THE OKONITE COMPANY

SELF-SUPPORTING AERIAL CABLES



Setting the Standard

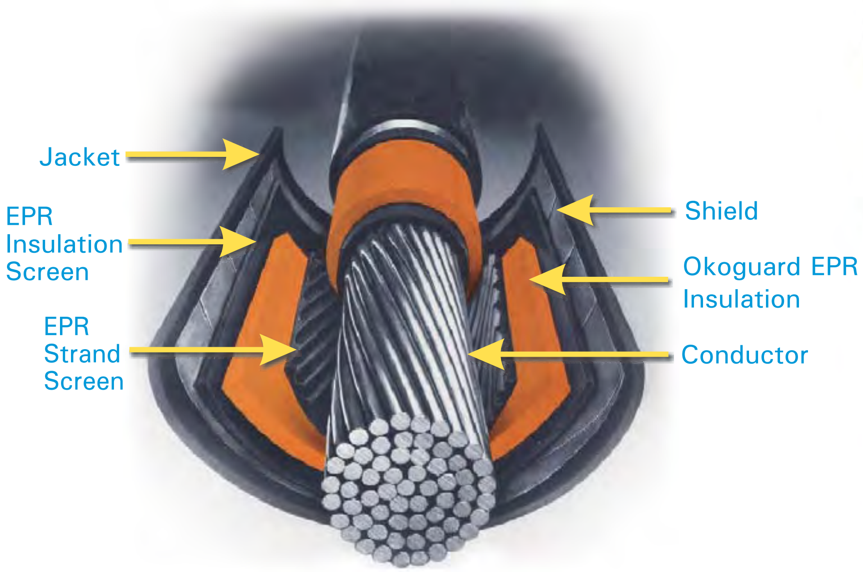
Introduction

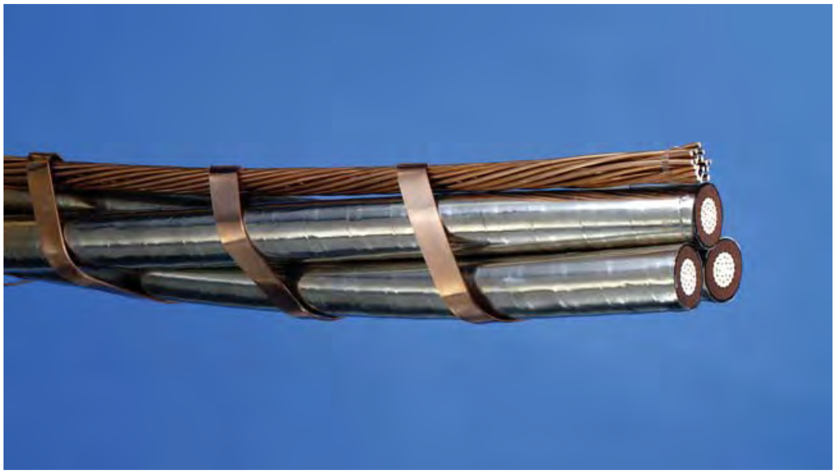
Okonite's factory assembled aerial cables have been successfully used for over 75 years on distribution systems from 600V to 46kV. Okonite's aerial cables are a product of closely coordinated efforts in research, engineering and manufacturing to bring to the market the lowest cost and most reliable Self-Supporting Aerial Cables that can be made today.

Okonite's aerial cable designs combine over 40 years of reliable service, using an all EPR Okoguard insulation system, together with engineered installation technology.

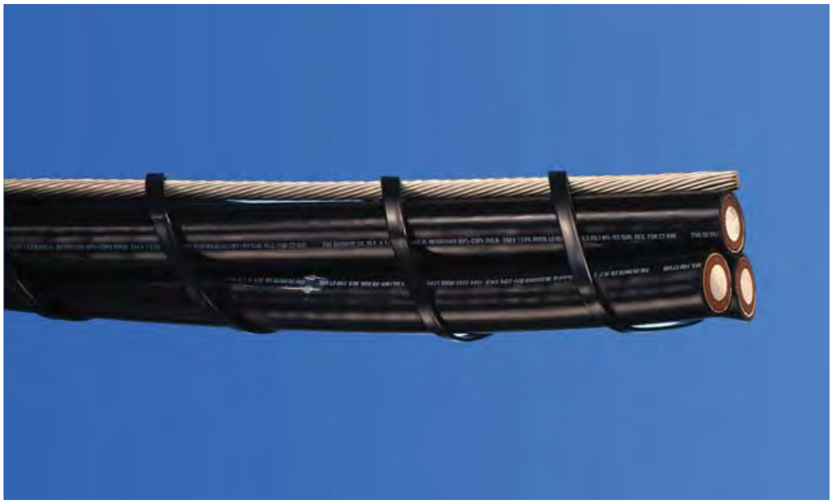
The following two constructions are typical of EPR Self-Supporting Aerial Cable designs.

EPR Materials



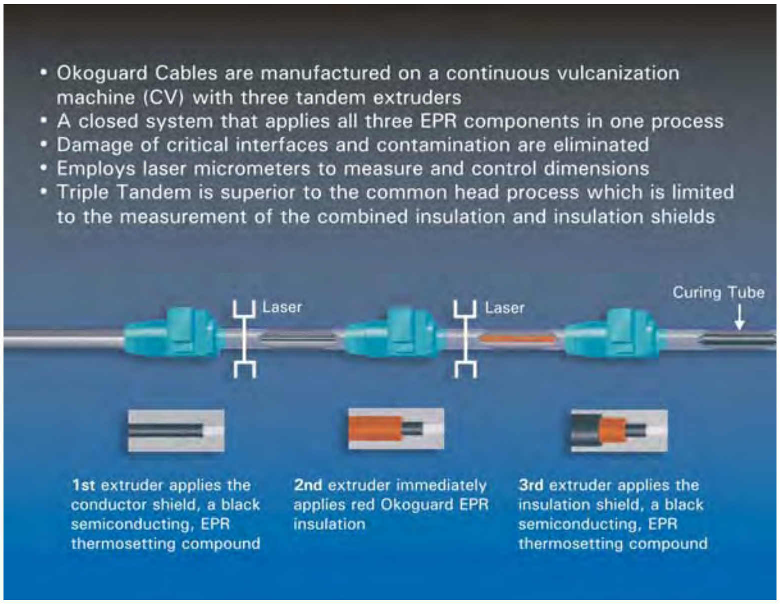


Self-Supporting 15kV Unjacketed Aerial Cable with Bare Copper Binder Strap.



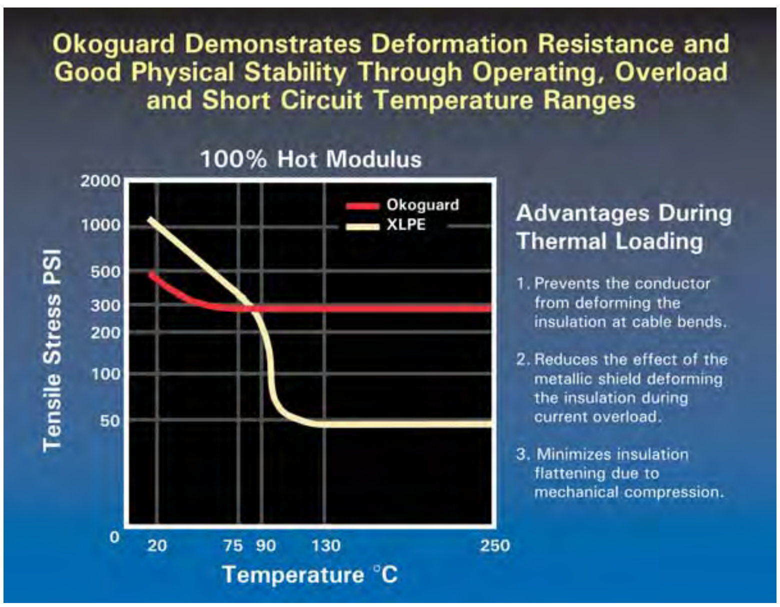
Self-Supporting 15kV Jacketed Aerial Cable with Thermoplastic Coated Binder Strap.

Important Features of the Okoguard System Used in Factory Assembled Aerial Cables



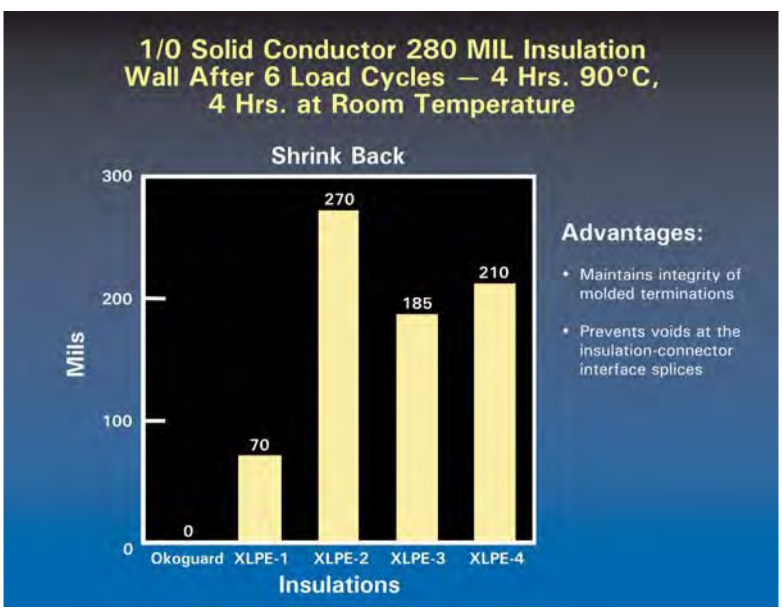
Triple Tandem All EPR Insulation System

Okonite manufactures the exclusive Okoguard all EPR insulation system. The insulation system is applied using a triple tandem extrusion process that assures compatibility between the extruded layers. Laser measurements are utilized between the layers to verify diameters of the insulation and semiconducting screens.



