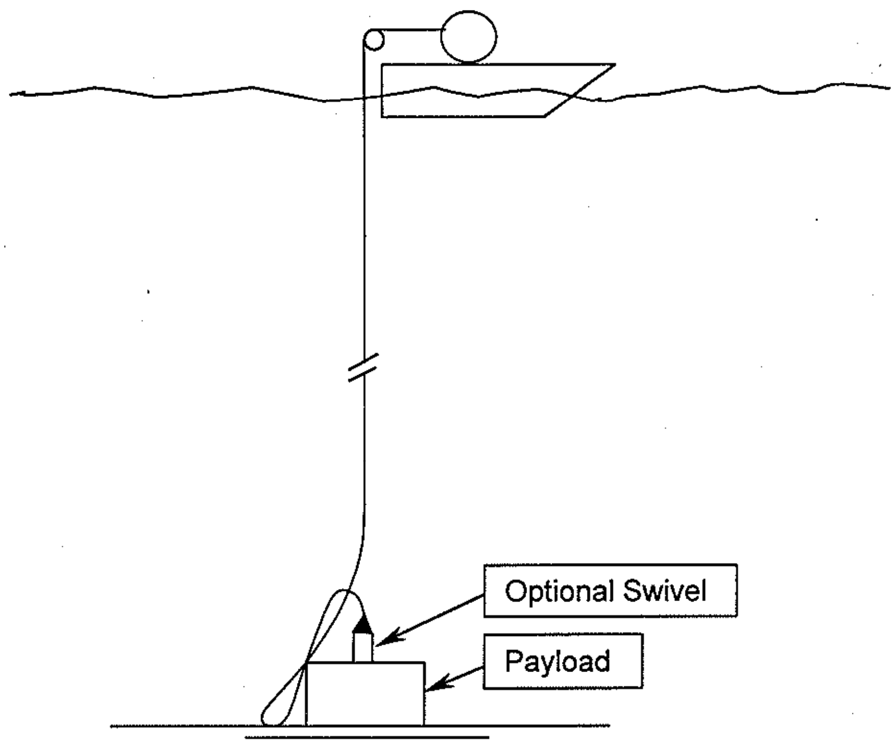


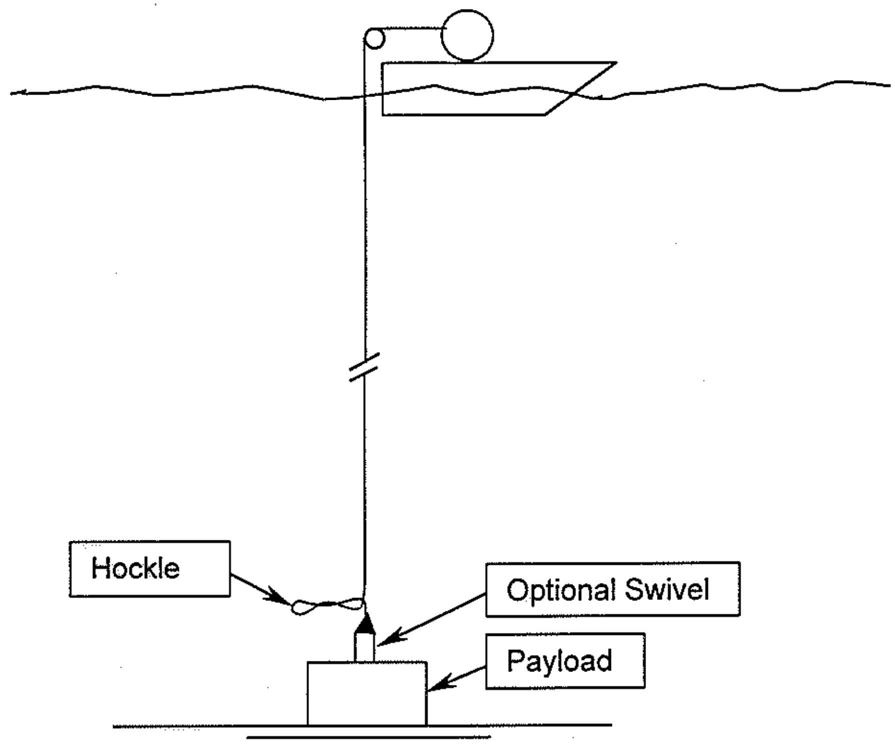

Optional Swivel
Payload


Optional Swivel
Payload






Optional Swivel
Payload


Hockle
Optional Swivel
Payload

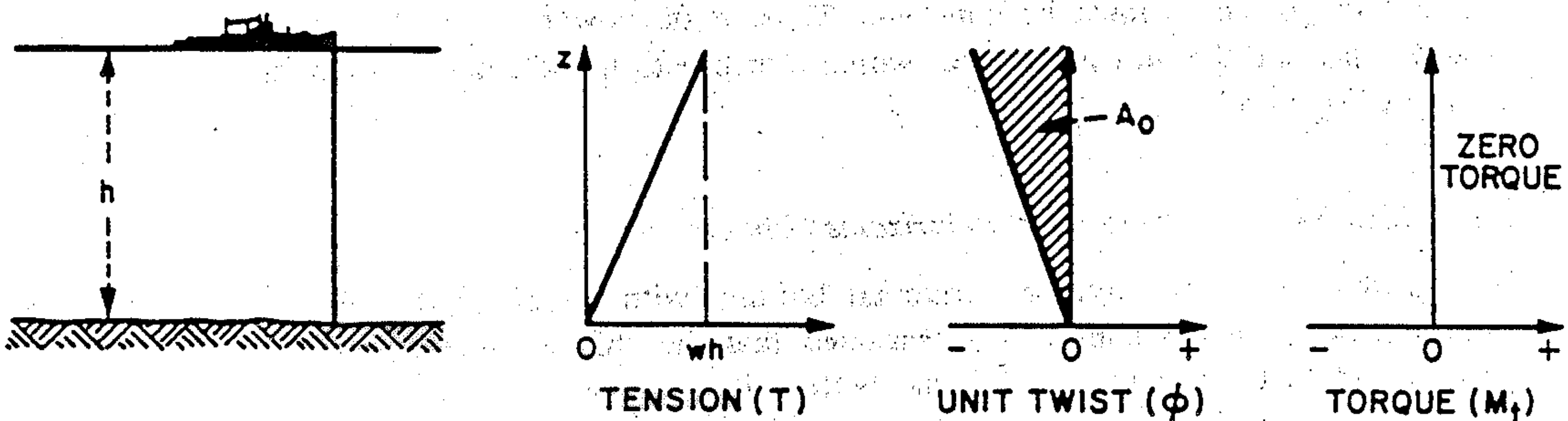


Figure 42. Behavior of Cable with Lower End Free to Rotate

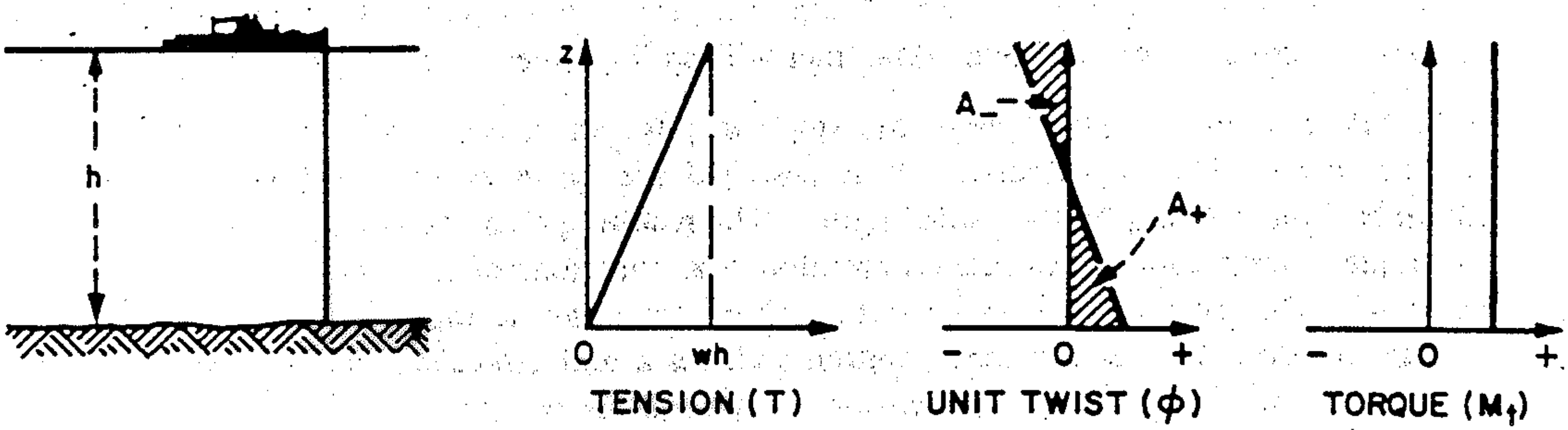


Figure 43. Behavior of Cable with Lower End Restrained from Rotating

DEPLOYMENT AND RECOVERY SCENARIOS - Page 1

Fixed-End Deployment (Payload not allowed to rotate - use of thrusters, tag lines, etc.)

