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IPCEA P-46-426

IEEE —IPCEA Power Cable Ampacities

- Copper Conductors
- Aluminum Conductors

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IEEE S-135
IPCEA Pub. No. P-46-426

Power Cable Ampacities

Volume I—Copper Conductors

INSULATIONS: IMPREGNATED PAPER
VARNISHED CLOTH
RUBBER AND THERMOPLASTIC
ASBESTOS-VARNISHED CLOTH

INSTALLATIONS: IN UNDERGROUND DUCTS
BURIED DIRECTLY IN EARTH
IN FREE AIR
IN CONDUIT



Sponsored and Computed by

Insulated Power Cable Engineers Association

In Collaboration with

Insulated Conductors Committee

IEEE Power Engineering Society



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Preface

The original edition of the tables of "Current Carrying Capacity of Impregnated Paper, Rubber, and Varnished Cambric Insulated Cables" was published in December 1943 by the Insulated Power Cable Engineers Association (IPCEA). These excellent tables were based on the best American practice at the time when they were published, and, as the title implied, were quite extensive in their scope. They served the industry well from the time of their publication to the present date.

The 11 years subsequent to their publication, however, were a period of rapid development both in design and application practice, and in the underlying theory; and at the end of 1954, when the supply of copies was found to be running low, the question arose as to whether to reprint the tables or to prepare an entirely new edition which would cover new types of cable, such as oil-filled paper-insulated and pipe-type paper-insulated; provide a greater coverage of installations, such as directly buried cables in addition to cables in ducts, conduits, and in air; and take advantage of the new techniques which have been developed for making current-carrying capacity or "ampacity" calculations, such as better knowledge of the thermal circuit. It was decided by IPCEA in 1954 that a new edition should be published.

As the AIEE Insulated Conductors Committee was interested in the subject matter, a Joint AIEE-IPCEA Working Group was formed to handle the technical aspects involved in the preparation of this new edition. This working group set up a scope of objectives covering all conductor sizes, voltages, and operating temperatures likely to be used for paper-insulated, rubber- and thermoplastic-insulated, varnished-cloth-insulated, and asbestos-insulated cables installed in ducts, directly buried, in conduits, ladders, raceways, trays, and in air.

The actual calculations were made on the Anaconda Wire and Cable Company's International Business Machines (IBM) *650* computer under the direction of F. H. Buller. The financing of the machine computations has been underwritten by IPCEA.

The tables have been printed by the photo-offset process directly from the sheets turned out by the IBM tabulating machine. This was done in the interest of accuracy, since, if the tables had been set up in type or even retyped from the IBM sheets, some typographical errors would have been inevitable, which might not have been caught by even the most diligent proofreader.

The AIEE very graciously assumed the task of publishing this book.

Joint AIEE-IPCEA Working Group on Power Cable Ampacities

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Cable		Installation										
		In Ducts					Buried			In Air		
		No. of Cables in Duct Bank					No. of Circuits			1 Circuit or 1 Cable*		
Construction	Rated Voltage, Kv	1	3	6	9	Cable Constants	1	2	Cable Constants	Ampacities		Cable Constants
		Ampacities					Ampacities					
Solid-Type Impregnated-Paper-Insulated Cable												
Single-conductor												
	8		1	1	2	2	52	52	58	100		101
	15		3	3	4	4	53	53	58	100		101
	25		5	5	6	6	54	54	59	100		102
	37		7	7	8	8	55	55	59	100		102
	46		9	9	10	10	56	56	60	100		103
	69		11	11	12	12	57	57	60	100		103
Three-conductor belted												
	8	13	13	13	13	15	61	61	62	104		104
	15	14	14	14	14	15	61	61	62	104		104
Three-conductor shielded												
	8	16	16	16	16	20	63	63	65	105		106
	15	17	17	17	17	20	63	63	65	105		106
	25	18	18	18	18	20	64	64	65	105		106
	37	19	19	19	19	20	64	64	65	105		106
Triplexed†												
	8	21	21	21	21	24				105		107
	15	22	22	22	22	24				105		107
	25	23	23	23	23	24				105		107
Low-Pressure Gas-Filled Cable												
Three-conductor												
	15	25	25	25	25	29	66	66	68	108		109
	25	26	26	26	26	29	66	66	68	108		109
	37	27	27	27	27	29	67	67	68	108		109
	46	28	28	28	28	29	67	67	68	108		109
Low-Pressure Oil-Filled Cable												
Single-conductor												
	15		30	30	31	31	69	69	77	110		111
	25		32	32	33	33	70	70	77	110		111
	37		34	34	35	35	71	71	78	110		112
	46		36	36	37	37	72	72	78	110		112
	69		38	38	39	39	73	73	79	110		113
	115		40	40	41	41	74	74	79	110		113
	138		42	42	43	43	75	75	80	110		114
	161		44	44	45	45	76	76	80	110		114
Three-conductor												
	15	46	46	46	46	51	81	81	83	115		116
	25	47	47	47	47	51	81	81	83	115		116
	37	48	48	48	48	51	82	82	83	115		116
	46	49	49	49	49	51	82	82	83	115		116
	69	50	50	50	50	51	82	82	83	115		116

* 1 circuit triplexed; or 1-1/c or 3/c cable.
† No. of circuits in duct bank.

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Cable		Installation															
		In Ducts					Buried			In Air		In Conduit					
		No. of Cables in Duct Bank				Cable Constants	No. of Circuits		Cable Constants	1 Pipe or 1 Cable*	Cable Constants	1 Cable	Cable Constants				
Construction	Rated Voltage, Kv	1	3	6	9		1	2		Ampacities		Ampacities					
		Ampacities					Ampacities										
High-Pressure Oil-Filled Pipe-Type Cable																	
Single-conductor																	
	15						84	84	90	117	118						
	25						85	85	90	117	118						
	69						86	86	91	117	119						
	115						87	87	91	117	119						
	138						88	88	92	117	120						
	161						89	89	92	117	120						
High-Pressure Gas-Filled Pipe-Type Cable																	
Single-conductor																	
	15						93	93	98	121	121						
	25						94	94	98	121	122						
	69						95	95	99	121	122						
	115						96	96	99	121	123						
	138						97	97	99	121	123						
Varnished-Cloth-Insulated Cable																	
Single-conductor																	
	1		124	124	125	125	139	139	143	150	151						
	8		126	126	127	127	140	140	143	150	151						
	15		128	128	129	129	141	141	144	150	152						
	25		130	130	131	131	142	142	144	150	152						
Three-conductor belted																	
	1	132	132	132	132	134	145	145	146	153	153	155	155				
	8	133	133	133	133	134	145	145	146	153	153	155	155				
Three-conductor shielded																	
	8	135	135	135	135	138	147	147	149	154	154	156	156				
	15	136	136	136	136	138	147	147	149	154	154	156	156				
	25	137	137	137	137	138	148	148	149	154	154	156	156				

* 1 pipe if pipe-type cable; 1 cable if V-C cable.

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Cable			Installation									
			In Ducts					Buried			In Air	
			No. of Cables in Duct Bank					No. of Circuits			1 Cable	
Construction	Rated Voltage, Kv	Conductor Temperature, C	1	3	6	9	Cable Constants	1	2	Cable Constants	Ampacities	Cable Constants
			Ampacities					Ampacities				
Rubber- or Thermoplastic-Insulated Cable												
Single-conductor												
	1	60	157	157	157			185	185		213	
	8		158	158	158			186	186		213	
	15		159	159	159			187	187		213	
	25		164	164	164			188	188		213	
	1	65	161	161	161			189	189		213	
	8		162	162	162			190	190		213	
	15		163	163	163			191	191		213	
	25		160	160	160			192	192		213	
	1	70	165	165	165			193	193		213	
	8		166	166	166			194	194		213	
	15		167	167	167			195	195		213	
	25		168	168	168			196	196		213	
	1	75	169	169	169	183		197	197	211	214	215
	8		170	170	170	183		198	198	211	214	215
	15		171	171	171	184		199	199	212	214	216
	25		172	172	172	184		200	200	212	214	216
	1	80	173	173	173			201	201		214	
	8		174	174	174			202	202		214	
	15		175	175	175			203	203		214	
	25		176	176	176			204	204		214	
	1	85	177	177	177			205	205		214	
	8		178	178	178			206	206		214	
	15		179	179	179			207	207		214	
	1	90	180	180	180			208	208		215	
	8		181	181	181			209	209		215	
	15		182	182	182			210	210		215	