Deformation Resistance

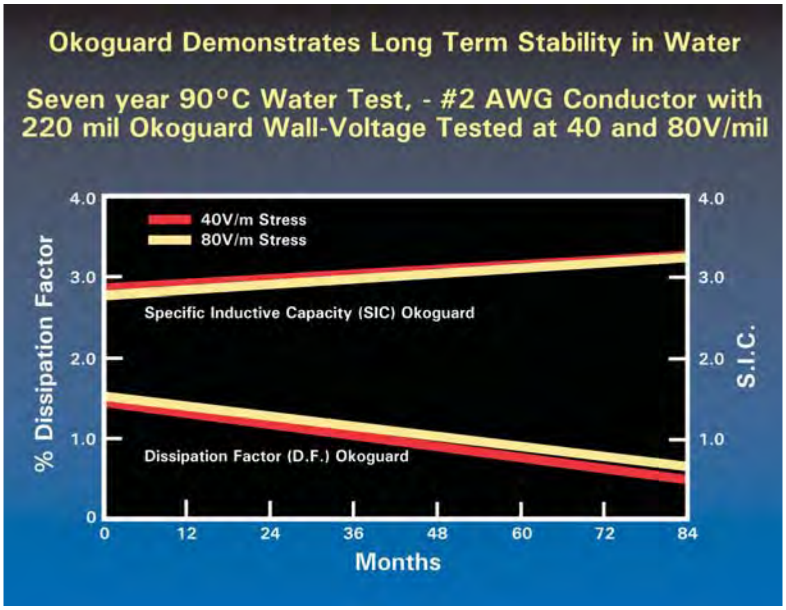
Okoguard insulation exhibits excellent deformation resistance over the entire spectrum of its temperature operating range and is unaffected by pressure that may be applied by the aerial cable binder strap and messenger.



Thermal Stability Shrink-Back

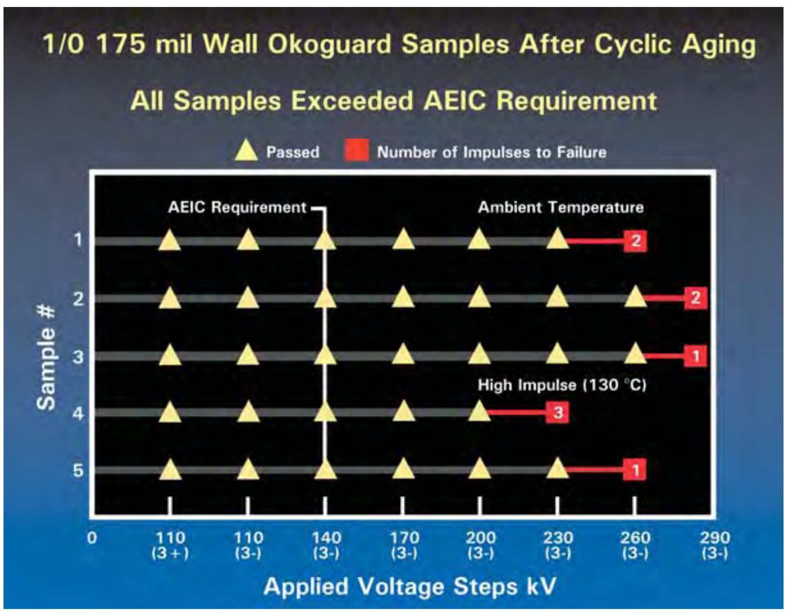
Good thermal stability and minimum shrink-back are other important features provided by the Okoguard insulation system, especially since cables are exposed to direct sunlight. Thermal stability with minimum shrink-back eliminates concerns on moisture ingress into splices and terminations.

Important Features



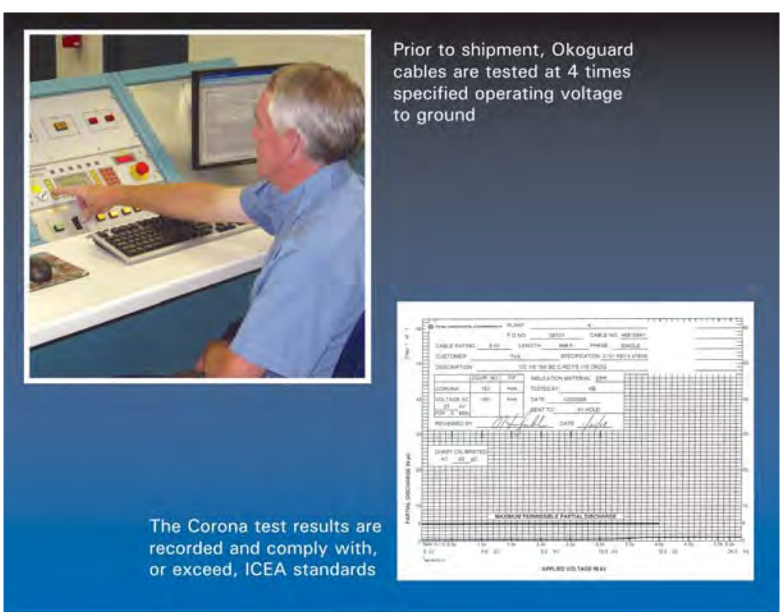
Moisture Resistance

Long term water immersion tests have verified Okoguard's moisture resistance and assures its suitability when exposed to rain, snow and sleet that are common to an aerial cable environment.



AEIC Qualification-Impulse Test

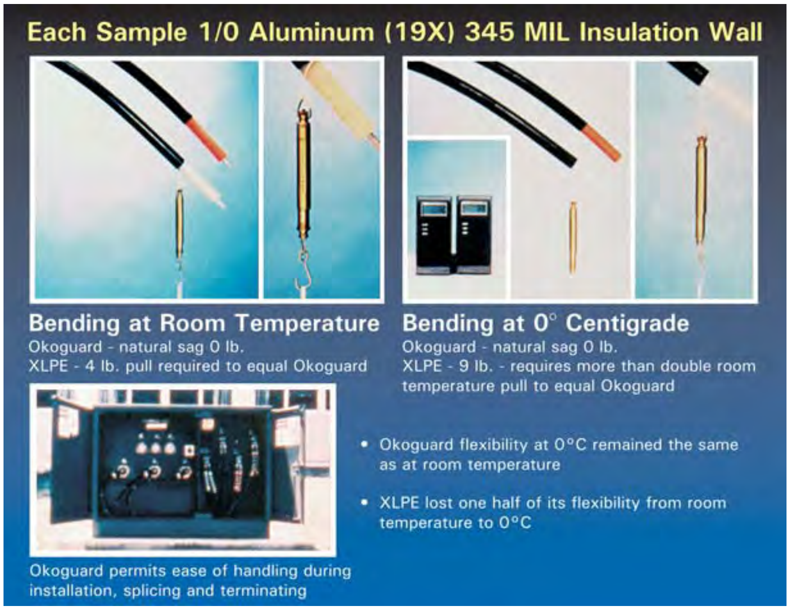
The AEIC Qualification-Impulse Test data illustrates the Okoguard insulation system's ability to withstand lightning strikes and switching surges or "spikes" that can damage aerial cables.



Corona Testing

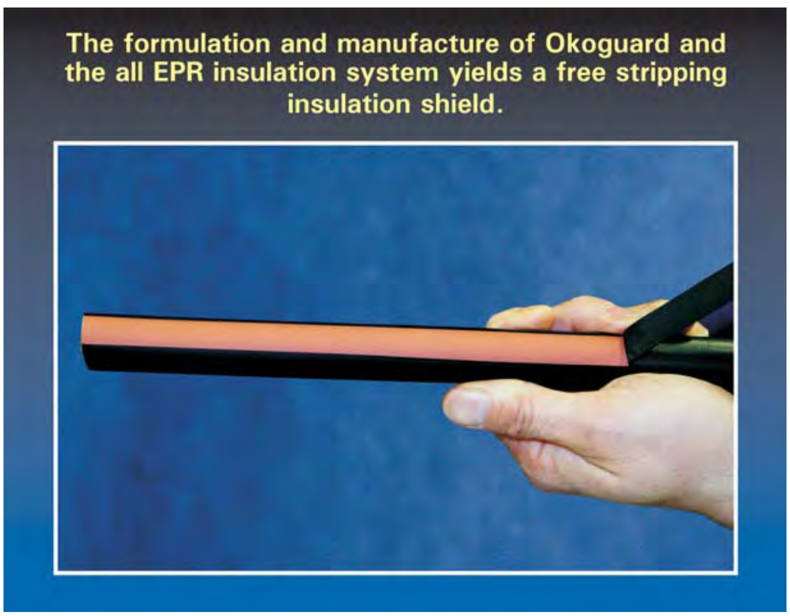
Partial discharge testing of all Okoguard cables verifies the absence of voids in the insulation and in the interface between semiconductor shields and the insulation.

