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I. DEFINITIONS

Abbreviation	Definition
AA	All Aluminum
ACSR	Aluminum Conductor – Steel Reinforced
AL	Aluminum
CU	Copper
CW	Copperweld (steel wire with a copper coating)
HD	Hard Drawn
KCM	Kilo Circular Mils (1 mil = 1/1,000 of a square inch) – measure of the cross-sectional area of a conductor. KCM and MCM used interchangeably
MHD	Medium Hard Drawn
Poly	Polymer (usually indicating a semi-insulating covering)
Ruling Span	A span that is an approximate representation of all spans in a line.
Sol	Solid (one strand conductors)
Str	Stranded
TBWP	Triple Braid Weather Proof

II. CONDUCTOR SAG AND TENSION DESIGN GUIDELINES

Company overhead line designs are based on the ruling span theory. The ruling span theory allows for the calculation of a line's tension and sag when installed with sheaves (rollers) and deadended prior to tying the conductor to the insulators. The ruling span is representative of the entire line (deadend to deadend), but it is still an approximation, and each span will vary by a small amount compared to the actual values. However, for most line construction, this variation is very small and usually negligible. The design tool calculates a ruling span based on each individual design. However, the ruling span can be calculated using the equation below:

$$RS = \sqrt{\frac{S_1^3 + S_2^3 + \cdots S_n^3}{S_1 + S_2 + \cdots S_n}}$$

Where:

RS = Ruling Span
S_1 = Span length of first span
S_2 = Span length of second span
S_n = Span length of n^{th} span

When the sag tables were developed in the OSAG section of the Standards Manual, a ruling span was selected that represented the most common span length for the type of conductor installation. Additionally, a maximum guying tension was selected based on sag characteristics of the line and the initial tension. The maximum guying tension must be less than 60% of the rated breaking strength of a conductor.

Maximum Guying Tension = Final Tension + Ice Loading + Wind Loading

By knowing the maximum guying tension, initial and final tensions and sags can be calculated for different temperature, wind, and ice loading conditions for various span lengths. This information is contained in the sag tables for each type of conductor. Some conductors have different sag tables based upon the ruling span that fits the construction.

Using the ruling span theory and maximum guying tension for overhead line design may cause confusion because some aspects of installation can be counterintuitive. For example, a line with shorter span lengths will need to be pulled to a higher initial tension than a line with longer span. This is due to the fact that a line with shorter spans has less area for ice loading and wind loading, meaning a higher initial tension is required to reach the designed maximum guying tension.

Conductor Size & Type	Approx. Ft./lb.	Dia. Bare In Inches	Dia. with Armor Rod In Inches	Dia. With Line Grd. In Inches
ACSR				
4, 6/1	27.62	0.250	0.542	0.492
2, 6/1	10.92	0.316	0.588	0.588
2, 7/1	9.33	0.325	0.597	0.567
1/0, 6/1	6.87	0.398	0.732	0.640
4/0, 6/1	3.42	0.563	0.927	0.805
266.8 KCM 26/7	2.86	0.642	1.006	0.934
336.4 KCM 18/1	2.80	0.684	1.092	0.976
336.4 KCM 26/7	2.27	0.721	1.129	1.013
397.5 KCM 26/7	1.827	0.783	1.283	
477 KCM 24/7	1.70	0.846	1.346	1.138
795 KCM 26/7	.91	1.108	1.728	1.608
954 KCM 54/7	.751	1.196	1.816	1.696
2156 KCM 84/19	0.398	1.762	2.634	
All Aluminum				
4/0, 7 Str	5.03	0.522	0.856	0.764
336.4 KCM 19 Str	3.17	0.666	1.030	0.958
795 KCM 37 Str	1.34	1.026	1.646	1.390
1272 KCM 61 Str	.84	1.3	2.030	1.800
Stranded Copperweld Copper				
8A	13.46	0.199		
6A	9.84	0.230		
6C	10.27	0.225		
4A	6.19	0.290		
2A	3.89	0.366		
2F	3.89	0.308		
Stranded Bare Copper				
4 7 Str	7.76	0.232		
2	4.88	0.292		
1	3.87	0.328		
1/0	3.07	0.368		
2/0	2.43	0.414		
4/0	1.53	0.522		
TBWP				
8 Solid	13.33	0.128		
6 Solid	8.93	0.162		
4 Solid	6.10	0.204		
2 Stranded	3.70	0.292		
1 Stranded	3.05	0.328		
1/0	2.36	0.368		
2/0	1.92	0.414		
3/0	1.53	0.464		
4/0	1.25	0.528		
250 KCM	1.02	0.574		
500 KCM	.528	0.81		
ACAR				
493.7 KCM 12/7	2.157	0.806	1.306	
543.9 KCM 12/7	1.96	0.846	1.346	
Shield and Guy Wire				
10M	6.1	0.306	0.534	
5/16” H.S. Steel	4.88	0.312		
3/8” H.S. Steel	3.66	0.360		
3/8” E.H.S. Steel	3.66	0.360		
7/16” E.H.S. Steel	2.51	0.435		
1/2” E.H.S. Steel	1.93	0.495		

The above values give the diameters of standard bare conductor and the diameters of these same conductors when armor rod or line guard are installed. These values shall be used to determine the range of conductor accessory (post top clamp, connector, etc.) to use.

DOWNWARD FORCE OF CONDUCTORS WHEN POLE HEIGHTS ARE EQUAL OR FIVE FOOT RAISE IS PRESENT

Conductor	Span	Pole Height Difference	Downward Force
#2 ACSR	200’	No	21.34 lbs
#2 ACSR	200’	5’	54.71 lbs
#2 ACSR	370’	No	39.48 lbs
#2 ACSR	370’	5’	57.44 lbs
1/0 ACSR	200’	No	29.04 lbs
1/0 ACSR	200’	5’	74.74 lbs
1/0 ACSR	370’	No	53.72 lbs
1/0 ACSR	370’	5’	78.18 lbs
4/0 ACSR	200’	No	58.22 lbs
4/0 ACSR	200’	5’	177.78 lbs
4/0 ACSR	370’	No	107.71 lbs
4/0 ACSR	370’	5’	171.82 lbs
336.4 ACSR	200’	No	73.06 lbs
336.4 ACSR	200’	5’	169.29 lbs
336.4 ACSR	370’	No	135.16 lbs
336.4 ACSR	370’	5’	186.59 lbs
795 AA	240’	No	179.11 lbs
795 AA	240’	5’	259.99 lbs
1272 AA	200’	No	238.10 lbs
3c 1/0	200’	No	85.84 lbs

These conductor weights are approximate weights and are not to be relied upon in determining safe working loads on lifting equipment, material handling equipment, and equipment that has a safe working load, such as auxiliary conductor arms, pins and live line maintenance. The conductor should be weighed with a calibrated device, such as a load cell or Dynamometer. Contact the Operations Training – Training Consultants if information is needed on conductors not listed on this page.

DETERMINATION OF STRANDED WIRE SIZE

Wire and Cables

		Measurement of One Strand			
Size of Wire	No. of Strands	Max. Loose Fit (AWG)	Min. Will Not Fit (AWG)	Single Strand Diameter	Cable Diameter Under Insulation
#2	7	10	11	.0974	.292
#1	7	9	10	.1093	.328
1/0	7	8	9	.1228	.368
2/0	7	7	8	.1379	.414
3/0	7	6	7	.1548	.464
4/0	7	5	6	.1739	.522
4/0	19	9	10	.1055	.528
250 KCM	19	8*	9	.1147	.574
300 KCM	19	8*	9	.1257	.629
336.4 KCM	19	7*	8	.1331	.666
350 KCM	19	7*	8	.1357	.679
350 KCM	37	10	11	.0973	.681
400 KCM	19	7*	8	.1451	.726
450 KCM	19	7*	8	.1539	.772
500 KCM	37	8*	9	.1162	.813
550 KCM	37	8*	9	.1219	.853
600 KCM	37	8*	9	.1273	.891
650 KCM	37	7*	8	.1325	.929
700 KCM	37	7*	8	.1375	.964
750 KCM	37	7*	8	.1424	.998
750 KCM	61	8	9	.1109	.998
795 KCM	37	6*	7	.1466	1.026
795 KCM	61	8	9*	.1142	1.028
1000 KCM	37	5*	6	.1644	1.152
1272 KCM	61	7*	8	.1441	1.300

To determine the size of cable, measure the size of an individual strand and count the number of strands in the cable. Wire should pass easily into groove in wire gauge for larger size wire and should be too large to fit in groove for smaller size shown opposite each size of wire and cable.