- TB Cable (assume ideal case - cable torque balanced at all tensions)

    - Cable will have zero torque and rotation over deployed length
        - Unless rotation was induced by the cable handling equipment during prior D/R events
        - Unless cable develops torque in response to hydrostatic pressure

    - Cable probably will not hockle if payload is placed seafloor and excess cable is deployed
        - Unless cable has high torsional energy due to rotation induced by handling equipment
        - Unless cable has high torsional energy due to effects of hydrostatic pressure

- NTB Cable (assume cable has linear torque-versus-tension behavior)

    - Cable will have non-zero torque (net torque equal to test torque at mid-depth tension)
    - Cable will have a rotation gradient (loosened at top, no change at middle, tightened at bottom)
    - Torque and rotation may be affected by handling equipment and/or hydrostatic pressure
    - Cable probably will hockle if payload is placed seafloor and excess cable is deployed

DEPLOYMENT AND RECOVERY SCENARIOS - Page 2

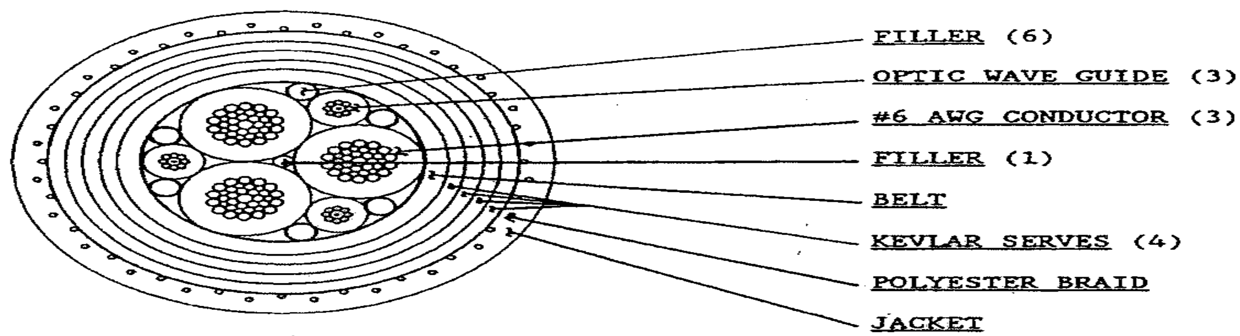
Free-End Deployment (Swivel used at payload or payload allowed to rotate)

- TB Cable (assume ideal case - cable torque balanced at all tensions)

  - Cable will have zero torque and rotation over deployed length
    - Unless rotation was induced by the cable handling equipment during prior D/R events
    - Unless rotation is induced by hydrodynamic forces acting on descending payload
    - Unless cable develops torque in response to hydrostatic pressure
  - Cable probably will not hockle if payload is placed seafloor and excess cable is deployed (Certainly true if cable is allowed to achieve zero torque prior to payload set down)

- NTB Cable (assume cable has linear torque-versus-tension behavior)

  - Cable will have zero torque over deployed length (given enough time)
    - Either the cable will rotate at a swivel to achieve zero torque, or
    - Without a swivel, the payload will rotate to seek zero cable torque, although
      - Rotation may lag due to rotational inertia of payload
      - Rotation may be affected by hydrodynamic forces acting on descending payload
      - Payload may overshoot the zero-torque condition and then act as a torsional pendulum
  - Rotation may be affected by handling equipment and/or hydrostatic pressure
  - Even with a swivel, cable may hockle if payload is placed seafloor and excess cable is deployed unless the tension is reduced slowly enough to allow the cable to achieve zero torque as the tension drops to zero
  - Without a swivel, cable probably will hockle if payload is placed seafloor and excess cable is deployed



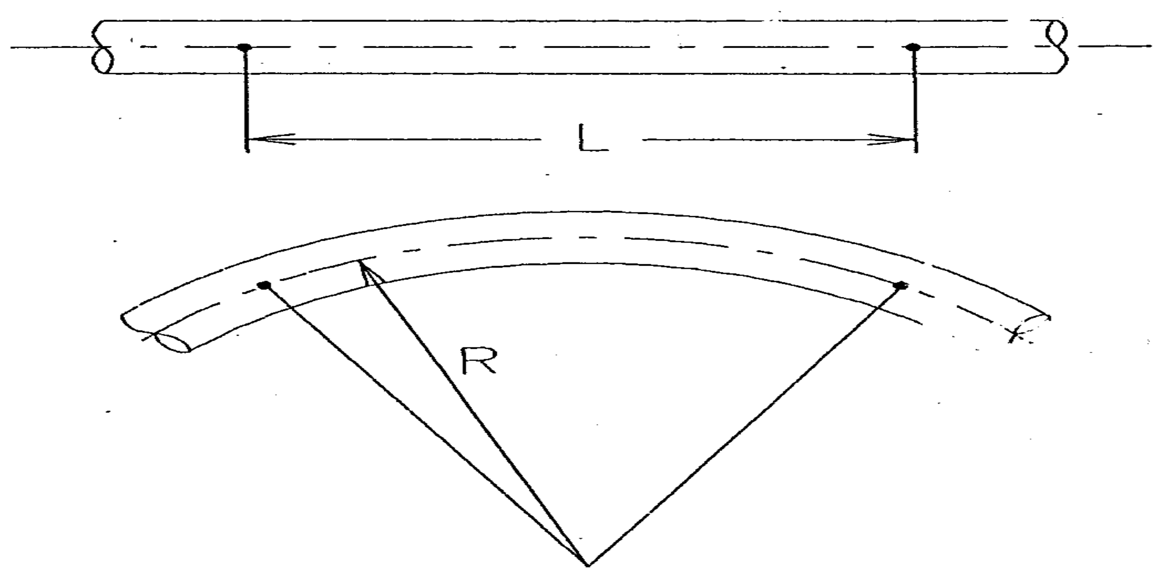
STEEL LIGHT ELECTRO-OPTICAL ROV CABLE
FIGURE 1

BENDING OF A SIMPLE ROD

Material stress remains within the elastic range

Material has the same tensile and compressive elastic properties

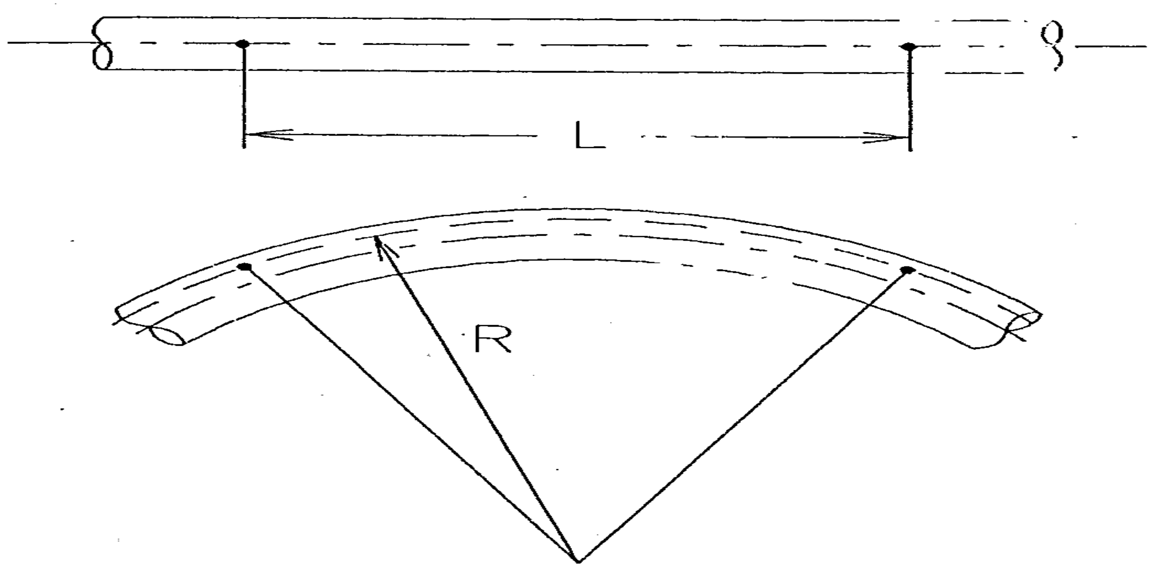
The neutral bending axis remains in the geometric center of the rod

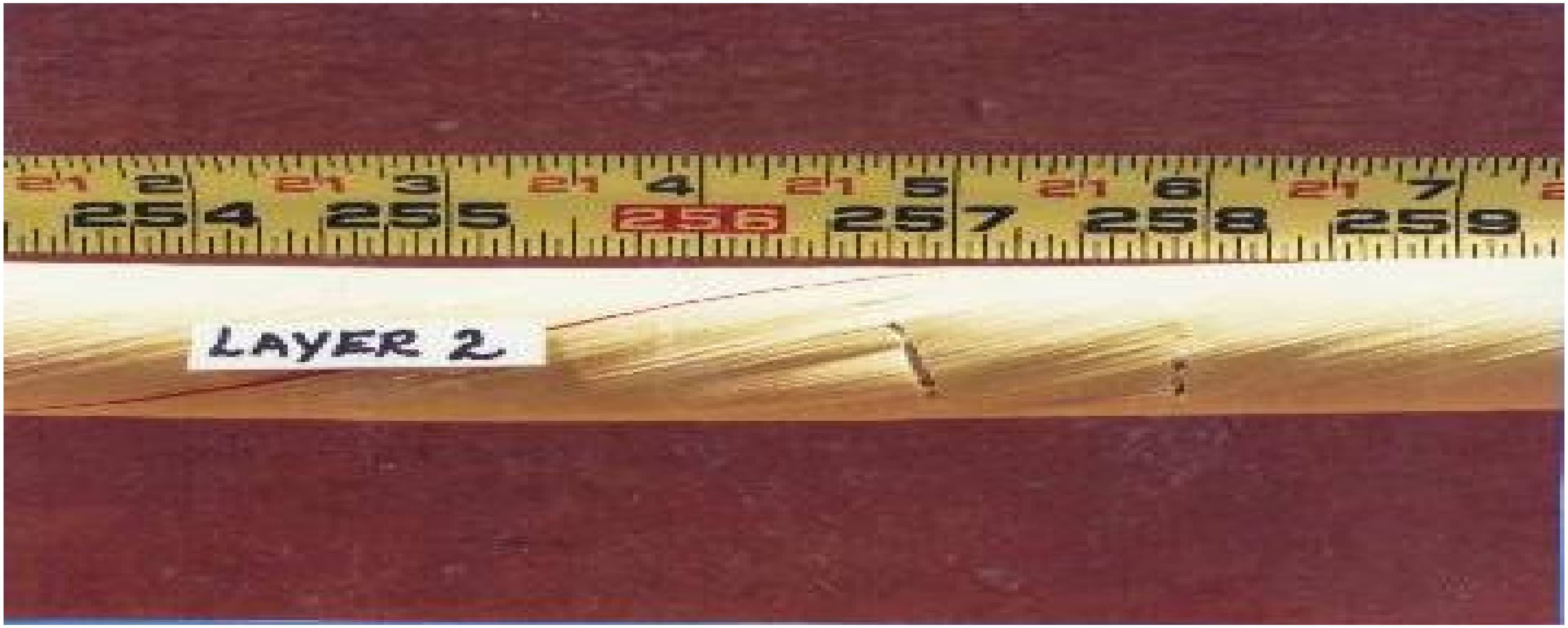


BENDING OF A COMPLEX CABLE

Material <u>does not</u> have the same tensile and compressive elastic properties