Important Features



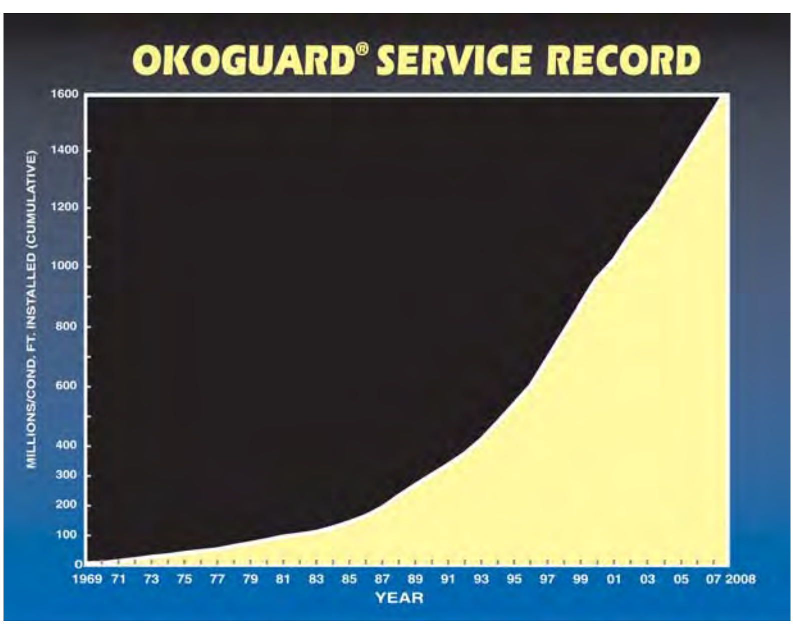
Flexibility

The flexibility of Okoguard over extreme temperature ranges facilitates installation under harsh climatic conditions.



Strippability

Good strippability, by controlled adhesion of the EPR semiconducting insulation shield, simplifies splicing and terminations, minimizing the possibility of damage to the insulation.



The Okoguard service record of over 45 years is a testimonial to its reliability in a broad spectrum of applications.

Design Features of Okonite's Preassembled Aerial Cable

- Messenger design provides a safety factor of 4 times the allowable messenger stress to allow ample safety margin for wind and ice loading.
- Messengers are copper clad steel, galvanized steel or stainless steel to prevent corrosion damage.
- Binder straps have rounded edges and are protected with a thermoplastic covering to prevent damage of the jacket.
- Engineered factory packaging helps to prevent installation problems.
- The use of an all EPR insulation system provides flexibility for easier installation.
- Jackets are designed to withstand cold flexure damage and are UV light resistant.
- Okoguard 105°C Medium Voltage and 90°C Low Voltage insulations are moisture resistant EPR compounds, designed and tested for long-term stability.
- Messengers, when properly grounded, provide protection against lightning and surge currents.

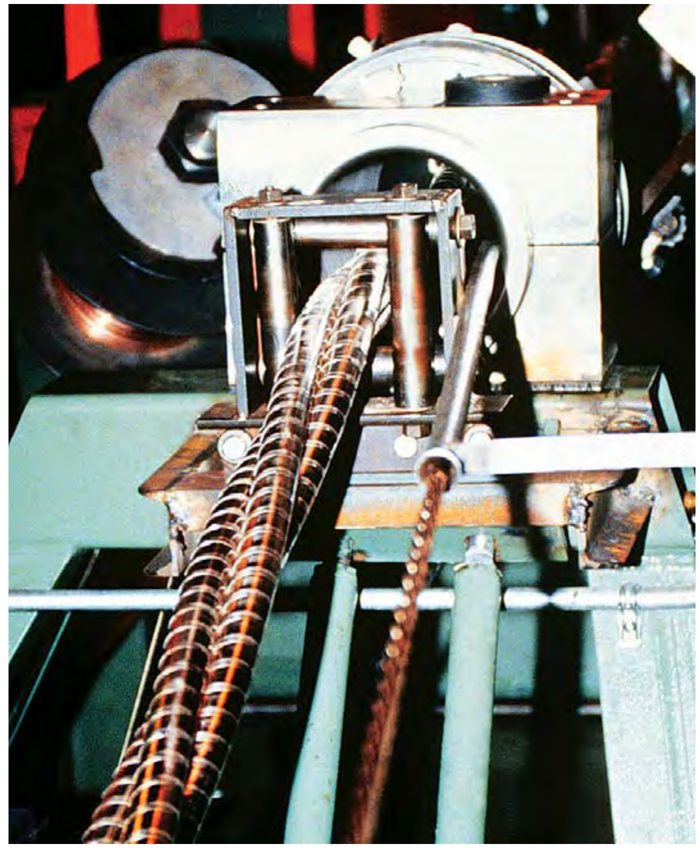
Aerial Cable Construction

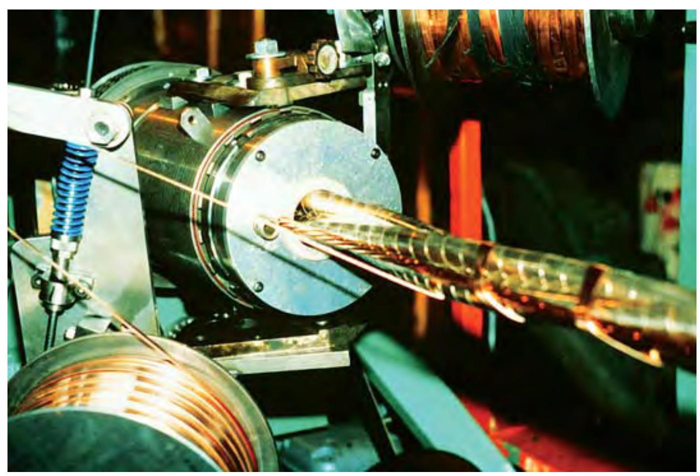
600 volt — Three 1/C Class B stranded copper or aluminum conductors, tandem extruded Okoguard EPR insulation, and Okolon jacket. Three single conductors are cabled together and laid parallel to a copper clad steel, galvanized steel or stainless steel messenger. The messenger and triplexed assembly are bound together with a PE coated copper or stainless steel strap.

2.4 kV or 5 kV non-shielded — Three 1/C Class B stranded copper or aluminum conductors, triple tandem extruded, EPR strand screen Okoguard EPR insulation and Okolon jacket. Three single conductors are cabled together and laid parallel to a copper clad steel, galvanized steel or stainless steel messenger. The messenger and triplexed assembly are bound together with a PE coated copper or stainless steel strap.

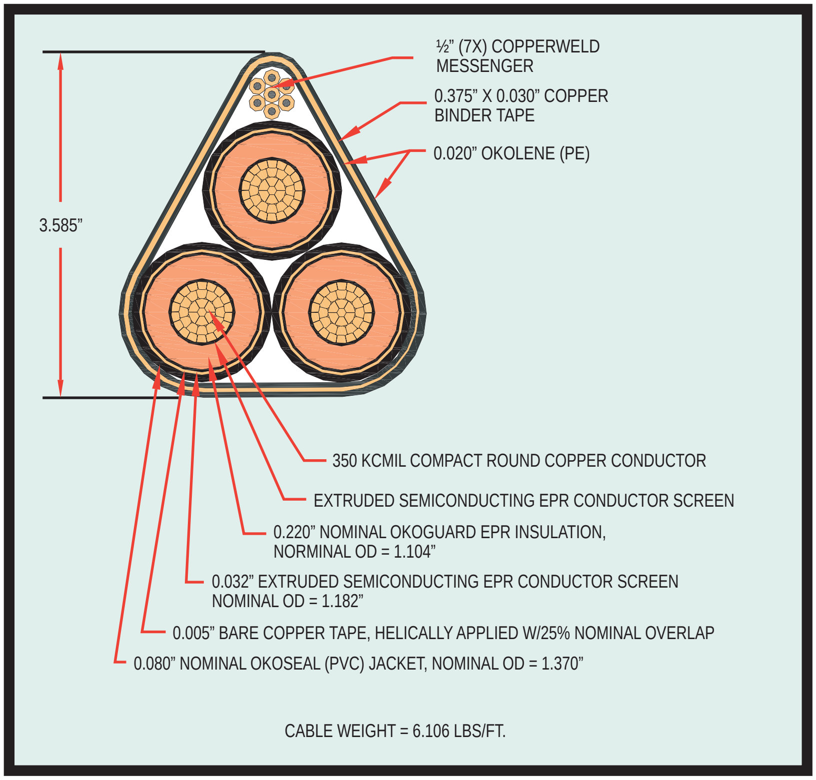
Medium voltage 5-46kV shielded — Three 1/C Class B stranded copper or aluminum conductors, triple tandem extruded, semiconducting EPR strand screen— Okoguard EPR insulation — extruded semiconducting EPR insulation screen, shielding tape and an overall jacket. This construction is also available in unjacketed form and with alternate type shielding tapes. Three single conductors are cabled together and laid parallel to a copper clad steel, galvanized steel or stainless steel messenger. The messenger and triplexed assembly are bound together with a PE coated copper or stainless steel strap.