* Wire gauge measurement will give size only approximately; use calipers and compare with measurement under “Single Strand Diameter.”

Wire Size	Horizontal Transverse Load (lbs) - (Average of 2 Adjacent Spans) 1/2" Radial Ice, 4 lbs Wind						
	100'	150'	200'	250'	300'	350'	400'
Weatherproof Copper							
6 Sol.	40.7	61	81.3				
4 Sol.	42.3	63.5	84.7				
2 Str.	46.3	67.7	92.7	115.8	139		
1 Str.	47.3	71	94.7	118.3	142		
1/0 Str.	49.7	74.5	99.3	124.2	149		
2/0 Str.	51.3	77	102.7	128.3	154		
3/0 Str.	53	79.5	106	132.5	159		
4/0 Str.	55	82.5	110	137.5	165		
250 Str.	56.7	83	113.3	141.7	170		
Bare Copper							
6 Sol.	38.7	58.1	77.5				
4 Sol. & Str.	40.1	60.2	80.3				
4 Str.	41.8	62.7	83.6				
2 Str.	43.1	64.6	86.1	107.7	129.2		
Copperweld							
8A & 3/12	40.0	60	79.9	99.9	119.9	139.9	159.9
6A & 6C	41.0	61.5	82	102.5	123	143.5	164
4A	43.0	64.5	86	107.5	129	150.5	172
3/10	40.7	61	81.3	101.7	122	142.3	162.7
2F	44.0	65.4	87.2	109	130.8	152.6	174.4
3/12	39.1	58.7	78.3	97.8	117.4	137	156.5
6C	40.8	61.3	81.7	102.1	122.5	142.9	163.7
ACSR							
4 ACSR	41.7	62.5	83.3	104.2	125.0	145.8	166.7
2 ACSR 6/1 & 7/1	44.2	66.3	88.3	110.4	132.5	154.6	176.7
1/0 ACSR	46.6	69.9	93.2	116.5	139.8	163.1	186.4
4/0 ACSR	52.1	78.2	104.2	130.3	156.3	182.4	208.4
336.4 ACSR 18/1	56.1	84.2	112.3	140.3	168.4	196.5	224.5
All Aluminum							
4/0 Bare	50.7	76.1	101.5	126.8	152.2	177.6	202.9
336.4 Bare	55.5	83.3	111.1	138.8	166.6	194.4	222.1
336.4 Poly	60.7	91.1	121.5	151.8	182.2	212.6	242.9
795.0 Bare	67.5	101.3	135.1	168.8	202.6	236.4	270.1
795.0 Poly	73.8	110.7	147.6	184.5	221.4	258.2	295.1
1272.0 Bare	76.7	115.0	153.3	191.7	230.0	268.3	306.7
Cable							
#6 Duplex	48.4	72.6	96.8	121			
#2 Triplex ACSR	59.0	88.5	118.0	147.5			
1/0Triplex ACSR	66.3	99.5	132.7	165.8			
1/0 Quadruplex ACSR	70.7	106.0	141.3	176.7			
1/0 Quadruplex AA	69.7	104.5	139.3	174.2			
336.4 Triplex	91	136.5	182	227.5			
336.4 Quadruplex	99.1	148.7	198.2	247.8			

Formula for this calculation:

$$Horizontal\ Transverse\ Wire\ Load\ (lbs) = \left(Wind\ Load\left(\frac{lbs}{ft^2}\right) \times Span\ Length\ (ft)\right) \times \left(\frac{Wire\ Diameter\ (inches) + Ice\ Diameter\ (inches)}{12\left(\frac{inches}{foot}\right)}\right)$$

Example for 250 foot span of 1/0 ACSR:

$$Horizontal\ Transverse\ Wire\ Load\ (Lbs) = \left(4\left(\frac{lbs}{ft^2}\right) \times 250\ ft\right) \times \left(\frac{0.398\ in + 1.0\ in}{12\left(\frac{inches}{foot}\right)}\right) = 116.5\ lbs$$

The ampacities below for 194°F conductor temperature are maximum values. Currents greater than those shown will weaken the wire by annealing. If currents greater than those listed below might be experienced, contact the Material & Standards group to determine the amount of damage that will occur.

The values given below are for distribution conductors only and vary from the values given for transmission as distribution lines are more protected from the wind than transmission.

Conductor Temperature Ambient Temperature Wind Speed (miles/hour)			120°F 104°F 1.36	194°F 104°F 1.36	194°F 30°F 1.36
Size	Type	Stranding	Summer Loading (Amps)		Winter Loading (Amps)
#4	Alum – 3 Conductor	1	**	110	150
#2	Alum – 3 Conductor	7	**	170	220
1/0	Alum – 3 Conductor	7	**	225	300
1/0	Alum – 4 Conductor	7	**	200	260
336.4	Alum – 3 Conductor	19	**	485	630
336.4	Alum – 4 Conductor	19	**	420	545
3/0	AA – Covered	19		330	458
336.4	AA – Covered – Anona XLP	19	---	519	723
700	AA – Covered	61	---	816	1,146
795	AA – Covered	37	---	893	1,253
795	AA – Covered - Persimmon	61	---	893	1,253
795	AA – Bare - Arbutus	37	**	869	1,200
795	AA – Bare - Lilac	61	**	869	1,200
1272	AA – Bare - Narcissus	61	**	1,151	1,603
#4	ACSR – Bare - Swan	7/1	---	136	186
#2	ACSR – Bare - Sparrow	6/1	*58	179	246
#2	ACSR – Bare - Separate	7/1	*58	179	246
1/0	ACSR – Bare - Raven	6/1	*73	236	324
4/0	ACSR & AA – Bare – Penguin & Oxlip	6/1	**	356	490
336.4	ACSR & AA – Bare – Merlin & Tulip	18/1 & 19	*292	512	704
477	ACSR - Flicker	24/7		650	886
795	ACSR - Drake	26/7		907	1,240
8	CU – Bare & Covered	1	---	93	127
6	CU – Bare & Covered	1 & 7	---	125	170
4	CU – Bare & Covered	1 & 7	---	169	231
2	CU – Bare & Covered	1 & 7	---	227	311
1	CU – Bare & Covered	1 & 7	---	265	363
1/0	CU – Bare & Covered	1 & 7	---	304	416
2/0	CU – Bare & Covered	1 & 7	---	355	487
3/0	CU – Bare & Covered	1 & 7	---	407	558
4/0	CU – Bare & Covered	7	---	476	654
250	CU – Bare & Covered	19	---	530	729
500	CU – Bare & Covered	37	---	836	1,169
1000	CU – Bare & Covered	61	---	1,291	1,805
3/12	CW – Bare	3	---	69	94
3/10	CW – Bare	3	---	92	126
8A	CW – Bare	3	---	104	142
6A & 6C	CW – Bare	3	---	136	186
4A	CW – Bare	3	---	181	247
2A	CW – Bare	3	---	240	329
2F	CW – Bare	7	---	232	318

* For the purpose of additional clearance required by code, on lightly loaded primary branches that will at no time in the future exceed these load currents, a maximum conductor operating temperature of 120°F for 2 ACSR and 1/0 ACSR or less may be assumed, and for 336.4 ACSR, a maximum operating temperature of 140°F or less may be assumed.

** For the purposes of additional clearances required by code, these conductors are assumed to have a maximum conductor operating temperature of 194°F.

GENERAL

No. 6 bare stranded copper, Code No. 133-0917, is the only bare copper conductor authorized to be purchased for general use on distribution. It is required for ground wire and is also used for small jumpers.

The purchase of other bare copper and copperweld conductors has been discontinued because of the high cost of those conductors compared to all aluminum and ACSR.

The purchase of weatherproof copper has been curtailed and is restricted to those uses indicated below. Salvaged triple-braid weatherproof conductor in good condition shall be used at secondary voltages before any polyethylene covered copper is purchased for this purpose.

WEATHERPROOF COPPER

Primary and Secondary Lines: Weatherproof copper conductors should be used only for the repair of existing primary (#6TBWP is hard drawn and was used on primary. Need bare solid 133-0680 for repair of #6TBWP) and secondary line conductors.

Where an existing line consisting of weatherproof copper is to be extended, aluminum conductor shall be used. If it would be desirable to extend the line with a matching weatherproof copper conductor to avoid guying, it is recommended that the existing weatherproof copper be replaced with aluminum back to a point where guying can be installed.

Secondary Bus and Risers: When copper conductors are to be used for bus and risers on transformer settings, they shall be weatherproof.

Primary Risers: #4 Str. Copper polyethylene covered conductor (Code #133-6980) shall be used for the primary risers from transformer bushings to the cutout and neutral, along with 1/2" carlon 135-3835.