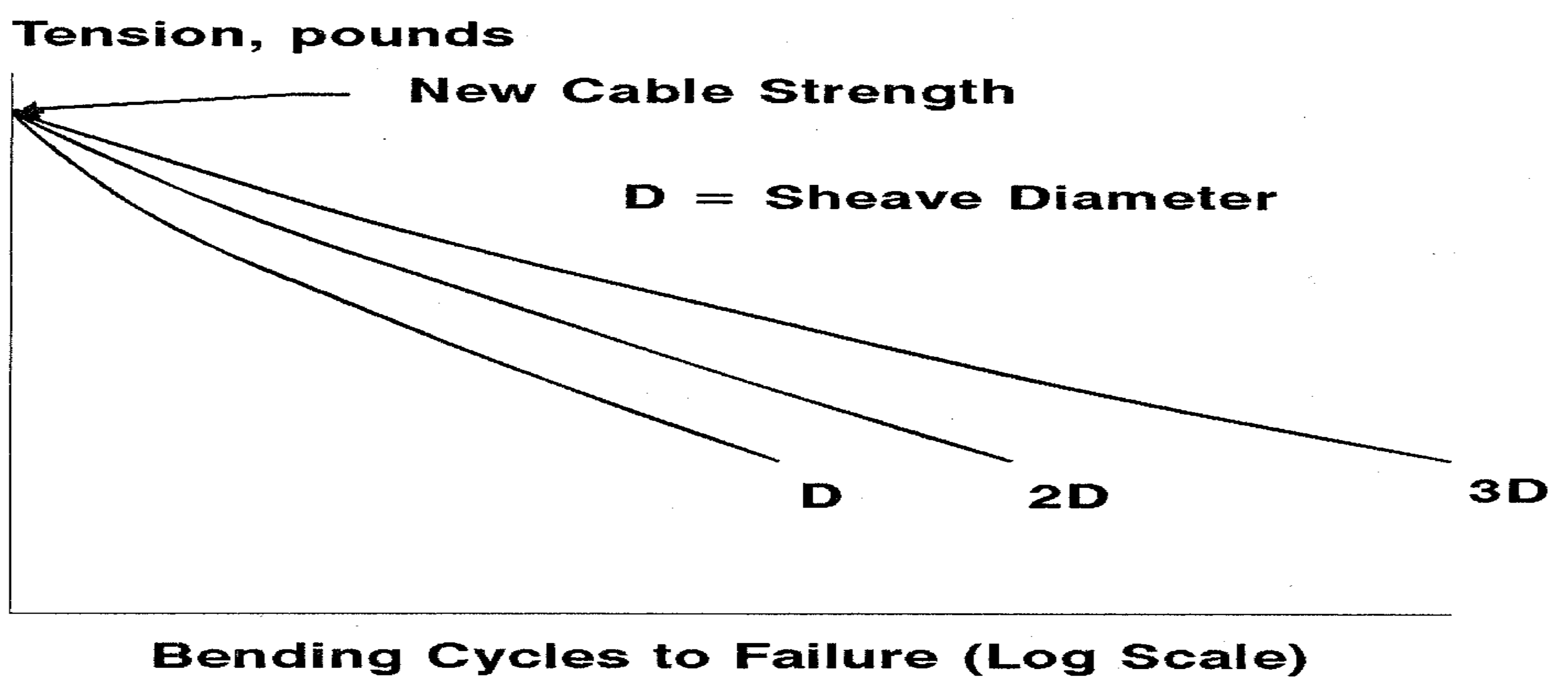
The neutral bending axis <u>does not</u> remain in the geometric center of the cable



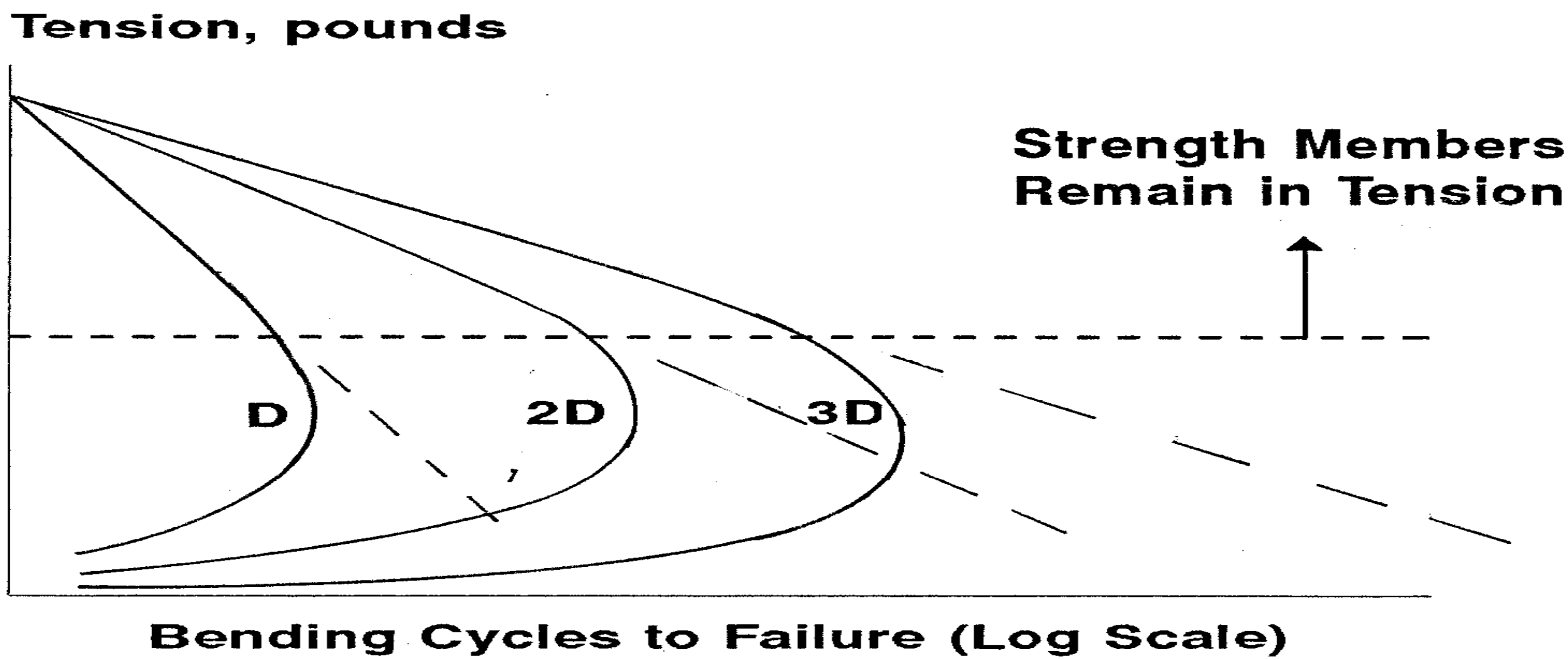

LAYER 2

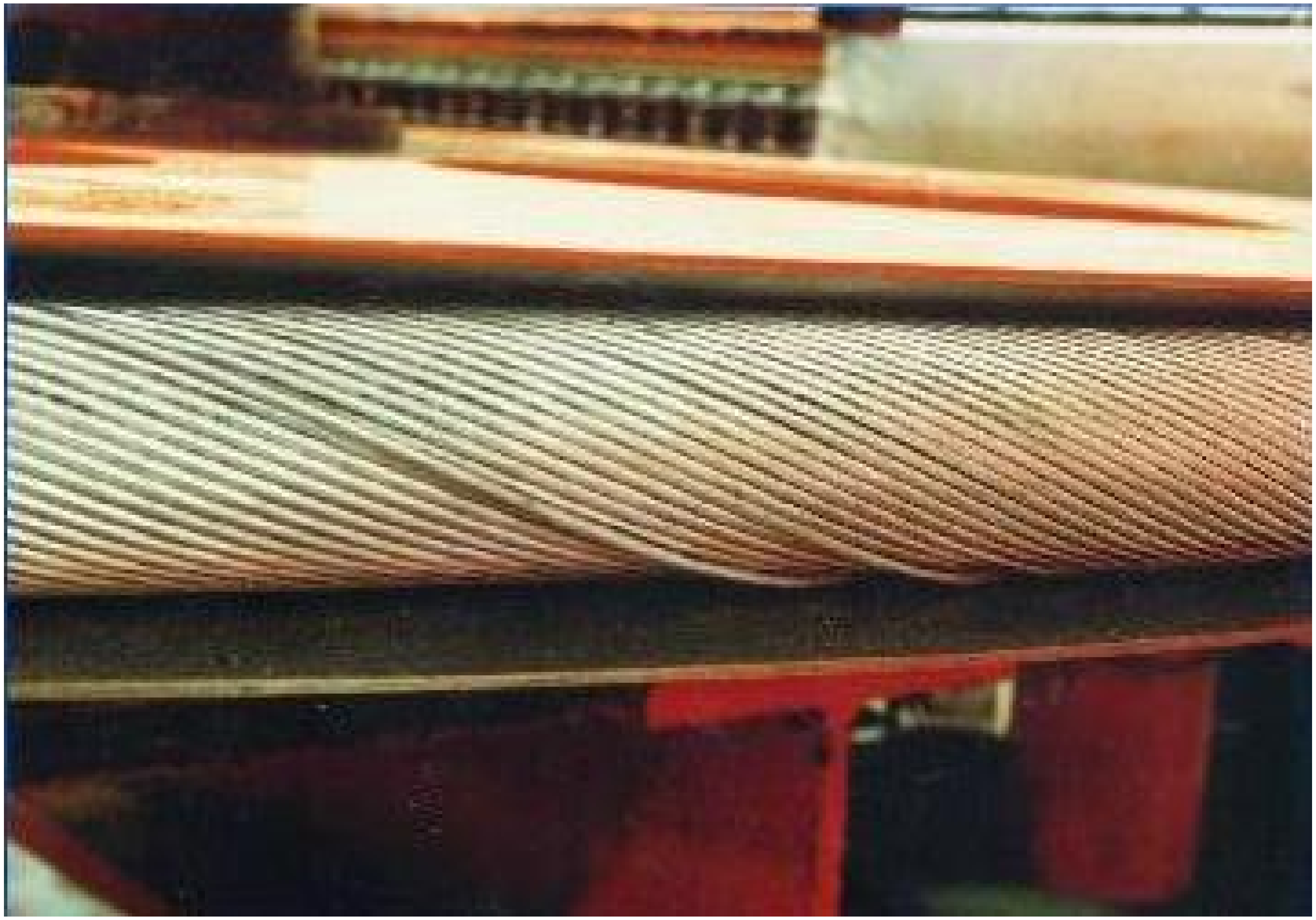

LAYER 2

Typical Bending Fatigue Performance of Cables Having Steel-Wire Strength Members (Armor)