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Cable			Installation													
			In Ducts					Buried			In Air		In Conduit			
			No. of Circuits in Duct Bank					No. of Circuits			1 Circuit		1 Circuit			
Construction	Rated Voltage, Kv	Conductor Temperature, C	1	3	6	9	Cable Constants	1	2	Cable Constants	Ampacities	Cable Constants	Ampacities	Cable Constants		
			Ampacities					Ampacities								
Rubber- or Thermoplastic-Insulated Cable																
Triplexed																
	1	60	217	217	217	217		244	244		258		262			
	8		218	218	218	218		244	244		258		262			
	15		219	219	219	219		245	245		258		262			
	25		220	220	220	220		245	245		258		262			
	1	65	221	221	221	221		246	246		258		262			
	8		222	222	222	222		246	246		258		262			
	15		223	223	223	223		247	247		258		262			
	25		224	224	224	224		247	247		258		262			
	1	70	225	225	225	225		248	248		258		262			
	8		226	226	226	226		248	248		258		262			
	15		227	227	227	227		249	249		258		262			
	25		228	228	228	228		249	249		258		262			
	1	75	229	229	229	229	243	250	250	254	259	260	263	264		
	8		230	230	230	230	243	250	250	254	259	260	263	264		
	15		231	231	231	231	243	251	251	257	259	261	263	265		
	25		232	232	232	232	243	251	251	257	259	261	263	265		
	1	80	233	233	233	233		252	252		259		263			
	8		234	234	234	234		252	252		259		263			
	15		235	235	235	235		253	253		259		263			
	25		236	236	236	236		253	253		259		263			
	1	85	237	237	237	237		254	254		259		263			
	8		238	238	238	238		255	255		259		263			
	15		239	239	239	239		255	255		259		263			
	1	90	240	240	240	240		256	256		260		264			
	8		241	241	241	241		256	256		260		264			
	15		242	242	242	242		257	257		260		264			

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Cable			Installation													
			In Ducts					Buried			In Air		In Conduit			
			No. of Cables in Duct Bank					No. of Circuits			1 Circuit or 1 Cable*		1 Circuit or 1 Cable*			
Construction	Rated Voltage, Kv	Conductor Temperature, C	1	3	6	9	Cable Constants	1	2	Cable Constants	Ampacities	Cable Constants	Ampacities	Cable Constants		
			Ampacities					Ampacities								
Rubber- or Thermoplastic-Insulated Cable																
Three-conductor																
	1	60	266	266	266	266		293	293		307		311			
	8		267	267	267	267		293	293		307		311			
	15		268	268	268	268		294	294		307		311			
	25		269	269	269	269		294	294		307		311			
	1	65	270	270	270	270		295	295		307		311			
	8		271	271	271	271		295	295		307		311			
	15		272	272	272	272		296	296		307		311			
	25		273	273	273	273		296	296		307		311			
	1	70	274	274	274	274		297	297		307		311			
	8		275	275	275	275		297	297		307		311			
	15		276	276	276	276		298	298		307		311			
	25		277	277	277	277		298	298		307		311			
	1	75	278	278	278	278	292	299	299	303	308	309	312	313		
	8		279	279	279	279	292	299	299	303	308	309	312	313		
	15		280	280	280	280	292	300	300	306	308	310	312	314		
	25		281	281	281	281	292	300	300	306	308	310	312	314		
	1	80	282	282	282	282		301	301		308		312			
	8		283	283	283	283		301	301		308		312			
	15		284	284	284	284		302	302		308		312			
	25		285	285	285	285		302	302		308		312			
	1	85	286	286	286	286		303	303		308		312			
	8		287	287	287	287		304	304		308		312			
	15		288	288	288	288		304	304		308		312			
	1	90	289	289	289	289		305	305		309		313			
	8		290	290	290	290		305	305		309		313			
	15		291	291	291	291		306	306		309		313			
Asbestos-Varnished-Cloth-Insulated Cable																
AVA, single-conductor																
	1	110									315	316				
AVA, triplexed																
	1	110									315	316	315	316		
AVL, single-conductor																
	1	110									315	317				
AVL, triplexed																
	1	110									315	317	315	317		

*1 circuit triplexed; or 1-1/c or 3/c cable. Reference to 1/c cable applies only to Types AVA and AVL.

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Use of The Ampacity Tables

I. Introduction

The present tables are intended as successors to the tables compiled and issued by the IPCEA in 1943. Those were based on work by the former National Electric Light Association (NELA). The Foreword to those tables may well serve for the present tables.

"The following Tables of Current-Carrying Capacities represent the conservative views of engineers based on operating experience and laboratory work and are intended as a guide to assist operating engineers in selecting cables for safety and reliability. These current-carrying capacities are in no sense fixed standards or ratings."

There are several reasons why there has been a need for a revision of the 1943 tables. These are:

1. The ampacities of cables in ducts, in the 1943 tables, did not take into account the thermal resistivity of the surrounding soil. They were based on "duct-correction factors" believed to be "representative of average field conditions in this country as determined by measurements in different localities and by different organizations."

   These duct-correction factors were used as additions to the thermal resistance of the insulation and the thermal resistance of the cable-surface heat dissipation, as calculated for cables in free air, and were, therefore, not representative of any physical thermal resistance.

   While this method of calculation gave fairly reasonable results, its adequacy was questioned when it became necessary to compare the ampacities of cables in ducts with those of buried cables and cables in pipes.

   In these latter cases there was no accumulated experience similar to that available for duct cables, but there was an obvious and uncomplicated series of thermal resistances through which heat generated in the cables would have to pass to reach the ambient "thermal sink." One of these thermal resistances was that of the earth, and experience showed that this is a very vital factor in determining the ampacity of such cables. It therefore became obvious that the earth thermal resistance as a definite quantity and not as a mere "average of field conditions" should likewise be used in determining the ampacities of cables in ducts.

2. The 1943 tables should be amplified by tables for pipe cables, oil-filled cables, low-pressure gas-filled cables, and directly buried cables.

3. Since 1943, new and improved types of insulation have become available, both in the fields of rubber and thermoplastics, which permit higher operating temperatures.

4. The better understanding of the effect of thermal transients on cable temperatures.

5. The use of aluminum conductors for insulated cables.

6. The improved technique for calculating skin effect, proximity effect, and other a-c losses, which has come into general use since 1943.[1]

An extensive series of investigations in field and laboratory and by theory was required before the 1943 tables could be replaced by tables embodying these requirements. These were undertaken by the Insulated Conductors Committee of the AIEE in collaboration with other societies and reported in a series of papers in the *AIEE Transactions*.[1-6]

The application of the new knowledge to the revised ampacity calculations was summarized in a paper by J. H. Neher and M. H. McGrath,[1] and the procedures given therein were modified to facilitate calculations on a digital computer; see Section III. The relation between load factor and loss factor is based on a study of utility load diagrams. The effect of repetitive load cycles is approximated for commercial loads by the assumption of a sinusoidal loss curve, as described in reference 1.

The tables give ampacities for cables with various types of insulations, voltage classes, and modes of installation. Conductor temperatures used are those set forth in industry standards, which take into account the following considerations:

1. Chemical deterioration of the adjacent insulation under combined action of heat and electric stress.

2. Dielectric loss at high temperatures and its effect on curtailing the ampacity.

3. Effect of thermal expansion and contraction on integrity of metallic sheaths.

4. The number of allowable failures per unit length per annum not to exceed a determined economic limit.

In the case of cables in ducts or pipes, or buried in the ground, variations of thermal resistivity of the soil or the presence of other sources of heat, such as steam pipes, result in different temperatures along the cable.

The Association of Edison Illuminating Companies (AEIC) Guide for Impregnated-Paper-Insulated Cables, given in Appendix II, makes suggestions for cases where there has been a thorough thermal survey of the cable route and where the four conditions cited previously are also complied with. The Guide also gives many other useful suggestions concerning cable loading.

Appendix III presents a similar guide for rubber-, thermoplastic-, varnished-cloth-, and asbestos-insulated cables. It is important to note the distinctions.

The 1943 tables gave ampacities for cables in ducts and in free air only. For those who have used these tables and are interested in comparing them with the present tables for cables in duct, the following formulas will be found useful. The nomenclature is that used in reference 1; see Section IV.