#4 Str. Copper polyethylene covered conductor (Code #133-6980) shall be used for the H-2 neutral lug on single bushing transformers (tank ground).

BARE COPPER

Bare copper conductors should be used only for the repair of existing conductors.

Where an existing line consisting of bare copper is to be extended, aluminum conductor shall be used. If it would be desirable to extend the line with a matching bare copper conductor to avoid guying, it is recommended that the existing bare copper be replaced with aluminum back to a point where guying can be installed.

COPPERWELD

Retain only sufficient quantities and lengths in stock as necessary for emergency purposes.

Copperweld conductors shall not be installed as line conductors for new construction for any reason.

I. Phase Conductor

A. Conductor sizes on new construction shall be #2 ACSR, 1/0 ACSR, 336.4 18/1 ACSR and 795 AA.

B. See Std OHC25 for information on reuse of salvaged copper and copperweld as primary conductors. For emergency repairs, 4/0 ACSR can be spliced into 4/0 AA, and 336.4 ACSR can be spliced into 336.4 AA. For proper tension splices, see Std OHC55.

II. Neutral Conductors

A. Three-phase lines.

The primary neutral conductor may be smaller than the phase conductor as indicated below. The size of a common and secondary neutral shall be larger when required for secondary purposes.

Phase	#2 ACSR	1/0 ACSR	4/0 ACSR	336.4 ACSR	795 AA
Neutral	#2 ACSR	1/0 ACSR	1/0 ACSR	1/0 ACSR	336.4 ACSR*

*EXCEPTION: For reconductoring of urban feeders serving only urban areas, existing bare 1/0 ACSR neutrals and 1/0 ACSR triplex secondary neutrals may be left in place.

Listed below are the minimum sizes of existing conductors that can be used as neutrals when conductors are replaced on or added to existing pole lines. Copper equivalents to aluminum are listed below the neutral sizes.

Phase	#2 ACSR	1/0 ACSR	4/0 ACSR	336.4 ACSR	795 AA
Neutral	#4 ACSR	#4 ACSR	#2 ACSR	1/0 ACSR	4/0 ACSR
Copper Equivalent	6 CU	6 CU	4 CU	2 CU	2/0 CU

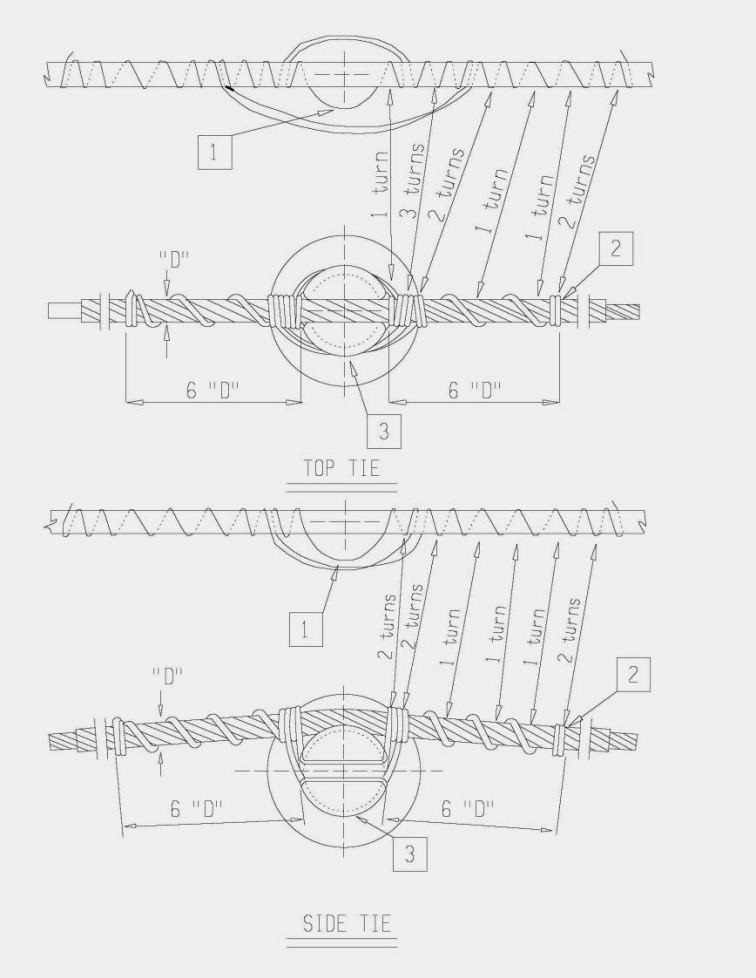
Do not use the neutral of aluminum service drop cables as a common neutral.

B. Single and two-phase lines.

The primary neutral conductor shall be the same size or the copper equivalent of the phase conductor up to and including 1/0 ACSR. Install a reduced neutral when the line is built for future full three phase, with conductor larger than 1/0 ACSR.

Do not use the grounded phase of 3-wire three-phase 240 volt delta service or secondary for a neutral.

Do not use the neutral of aluminum service drop cables as a common neutral.



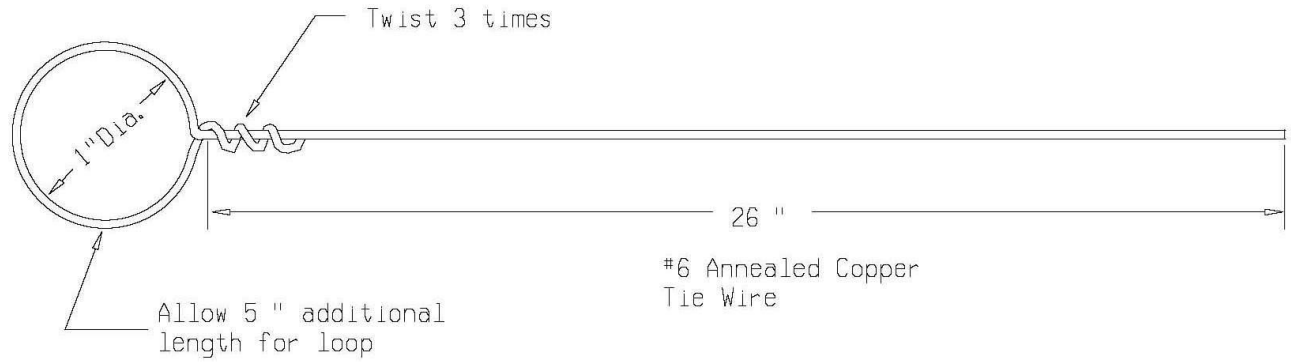
SIDE TIE

	Tie wire length required for:				"D" = Diameter			
	Top Tie		Side Tie		Bare		With Armor	
Conductor	Bare	With Armor	Bare	With Armor	"D"	6 "D"	"D"	6 "D"
4 ACSR	-	78"	-	72"	.25"	1-1/2"	.54"	3-1/4"
2 ACSR	66"	84"	58"	72"	.35"	2-1/8"	.59"	3-3/4"
1/0 ACSR	72"	86"	63"	78"	.40"	2-1/2"	.73"	4-1/2"
4/0 ACSR	90"	102"	76"	89"	.55"	3-1/4"	.90"	6-1/4"
4/0 AA	86"	-	72"	-	.53"	3-1/4"	.85"	5"
336.4 ACSR	-	118"	-	96"	.72"	4-1/4"	1.1"	6-1/2"
336.4 AA	96"	-	88"	-	.67"	4"	1.0"	6"
795 AA	112"	-	100"	-	1.0"	6"	1.6"	9-1/2"

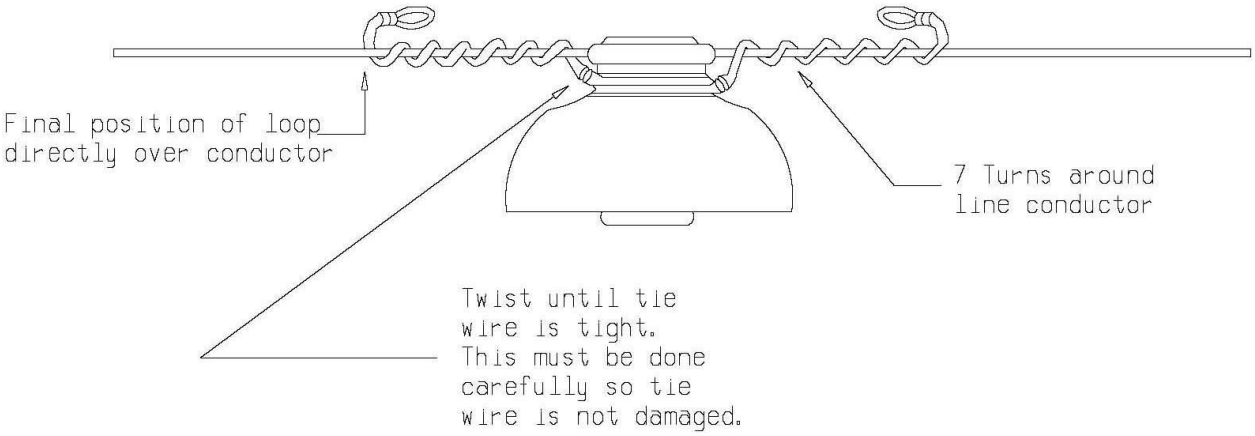
□ Notes:

1. Start making tie in the middle of the length of wire where indicated.
2. Make tie as snug and tight as possible by hand up to the last two turns at the outer ends, then use pliers to continuously cinch these last two turns.
3. Avoid tie wire crossovers in neck of insulator.
4. For 8A, 6A, 3/12, #6, or #4 copper, use a #8 copper tie wire. For all other copper or copperweld conductors, use #6 copper tie wire.
5. Use #4 aluminum tie wire on all aluminum or ACSR conductors unless using preformed tie as covered on Std OHC50.