Typical Bending Fatigue Performance of Cables Having High-Modulus-Fiber Served Strength Members

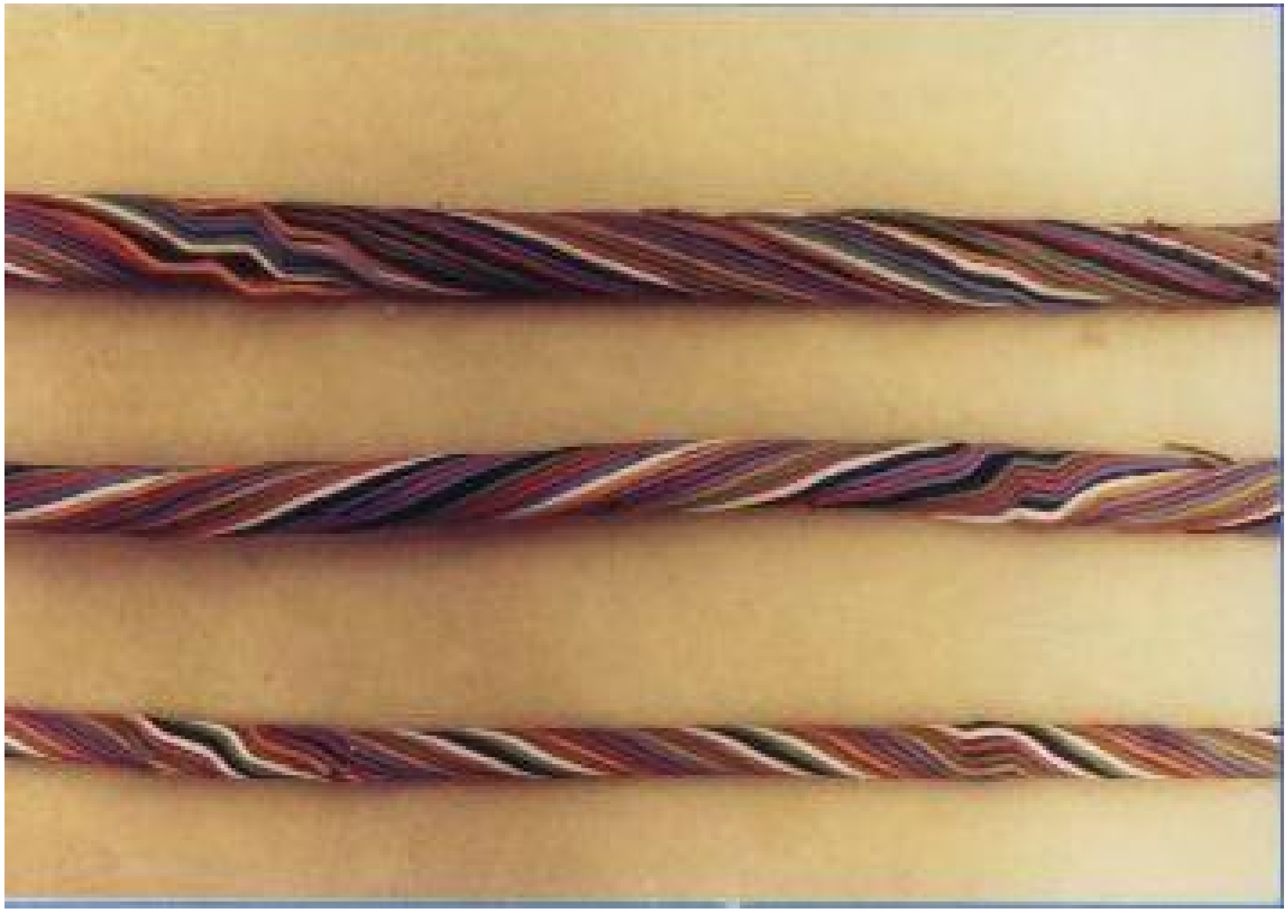


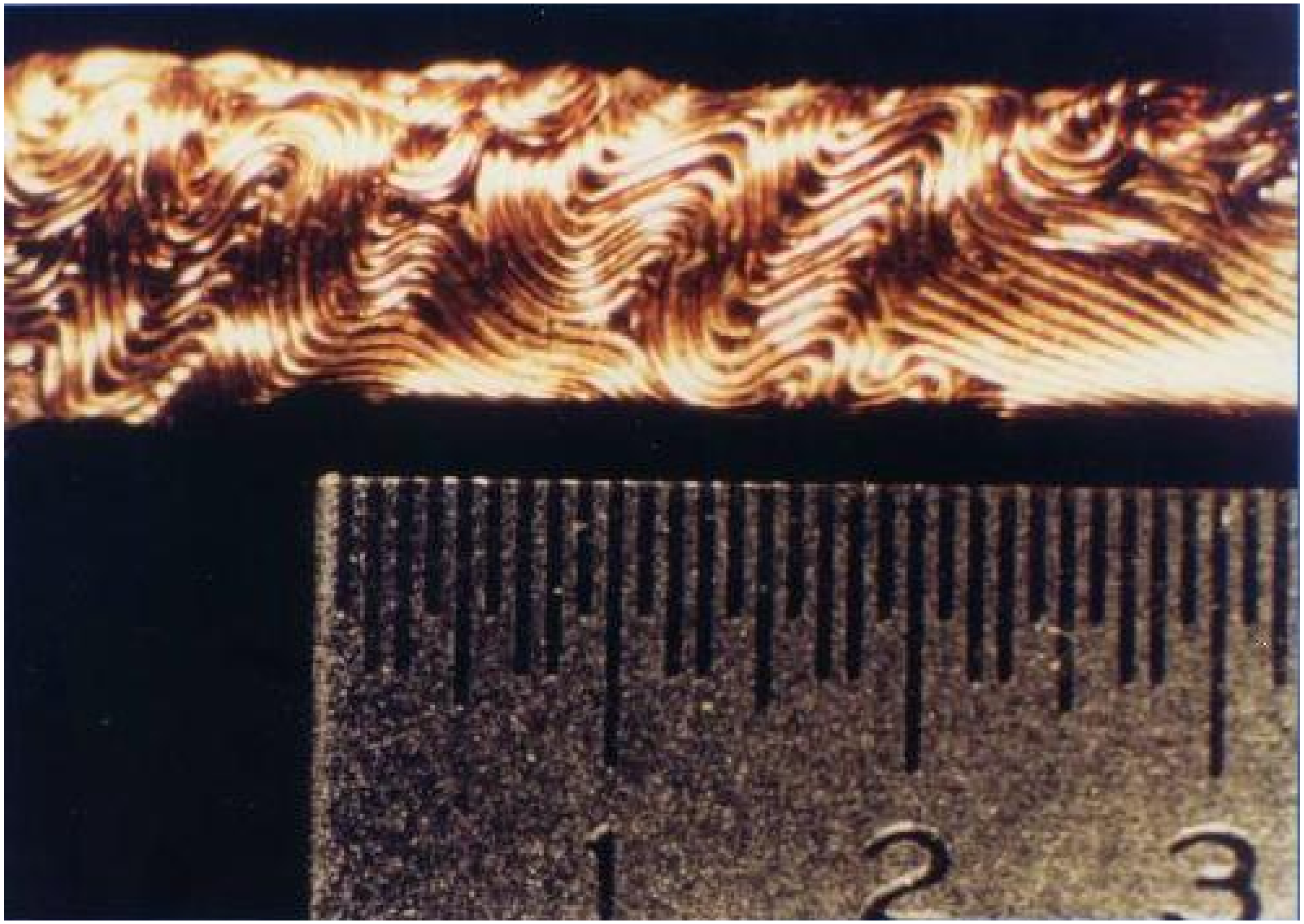


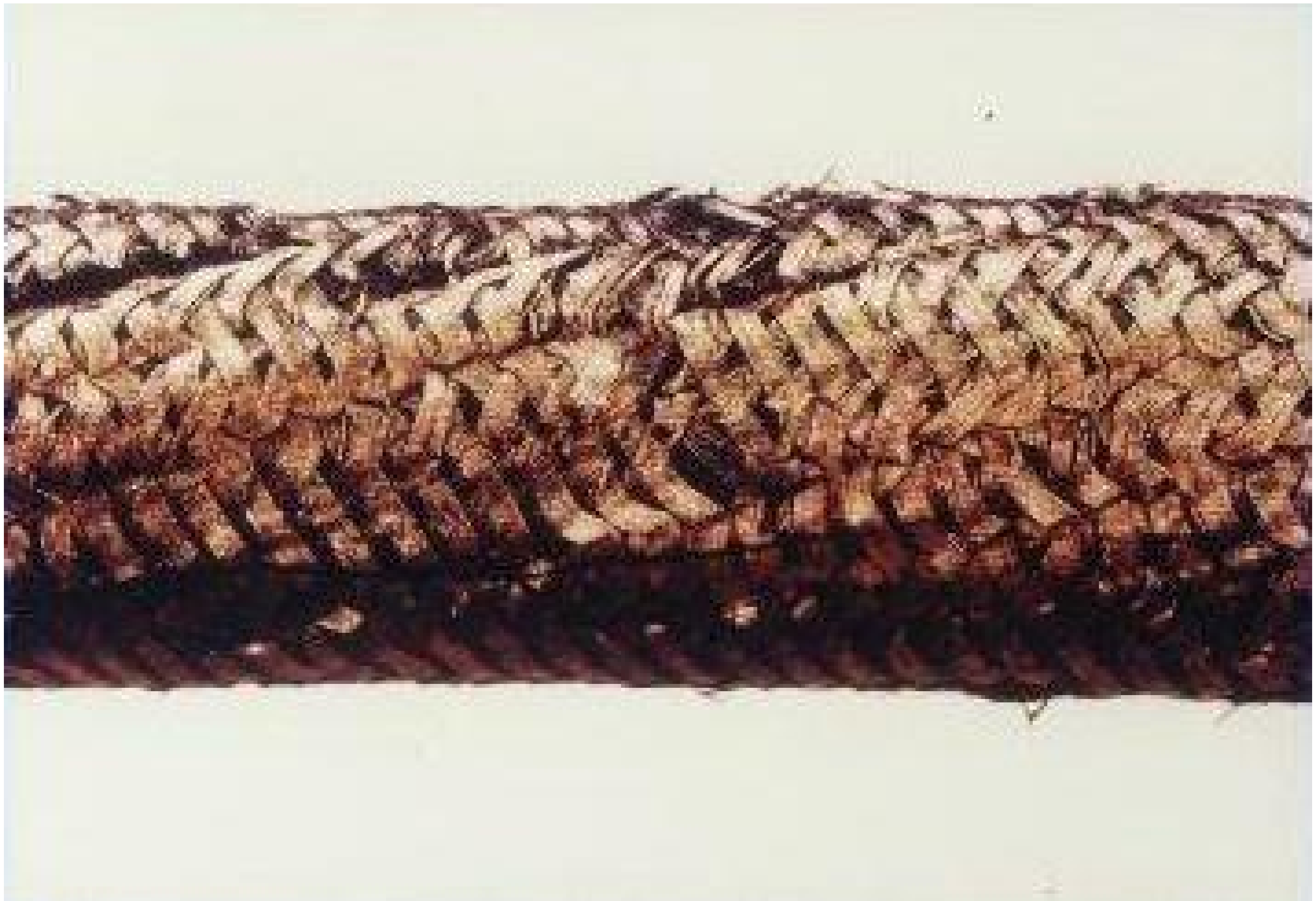
21 2
21 3
21 4
21 5
21 6
21 7
254 255 256 257 258 259
LAYER 2


LAYER 2
149
150
151


7F
11
8
F
1
8F
2

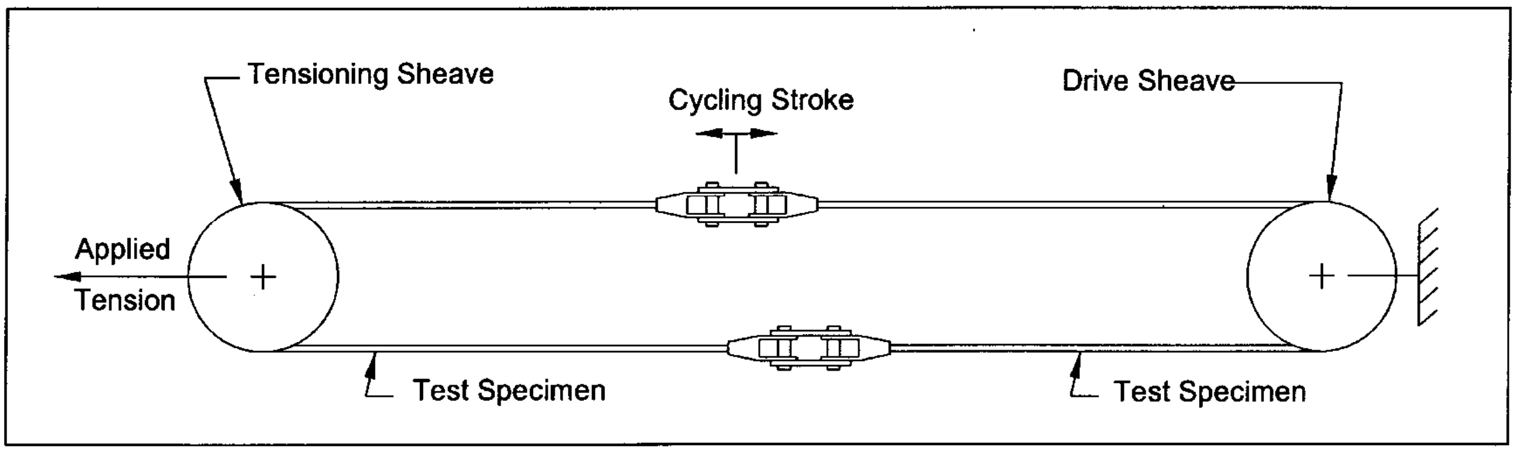



1
2
3




CROSBY
20

Bending Fatigue Tests