The difference in procedure lies in the formulation of the effective thermal resistance between cable sheath and ambient earth. In both methods this thermal resistance may be divided into two parts, one part independent of and the other part dependent upon the loss factor of the cable system. Thus,

$$\bar{R}_{ca} = \bar{R}_{cr} + K\,(\bar{R}_{ra}) \text{ thermal ohm-feet} \qquad (1)$$

In the IPCEA-NELA method, $\bar{R}_{cr}$ indicated as $\bar{R}_t$, is defined as the surface thermal resistance of a single isolated cable in free air.

$$\bar{R}_t = \frac{0.00411\ B}{D_t} \text{ thermal ohm-feet} \qquad (2)$$

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Table I. Table of American Cable Sizes

Conductor Size, Awg	Cross-Sectional Area: Circular Mils	Square Inches	Square Millimeters	Conductor Size, MCM	Cross-Sectional Area: Circular Mils	Square Inches	Square Millimeters
8	16510	0.01297	8.367	250	250000	0.1964	126.7
6	26240	0.02061	13.30	350	350000	0.2749	177.3
4	41740	0.03278	21.15	500	500000	0.3927	253.4
2	66360	0.05212	33.62	750	750000	0.5891	380.0
1	83690	0.06573	42.41	1000	1000000	0.7854	506.7
1/0	105600	0.08291	53.49	1250	1250000	0.9818	633.4
2/0	133100	0.1045	67.43	1500	1500000	1.178	760.0
3/0	167800	0.1318	85.01	1750	1750000	1.374	886.7
4/0	211600	0.1662	107.2	2000	2000000	1.571	1013
				2250	2250000	1.767	1140
				2500	2500000	1.964	1267
				3000	3000000	2.356	1520

where $B = 1{,}200$ for D_s greater than 1.75.

In the Neher-McGrath procedure[1]

$$\bar{R}_{sx} = \bar{R}_{sd} + \bar{R}_{ex}$$

$$= \frac{4.6}{D_s + 0.27} + 0.42 \text{ thermal ohm-feet} \quad (3)$$

where $\bar{R}_{ex}$ is given by equation 14.

By comparing these two procedures, it becomes apparent that the difference between the values obtained is less than the accuracy with which this term can be calculated.

Sheath Diameter, D_s	$\bar{R}_{sx}$: IPCEA	Neher-McGrath
2	2.47	2.45
3	1.64	1.85
4	1.23	1.50

In the IPCEA-NELA method $\bar{R}_{xa}$ is expressed as NH, where N is the number of occupied ducts and H is the corresponding NELA duct constant. In the Neher-McGrath procedure, used in the preparation of these tables, $\bar{R}_{xa}$ is given by the following expression (refer to equations 13, 15, and 16):

$$\bar{R}_{xa} = \bar{R}_{xd} + \bar{\rho}_e(G_{da}) \text{ thermal ohm-feet} \quad (4)$$

Using the values of $\bar{R}_{xd}$ and G_{da} given in Table VI, the values of $\bar{\rho}_e$ in equation 4, required to match the NELA duct constants for various values of N, are as follows:

N	NH (NELA)	Earth Thermal Resistivity $\bar{\rho}_e$ to Match
1	1.45	100
3	3.12	79
6	4.92	60
9	6.75	62

II. Technical Features of the Tables

The calculations for ampacities are based on the parameters noted in this section. It is intended to cover the various factors influencing the ampacity of a cable.

A. Scope

Conductors: Sizes from No. 8 American wire gage (Awg) to 3,000 MCM (thousand circular mils) as indicated in each table. For paper and varnished-cloth insulation: copper, untinned, and aluminum, oil-coated. For AVA, AVL, and plastic insulation: copper, untinned, and aluminum, oil-free For rubber insulation: tinned copper and aluminum, oil-free. The cross-sectional areas of the conductors used are given in Table I.

Voltages

0–1, 8, 15, 25, 37, 46, 69, 115, 138, and 161 kv as indicated for each cable type.

Load and Loss Factors

Single-conductor (except low-pressure oil-filled) 1, 8, and 15 kv: 30, 50, 75, and 100% load factors (LF). All others: 50, 75, and 100% load factors. These are indicated as 30 LF, 50 LF, 75 LF, and 100 LF. The corresponding loss factors are 0.15, 0.33, 0.625, and 1.00.

Earth Thermal Resistivity

60, 90, and 120 degrees centigrade centimeters per watt (C-cm/watt), indicated as RHO-60, RHO-90, and RHO-120. *When the earth thermal resistivity is not known, it is suggested that RHO-90 be used.*

Sheaths and Jackets

The following constructions are covered:

1. Lead sheaths for all paper cable (except pipe type), varnished cloth and asbestos (AVL).
2. Metallic shielding on rubber and thermoplastic cables above 1 kv. Ampacities for lead-sheathed rubber and thermoplastic cables may be taken as that for metallic shielding.
3. Nonmetallic jackets for rubber, thermoplastic, and asbestos (AVA).
4. Lead sheath and jacket thicknesses as per applicable specifications and standards given subsequently. Core diameter is limited to 4 inches.

Types of Installation

1. In air with no wind and no solar radiation; 40 C ambient; see reference 1, page VI.
2. In ducts, as indicated in Figs. 1–4. Depth of cover is 30 inches. Note that, if a noncircular arrangement is used for nine occupied ducts, the impedance of single-conductor cables must be balanced by other means, but the same ampacity may be used as indicated for the circular arrangement.

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Table II

Insulation	Thermal Resistivity	Specific Inductive Capacity	Applicable Specification or Standard
1. Paper, solid type	700 C-cm/watt	3.7	AEIC 9th edition
2. Paper, low-pressure gas-filled	700 C-cm/watt	3.7	AEIC 1st edition
3. Paper, low-pressure oil-filled	500 C-cm/watt	3.7	AEIC 5th edition
4. Pipe cable, fully impregnated, oil-pressure	500 C-cm/watt	3.7	AEIC 1st edition
5. Pipe cable, gas-filled, gas-pressure	550 C-cm/watt	3.7	(See above)
6. Rubber or plastic with neoprene or plastic jacket	500 C-cm/watt	4.5	IPCEA S-19-81, 3rd edition and S-61-402
7. Varnished cloth	600 C-cm/watt	5.0	IPCEA S-62-375
8. AVA and AVL	600 C-cm/watt	...	IPCEA S-28-357

3. Buried, as indicated in Figs. 5–7. Depth to cable axis is 36 inches.
4. For single-conductor cables with metallic sheaths or shields installed in separated ducts or directly buried with separation, calculations have been made for open-circuit sheath operation.
5. Triplexed cables with paper, rubber, and thermoplastic insulation have been calculated for short-circuited sheaths or shields.

Insulation

The types of insulations covered and their characteristics are given in Table II. The thicknesses of insulation used in the calculations are those given in the specifications and standards listed in Table II, except for item 5 for which thicknesses are as follows: 15 kv—160 mils; 25 kv—160 mils; 69 kv—315 mils; 115 kv—500 mils; 138 kv–600 mils; and item 4, 15 and 25 kv—160 mils.

Conductor Temperatures and Insulation Power Factors

The values of temperature and power factor used for paper-insulated cables, are those given in Tables I–IV of the "Guide for Application of AEIC Maximum Insulation Temperatures at the Conductor for Impregnated-Paper-Insulated Cables;" see Appendix II.

For other types of insulation, i.e., rubber, thermoplastic, varnished cloth, and asbestos, see Appendix III, "Guide for the Application of Maximum Insulation Temperatures at the Conductor for Rubber-, Thermoplastic-, Varnished-Cloth-, and Asbestos-Insulated Cables." This guide indicates the temperatures at which these various types of insulation may be operated. The ampacity tables for rubber are set up for conductor temperatures of 60, 65, 70, 75, 80, 85, and 90 C. The power factor for rubber-insulated cables has been taken as 3.5%. For varnished-cloth-insulated cables, each table gives the conductor temperatures. For these, the power factor has been taken as 9% for single-conductor and shielded multiple-conductor cables, and as 17% for multiple-conductor belted cables.

B. Adjustment for Change in Parameters

Each table for a given cable type, voltage, and mode of installation has been prepared on the basis of the values for conductor temperature T_c and ambient temperature T_a given at the head of the table and also for the applicable value of dielectric-loss temperature rise (DELTA-TD) tabulated in the right-hand columns. Any value of ampacity I appearing in the table may be corrected for a change in any or all of these parameters by use of the following expression in which the prime mark indicates the desired new parameters.

$$I' = I\sqrt{\frac{T_c' - T_a' - \text{DELTA TD}'}{T_c - T_a - \text{DELTA TD}} \times \frac{234.5 + T_c}{234.5 + T_c'}} \text{ amperes*} \qquad (5)$$

It will be noted that DELTA-TD varies directly with the insulation power factor and also directly with the specific inductive capacity (SIC).