ITEM	MATERIAL		NO.REQ.	ITEM	MATERIAL		NO.REQ.
1	COPPER TIE WIRE #6	133-5597	AS REQ	3	COPPER TIE WIRE #8	133-5361	AS REQ
2	ALUMINUM TIE WIRE #4	133-5602	AS REQ				

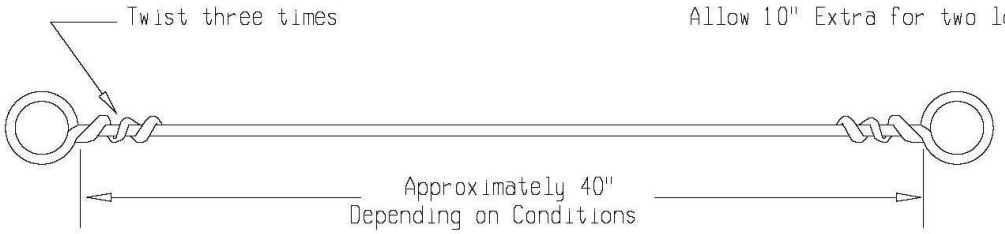


DETAIL OF TIE
(2 required)



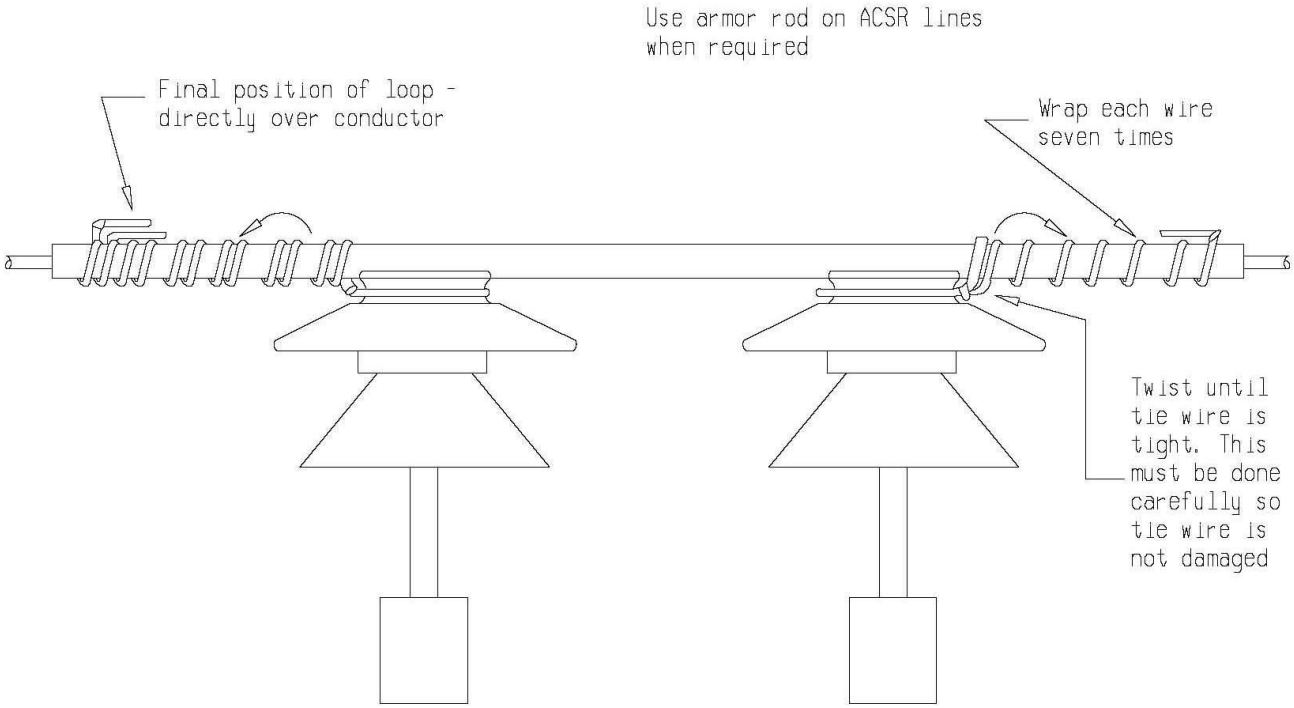
□ Notes:

1. Use this tie only where a hot line tie is required on lines 15 KV and below, conductors #2 and smaller.



Use #6 annealed copper tie wire for copper lines
Use #4 aluminum tie wire for ACSR or all aluminum lines.

DETAILS OF TIE WIRE
(One Required Per Insulator)



GENERAL INFORMATION

Preformed ties with conductor pads shall be used on #2, 1/0, 4/0, 336.4 ACSR, 4/0 AA, and on 795 AA on all new construction and when convenient on existing lines. Preformed ties will fit any of the following insulators:

	pin insulator (17 KV, F neck) (not in stock)
134-4955	pin insulator (25 KV, F neck)
134-5080	post insulator (25 KV, F neck)
135-4240	spool insulator (spool tie only)

The preformed ties eliminate the need for both hand ties and armor rod. They shall be used for top ties, side ties, and spool ties. Use the double preformed ties when two insulators are required. The rubber pad must be used and properly oriented on all installations to prevent abrasion of the conductor and insulator.

Preformed ties shall not be salvaged. They should not be reused except when circumstances make it impractical to obtain new ties.

Tie Type	Conductor	Stock Code No.	Insulator Neck Size	Replacement Pad
Single insulator top tie	#2 ACSR	134-7800	F	135-4501
"	1/0 ACSR	134-7802	F	135-4501
"	4/0 ACSR & AA	134-7804	F	135-4502
"	336.4 ACSR	134-7806	F	135-4503
"	477 ACSR	134-7807	F	NA
"	795 AA	134-7808	F	135-4509
Single insulator side tie	#2 ACSR	134-7810	F	135-4504
"	1/0 ACSR	134-7812	F	135-4504
"	4/0 ACSR & AA	134-7814	F	135-4505
"	336.4 ACSR	134-7816	F	135-4506
"	477 ACSR	134-7817	F	NA
"	795 AA	134-7818	F	135-4510
Double insulator top tie	#2 ACSR	134-7820	F	135-4501
"	1/0 ACSR	134-7822	F	135-4501
"	4/0 ACSR & AA	134-7824	F	135-4502
"	336.4 ACSR	134-7826	F	135-4503
"	795 AA	134-7838	F	NA
Double insulator side tie	#2 ACSR	134-7830	F & C	135-4504
"	1/0 ACSR	134-7832	F	135-4504
"	4/0 ACSR & AA	134-7834	F	135-4505
"	336.4 ACSR	134-7836	F	135-4506
Spool insulator tie	#2 ACSR	134-7840	F	135-4504
"	1/0 ACSR	134-7842	F	135-4504
"	4/0 ACSR	134-7844	F	NA

COLOR CODING

Conductor Size

See the diagram on the next page to determine the location of the "conductor size color code" on each type of tie. The code is as follows:

Conductor Size	Color
#2 ACSR	Red
1/0 ACSR	Yellow
4/0 ACSR & AA	Red
336.4 ACSR	Brown

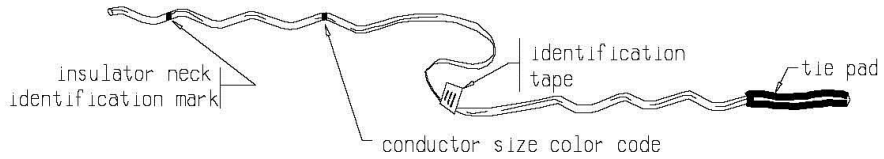
Insulator Neck

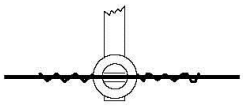
See the diagram on the next page to determine the location of the "insulator neck identification mark" on each type of tie. The code is as follows:

Neck Type	Neck Diameter	Color
F neck	2-7/8" – 1/8"	Yellow
C neck	2-1/4" – 1/8"	Black
J neck	3-1/2" – 1/8"	Green

Note: At present, we stock ties for F neck and spool insulators only. The pin and post insulators listed above all have F necks. Ties shall not be installed on C & J necks except in the case of double side ties which may be installed on either F or C neck insulators.