Bending Fatigue Test Apparatus

Testing Rope Specimens over Single Sheaves

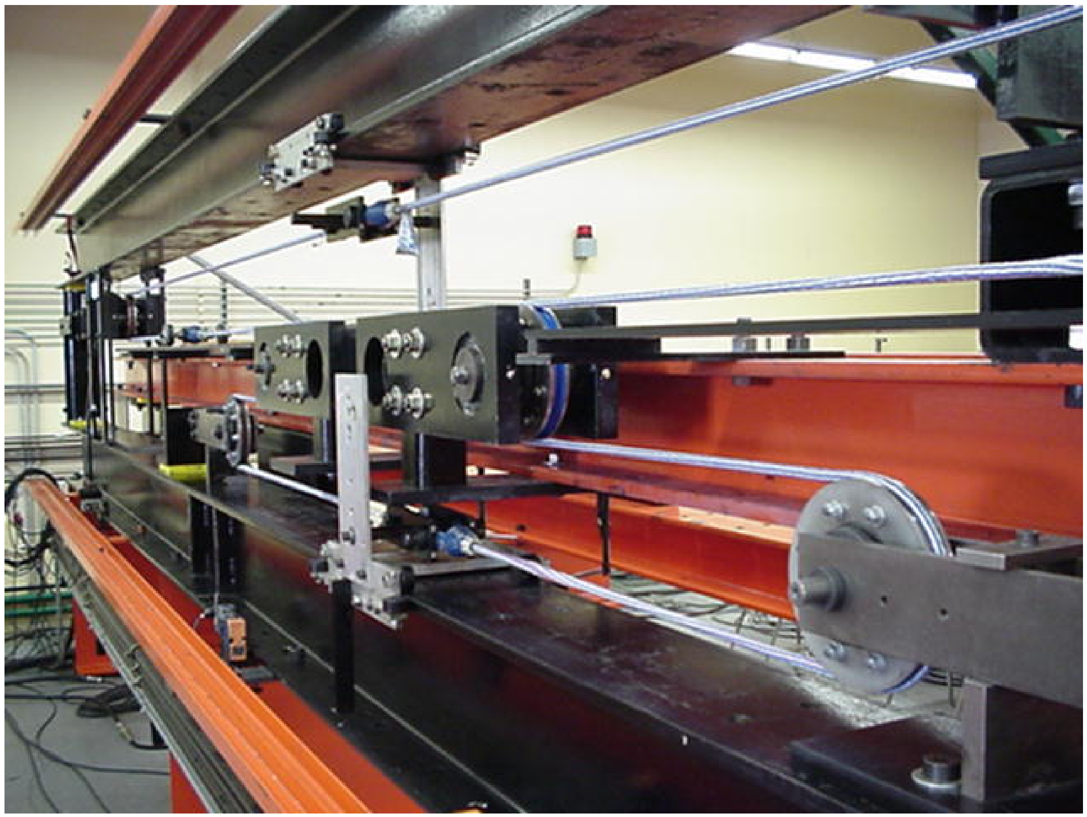
Two-Bay Test Machine

Hydraulic Cylinder, Load Cell, and Tension Sheave Assembly

Testing Rope Specimens in Reverse Bending over Two Sheaves

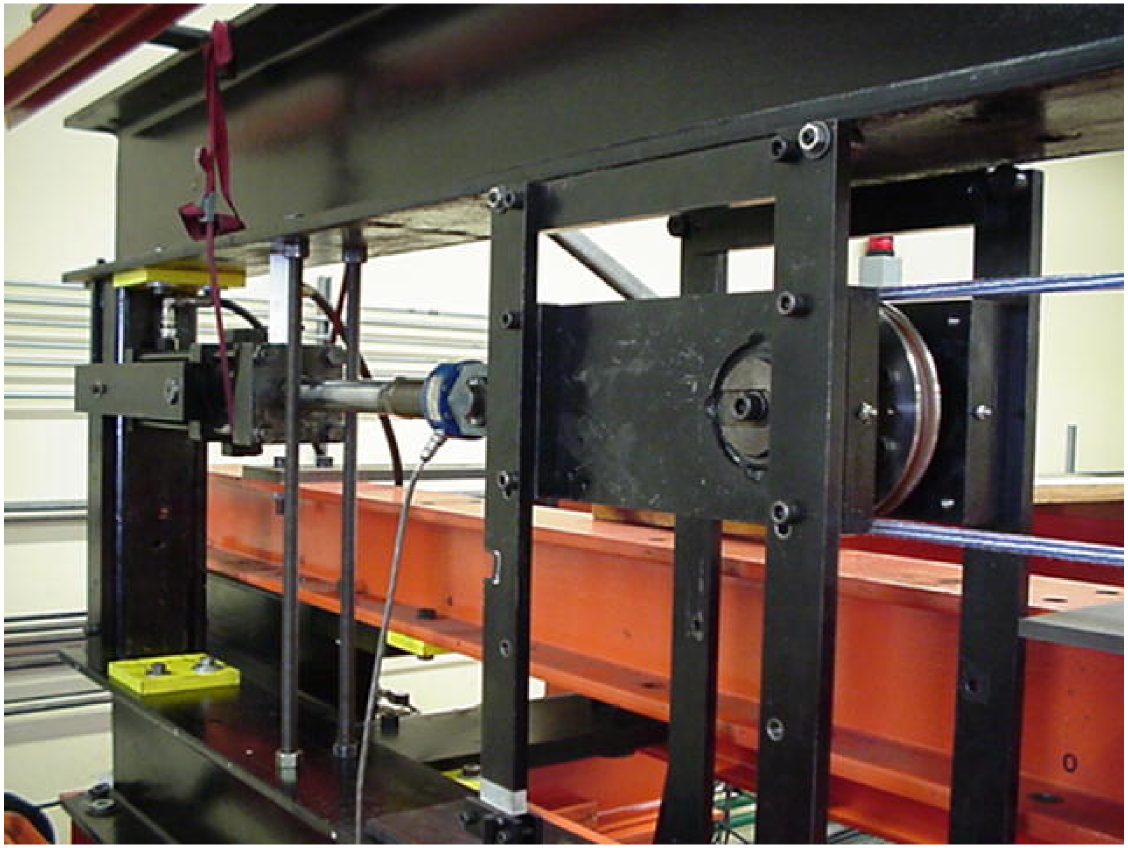
Overall View of Test Machine with Drive Motor and Sheave at Right and Tension Sheave at Far Left