*Alternate aerial cable constructions are available upon request.





Typical Self-Supporting Aerial Cable Designs

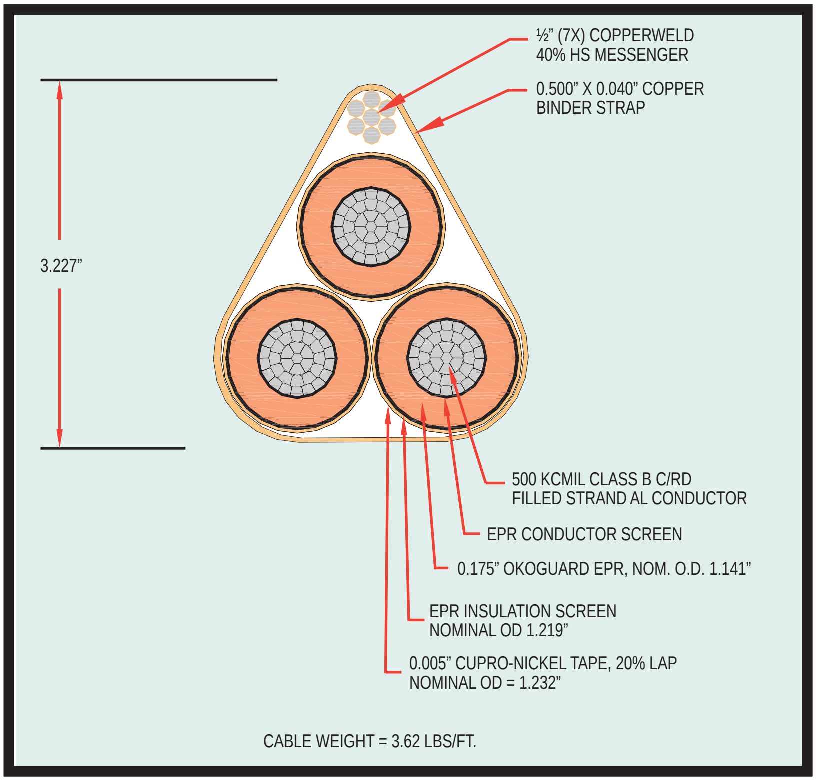


Jacketed Shielded Construction 5-46kV

Design and assembly of Okonite aerial cables are a product of dedicated engineering efforts to provide cables which install without twisting or snagging and withstand the hostile environmental conditions of wind, rain and ice.

Many assembly parameters must be considered and optimized in the manufacture of these cables. These include:

- Balancing torsional characteristics of the components
- Quality control and assurance
- Proper spacing of the components
- Precise messenger tension
- Controlled binder tension
- Cable length of lay
- Preparation of cable ends
- Packaging for shipment



Unjacketed Shielded Construction 5-46kV

"

Aerial Cable Constructions

Typical triplexed Self-Supporting Aerial Cable Designs (150 ft. spans)

Conductor	Strands	Insulation Thickness Mils	Jacket Thickness Mils	Copper Clad Steel Messenger Size	Approx. O.D. Inches	Approx. NWM Lbs.	Ampacity Amps
600 Volt Non-Shielded Copper Conductor							
#2	7X	45	30	.375	1.57	1208	158
4/0	19X	55	45	.375	2.18	2796	335
350	37X	65	65	.500	2.75	4557	464
500	37X	65	65	.563	3.13	6323	580
2.4 kV or 5 kV Volt Non-Shielded Copper Conductor							
#2	7X	125	80	.375	2.23	1767	158
4/0	19X	125	95	.375	2.79	3547	335
350	37X	140	110	.563	3.48	5786	464
500	37X	140	110	.563	3.76	7414	580
2.4 kV or 5 kV Non-Shielded Aluminum Conductor							
#2	7X	125	80	.375	2.28	1394	123
4/0	19X	125	95	.375	2.79	2203	262
350	37X	140	110	.375	3.28	3111	364
500	37X	140	110	.500	3.66	3973	458
15 kV 133% Level Copper Conductor, .005" Copper Shield Jacketed							
#2	7X	220	80	.500	2.91	2576	173
4/0	19X	220	80	.500	3.41	4406	349
350	37X	220	80	.563	3.90	6383	472
500	37X	220	80	.563	4.18	8067	583
15 kV 133% Level Aluminum Conductor, .005" Copper Shield Jacketed							
#2	7X	220	80	.375	2.81	1962	135
4/0	19X	220	80	.375	3.47	2871	273
350	37X	220	80	.500	3.79	3892	372
500	37X	220	80	.500	4.07	4617	462
15 kV 133% Level Copper Conductor, .005" Cu-Ni Shield Unjacketed							
#2	7X	220	—	.375	2.27	2017	173
4/0	19X	220	—	.500	2.87	3960	349
350	37X	220	—	.500	3.30	5750	472
500	37X	220	—	.563	3.80	7552	583
15 kV 133% Level Aluminum Conductor, .005" Cu-Ni Shield Unjacketed							
#2	7X	220	—	.375	2.27	1628	135
4/0	19X	220	—	.375	2.80	2467	273
350	37X	220	—	.500	3.30	3440	372
500	37X	220	—	.500	3.53	4060	462

The Economics of Self-Supporting Aerial Cable

Installed Costs are Surprisingly Low

Okonite Self-Supporting Aerial Cable is an economical solution, and may actually cost less than other overhead constructions, where annual tree trimming, taller poles, extra labor or additional hardware may be required.

Here are the various types of construction available when primary power distribution lines are to be installed overhead.

1. Ordinary bare conductor strung through or above trimmed trees on insulators and crossarms on conventional length poles.
2. Tree wire with rubber insulation, strung through trees on insulators and crossarms on conventional length poles.
3. Ordinary weatherproof wires strung above trees on insulators and crossarms on extra length poles.
4. Aerial cable pre-assembles with a messenger (self-supporting) and strung through trees on conventional length poles.
5. Aerial cables spun to the messenger in the field and strung on conventional length poles in open areas or below tree limbs.
6. Aerial cable pulled into rings on a messenger on conventional length poles with comparatively little or no tree trimming necessary.
7. Spacer cable. Three single conductors, partially insulated, suspended from a messenger and held by a spacer.

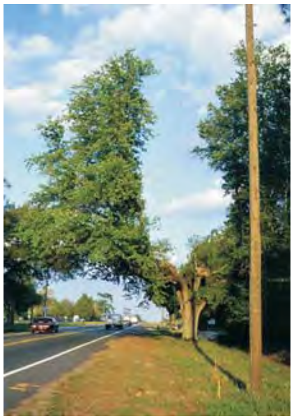
Reliability Improvements

Okoguard Insulated Self-Supporting Aerial Cables typically provide higher reliability, which translates into lower Total Owning Costs when evaluating against other overhead construction methods.

System reliability has been the focus of Distribution System owners and continues to be the key component for capital investment and customer satisfaction.

Reduced Need for Tree Trimming

Since the SSAC system is completely insulated, the requirements for tree trimming are reduced. This not only saves operating costs, but alleviates problems with customers sensitive to aesthetics.



Where to use Okonite Self-Supporting Aerial Cable

In Utility and Industrial Distribution Applications

- Where tree conditions prohibit the use of open wires or require constant trimming.
- Where taller poles would be needed to clear trees.

- Where greater reliability of service is required that can't be obtained from open wire circuits.

- Where improved aesthetics are needed.
- Where an existing pole line is incapable of carrying any additional open wire circuits but can accommodate one or more aerial cables below the open wire construction.

- Where narrow clearances from structures and other lines prohibit the use of open bare wire.
- Where overhead line approaches to power stations and substations are already congested and space for additional pole lines is limited.
- Where the voltage to be used makes it impractical to have open wire circuits.
- Where right-of-way for open bare wire is unobtainable.
- Where cable circuits are urgently required and aerial cable can be installed much more quickly than underground cable.
- Where joint construction in connection with other utilities is best provided for by the use of Self-Supporting Aerial Cable.

Where to use Okonite Self-Supporting Aerial Cable

- Where additional safety is needed for crossing private properties, freight yards, bridges, trestles, and in other public areas.

- Where cable has to be continued across marshy ground that would otherwise necessitate costly pile foundations for underground conduit.

In Mines

- To carry power circuits along haulage ways and drifts within the mine.

- Where power lines are carried overhead through trees to distant shafts and bore holes in outdoor locations.

In Industrial Plants

- Where power circuits can be carried overhead supported by beams or trusses rather than by hazardous open wire on insulators, or with cable in conduit.

- Outdoors, on brackets attached to buildings or on poles in the open.

Installation of Self-Supporting Aerial Cable

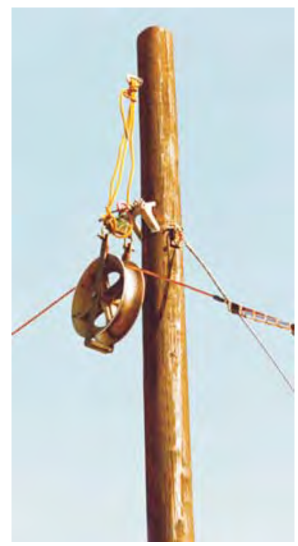
The following instructions and sketches are intended to suggest methods for installing Self-Supporting Aerial Cables. In general, operating companies can use fittings and practices that are most convenient and in line with their normal usage and needs.