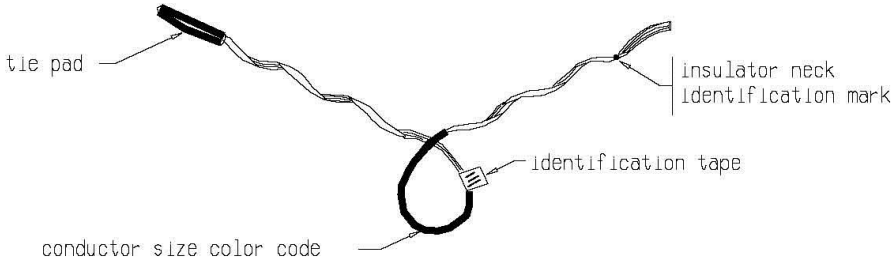
Single Insulator Top Tie

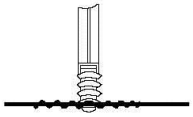




typical use

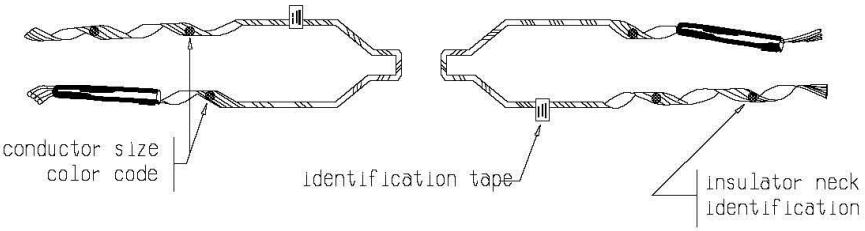
Single Insulator Side Tie

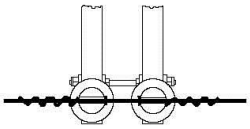




typical use

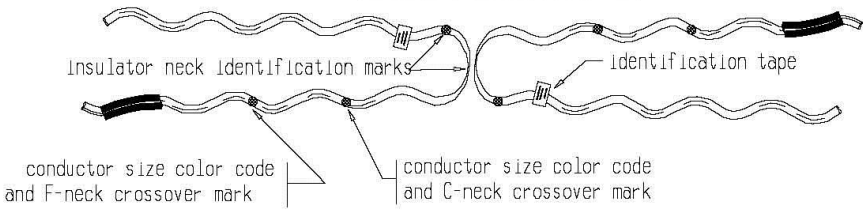
Double Insulator Top Tie

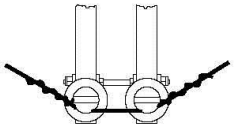




typical use

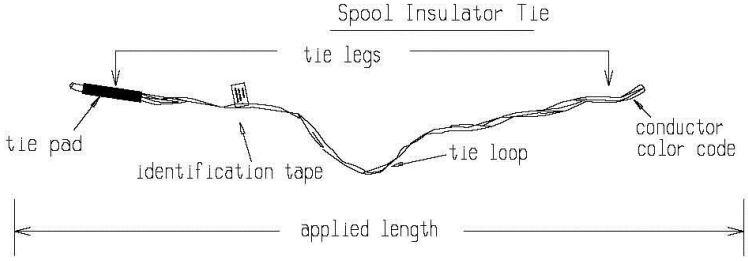
Double Insulator Side Tie

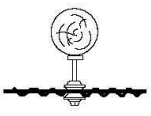




typical use

Spool Insulator Tie





typical use

I. GENERAL

The automatic splices listed on page 2 of Std OHC55 can be used on full tension primary open wire secondary conductors and the messengers of secondary cables. Use only the listed splices on the designated conductors. Do not attempt to remove strands or add filler strands to make the conductor fit.

Automatic splices shall not be used in services, slack spans, insulated conductors of cabled secondary lines, or transmission lines.

Automatic splices shall not be salvaged and shall be junked when removed from service. Never reuse an automatic splice.

Never use an automatic splice that has a dented or deformed barrel.

Never pull automatic splices through stringing sheaves.

II. GUIDE CUPS

The guide cups in each end of the splice are required to guide the conductor through the jaws. Do not attempt to remove the guide cups from the ends of the splice and do not use any automatic splice without guide cups.

If the conductor has not been inserted to depth, the guide cup will not allow the jaws to tighten on the conductor (Fig. 1) and the conductor can easily be withdrawn. When the conductor is inserted properly, the guide cup clears the back of the jaws and allows the jaws to tighten on the conductor (Fig. 2).

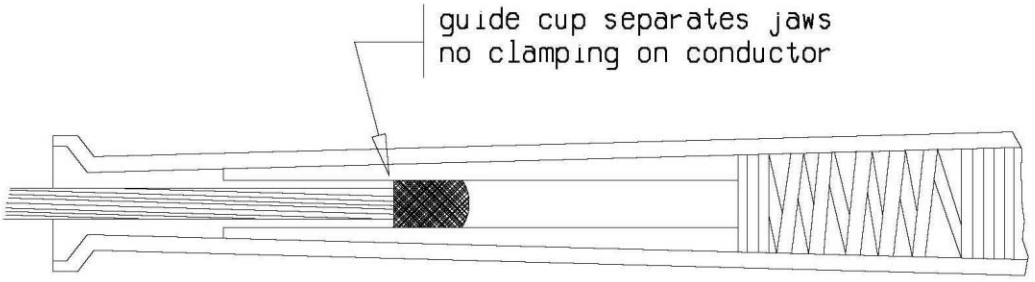


Fig. 1

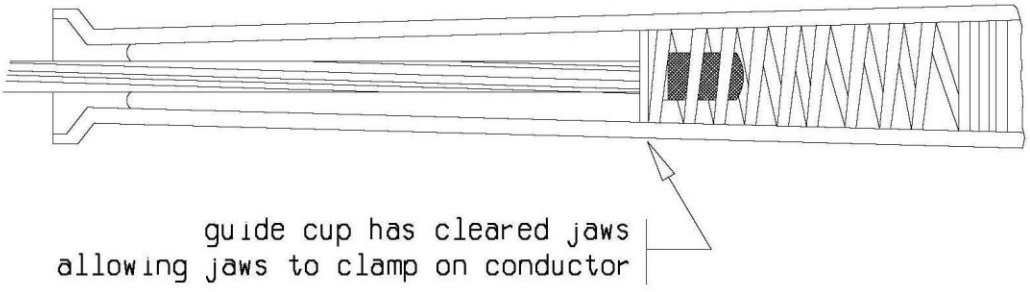


Fig. 2

When used below 0 degrees F, splices should be warmed in truck cab to keep grease softened.

Automatic Splice Identification

Wire Size	Stock Code #
#4 ACSR 6/1	135-7160
#2 ACSR 7/1 & 6/1	134-7024
#1/0 ACSR 6/1	134-7026
#4/0 ACSR 6/1 & AA 7 Str.	134-7030
336.4 KCM 18/1 & AA 19 Str.	134-7036
795 AA 37 Str.	134-7038

Installation

1. Do not remove the splice from its protective jacket until ready to install. Do not allow dirt or other contaminants to enter the splice.
2. The conductor may be cut with standard wire cutters. Care should be taken to cut the conductor as cleanly and evenly as possible without pushing individual strands out of position. The table below may be used as a guide to determine the amount of conductor that should be cut out to maintain proper sag when installing an automatic splice in an existing line.