Testing Rope Specimens in Reverse Bending over Two Sheaves



Reverse-Bend Sheaves at Center of Machine with Rope Specimens attached to Support Trolleys and Tension Sheave at Far Upper Left

Testing Rope Specimens in Reverse Bending over Two Sheaves



Hydraulic Cylinder, Load Cell, and Tension Sheave Assembly

Testing Rope Specimens in Reverse Bending over Two Sheaves

Reverse-Bend Sheaves at Center of Machine
With Drive Sheave at Far Upper Right

Long Test Bed

TENSILE TESTS

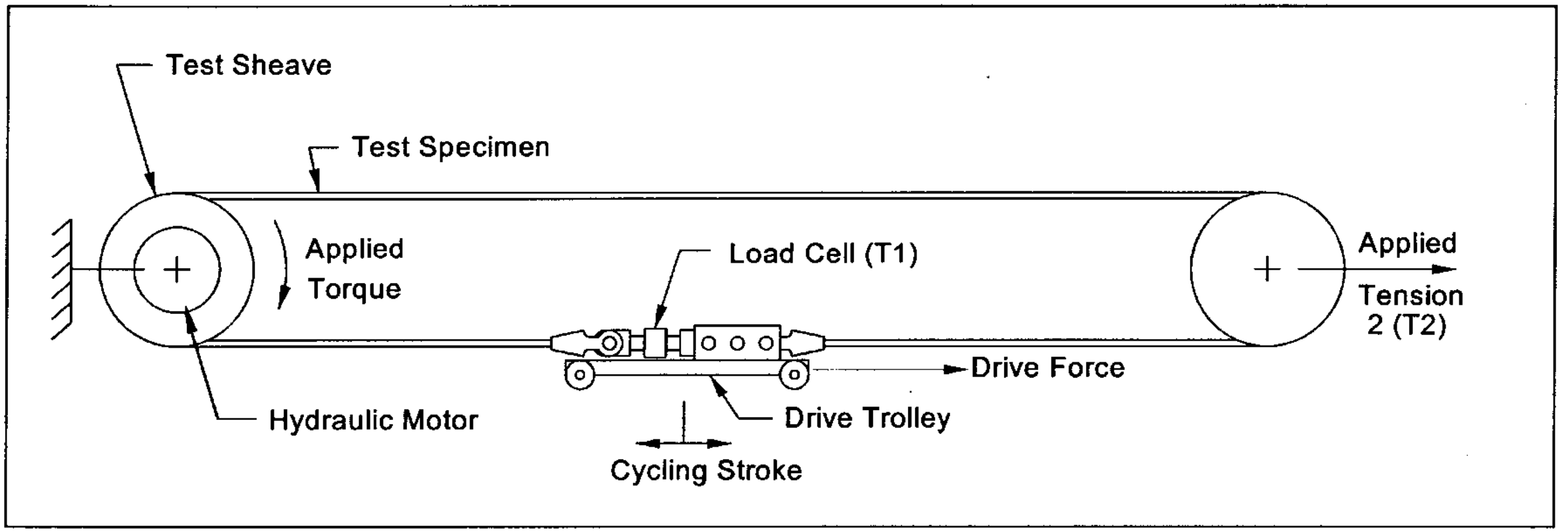
- 125 feet pin to pin length
- Tension to 180,000 pounds
- Cylinder stroke 99 inches

CYCLIC BENDING TESTS

- 125-foot sheave spacing
- Maximum cable tension 90,000 pounds
- Maximum cycling stroke length 115 feet

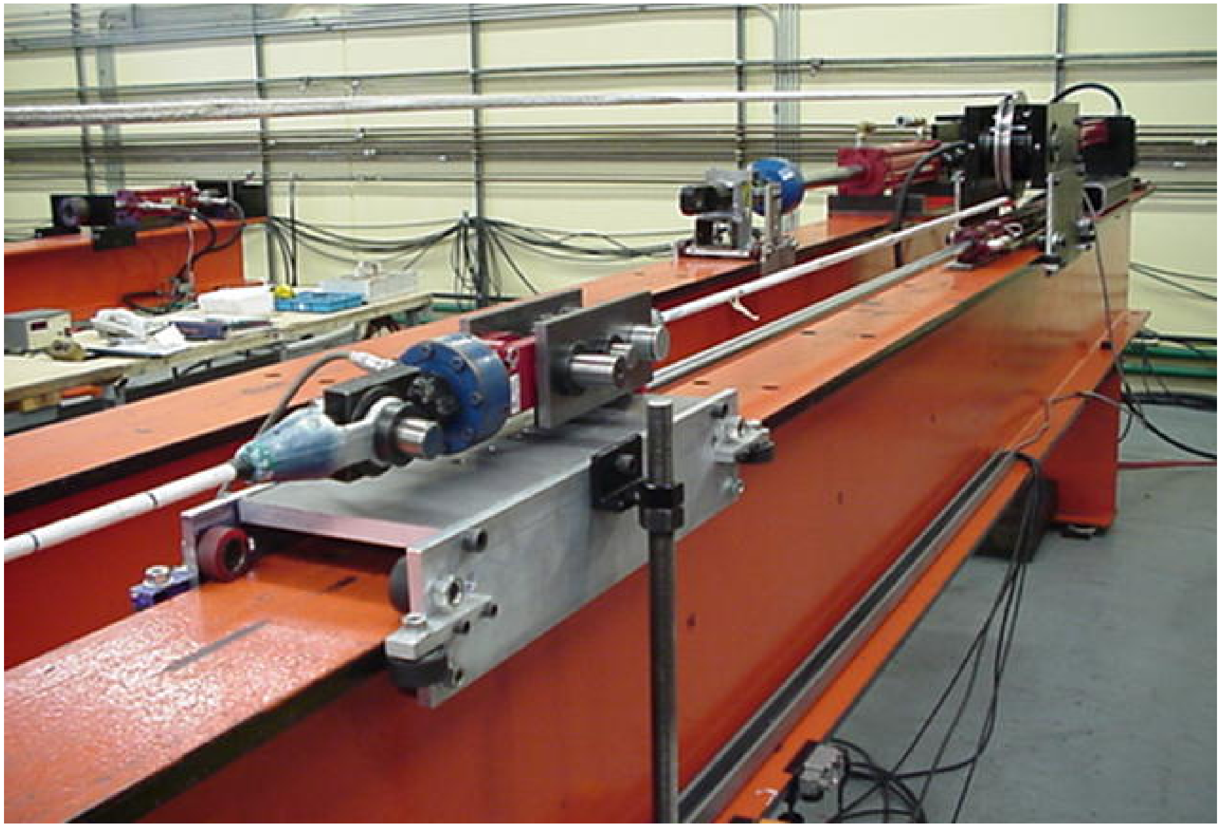
Bending Fatigue Test of 80-mm Rope on 2400-mm Sheave