Self-Supporting Aerial Cable can be supplied in long lengths, which result in minimizing the number of splices. The practical limit is usually the reel size, which can be handled by the power drive reel trailer or cable truck.

The cable is normally transported to the installation site on a power drive reel trailer or cable truck and set up 50-75 feet from the terminal pole.

Pulleys are mounted on each pole and a pulling line threaded using the pulleys, through any trees which the cable will pass. In some cases additional pulleys may be necessary to prevent the cable catching in limbs or at road crossings to prevent sagging which could block traffic. These additional pulleys are sometimes mounted from a temporary messenger or a bucket truck. All pulleys should be large enough to allow ample clearance around the cable so that there will be no danger of the binder tape catching against the frame of the pulley. A minimum diameter of ten inches for the inside of the pulley and a minimum clearance of 1 inch on both sides of the cable is recommended. *Figure 1* shows a typical straight line pulley. The top is hinged and fastened with a loose pin so the cable can be readily removed and the messenger can be placed in the messenger clamp.

When the cable must make a change in direction, a multisheave radius roller assembly is necessary. *Figure 2* shows a corner pulley. This is hung by a bracket pinned to the center top of the pulley frame. It can be mounted on the pole slightly above or connected to the messenger clamp. The side of the frame next to the pole is hinged so the cable may be pulled out and placed in the clamp. For large diameter or heavy cables a large radius (4 or 5 ft.) multisheave roller is recommended.



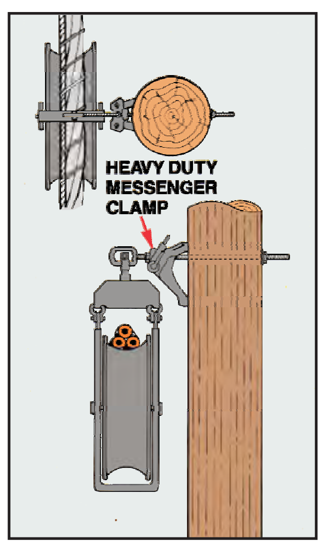


Figure 1 — Typical pulley for use on tangent poles

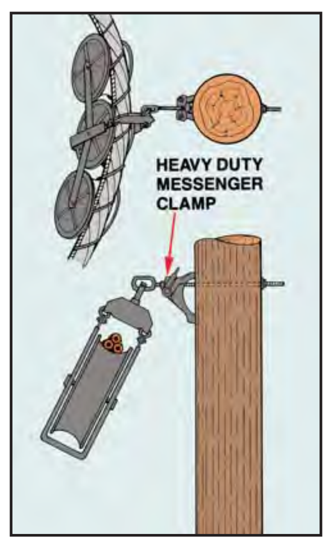


Figure 2 - Typical pulley for use on offset or corner poles

Installation of Self-Supporting Aerial Cable

The pulling line is fastened to the overlength of messenger with a swivel connection. A ball bearing or roller bearing swivel is recommended. The end of the cable should be tapered and tightly bound to the messenger to prevent slippage of the messenger and to facilitate passing through the pulleys.

The speed of the reel must be controlled so as to maintain a reasonable sag between the poles. This sag should be controlled to prevent dragging the cable on the ground between spans or rubbing on tree limbs and other cables. Using the greatest sag possible results in lower pulling tension and helps prevent twisting of the cable. The tension on the cable leaving the reel should be kept to a minimum.

A cable will sometimes rotate or twist as it goes through a pulley. This twist can usually be removed by temporarily halting the pull and having line-personnel untwist the cable. Once the cable passes through the pulley there should be no further tendency for the cable in that span to twist.

After the entire reel has been pulled, the end should be dead-ended at the pole leaving ample cable for making connections to fuse cutouts, splices, or other devices. Sometimes an additional 100-150 feet of messenger is coiled on the reel drum, so that the trailing cable end can be pulled up to the desired location. This method eliminates the previous procedure of temporarily tying off the cable at the first pole, unreeling the last couple of cable coils still on the reel, and attaching a winch to the trailing end of the messenger.

The cable should be pulled to a tension 25% higher than the final tension, and then loosened to facilitate the placement of holding clamps. A come-along is then applied to the cable at the last pole to maintain the tension. This tensioning is not intended to prestretch the messenger but rather to equalize the tension in the various spans. It is impossible to prestress unidirectional cable completely as the messenger will not slide for the entire distance. Some strain will always be taken by the conductors in the center of the section but this will gradually relax with time.

Installation of Self-Supporting Aerial Cable

Figure 3 shows a typical arrangement of a dynamometer being used for tensioning and a come-along for holding tension. Temporary guys may be required.

The binder strap is then removed for about a foot on each side of the pulley and clamped to the messenger.

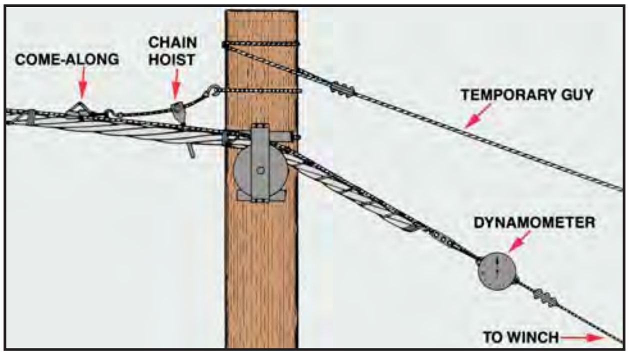


Figure 3 — Tensioning Self-Supporting Cable

The pulleys are then removed, as the messenger is placed in position in permanent supporting clamps at each pole. The messenger should be placed in corner clamps before final tensioning. A block and fall is usually required to pull the messenger over the clamp. The clamp is left loose and the messenger allowed to slide during tensioning. The cable is not removed from straight pulleys until after tensioning, as the cable can be readily removed and placed in the messenger clamps under final tension. The pulleys are then moved along to the next section and the pulling line threaded.

Figure 4 shows a typical straight line support. *Figure 5* shows a typical angle support.

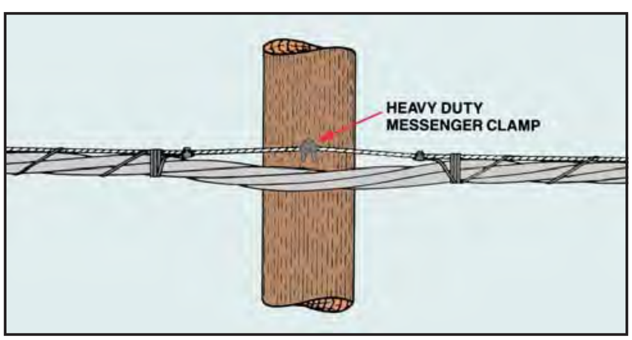


Figure 4 — Permanent tangent messenger hanger

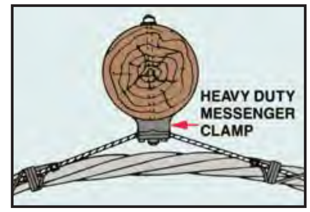


Figure 5 — Permanent angle messenger hanger

Figure 6 shows a typical corner pole. Note that the messenger has been spliced to obtain additional length for passing through thimbles. In this case the cable must be tensioned at this intermediate pole. The entire length is pulled in but not tensioned. Then the section back from this corner pole is tensioned with a come-along and dead-ended. The messenger is spliced and the cable trained at the corner. The rest of the cable is then tensioned as for a straight pull.

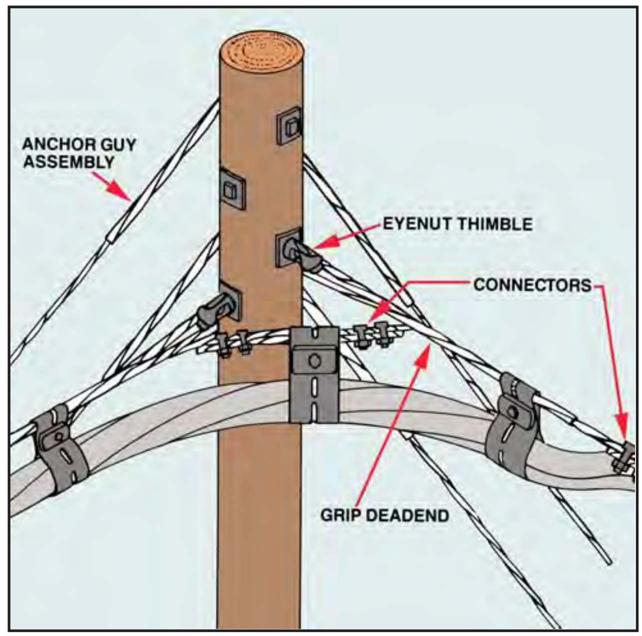


Figure 6 — Corner pole

The next section is pulled similar to the first section, except that instead of dead-ending the last end off the reel it is spliced to the first section, leaving an overlap of insulated cable. This section is then pulled, tensioned and fastened at the last pole. The temporary fastening at the last pole of the first section is then removed.

It is recommended that the cable be left at least a day before splicing so any uneven tension may equalize throughout the length.