As an example, consider a 2,000-MCM 138-kv oil-filled buried-pipe-type cable system, 1 circuit, for which the following values appear in the appropriate table:

$T_c = 75$ C; $T_a = 20$ C; $I = 1{,}078$ for 75 LF and RHO-90; DELTA TD = 9.10 based on a power factor of 0.55%.

It is desired to determine the ampacity for

$T_c' = 85$ C $T_a' = 15$ C and a power factor of 1.0%

$$I' = 1{,}078\sqrt{\frac{85 - 15 - \frac{1.00}{0.55} \times 9.10}{75 - 20 - 9.10} \times \frac{234.5 + 75}{234.5 + 85}}$$

$= 1{,}145$ amperes

When ambient temperature only is changed, equation 5 reduces to

$$I' = I\sqrt{\frac{T_c' - T_a' - \text{DELTA TD}'}{T_c - T_a - \text{DELTA TD}}} \text{ amperes} \qquad (5a)$$

Thus to change T_a only from 20 to 30 C in the case of six 500-MCM 15-kv triplex concentric-stranded rubber-insulated cables in duct for RHO-90, 75 LF, and a conductor temperature of 85 C; from the appropriate table:

$$I' = 329\sqrt{\frac{85 - 30 - 3.58}{85 - 20 - 3.58}} = 301 \text{ amperes}$$

A close approximation of this current I' may be determined directly from the tables using a conductor temperature differing inversely from the maximum conductor temperature by the same amount as the change in ambient temperature, where tables for various conductor temperatures for the same voltage are available (rubber and thermoplastic insulations). Thus in the case just cited the corresponding table for a conductor temperature of 75 C and an ambient temperature of 20 C gives 306 amperes.

Interpolation or extrapolation for ampacities at values of earth thermal resistivity and load factors other than those given in the tables may be ac-

* Note: The figure 234.5 applies to copper conductors; for aluminum conductors use 228.1.

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complished by use of Figs. 9 and 10, as described in Appendix I. Alternatively, rigorous calculations may be made using the Supplementary Tables, as discussed in Section F.

C. Method of Calculation

The Neher-McGrath procedure[1] has been supplemented and modified in the following respects in order to adapt it better to calculations on a digital computer. For directly buried cables, the thermal resistance and increased-diameter effects of supplementary coverings have not been introduced, but a 1 2-inch coating of somastic has been applied to buried pipes.

Equations 21 and 24 of reference 1.

The skin effect factor has been calculated by

$$F(x) = \frac{11.0}{\left[\frac{R_{dc}}{k} + \frac{4k}{R_{dc}} - 2.56\left(\frac{k}{R_{dc}}\right)^2\right]^2} \qquad (6)$$

Equations 37 and 39 of reference 1.

The geometric factors G_1 and G_2 for 3-conductor belted cables and the sector-correction factor were computed from mathematical expressions. Suitable equations are given in reference 2. For 3-conductor shielded cables, G_1 was computed from the following expressions.

$$G_1 = \ln (D_c + 3T) - 0.86 \ln D_c + 0.050 \text{ for round conductors} \qquad (7a)$$

$$= \ln (D_c + 2T) - 0.95 \ln D_c + 0.030 \text{ for sector conductors} \qquad (7b)$$

D_c is the diameter of compact round conductors of the same area as the actual sector. For buried pipes the thermal resistance of the somastic coating is

$$\bar{R}_{pe} = 0.0104 \times 100 \times 3 \times \frac{0.5}{D_{po} + 0.5} = \frac{1.56}{D_{po} + 0.5} \text{ thermal ohm-feet} \qquad (8)$$

where D_{po} is the outside diameter of the pipe of 1/4-inch wall thickness.

The values of D_{po} and the corresponding values of $\bar{R}_{pe}$ and G_{ex} (see equation 11) for various ranges in cable diameters D_s (measured over the skid wire) are tabulated in Table III. In the determination of the pipe size for a given installation, consult Section 5 of AEIC Specifications for Impregnated-Paper-Insulated Cable, High-Pressure Pipe-Type.

Table III

D_s	D_{po}	$\bar{R}_{pe}$	G_{ex}
0–1.35	4	0.35	0.0079
1.36–1.60	4½	0.31	0.0064
1.61–2.10	5 9/16	0.26	0.0037
2.11–2.60	6 5/8	0.22	0.0013
2.61–3.40	8 5/8	0.17	−0.0023
3.41–4.00	10¾	0.14	−0.0054

Equation 42 of reference 1.

The thermal resistance from cables or pipes suspended in air has been calculated by the following equation:

$$\bar{R}_e = \frac{n' A''}{D_s'^{3/4} + B''} \text{ thermal ohm-feet} \qquad (9)$$

This equation is obtained from equation 42 of reference 1, by substituting 20 C for $\Delta T (T_s = 60$ C; $T_a = 40$ C) and 50 C for T_m. In addition, the resulting 0.136 $(D_s')^{3/4}$ term in the denominator is replaced by the approximate equivalent expression $0.06 + 0.080\ D_s'$ for values of D_s' up to 4.0 inches, and by $0.14 + 0.063\ D_s'$ for values of D_s' from 4.5 to 11 inches.

Table IV

T_m	ε	A''	B''	Surface
50 C	0.63	5.0	0.30	Lead sheath
50 C	0.92	4.0	0.24	Rubber jacket
50 C	0.82	4.2	0.25	Conduit
50 C	0.82	4.6	0.65	Pipe cable

Equation 44 of reference 1.

In order to facilitate the calculations for several different values of earth resistivity and load factor, $\bar{R}_e'$ for buried cables and pipes may be written in the following form, where K represents the per-unit loss factor (0.150 for 30 LF, 0.330 for 50 LF, 0.625 for 75 LF, and 1.000 for 100 LF).

$$\bar{R}_e' = \bar{\rho}_e [G_{ex} + K\ (G_{xa})] \text{ thermal ohm-feet} \qquad (10)$$

Buried single-conductor cables in trefoil have been considered as a group with D_e equal to the geometric mean diameter 1.60 D_s.

$$G_{ex} = 0.0120\ n' \log \frac{8.3}{D_e} \qquad (11)$$

$$G_{xa} = 0.0120\ n' \log \frac{4 \times 36 \times F}{8.3} \qquad (12)$$

Equation 44a of reference 1.

For cables in duct $\bar{R}_e'$, starting from the inside of

Table V

Condition	Figure	n'	D_e	F	G_{xa}
One 3-conductor cable or pipe	5	3	D_s or $D_{po} + 1$	1	0.0446
Two 3-conductor cables or pipes	5	3	D_s or $D_{po} + 1$	3.16	0.0626
Three single-conductor cables	6	1	D_s	93.2	0.0385
Six single-conductor cables	6	1	D_s	899	0.0503
Three single-conductor cables in trefoil	7	3	1.60 D_s	1	0.0446
Six single-conductor cables in trefoil	7	3	1.60 D_s	3.16	0.0626

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Table VI

Condition	Figure	n′	N	L	F	G_b	$\bar{R}_{ex}$	$\bar{R}_{xd}$	G_{da}
One 3-conductor cable*	1	3	1	35.8	1	1.05	1.26	0.569	0.0378
Three 3-conductor cables*	2	3	3	35.8	102	0.87	1.26	1.928	0.0940
Six 3-conductor cables*	3	3	6	43.3	1.02×10^5	0.86	1.26	3.574	0.1858
Nine 3-conductor cables*	4	3	9	57.7	6.81×10^6	0.69	1.26	6.325	0.2236
Three single-conductor cables	2	1	3	35.8	102	0.87	0.42	0.643	0.0313
Six single-conductor cables	3	1	6	43.3	1.02×10^5	0.86	0.42	1.191	0.0619
Nine single-conductor cables	4	1	9	57.7	6.81×10^6	0.69	0.42	2.108	0.0745

* Note: This applies to a conventional 3-conductor cable or to a triplex assembly of three single-conductor cables.