Traction Sheave Tests



Traction Sheave Test Apparatus

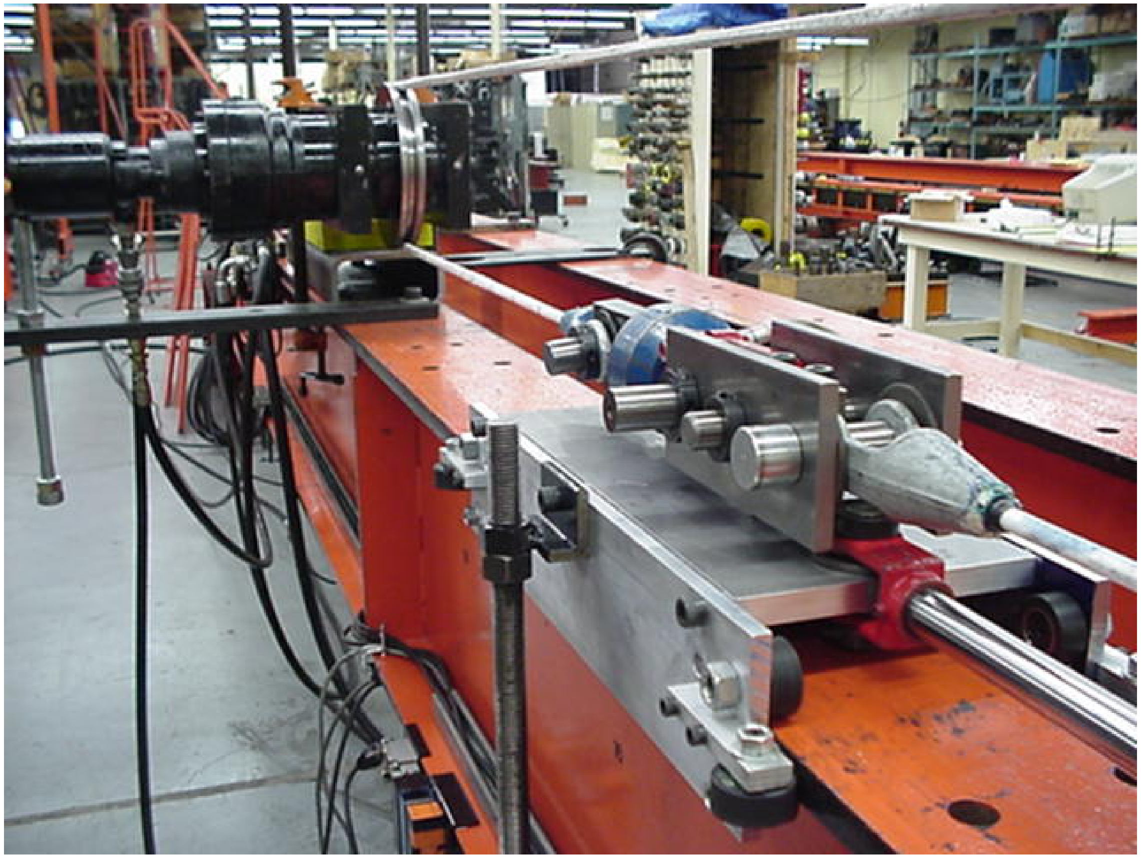
Traction Sheave Tests



Drive Trolley and Load Cell in Foreground

Tensioning Sheave at Far Right

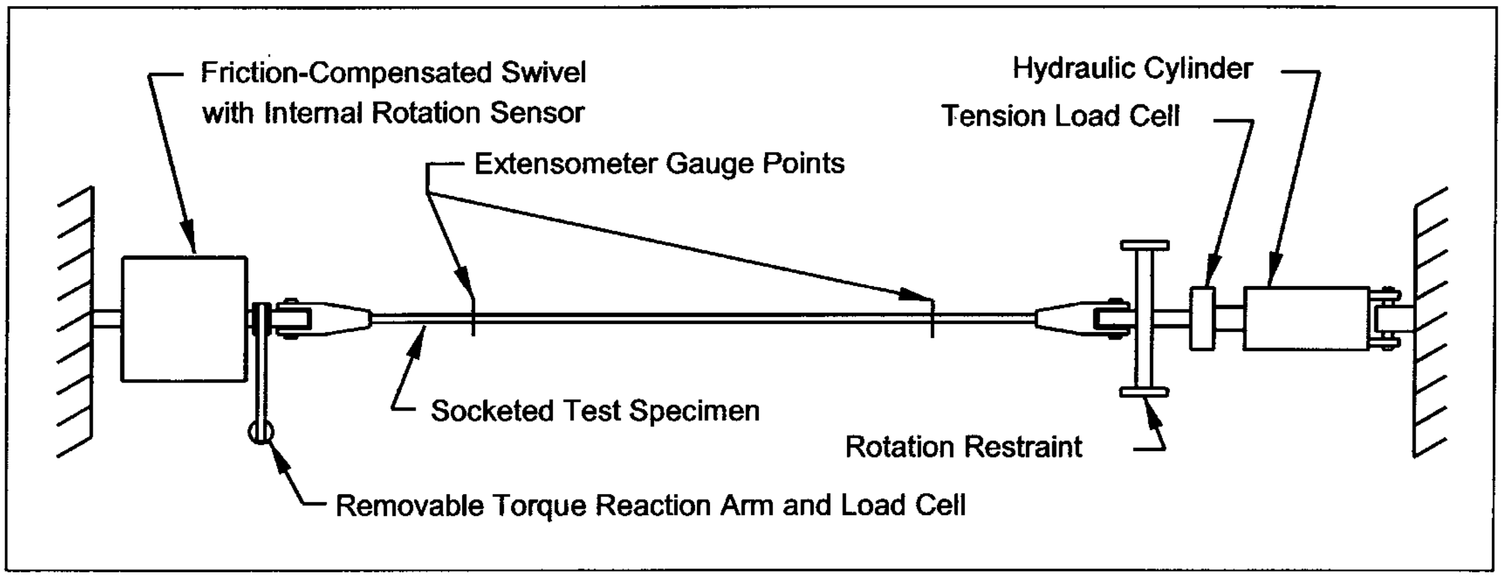
Traction Sheave Tests



Drive Trolley and Load Cell in Foreground

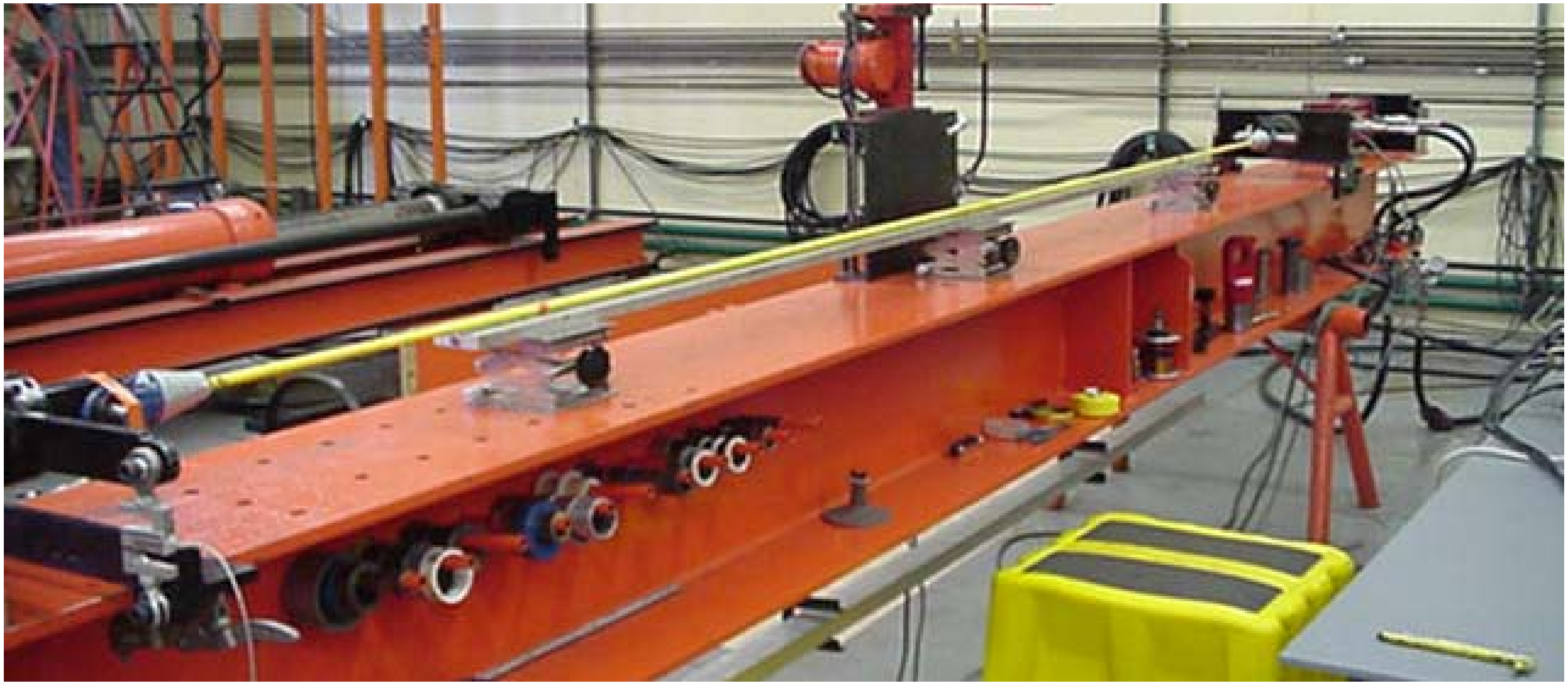
Traction Sheave and Motor in Background

Torque and Rotation Tests



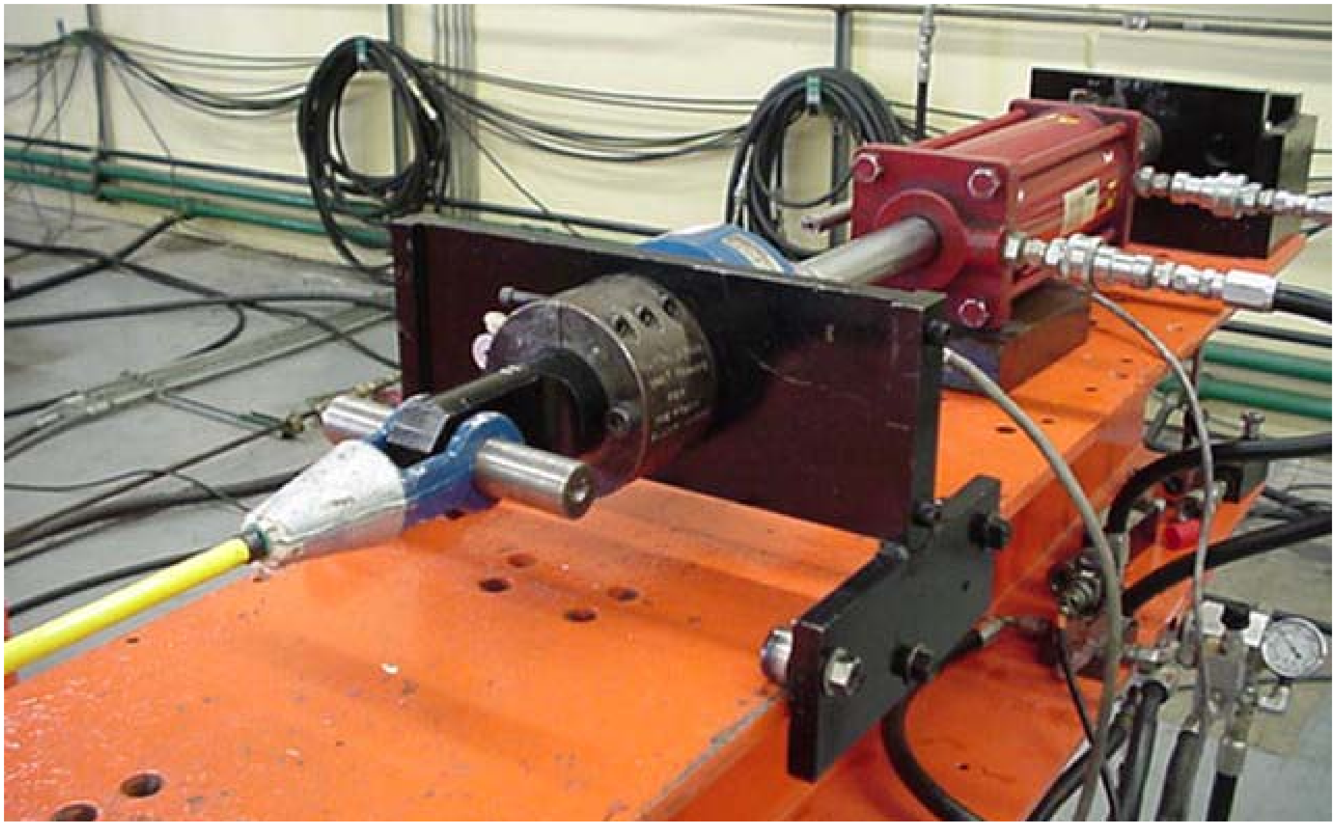
Torque and Rotation Test Apparatus

Torque and Rotation Tests



Overall View of Test Machine

Torque and Rotation Tests



Test Specimen Attached to Crosshead, Load Cell, and Tensioning Cylinder

Torque and Rotation Tests

Test Specimen Attached to Friction-Compensated Swivel with Torque Arm and Torque Load Cell in Place

The TMT Companies

Tension Member Technology

aka TMT Laboratories

Coordinated Equipment Company

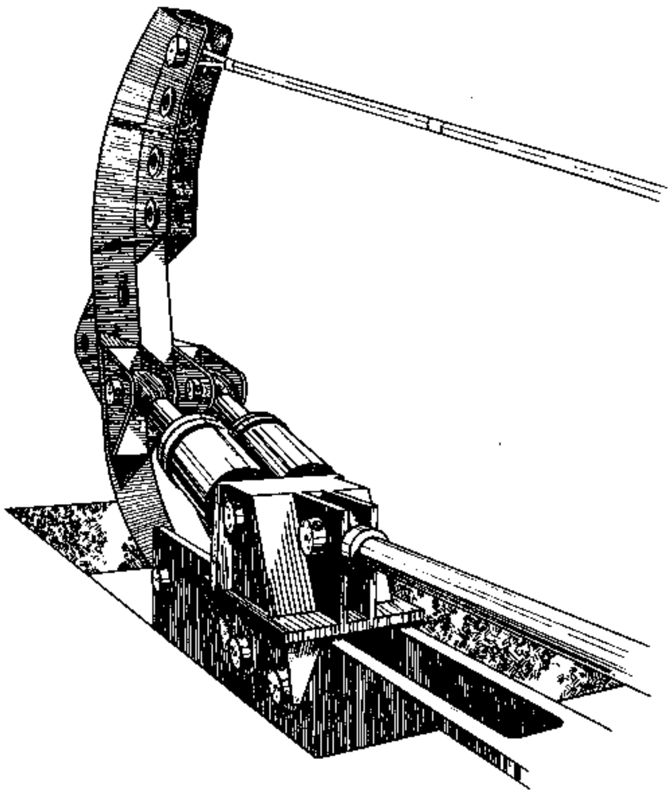