Conductor Size	Separation Between Conductor Ends
#4 ACSR	1/2”
#2 ACSR	1”
1/0 ACSR	1-1/2”
4/0 ACSR & AA	2”
336.4 ACSR & AA	1-1/2”
795 AA	1-1/2”

3. Make sure the conductor is free of burrs and that all strands are in lay. Do not try to force a strand that is out of lay into the splice.
4. Make sure the conductor is straight. Remove any curvature from coiling.
5. Use the center marks on the splice to measure and mark the conductor for full insertion.
6. Wire brush both ends of the conductor.
7. Push the conductors straight into the ends of the splice with a smooth, firm thrust. Do not twist the conductors while inserting. Once the conductor is started into the splice, do not allow it to back up until it has been completely inserted. Hold the conductor tightly against the stop and work the conductor sideways in the splice several times to allow the splice jaws to advance the maximum distance.
8. If error is made during installation, splice may be removed by cutting it in the center with a hack saw. Remove center butt plates springs and jaws. Then remove outside housing from wire.
9. Apply hand tension to the splice to assure that the guide cup has cleared the jaws. This tension will then start to set the jaws.
   If the guide cup has not cleared the jaws, the conductor will pull out of the splice. Discard the splice and install a new one. Do not attempt to reinsert the conductor with the guide cup partially pushed through the jaws.
10. When normal line sag tension is applied, it will give the splice excellent electrical properties without pre-tensioning.
11. If the line cannot be pulled up to full sag tension prior to energizing, the splice shall be pre-tensioned according to the procedure below.

Pre-tensioning Procedure:

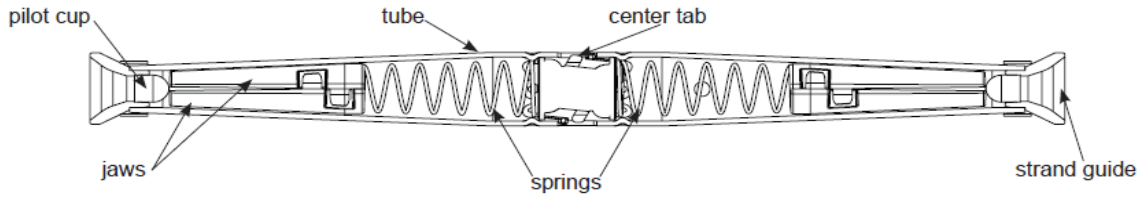
With the come-alongs and blocks and, in the case of hot line work, the jumpers still in position, a hand line link stick when required shall be attached to the conductor. Then a downward force of between 100 and 200 pounds shall be exerted on the hand line.

VIP CRS Automatic Splices
Visual Indicator Projection Corrosion Resistant Automatic Splice

Installation Instructions

1. Remove the splice from its bag prior to installation.

2. Do not remove the following components prior to installation:
   - The stranded guide (funnel-shaped piece at the nose of the splice)
   - The pilot cup (metal capsule in the nose of the splice)



3. Check the conductor size and type stamped on the splice to make sure it is the correct size for your application.

4. Straighten the conductor to remove any coil or curvature. CONDUCTOR MUST BE STRAIGHT AS POSSIBLE FOR PROPER INSTALLATION.

5. Cut the conductor squarely so that all strands are even. Taping the conductor next to the cut point will keep the conductor strands in lay. Remove this tape after cutting the conductor. If the conductor is damaged, it should be cut back sufficiently to remove all damaged strands.
   The table below may be used as a guide to determine the amount of conductor that should be cut out to maintain proper sag when installing an automatic splice in an existing line.

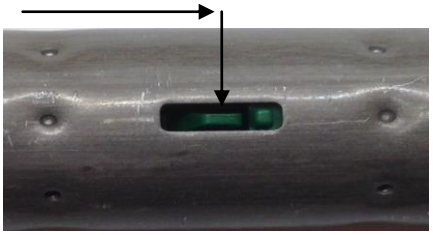
Conductor Size	Separation Between Conductor Ends
#4 ACSR	1/2”
#2 ACSR	1”
1/0 ACSR	1-1/2”
4/0 ACSR & AA	2”
336.4 ACSR & AA	1-1/2”
795 AA	1-1/2”

6. File the burrs from the conductor end.

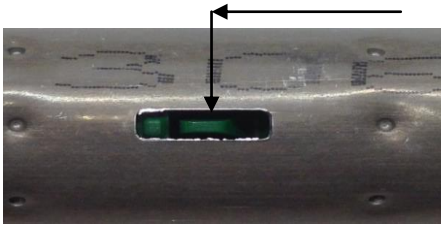
7. Wire brush the conductor to remove any oxides on the conductor surface. WIRE BRUSH ALL CONDUCTORS, EVEN NEW CONDUCTORS, PRIOR TO INSERTION.

8. Inspect splice to see which end will pop.

Conductor from this direction activates this tab.

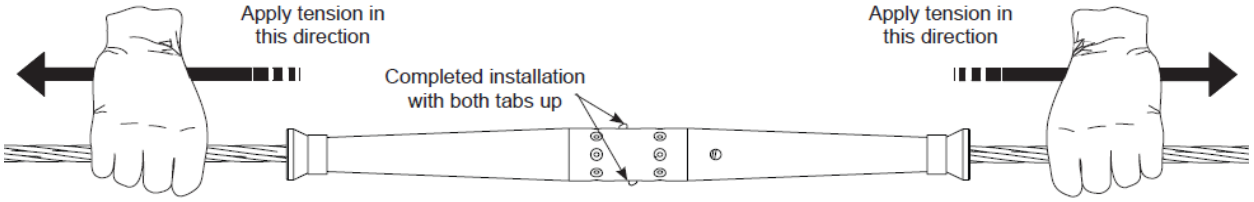


Conductor from this direction activates this tab.



9. Fit the conductor into the pilot cup and push the conductor straight into the automatic in a single, smooth motion until the tab pops up indicating full insertion has been reached. If resistance is felt when inserting the conductor, continue to push; DO NOT pull the conductor out and attempt a second insertion. IF YOU PULL OUT THE CONDUCTOR BEFORE A FULL INSERTION, USE A NEW SPLICE AND TRY AGAIN. Do not twist the conductor or splice during or after the insertion. Repeat on other side.

10. Apply some momentary tension on the conductor in the direction shown in the image below (hand set if appropriate or pull down the installed splice to create some tension) to insure a positive grip on the conductor. Do not tap or strike the splice to set the jaws. This can damage the splice. As span tension is applied, there will be some movement of the conductor (possible up to one inch) due to the setting motion of the jaws.



Caution!

Do not release hoist or come-a-long unless both tabs have popped up.
Automatic splices should not be used in slack span application.
Do not reuse automatic splices or dead ends. It is not possible to adequately clean internal components after they have been exposed to service conditions.

I. PRIMARY AND SECONDARY DEADENDS

	Primary	Secondary
Wire Size	Stock No.	Stock No.
4 ACSR	134-1889	
2 ACSR 6/1 & 7/1	134-1889	135-3485
1/0 ACSR 6/1	134-1889	135-3500
4/0 ACSR 6/1	134-1889	
336.4 KCM ACSR 18/1	134-1889	
4/0 AA – Bare	134-1889	
336.4 KCM AA – Bare	134-1889	
336.4 KCM AA – Polyethylene	134-1889	
700 KCM AA 61 Str – Polyethylene	134-1656	
795 KCM AA – Bare	134-1656	
795 KCM AA – Polyethylene	134-1656	134-1656
1,272 KCM AA – Bare	134-1658	

II. SERVICE DEADENDS

Wire Size	Stock No.	Stock No.
336.4 KCM AA – Polyethylene	134-3099	
795 KCM AA – Polyethylene	134-3060	

III. ANGLE SUSPENSION CLAMPS

Wire Size	Stock No.	Stock No.
#4 ACSR with Armor Rod	135-1720	
#4 ACSR with Line Guard	134-3060	
3/12 Copperweld	135-1721	
8A Copperweld	135-1721	
6A Copperweld	135-1721	
#4-4/0 ACSR with Armor Rod	134-1886	
#2-336.4 ACSR & 4/0-336.4AA with Line Guard	134-1886	
4/0, 250 & 500 KCM Copper	134-1886	
1272 KCM Bare	134-1881	
336.4-477 ACSR with Armor Rod	134-1881	
477 ACSR & 795AA with Line Guard	134-1881	

The following table shall be used in selecting dead-end material for copper and copperweld conductor on distribution lines.