Table VII. Factors for Cables with Maintained Spacing

Number Vertically	Number of Cables Horizontally					
	1	2	3	4	5	6
1	1.00	0.93	0.87	0.84	0.83	0.82
2	0.89	0.83	0.79	0.76	0.75	0.74
3	0.80	0.76	0.72	0.70	0.69	0.68
4	0.77	0.72	0.68	0.67	0.66	0.65
5	0.75	0.70	0.66	0.65	0.64	0.63
6	0.74	0.69	0.64	0.63	0.62	0.61

the duct wall, may be expressed as

$$\bar{R}_e' = \bar{R}_{ez} + K[\bar{R}_{zd} + \bar{\rho}_e(G_{da})] \text{ thermal ohm-feet} \quad (13)$$

where, assuming a thermal resistivity of 85 C-cm per watt for concrete and 5-inch-inside-diameter fiber ducts ($\bar{\rho}_{dw} = 480$, $t = 0.25$ inch),

$$\bar{R}_{ez} = n'\left[0.0104 \times 480 \times \frac{0.25}{5+0.25} + 0.012 \times 85 \log \frac{8.3}{5+0.50}\right]$$
$$= n'[0.24 + 0.18] = 0.42\ n' \text{ thermal ohm-feet} \quad (14)$$

$$\bar{R}_{zd} = 0.012 \times 85\ n'\left(\log \frac{4L \times F}{8.3} - NG_b\right) \text{ thermal ohm-feet} \quad (15)$$

$$G_{da} = 0.012\ n'\ NG_b \quad (16)$$

D. Grouping Factors for Cables on Ladder Supports, in Expanded Metal Troughs, and in Solid Metal Trays

The ampacity of cables installed on ladder supports, in expanded metal troughs, and in solid metal trays may be determined by multiplying the values given for cables in air by the grouping factors given in Tables VII and VIII. These factors are taken from reference 7 and from Table G, page 49 of reference 8.

1. Cable Spacing Maintained

Where cables are installed on ladder supports or in expanded metal troughs, at a maintained spacing of from 1/4 to 1 cable diameter, apply the appropriate factors from Table VII.

2. Cable Spacing Not Maintained

Where cables are installed on ladder supports or in expanded metal troughs and where spacings are not maintained:

(a). For single-conductor shielded or nonshielded, 3-conductor triplex-shielded or nonshielded, and 3-conductor shielded cables, apply the appropriate factor from Table VIII to the ampacity of a 3-conductor shielded cable of the same conductor size, operating temperature, and voltage rating given in the tables for cables in air.

(b). For 3-conductor nonshielded cables, apply the appropriate factor from Table VIII to the ampacity of the identical cable given in the tables for cables in air.

Table VIII. Factors for Cables without Maintained Spacing

Total Number of Conductors	Factor
3	1.00
4–6	0.80
7–9	0.70
10–24*	0.70
25–42*	0.60
43 and up*	0.50

* These factors include the effects of load diversity.

3. Solid Metal Trays; Cables with any Spacing

Where cables are installed in solid metal trays:

(a). For single-conductor cables apply the appropriate factor from Table VIII to the ampacity for three identical single-conductor cables in isolated conduit in air.

(b). For 3-conductor cables apply the appropriate factor from Table VIII to the ampacity of the identical cable in isolated conduit in air.

E. Grouping Factors for Cables in Exposed or Enclosed Conduits in Air

For cables installed in exposed or enclosed groups of conduits in air, the ampacity may be determined by multiplying the values given for cables in isolated conduit in air, by the grouping factors given in Table IX, when the spacing between conduit surfaces is not greater than the conduit diameter or less than 1/4 of the conduit diameter. These are taken from Table G, page 49 of reference 8.

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Table IX. Cables in conduit, Values of Multiplier

Number Vertically	Number Horizontally					
	1	2	3	4	5	6
1	1.00	0.94	0.91	0.88	0.87	0.86
2	0.92	0.87	0.84	0.81	0.80	0.79
3	0.85	0.81	0.78	0.76	0.75	0.74
4	0.82	0.78	0.74	0.73	0.72	0.72
5	0.80	0.76	0.72	0.71	0.70	0.70
6	0.79	0.75	0.71	0.70	0.69	0.68

F. Supplementary Tables, Cable Constants

In order to permit the calculation of ampacities for conditions not covered by the main tables, a set of Supplementary Tables is provided which presents for each main table the basic parameters involved in the preparation of that table. The parameters are presented in capital letters as necessitated by the computer tabulator employed.

SIZE = conductor size, Awg or MCM
OD = outside diameter of cable, inches = D_s
WD = dielectric loss, watts per conductor foot = W_d
RI = thermal resistance of insulation, thermal ohm-feet = $\bar{R}_i$
RSD = thermal resistance between cable and duct wall, or pipe ($\bar{R}_{sd}$), or air for cable in air ($\bar{R}_c$), thermal ohm-feet
QS = ratio of sum of the losses in the conductors and sheaths or shields to the losses in the conductors = Q_s
QE = ratio of sum of the losses in the conductors, sheath, and pipe to the losses in the conductors = Q_e
PIPE = outside diameter of pipe or conduit, inches = D_{po}
RAC = a-c resistance of the conductor including skin and proximity effects only, microhms per foot = $R_{dc}(1+Y_c)$; see reference 1

As an example in the use of the Supplementary Tables, the ampacity for six 500-MCM 3-conductor 15-kv shielded solid paper cables in a duct bank is calculated for 75 LF, RHO-90, conductor temperature 80 C, and ambient temperature 20 C as follows:

From the appropriate Supplementary Table,

WD = 0.147 watt per foot
RI = 1.475 thermal ohm-feet
RSD = 5.155 thermal ohm-feet
QS = 1.030
RAC = 26.74 microhms per foot

From Table VI,

$\bar{R}_{ex} = 1.26$ thermal ohm-feet
$\bar{R}_{xd} = 3.574$ thermal ohm-feet
$G_{da} = 0.1858$

$$\text{DELTA TD} = \text{WD}\,(\text{RI}/2+\text{RSD}+\bar{R}_{ex}+\bar{R}_{xd}+\text{RHO}\times G_{da}) = 0.147\,(0.737+5.155+1.26+3.574+90\times 0.1858) = 4.04 \text{ C} \quad (17)$$

$$\bar{R}_{ca}' = \text{RI}+\text{QS}\,[\text{RSD}+\bar{R}_{ex}+K\,(\bar{R}_{xd}+\text{RHO}\times G_{da})] = 1.475+1.030\,[5.155+1.26+0.625\,(3.574+90\times 0.1858)] = 20.948 \text{ thermal ohm-feet} \quad (18)$$

$$I = 1{,}000\sqrt{\frac{T_c - T_a - \text{DELTA TD}}{\text{RAC}\times \bar{R}_{ca}'}} \quad (19)$$

$$= 1{,}000\sqrt{\frac{80-20-4.04}{26.74\times 21.15}} = 314 \text{ amperes}$$

Also, the ampacity of a pipe cable having 2,000-MCM segmental conductors with 138-kv insulation in an isolated oil-filled pipe (75 LF, RHO-90, conductor temperature 75 C, and ambient temperature 20 C) is calculated as follows:

From the appropriate Supplementary Table,

WD = 1.706 watts per foot
RI = 1.254 thermal ohm-feet
RSD = 0.725 thermal ohm-foot
QS = 1.014
QE = 1.337
PIPE = 8.625 inches
RAC = 7.46 microhms per foot

From Tables III and V,

$\bar{R}_{pe} = 0.17$
$G_{xa} = 0.0446$
$G_{ex} = -0.0023$

$$\text{DELTA TD} = \text{WD}\,[RI/2+\text{RSD}+\bar{R}_{pe}+\text{RHO}\,(G_{ex}+G_{xa})] = 1.706\,[0.627+0.725+0.17+90\,(-0.0023+0.0446)] = 9.10 \text{ C} \quad (20)$$

$$\bar{R}_{ca}' = \text{RI}+\text{QS}\times\text{RSD}+\text{QE}\,[\bar{R}_{pe}+\text{RHO}\,(G_{ex}+K\times G_{xa})] = 1.254+1.014\times 0.725+1.337\,[0.17+90\,(-0.0023+0.625\times 0.0446)] = 5.297 \text{ thermal ohm-feet} \quad (21)$$

$$\text{I} = 1{,}000\sqrt{\frac{75-20-9.10}{7.46\times 5.30}} = 1{,}078 \text{ amperes}$$

For buried cables, equations 20 and 21 reduce to

$$\text{DELTA TD} = \text{WD}\,[\text{RI}/2+\text{RHO}\,(G_{ex}+G_{xa})] \quad (22)$$

$$\bar{R}_{ca}' = \text{RI}+\text{QS}\times\text{RHO}\,(G_{ex}+K\times G_{xa}) \quad (23)$$

Values of G_{ex} may be obtained from Fig. 8.

In the case of cables or pipes in air, $\bar{R}_{pe}$ and the earth terms, appearing in equations 20 and 21 or in 22 and 23, are replaced by $\bar{R}_e$, as calculated by equation 9.

III. References

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13. Varnished-Cloth Insulated Cables. *IPCEA Standard S-62-375*

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IV. Nomenclature

The following nomenclature, corresponding to that used in reference 1, applies to equations 1–16.