Surplus Equipment Sales, Repair, and Rental

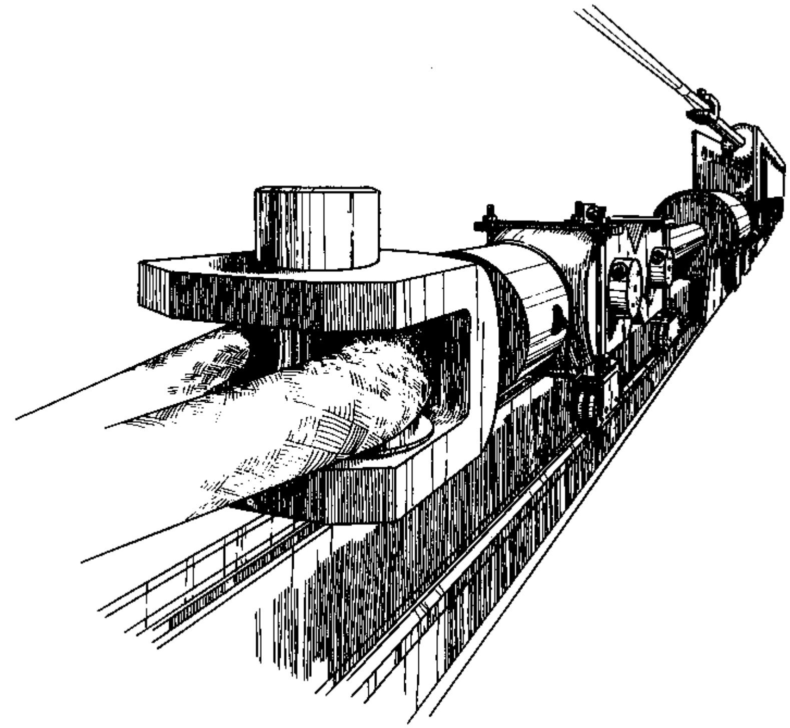
CEC Testing Services

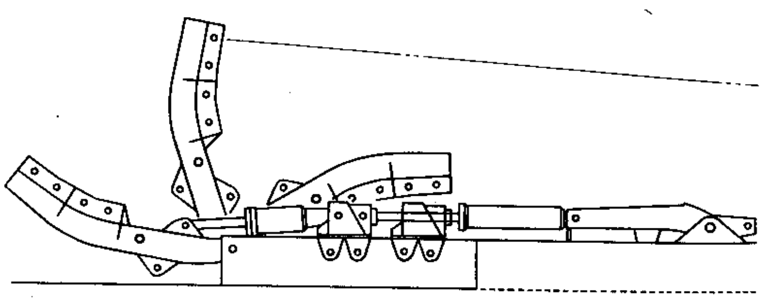
Coordinated Wire Rope and Rigging

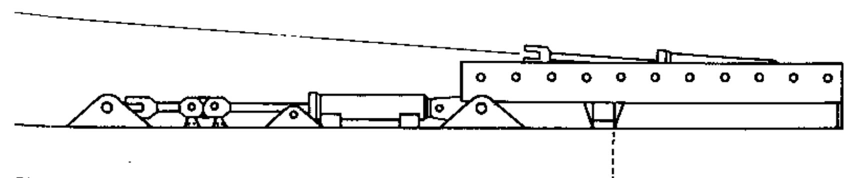
CWR Ventura	CWR San Diego	CWR San Leandro

1,500-Ton Test Bed









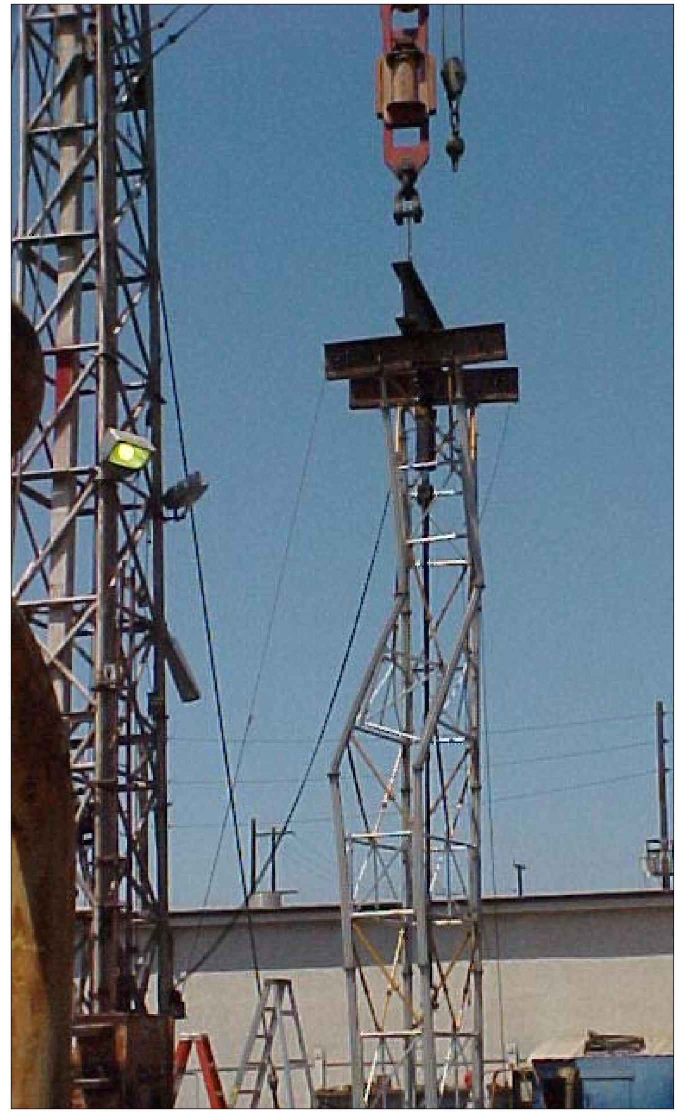
Cyclic-Tension Fatigue Tests of Mooring Lines and Hawsers

- **Computerized Data Acquisition and Control Systems**
- **Automatic Cyclic Operation**
- **Tensile Loads to 3,000,000 pounds**
- **Up to 54 feet of elongation**

Break Test of 7-inch Diameter Nylon Rope

Machine Arm at Mid Stroke

Destructive Testing – Scaffold Systems



Cyclic-Compression Fatigue Testing

Polyurethane Fenders

Proof Load Testing to 8,000,000 Pounds

Destructive Compression Testing of Shoring Columns

Destructive Test – 3,200,000 Pounds

Displacement vs. Load and Strain vs. Load