Wire Size	Stock #
Primary and Secondary Bolt Type	
3/12, 3/10, 8A, 6A, 4A, 2F copperweld	135-1700
#6 Sol, #6 Str, #4 Sol, #4 Str, #2 Sol, #2 Str, #1 Sol, #1 Str, 1/0 Sol, 2/0 Sol Copper	135-1700
1/0 Str, 2/0 Str,3/0 Str, 4/0 Str, 250 KCM, 500 KCM	134-1884
750 KCM & 1000 KCM	134-1880
Primary and Secondary Automatic Type	
#1 Str, 1/0 Sol	134-3074E
1/0 Str, 2/0 Sol	134-3078
4/0 Str	134-3092
250 KCM	134-3096
Secondary Only Automatic Type	
#6 Str & #4 Sol	135-3290
#2 Str & #1 Sol	134-3068

ARMOR ROD FOR ACSR CONDUCTORS (DON'T USE WITH PREFORMED TIES)				
CONDUCTOR SIZE	STOCK NO.	LENGTH (INCHES)	COLOR CODE	NO. PER SET
#4 ACSR 6/1	135-5030	40	Orange	7
#2 ACSR 6/1 & 7/1	135-5060	44	Red	9
1/0 ACSR 6/1	135-5090	52	Yellow	9
4/0 ACSR 6/1	134-6450	60	Red	11
266 KCM 26/7	143-7161	64	Yellow	12
336.4 KCM 18/1	134-6470	68	Blue	12
336.4 KCM 26/7	143-7163	72	Green	12
397 KCM 26/7	143-7162	76	Purple	11
477 KCM 24/7	143-7164	78	Blue	12
795 KCM 26/7	143-7168	100	Orange	12

ARMOR ROD FOR ACSR CONDUCTORS				
CONDUCTOR SIZE	STOCK NO.	LENGTH (INCHES)	COLOR CODE	NO. PER SET
493 KCM 12/7	143-7162	76	Purple	11
543.9 KCM 12/7	143-7164	78	Blue	12

ARMOR ROD FOR ALUMINUM CABLE
The line guard for 1/0 ACSR, 135,3855, and 4/0 ACSR, 135-3885, will be used for armoring the neutral of secondary cable. See Std F41 when protection from trees is required.

ARMOR ROD FOR SHIELD WIRE				
CONDUCTOR SIZE	STOCK NO.	LENGTH (INCHES)	COLOR CODE	NO. PER SET
10 M (5/16" 7#10) Alumoweld	143-7160	46	Black	9

ARMOR ROD FOR EHV CONDUCTOR REPAIR – ENDS MUST BE PARROT BILLED				
CONDUCTOR SIZE	STOCK NO.	LENGTH (INCHES)	COLOR CODE	NO. PER SET
795 KCM 26/7	143-7165	100	Orange	12
954 KCM 54/7	143-7170	100	Red	13

LINE GUARD FOR ACSR & AA CONDUCTORS (DON'T USE WITH PREFORMED TIES)				
CONDUCTOR SIZE	STOCK NO.	LENGTH (INCHES)	COLOR CODE	NO. PER SET
#2 ACSR 6/1 & 7/1	135-3845	21	Red	9
1/0 ACSR 6/1	135-3855	25	Yellow	11
4/0 AA	135-3875	29	Black	14
4/0 ACSR 6/1	135-3885	31	Red	15
336.4 KCM AA	135-3895	35	Brown	15
795 KCM AA	134-4593	47	Brown	18
1272 KCM AA	134-4600	61	Aluminum	17

GENERAL

Armor rod and line guard may be used at conductor support points or for conductor repair.

On distribution lines, armor rods shall be used on all 4 ACSR and 2 ACSR 6/1, 2 ACSR 7/1, 1/0 ACSR, 4/0 ACSR and 336.4 ACSR 18/1 where preformed ties are not used. Line guard shall be installed on conductors as indicated on appropriate Primary, Secondary, and Transformer Standards pages.

Old rural or long span ACSR distribution lines that were built without armor rods shall have armor rods installed on conductors requiring them when work involving retying (such as insulator, crossarms, or pole replacement) is done. Preformed ties can be used as an alternate to using armor rods in some cases.

In almost all cases armor rods are to be installed on ACSR conductors on transmission construction below 345 KV. Use of dampers in some situations may eliminate the need for armor rod. Generally, application of armor rod and/or dampers on a specific line will not change from initial design. If there is a question concerning application of these items, consult the Material & Standards group.

DISTRIBUTION CONDUCTOR REPAIRS

Copper distribution conductors will be repaired by using compression splices specified in Std CON1.

Copperweld distribution conductors 3/12 and 3/10 can be repaired with split repair sleeves if one strand is damaged. The 8A, 6A and 4A conductors can be repaired with split repair sleeves if the copperweld strand is undamaged. The split repair sleeves are listed in Std CON1.

ACSR distribution conductors which have had any damage to the steel core will be repaired by using compression splices specified in Std CON1 or automatic splices listed on Std OHC55. When there is no damage to the steel core and no more than 1/3 of the aluminum strands are damaged, repairs maybe made by installing preformed aluminum alloy line guards.

All aluminum distribution conductors which have no more than 1/3 of the strands damaged can be repaired with preformed line guards.

SUB-TRANSMISSION CONDUCTOR REPAIRS

Copper sub-transmission conductors will be repaired by using compression splices and installation tools as specified in Std CON1 and Std TR105.

ACSR sub-transmission conductors which have had any damage to the steel core strand or strands will be repaired by using compression splices as specified in Std CON1 and Std TR105. When there is no damage to the steel core and not more than 40% of the outer aluminum strand layer or a maximum of 20% of the total aluminum strands are damaged, repairs may be made by installing standard preformed aluminum alloy armor rods over the defective strands. After the aluminum strands are thoroughly cleaned, the rods are installed the same as for conductor armoring.

I. Purpose

Faulted circuit indicators (FCI) can be used in a number of overhead applications. They can be helpful for: cross country lines, lines that run long distances without fusing, or when a solid blade is used on a riser. The latter helps identify if the fault is in the overhead or the underground system.

A. Overhead Fault Indicators

1. Faulted Circuit Indicators:

Stock #	OH/ URD	Indication	Cable Dia.	Approx. Wire Size	Reset	Minimum Pickup Trip Setting	Load Track Beyond
134-4801 **(Reference only)**	Both	Rotor	0.63 – 1.58”	OH - 336 & up URD - #2, #1, 4/0	Manual	300A	N/A
134-4814	OH	LED w/ lens	0.3 – 1.57”	#2 – 1272 KCM Bare	Manual, 4 hr, PPZ	50A Min @ 0.2 sec	30A
134-4815	OH	LED w/ lens	0.3 – 1.57”	#2 – 1272 KCM Bare	Manual, 4 hr, PPZ	200A Min @ 0.2 sec	40A
134-4816	OH	6 LED	0.3 – 1.25”	#2 – 795 KCM Bare	Manual, 4 hr, PPZ	200A Min @ 0.2 sec	30A

These units trip at a minimum pickup setting when the load current is less than 30A or 40A, depending on unit. They will load track beyond their designed minimum tracking rating; then the FCI trip settings increase by 3 to 5 times the load current.

These units also have an inrush restraint feature called PPZ (pulse, pause, zero). When the units detect a fault or inrush current that exceeds the trip setting, it begins flashing for 28 seconds (pulse). It then attempts to detect load current for the next 28 seconds (pause). If the load current (~3A for 134-4816 and ~7A for the other units) is detected, then the unit stops flashing. If it detects zero, it will remain flashing for four hours or until it is manually reset (zero). Six LED FCIs will change from 4 red LEDs to 2 yellow LEDs if a minimum of 3 amps of load current is detected. Note the unit can be used on a circuit without the minimum load current and will still detect faults but will not reset on current.

Stock numbers 134-4805 through 134-4815 devices contain a lithium ion battery with a 20 year shelf life that is non-replaceable. These FCI’s should be recycled with other lithium ion batteries.

134-4816 has 4 replaceable lithium oxide cells which have up to a 20-year shelf life. Orange LED will flash up to 5 months when batteries are low and must be replaced.

B. When to Install Overhead FCIs

1. Install permanent fault indicators in overhead systems in the following situations:
   a. At an accessible portion of a hard to patrol cross county line.
   b. To sectionalize a long un-fused portion of line.
   c. When a riser or reverse-riser has a solid blade.

2. The a circle with an F indicates the location of an FCI in our mapping system. Each location should have the FCI trip rating and the install date. When an FCI is installed, the Field Application Engineer should contact GIS with the: reset time, trip level, stock code, and install date.

C. Troubleshooting Fault Indicators

1. Fault Indicators with batteries have a shelf life anywhere from 15 to 20 years. When 15 years have passed since the install date, replace the FCI and notify Field Application Engineer and/or GIS to update records.

2. Choose 100 amp trip with any fuse between 10 and 50 amps. Use the 500 amp trip for any fuse between 65 and 100 amps. For fuses larger than 100 amps or for areas that may be sensitive to voltage dips from closing larger fuses into a fault, see Line Work Method (LWM 4007) regarding use of the cable tester.