Lightning arresters should be provided at junctions to open wire lines, being sure the arrester grounds are interconnected with the messenger to minimize surges across the insulation. Frequent grounding of the messenger is desirable for protection of the cable.

Installation Practices - Procedures

Sag and tension calculations for aerial cables

The sag and tension are based on the formulas for a parabola which are approximately the same as for a true catenary for small deflections. This well-known formula is:

$$t = \frac{s^2 W}{8d}$$

where t = horizontal tension in messenger (lbs.)*
s = span length (ft.)
w = weight of complete cable including messenger (lbs. per foot)
d = sag (ft.)

*Use 50% of messenger breaking strength for Heavy Loading and 25% of breaking strength for Normal Loading.

The total tension in the messenger at the support is the horizontal tension plus the vertical component due to the dead load. The vertical component has been neglected.

Some typical messenger breaking strengths are given below.

For more information see ICEA Publication P-79-561 "Guide for Selecting Aerial Cable Messengers and Lashing Wires". Also, see IEEE Std C2 (NESC) Section 250 for extreme wind loading on wind and ice loading for the installation load.

Determination of ice and wind loading

Ice and wind loading are determined by geographical location. The United States is divided into three districts for which standard loading conditions are specified in the National Electric Safety Code. The loadings for the various districts are as follows:

Loading District	Heavy	Medium	Light
Radial Thickness of Ice (in.)	1/2	1/4	0
Horizontal Wind Pressure (lbs/sq.ft)	4	4	9
Temperature (F)	0	15	30
Constant-k (lbs/ft.)	0.31	0.22	0.05

The resultant weight of loaded cables is calculated as follows:

i = Weight of ice loading (lbs/ft.)
= 1.24 t (D + t)
t = Thickness of ice (inches)
D = Diameter of cable (inches)
P = Force due to wind (lbs./sq. ft.)

$$h = \text{Force due to wind (lbs/ft.)} = \frac{P(D + 2t)}{12}$$

w' = Weight of unloaded cable
w" = Vertical weight of loaded cable

$$w'' = w' + i$$

The loaded weight of the cable is the resultant of the vertical and horizontal weights plus the proper constant.

w''' = Resultant weight of loaded cable

$$w''' = \sqrt{(w' + i)^2 + h^2} + k$$

Messenger Characteristics

Nominal Messenger Size	EHS Copperclad (30%) lb/ft	EHS Copperclad (30%) Breaking Strength (lbs)	EHS Copperclad (30%) Area x Modulus (ae)	Aluminum-Clad Steel lb/ft	Aluminum-Clad Steel Breaking Strength (lbs)	Aluminum-Clad Steel Area x Modulus (ae)	EHS Galvanized Steel lb/ft	EHS Galvanized Steel Breaking Strength (lbs)	EHS Galvanized Steel Area x Modulus (ae)	HS Stainless Steel Type 316 lb/ft	HS Stainless Steel Type 316 Breaking Strength (lbs)	HS Stainless Steel Type 316 Area x Modulus (ae)
1/4" 7x	—	—	—	.104	6301	825700	.121	6650	871000	.135	8500	1060000
5/16" 7x	.204	9196	1313000	.165	10020	1313000	.205	11200	1502000	.212	13200	1665000
3/8" 7x	.324	13890	2088000	.385	15930	2088000	.273	15400	1821000	.282	18000	2217000
7/16" 7x	.409	16890	2633000	.433	19060	2633500	.399	20800	2770000	.416	26000	3234000
1/2" 7x	.515	20460	3319000	.486	22730	3319000	.517	26900	3442000	.535	33700	4190000
9/16" 7x	.650	24650	4186000	.546	27030	4186000	.671	35000	4469000	—	—	—
9/16" 19x	.700	30610	4494000	—	—	—	.637	33700	4383000	.670	36200	5240000

Coefficient of Linear Expansion .0000072, Except Stainless Steel = .0000092 per degree F.

Installation Practices

*Typical example of sag and tension calculations**

Cable: 3 conductor 2/0 Self-Supporting Cable rated at 5 kV.

Messenger: 3/8" Extra High Strength (30% Conductivity) Copperweld

Ruling Span: 125 ft.

Normal Tension: 3470 lbs. (25% of ultimate strength)

To find the sag at 60F and the sag and tensions under heavy loading conditions:

Weight of complete cable w' = 2.712 lbs./ft. (2712 lbs./1000')

Diameter of cable (circumscribed circle) D = 2.50"

Normal Tension T = 3470 lbs.

Area x Modulus, ae = 2,088,000

Calculate normal sag at 60°F.

Span S = 125 ft.

$$\frac{Sw'}{T} = \frac{125 \times 2.712}{3470} = 0.0976$$

From Table on page 19 note that sag factor corresponding to $\frac{Sw'}{T} = 0.0976$ is 0.01221

Sag = 0.01221 x 125 = 1.530 ft.

= 18.3 inches

To find sag and tension under heavy loaded conditions:

Heavy loading **— 1/2" radial ice and 4 lb. sq. ft. horizontal wind force at 0 F.**

Constant k = 0.31

Weight of ice loading, i = 1.24 x t(D + t)

= 1.24 x .5 (2.50 + .5)

= 1.860 lbs.

Horizontal force, h $= \frac{P(D + 2t)}{12}$

= 1.167

Vertical weight of loaded cable, w" = w' + i

= 2.712 + 1.860

= 4.572 lbs

Resultant force, w'" $= \sqrt{h^2 + (w' + i)^2} + k$

$= \sqrt{1.167^2 + 4.572^2} + .31$

= 4.72 + .31 = 5.03

The procedure for calculating the sag and tension under loaded conditions consists of finding the unstressed length of the cable, changing its length for the change in temperature and then stressing the cable for the new loaded conditions and determining the new sag and tension.

In the above calculations of normal sag we calculated

$$\frac{Sw'}{T} = 0.0976$$

Calculate Elongation factor

$$\frac{Sw'}{ae} = \frac{125 \times 2.712}{2,088,000} = 0.000162$$

From the curves on pages 20 and 21 determine the unstressed length factor for the abscissa $\frac{Sw'}{ae} = 0.000162$

and the curve $\frac{Sw'}{T} = 0.0976$

This is found to be 0.99873 = unstressed length factor
Correct this from 60F to 0 F.

Temperature correction factor of linear expansion .0000072/F.

∴ Correction of length factor = -60 x (.0000072)
= -.000432

Unstressed length at 0 F. = 0.99873-0.000432
= 0.99830

Calculate elongation factor for loaded weight w" = 5.03 lbs./ft.

$$\frac{Sw'''}{ae} = \frac{125 \times 5.03}{2,088,000} = .000300$$

From the curves on pages 20 and 21 determine $\frac{SW}{T}$ for the ordinance of 0.99830 and the abscissa of 0.000300.

This is found to be 0.126.

Calculate Tension T' under loaded conditions from

$$\frac{Sw'''}{T'} = 0.126$$

$$T' = \frac{125 \times 5.03}{0.126} = 4990 \text{ lbs}$$

This is seen to be 35.9% of the ultimate strength of the messenger.

The sag factor is determined from Table on page 19 corresponding to $\frac{Sw'''}{T'} = 0.126$ and is found to be 0.01578

Sag = 0.01578 x 125 = 1.970 ft. = 23.6 inches.

For stringing the cable it is usual practice to calculate the stringing tension (unloaded) for various temperatures and plot a curve for ready reference. The procedure is the same as in the above example using the unloaded cable weight. The work can be speeded by tabulating the calculations.

Stringing Temp. F	0	30	60	90
Correction for length	-.00043	-.00022	0	+.00022
Unstressed length factor	.99830	.99851	.99873	.99895
For these values and $\frac{Sw'}{ae}$ =	.000162			
find $\frac{Sw'}{T}$ =	.082	.090	.098	.106
Solving for Stringing Tension T	4140	3760	3460	3200

The sags may also be calculated if desired, but the spans usually vary so it is more convenient to pull the entire length of cable up to the desired tension rather than measuring the sag.