B = surface-to-air thermal resistivity, C-cm²/watt
D = diameter, inches
- D_c = diameter of conductor (equivalent compact round conductor for sector conductor)
- D_e = outside of sheath or shield
- D_e' = effective (circumscribing circle) of several cables in contact
- D_{po} = outside diameter of pipe or conduit
- D_s = diameter at start of the earth portion of the thermal circuit
- D_x = fictitious diameter at which the effect of loss factor commences

F = factor to account for the mutual heating effect of nearby cables
G = geometric factor
- G_b = applying to a duct bank
- G_{da} = from duct bank to ambient earth
- G_{ex} = between diameters D_e and D_x
- G_{xa} = from diameter D_x to ambient earth

H = the NELA duct heating constant, thermal ohm-feet
I = tabulated value of ampacity, amperes
I' = ampacity under conditions not tabulated
K = loss factor, per unit = 0.003 LF + 0.00007 (LF)²
L = depth of burial, inches
LF = load factor, %
n' = number of conductors within a stated diameter
N = number of cables or cable groups in a system
$\bar{\rho}$ = thermal resistivity, C-cm/watt
- $\bar{\rho}_{dw}$ = of a duct wall
- $\bar{\rho}_e$ = of the earth (RHO)

$\bar{R}$ = thermal resistance, thermal ohm-feet
- $\bar{R}_{ca}'$ = effective from conductor to ambient earth or air
- $\bar{R}_{ea}'$ = effective from cable surface to ambient earth
- $\bar{R}_{ex}$ = from cable surface to diameter D_x
- $\bar{R}_{pe}$ = of somastic coating on a pipe
- $\bar{R}_e$ = from cable, conduit, or pipe surface to ambient air
- $\bar{R}_e'$ = effective from diameter D_e to ambient earth
- $\bar{R}_{ex}$ = between diameters D_e and D_x
- $\bar{R}_{xd}$ = from diameter D_x to duct-bank surface
- $\bar{R}_{xa}$ = from diameter D_x to ambient earth

T = temperature, C
- T_c = of conductor as tabulated (T_c' for other temperatures)
- T_a = of ambient earth as tabulated (T_a' for other temperatures)
- ΔT_d = temperature rise due to dielectric loss as tabulated (DELTA TD), ($\Delta T_d'$ or DELTA TD′ for other conditions)

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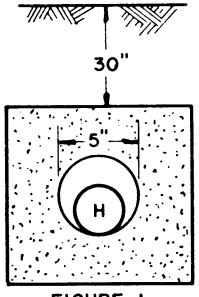


FIGURE 1
11.5" X 11.5"
DUCT BANK

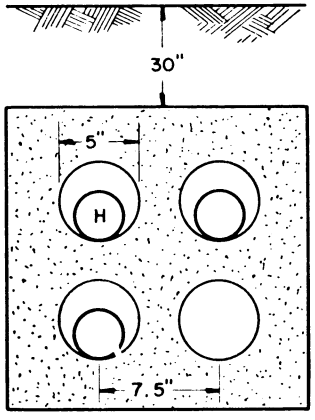


FIGURE 2
19" X 19" DUCT BANK

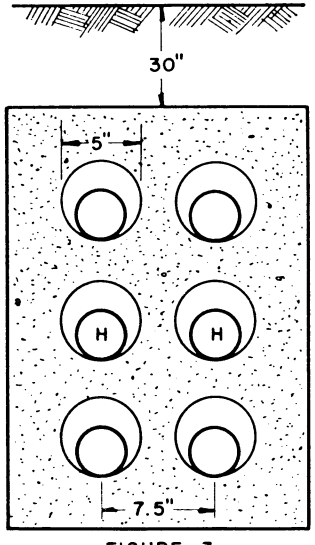


FIGURE 3
19" X 26.5" DUCT BANK

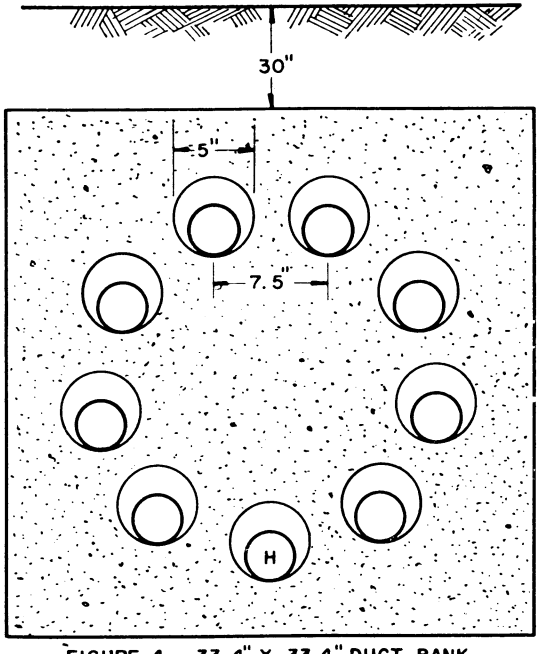


FIGURE 4— 33.4" X 33.4" DUCT BANK

NOTE— H INDICATES THE HOTTEST CABLE.