3. Test indicators before use by tripping with a magnet and resetting.
   a. To trip the indicator, pass the magnet across the area on the fault indicator labeled “trip”. A single pass (using a wide arc), the same direction as the label is read, is recommended.
   b. To reset the indicator, pass the magnet across the area on the fault indicator labeled “reset”. A single pass (using a wide arc), the same direction as the label is read, is recommended.

D. Suspected Mis-operation of Indicator

1. Report any and all suspected mis-operations to Field Application Engineer or the Material & Standards group.

2. Down-line FCI tripped:
   a. Possible inrush tripping due to too much connected transformer KVA down-line of fault. Establish an open point to split the remaining connected KVA in half, reset indicators, and re-fuse. This may occur on 14.4 KV systems where the connected KVA exceeds 200 KVA per phase for 100 amp indicators, 1000 KVA per phase for 500 amp indicators, and over 2 MVA of load for the 300 amp trip visible indicators.

3. Upstream FCI not tripped
   a. FCI may have reset if load is greater than reset rating. (See Figure 2)

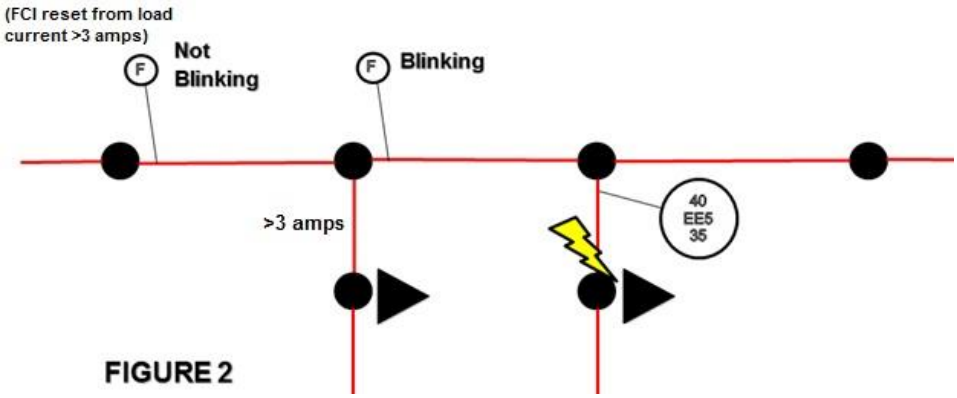


FIGURE 2

E. Manual Rotor FCI – with Visible Rotating Indicating Disk (Reference Only – Discontinued)

1. These indicators are water tight and submersible. These indicators will trip when 300 amp (or greater) of fault current is available. When tripped, they will show a visible indication with a rotating disk. These indicators are manual reset. They can be reset by swiping a magnet across the device.

2. These indicators should not be used downstream of fuses smaller than 30 amp or OCRs smaller than 70 amp. If used with fuses smaller than 30 amp or OCRs smaller than 70 amp, the upstream device will clear the fault before the FCI is tripped.

3. Test indicators before use by tripping with a magnet and reset.
   a. To trip the indicator (rotate the visible disk back), pass the magnet slowly along the side of the clear disk window (see Figure 1a). A single pass in a clockwise direction is recommended.

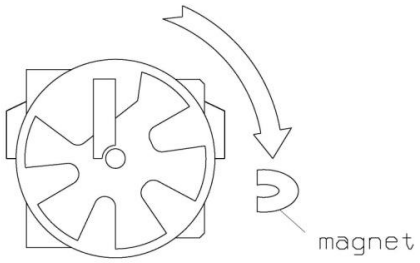


FIGURE 1a

   b. To reset the indicator (rotate the visible disk), pass the magnet from right to left across the top of the clear disk window over the word “HORSTMANN.” A single pass in a counterclockwise direction is recommended.

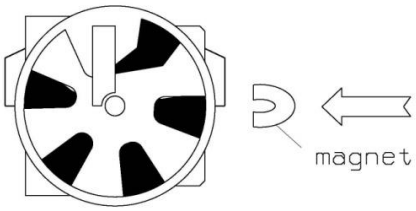
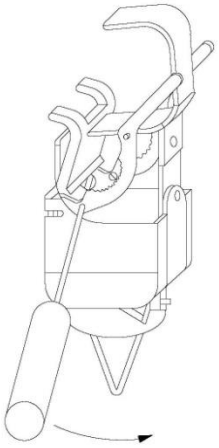


FIGURE 1b

F. Install FCI

1. Hold FCI body in hand.
2. Pull metal latch out until it locks in open position.
3. Install FCI on hot stick or apply by hand according to accepted practices.
4. Place locked open FCI on overhead line.
5. Press against conductor.
6. FCI will snap on conductor and attach to overhead line.

OVERHEAD LED TYPE FAULTED CIRCUIT INDICATOR (134-4815)



To Remove Metal Leg

Use Metal Leg for Conductor Diameter 5/16” to 1”
Remove Metal Leg for Conductor Diameters 1” to 1-9/16”

G. 6 LED FCI Installation and Operation (134-4816)

1. The Navigator dome LED FCI has many light combinations that mean different things.
   a. When first installed on an overhead line, if the load current exceeds 100 amps, all LEDs will flash. After 1 minute the red LEDs will quit and only 2 yellow LEDs will be flashing. The yellow LEDs can be reset with a magnet or will reset automatically with time

   b. When a fault event that exceeds the trip rating, all 6 LEDs will flash.

   c. A recloser operation that clears the fault will reset the 4 red LEDs with load current of 3 amps or more, and only the 2 yellow LEDs will remain flashing until reset by time.

   d. A single flashing LED on one side indicates a low battery condition and is an alert to replace batteries within 6 months.

Stock #	Item	Description
134-7710	Semi-conducting tape	3/4-inch x 15 ft. rolls. Primarily on hand-taped splices and terminations on non-standard underground cables. It is also used as a separator tape to keep other tapes off the semi-con jacket in waterproofing applications of jacketed cable. CAUTION: This tape is conducting and cannot be used for insulation.
134-7720	Electrical shielding tape (Scotch #24)	1-inch x 15 ft. rolls. Used on hand-taped splices and terminations on non-standard underground cables.
134-7721	Non-tracking silicon rubber tape (Scotch #70)	1-inch x 30 ft. rolls. Used for waterproofing the terminal lug on high voltage pole terminations where waterproofing boot is not provided.
134-7723	Glass cloth tape	1/2 inch x 66 ft. rolls. Used to hold fireproofing tape (134-7725) in place.
134-7725	Electric arc and fireproofing tape	3-inch x 20 ft. rolls. Used for fireproofing or arc proofing cables. This is sometimes done in manholes and vaults to protect critical circuits from arcing damage from failing cables. This tape has no adhesive and must be held in place with glass cloth tape (134-7723).
134-7726	Vinyl backed insulating compound tape	4-inch x 10 ft. Used to waterproof and insulate 600 V underground splices. It is also used to waterproof splices and terminations on 28 KV jacketed cables.
134-7730	Cold temperature tape (Alaskan Pipeline Tape)	1-1/2-inch x 18 yds, double gummed. This tape is used during cold weather to install company numbers and location tags when the outside temperature is below 40 degrees F.
135-8530	Electrical tape	3/4-inch x 66 ft. rolls. This is a warm weather tape. It is approved for insulating connections up to 600 volts on overhead and underground construction.
135-8535	Electrical tape	3/4-inch x 66 ft. rolls. This is a cold weather tape. It is approved for insulating connections up to 600 volts on overhead and underground construction.
135-8540 135-8541 135-8542 135-8543	Colored tape, white Colored tape, orange Colored tape, yellow Colored tape, blue	3/4-inch x 66 ft. rolls. Used for identifying underground conductors during burial or wire pulling operations. Used as part of the permanent cable identification method in multiconductored secondary and service systems. As per cable route tagging Std 3011 section IV.
135-8550	Friction tape	3/4-inch x 66 ft. roll. Used as a barrier between Scotchfill tape and line hardware when taping underground or overhead 600 volt connections. This permits easy removal of the Scotchfill tape.
135-8610	High-voltage corona resistant rubber tape (1" Scotch 130c)	3/4-inch x 30 ft. roll. Used on hand-taped splices and terminations on non-standard underground cables.
135-8680	Scotchfill insulating putty tape	1-1/2-inch x 5 ft. roll. Used for insulating and/or waterproofing 600 volt overhead and underground connections. It is also used for waterproofing terminations on jacketed 28 KV underground cables and the terminal lugs on 350 KCM and 750 KCM pole terminations.