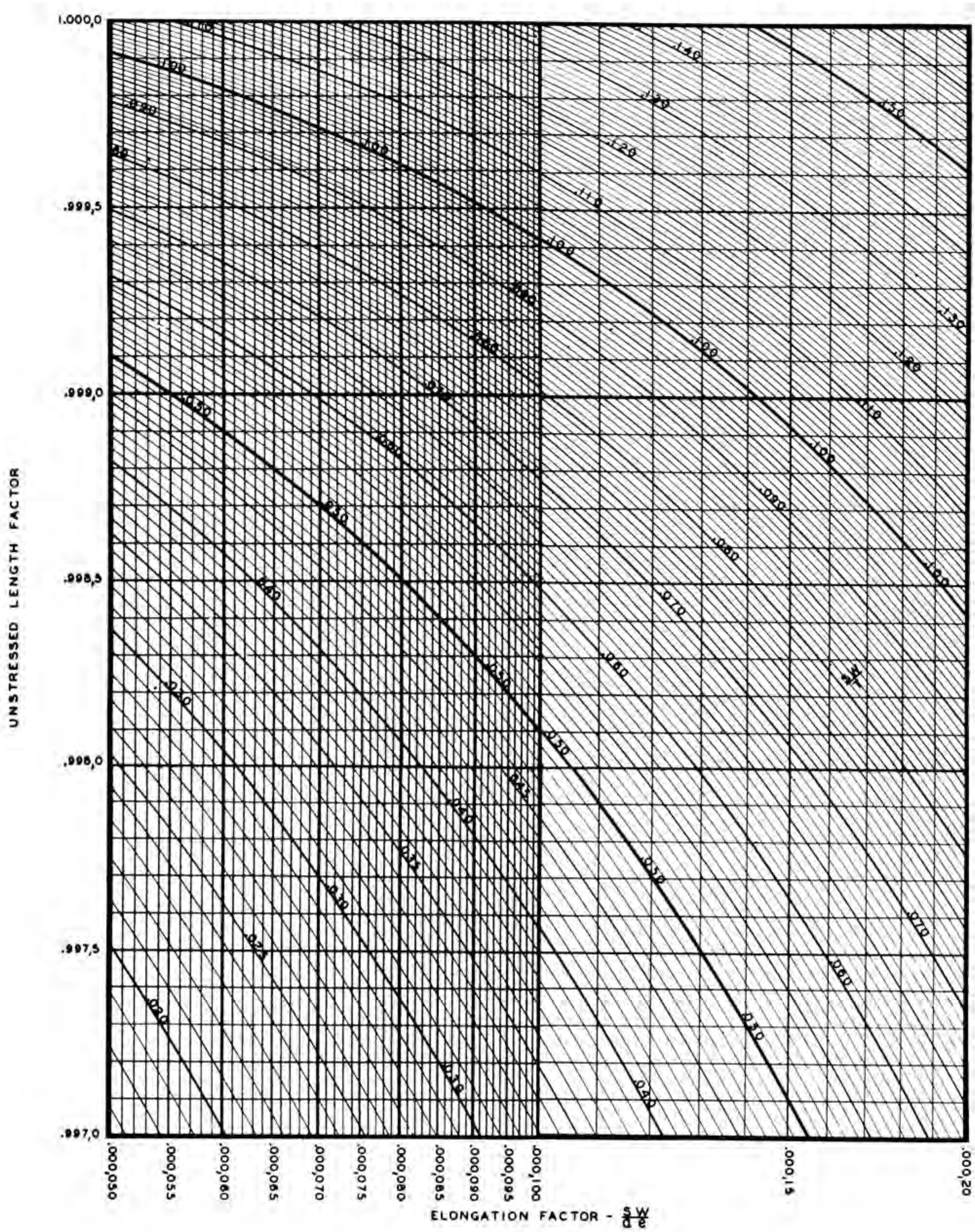
The above calculations are based on final stretch values. The messenger is usually over-stressed during installation so the final stretch values are more accurate than initial values.

*Additional information can be found in ANSI/ICEA P-79-561 "Guide for Selecting Aerial Cable Messengers and Lashing Wires[1].

Sag Tables

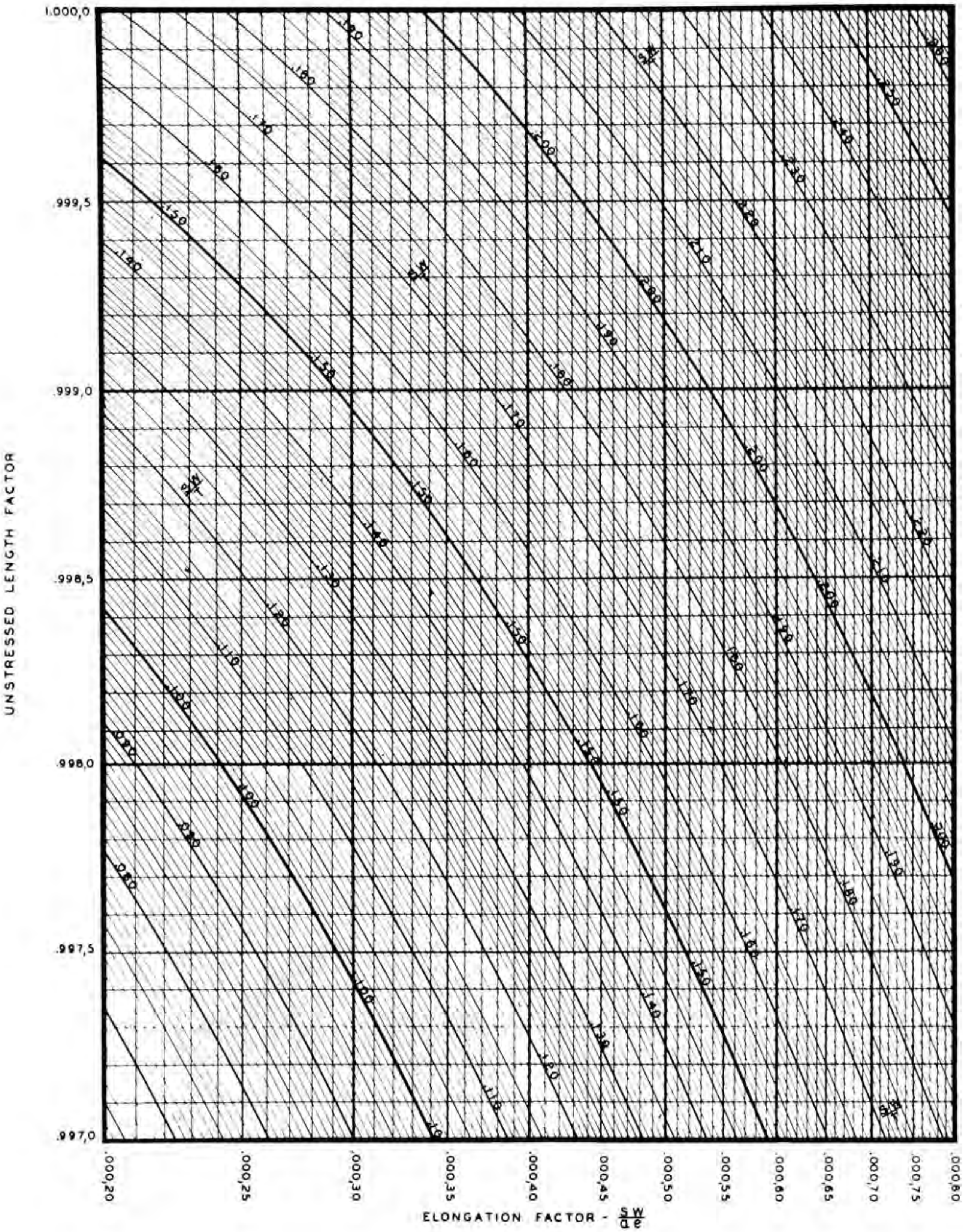
SW/T	Sag Factor	SW/T	Sag Factor	SW/T	Sag Factor	SW/T	Sag Factor	SW/T	Sag Factor	SW/T	Sag Factor	SW/T	Sag Factor
.050	.006 25	.100	.012 51	.150	.018 81	.200	.025 14	.250	.031 54	.300	.038 00	.350	.044 56
.051	.006 37	.101	.012 64	.151	.018 93	.201	.025 27	.251	.031 66	.301	.038 13	.351	.044 69
.052	.006 50	.102	.012 76	.152	.019 06	.202	.025 40	.252	.031 79	.302	.038 26	.352	.044 82
.053	.006 62	.103	.012 89	.153	.019 19	.203	.025 52	.253	.031 92	.303	.038 39	.353	.044 95
.054	.006 75	.104	.013 02	.154	.019 31	.204	.025 65	.254	.032 05	.304	.038 52	.354	.045 08
.055	.006 87	.105	.013 14	.155	.019 44	.205	.025 78	.255	.032 18	.305	.038 65	.355	.045 22
.056	.007 00	.106	.013 27	.156	.019 56	.206	.025 91	.256	.032 31	.306	.038 78	.356	.045 35
.057	.007 12	.107	.013 39	.157	.019 69	.207	.026 03	.257	.032 44	.307	.038 91	.357	.045 48
.058	.007 25	.108	.013 52	.158	.019 82	.208	.026 16	.258	.032 56	.308	.039 04	.358	.045 61
.059	.007 37	.109	.013 64	.159	.019 94	.209	.026 29	.259	.032 69	.309	.039 17	.359	.045 75
.060	.007 50	.110	.013 77	.160	.020 07	.210	.026 42	.260	.032 82	.310	.039 30	.360	.045 88
.061	.007 62	.111	.013 90	.161	.020 20	.211	.026 54	.261	.032 95	.311	.039 43	.361	.046 01
.062	.007 75	.112	.014 02	.162	.020 32	.212	.026 67	.262	.033 08	.312	.039 56	.362	.046 14
.063	.007 87	.113	.014 15	.163	.020 45	.213	.026 80	.263	.033 21	.313	.039 70	.363	.046 28
.064	.008 00	.114	.014 27	.164	.020 58	.214	.026 93	.264	.033 34	.314	.039 83	.364	.046 41
.065	.008 13	.115	.014 40	.165	.020 70	.215	.027 05	.265	.033 47	.315	.039 96	.365	.046 54
.066	.008 25	.116	.014 52	.166	.020 83	.216	.027 18	.266	.033 60	.316	.040 09	.366	.046 67
.067	.008 38	.117	.014 65	.167	.020 96	.217	.027 31	.267	.033 72	.317	.040 22	.367	.046 81
.068	.008 50	.118	.014 78	.168	.021 08	.218	.027 44	.268	.033 85	.318	.040 35	.368	.046 94
.069	.008 63	.119	.014 90	.169	.021 21	.219	.027 56	.269	.033 98	.319	.040 48	.369	.047 07
.070	.008 75	.120	.015 03	.170	.021 34	.220	.027 69	.270	.034 11	.320	.040 61	.370	.047 21
.071	.008 88	.121	.015 15	.171	.021 46	.221	.027 82	.271	.034 24	.321	.040 74	.371	.047 34
.072	.009 00	122	.015 28	.172	.021 59	.222	.027 95	.272	.034 37	.322	.040 87	.372	.047 47
.073	.009 13	.123	.015 40	.173	.021 72	.223	.028 08	.273	.034 50	.323	.041 00	.373	.047 61
.074	.009 25	.124	.015 53	.174	.021 84	.224	.028 20	.274	.034 63	.324	.041 13	.374	.047 74
.075	.009 38	.125	.015 66	.175	.021 97	.225	.028 33	.275	.034 76	.325	.041 27	.375	.047 87
.076	.009 50	.126	.015 78	.176	.022 10	.226	.028 46	.276	.034 89	.326	.041 40	.376	.048 01
.077	.009 63	.127	.015 91	.177	.022 22	.227	.028 59	.277	.035 02	.327	.041 53	.377	.048 14
.078	.009 75	.128	.016 03	.178	.022 35	.228	.028 71	.278	.035 15	.328	.041 66	.378	.048 27
.079	.009 88	.129	.016 16	.179	.022 48	.229	.028 84	.279	.035 28	.329	.041 79	.379	.048 41
.080	.010 00	.130	.016 29	.180	.022 60	.230	.028 97	.280	.035 40	.330	.041 92	.380	.048 54
.081	.010 13	.131	.016 41	.181	.022 73	.231	.029 10	.281	.035 53	.331	.042 05	.381	.048 67
.082	.010 26	.132	.016 54	.182	.022 86	.232	.029 23	.282	.035 66	.332	.042 18	.382	.048 81
.083	.010 38	.133	.016 66	.183	.022 98	.233	.029 35	.283	.035 79	.333	.042 32	.383	.048 94
.084	.010 51	.134	.016 79	.184	.023 11	.234	.029 48	.284	.035 92	.334	.042 45	.384	.049 07
.085	.010 63	.135	.016 92	.185	.023 24	.235	.029 61	.285	.036 05	.335	.042 58	.385	.049 21
.086	.010 76	.136	.017 04	.186	.023 36	.236	.029 74	.286	.036 18	.336	.042 71	.386	.049 34
.087	.010 88	.137	.017 17	.187	.023 49	.237	.029 87	.287	.036 31	.337	.042 84	.387	.049 47
.088	.011 01	.138	.017 29	.188	.023 62	.238	.029 99	.288	.036 44	.338	.042 97	.388	.049 61
.089	.011 13	.139	.017 42	.189	.023 74	.239	.030 12	.289	.036 57	.339	.043 10	.389	.049 74
.090	.011 26	.140	.017 55	.190	.023 87	.240	.030 25	.290	.036 70	.340	.043 24	.390	.049 88
.091	.011 38	.141	.017 67	.191	.024 00	.241	.030 38	.291	.036 83	.341	.043 37	.391	.050 01
.092	.011 51	.142	.017 80	.192	.024 13	.242	.030 51	.292	.036 96	.342	.043 50	.392	.050 14
.093	.011 63	.143	.017 92	.193	.024 25	.243	.030 64	.293	.037 09	.343	.043 63	.393	.050 28
.094	.011 76	.144	.018 05	.194	.024 38	.244	.030 76	.294	.037 22	.344	.043 76	.394	.050 41
.095	.011 89	.145	.018 18	.195	.024 51	.245	.030 89	.295	.037 35	.345	.043 90	.395	.050 55
.096	.012 01	.146	.018 30	.196	.024 63	.246	.031 02	.296	.037 48	.346	.044 03	.396	.050 68
.097	.012 14	.147	.018 43	.197	.024 76	.247	.031 15	.297	.037 61	.347	.044 16	.397	.050 82
.098	.012 26	.148	.018 55	.198	.024 89	.248	.031 28	.298	.037 74	.348	.044 29	.398	.050 95
.099	.012 39	.149	.018 68	.199	.025 02	.249	.031 41	.299	.037 87	.349	.044 42	.399	.051 08
.100	.012 51	.150	.018 81	.200	.025 14	.250	.031 54	.300	.038 00	.350	.044 56	.400	.051 22