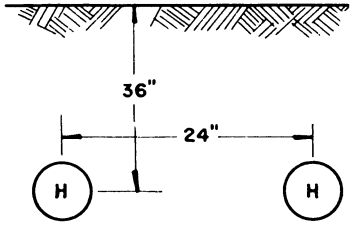


FIGURE 5
BURIED 3 CONDUCTOR
CABLES OR PIPES

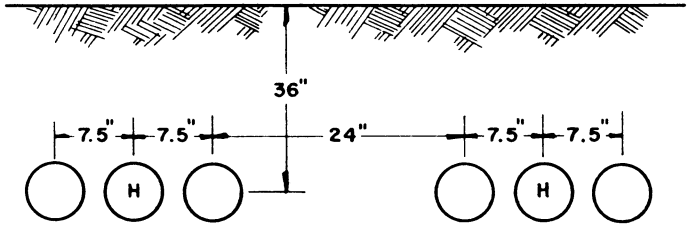


FIGURE 6— BURIED SINGLE CONDUCTOR CABLES

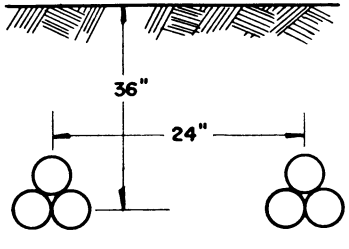


FIGURE 7
BURIED TRIPLEX CABLES

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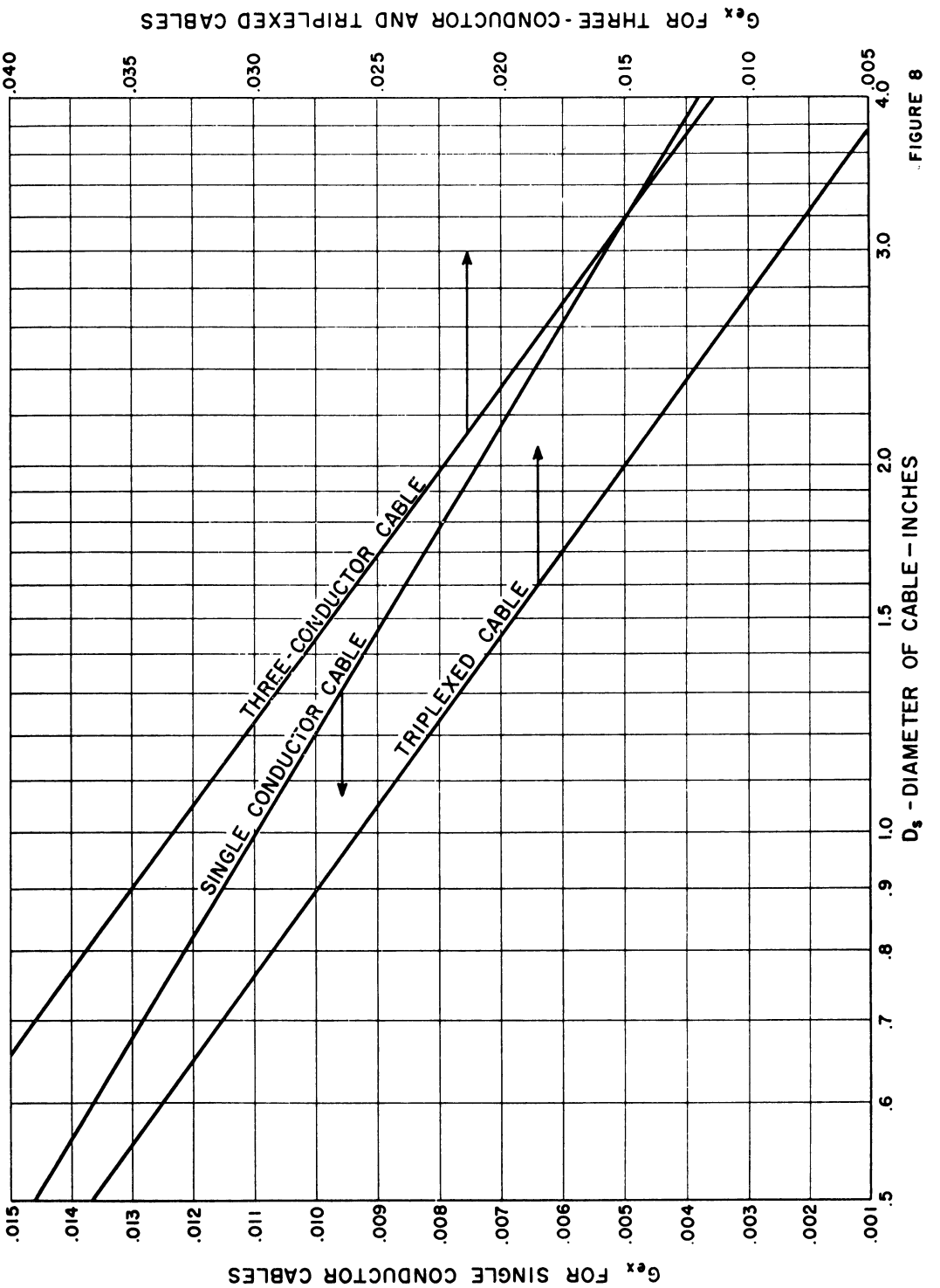
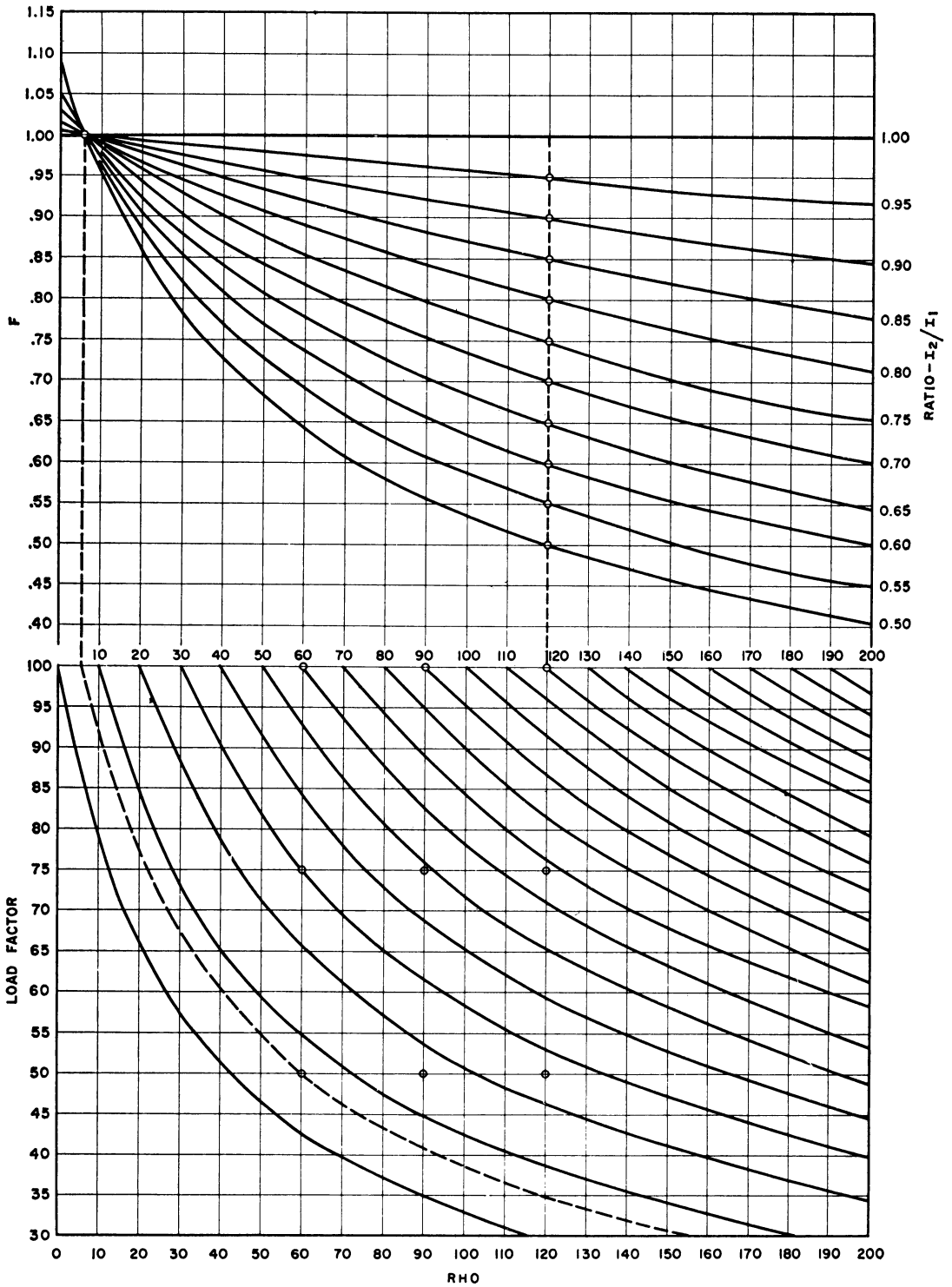


FIGURE 8

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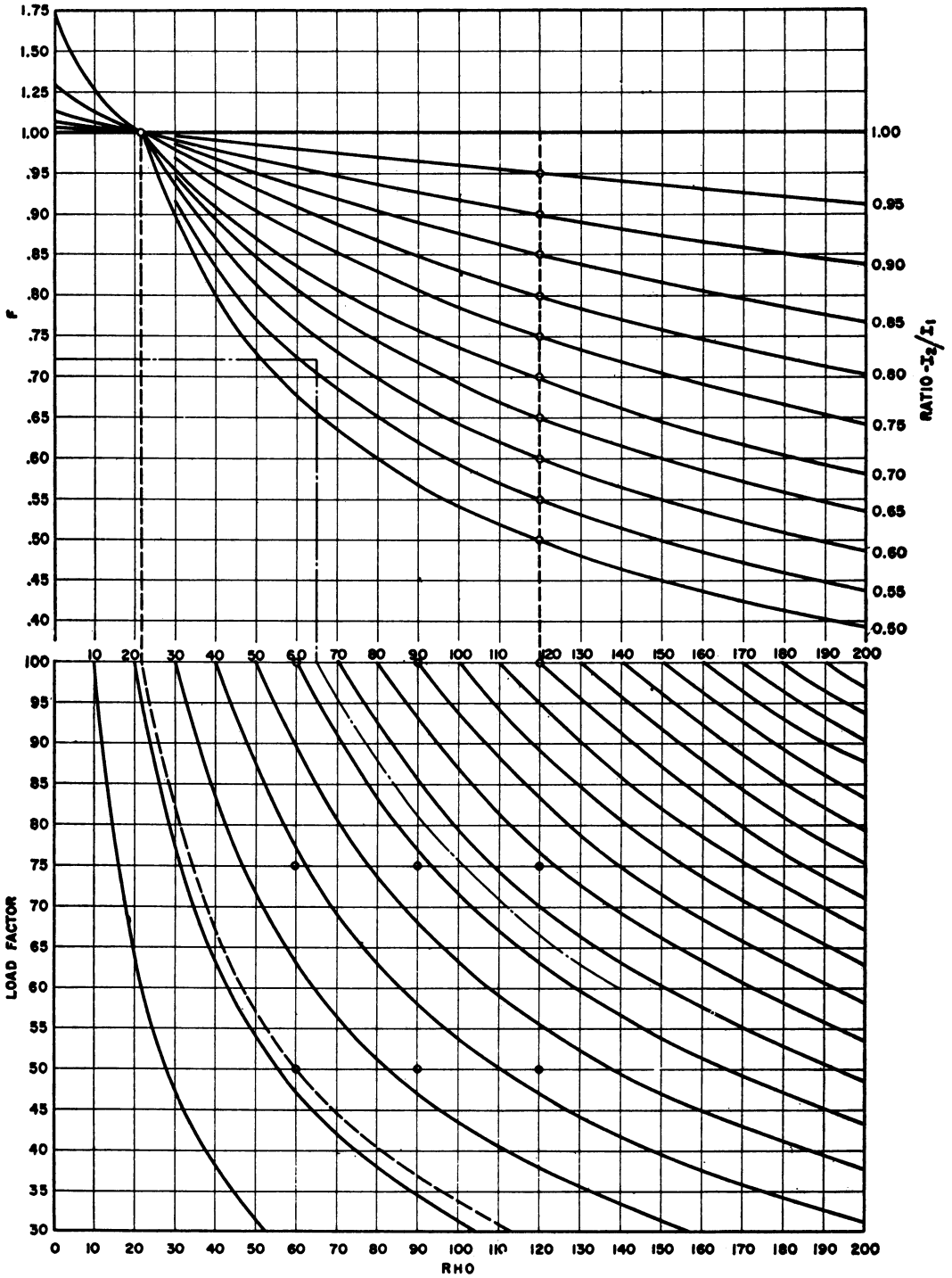
INTERPOLATION CHART FOR CABLES IN A DUCT BANK