Sag Calculating Charts



These charts reproduced through the courtesy of the Copperweld Steel Company

Sag Calculating Chart



Notes

Okonite Cables Facilities Overview

*Orangeburg, SC

*Orangeburg, SC - Compound Facility

*Richmond, KY

*Santa Maria, CA

*Ashton, RI

District Offices, Manufacturing Plants & Service Centers

OKONITE DISTRICT SALES OFFICES

Atlanta District Office
(770) 928-9778
FAX: (770) 928-0913
E-Mail: atlanta@okonite.com

Birmingham District Office
(205) 655-0390
FAX: (205) 655-0393
E-Mail: birmingham@okonite.com

Boston District Office
(603) 625-1900
(781) 749-3374
FAX: (603) 624-2252
E-Mail: boston@okonite.com

Charlotte District Office
(704) 542-1572
FAX: (704) 541-6183
E-Mail: charlotte@okonite.com

Chicago District Office
(630) 961-3100
FAX: (630) 961-3273
E-Mail: chicago@okonite.com

Cincinnati District Office
(513) 771-2122
FAX: (513) 771-2126
E-Mail: cincinnati@okonite.com

Cleveland Disrict Office
(330) 926-9181
FAX: (330) 926-9183
E-Mail: cleveland@okonite.com

Dallas District Office
(940) 383-1967
FAX: (940) 383-8447
E-Mail: dallas@okonite.com

Denver District Office
(303) 255-5531
FAX: (303) 255-3128
E-Mail: denver@okonite.com

Detroit District Office
(248) 349-0914
FAX: (248) 349-3710
E-Mail: detroit@okonite.com

Hartford District Office
(860) 258-1900
FAX: (860) 258-1903
E-Mail: hartford@okonite.com

Houston District Office and Service Center
(281) 821-5500
FAX: (281) 821-7855
E-Mail: houston@okonite.com

Kansas City District Office and Service Center
(913) 422-6958
FAX: (913) 422-1647
E-Mail: kansascity@okonite.com

Los Angeles District Office and Service Center
(714) 523-9390
FAX: (714) 523-1783
E-Mail: losangeles@okonite.com

Minneapolis District Office
(763) 432-3818
FAX: (763) 432-3811
E-Mail: minneapolis@okonite.com

New Orleans District Office and Service Center
(504) 467-1920
FAX: (504) 467-1926
E-Mail: neworleans@okonite.com

New York District Office
NJ (973) 742-8040
NY (212) 239-0660
FAX: (973) 742-2156
E-Mail: newyork@okonite.com

Philadelphia District Office
(856) 931-0595
(215) 567-5739
FAX: (856) 931-1193
E-Mail: philadelphia@okonite.com

Phoenix District Office
(480) 838-8596
FAX: (480) 897-8924
E-Mail: phoenix@okonite.com

Pittsburgh Service Center
(412) 734-2503
FAX: (412) 741-4620
E-Mail: pittsburgh@okonite.com

Portland District Office and Service Center
(503) 598-0598
FAX: (503) 620-7447
E-Mail: portland@okonite.com

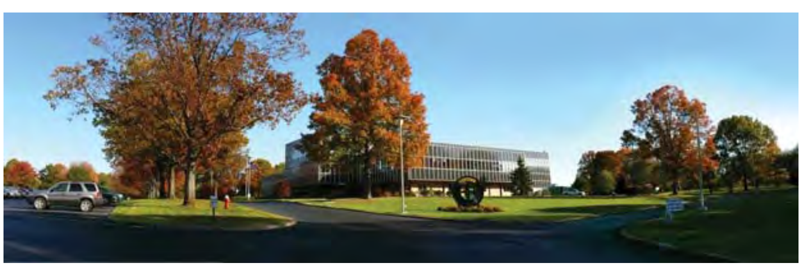
Salt Lake District Office
(801) 262-1993
FAX: (801) 262-3167
E-Mail: saltlake@okonite.com

San Francisco District Office
(925) 830-0801
FAX: (925) 830-0954
E-Mail: sanfrancisco@okonite.com

Tampa District Office
(813) 286-0581
FAX: (813) 287-1546
E-Mail: tampa@okonite.com

Washington District Office
(703) 904-9494
FAX: (703) 904-1610
E-Mail: washington@okonite.com

International Sales
(201) 825-0300
FAX: (201) 825-9026



Corporate Headquarters, Ramsey, NJ

Service Centers:
Houston
Kansas City
Pittsburgh
New Orleans
Portland
Los Angeles

*Qualified to provide nuclear Products

THE OKONITE COMPANY
102 Hilltop Road, Ramsey, NJ 07446 • 201.825.0300 Fax: 201.825.9026 • www.okonite.com

Printed on post consumer paper 05541