I_1 = AMPACITY FOR RHO-60, 50 LF; I_2 = AMPACITY FOR RHO-120, 100 LF; DESIRED AMPACITY = F x I_1

FIGURE 9

X

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INTERPOLATION CHART FOR PIPE-TYPE AND DIRECTLY BURIED CABLES
I_1 = AMPACITY FOR RHO-60, 50 LF; I_2 = AMPACITY FOR RHO-120, 100 LF; DESIRED AMPACITY = F x I_1

FIGURE 10

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Appendix I. Interpolation Charts for Variation in Rho and Load Factor

In Section B, reference is made to a procedure for determining the ampacity with values of rho or load factor which differ from those used in the tables. Fig. 9 may be used for interpolation or extrapolation for values of rho and load factor for cables installed in ducts, and Fig. 10 may be used for directly buried cables and directly buried pipe-type cables.

For both figures, the upper family of curves shows the variation in ampacity and rho at unity load factor in terms of I_1, the ampacity for RHO = 60 and 50 LF. Each curve is designated for a particular ratio I_2/I_1, where I_2 is the ampacity at RHO 120 and 100 LF (unity load factor).

The lower family of curves shows the relationship between rho and load factor which will give substantially the same ampacity as the indicated value of rho at unity load factor.

As an example in the use of these charts, suppose it is desired to find the ampacity of a 2,000-MCM 138-kv pipe-type cable at rho = 140, 60% load factor for which the tabulated ampacities are $I_1 = 1{,}414$ and $I_2 = 806$ amperes. Thus, the ratio $I_2/I_1 = 0.57$. Entering the lower curve of Fig. 10 with rho = 140 and load factor = 60, one finds that the equivalent rho is 65 at unity load factor. Following the value rho = 65 to the upper set of curves and going vertically to a point equivalent to rho = 65 and $I_2/I_1 = 0.57$, one obtains a value of $F = 0.72$. Therefore, the desired ampacity is $0.72 \times 1{,}414 = 1{,}018$ amperes. By rigorous calculation, the value is 1,020 amperes.

Appendix II. Guide for Application of AEIC Maximum Insulation Temperatures at the Conductor for Impregnated-Paper-Insulated Cable

1. Scope and Purpose

This Guide outlines definitions, assumptions, principles, and special considerations applying to the use of the maximum insulation temperatures at the conductor for normal operation and for emergency operation of paper-insulated cable which are set forth in the accompanying tables.

These new temperature limits and associated notes replace the similar information in the four existing cable specifications issued by the AEIC. The temperatures and notes may be modified in subsequent revisions of individual AEIC specifications.

Attention is drawn herein to precautions and limiting factors which should be taken into consideration when these temperatures are applied. Full consideration of these points will lead in some cases to the use of lower limits than the tabulated temperatures, and in many cases to the use of lower limits than provided by Note 2 of the tables in design calculations or in actual operation. Also, full consideration may lead to the use of more conservative factors in calculating the load capabilities.

This Guide applies to impregnated-paper-insulated cables of the following types which are manufactured under the AEIC specifications and are installed and operated in accordance with modern practices:

(a). Solid type.
(b). Low-pressure gas-filled type.
(c). Low-pressure oil-filled type.
(d). High-pressure pipe type.

2. Definitions

The recommended insulation temperature limits apply to the actual hottest portion of the line or circuit at any time. (As implied by Notes 1 and 2 of Tables I to IV of this Appendix, the actual temperature at the hottest spot is expected to be the same whether one uses the tabulated temperature limits in line with Note 1 or uses limits 10 C higher in line with Note 2.)

Limits for normal operating temperatures are the hottest-spot temperatures which may be reached at any time during regular daily loading of a line. The loads in normal operation may vary between days of a given week, including a considerable decrease in load during week ends, and the loads may vary considerably during any year or from one year to the next. (See Section 4(i).)

Limits for emergency operating temperatures apply only to the infrequent higher loading of a line necessitated by the unintentional loss of parallel or associated lines or of associated equipment. It is assumed that the shape of the daily load curve will be the same or similar to that under normal operation. (See Section 4(i).) The emergency temperatures are based on the assumption that their application will not exceed the following:

Type of Cable	Maximum Length of Each Period, Hours	Maximum Number of Emergency Periods	
		In any 12 Consecutive Months	Average per Year for Life of Cable
Solid	36	3	1.0
Low-pressure gas-filled	36	3	1.0
Low-pressure oil-filled	100 or 300*	1	0.2
High-pressure pipe	100 or 300*	1	0.2

*See Table IV for temperatures.

3. Temperature Limits

The recommended maximum normal and emergency operating temperatures are shown in the four tables entitled:

Table I: Solid-Type Multiple-Conductor Belted Cable
Table II: Solid-Type Multiple-Conductor Shielded and Single-Conductor Cable
Table III: Low-Pressure Gas-Filled Cable
Table IV: Low-Pressure Oil-Filled and High-Pressure Pipe-Type Cable

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These maximum temperatures should be used only after careful consideration of all the factors which have a bearing on the expected life and reliability of the installed line, as set forth in the following sections.

4. Principles and Basic Background Factors

(a). The use of these temperature limits is expected to result in a long service life.

(b). They apply to all types of cable installation: duct systems (conduits), buried pipes, direct burial, submarine, aerial, and inside buildings. Most of the discussion applies specifically to cables installed underground.

(c). The recommended temperature limits apply to cables of the quality and of the various constructions which are being manufactured at the present time. Allowances are made for deterioration that should be expected to occur under proper operation with daily load cycles typical of electric light and power systems.

(d). For cables of earlier vintage which may have suffered considerable deterioration of the insulation or covering, or both, lower operating temperatures may be advisable.

(e). It is assumed that good installation techniques are applied in accordance with present standards. This includes good workmanship.

(f). It is assumed that the conduit, manholes, and cable training for duct-lay cable are in accordance with modern standards, and that adequate provisions have been made to accommodate movement with temperature variations for all types of installation.

(g). It is assumed that joints and terminations are adequate in design and able to operate without restricting the loading of the cable. The ambient temperature of air in a manhole which has some ventilation may be 10 to 25 C lower than the maximum conduit temperature or than the temperature of the soil adjacent to a buried cable or pipe. However, the temperature of a connector in a joint in a manhole may be either lower or higher than that of the cable conductor in the run between joints, depending on the relative electrical resistances of the conductor and the connector, the relative thermal resistances of the cable and joint insulations, and the relative dielectric losses in the cable and in the joint. Where the accessories are exposed to the same ambient temperature as the cable, the hottest temperatures in the accessories may be equal to or above those for the cable.

(h). It is assumed that oil reservoir systems, gas supply systems, apparatus for circulating oil, etc., are properly designed so that they do not impose physical limitations on the operation of the cable at the temperatures in the tables and accompanying footnotes.

(i). It is assumed that the cables operate under normal daily load cycles with variations in maximum daily load over a period of years due to load growth and load relief and due to seasonal changes. If cables are subjected to unusually high daily load factors (more than 85%) and especially to loadings close to or at the calculated load capabilities for a very large portion of their entire life, the allowable temperatures should be reduced. Likewise, if the load factors are unusually low and the loading close to or at the calculated load capabilities is to be infrequent, then somewhat higher temperatures might be used after considering all physical factors, especially for the oil-filled and pipe-type cables.

5. Limiting Factors

Before the maximum insulation temperatures are applied, a careful study should be made of possible limiting factors. Following are some aspects to be considered.

(a). A serious limiting factor is the varying degree of knowledge of the effect of the heat generated by the losses in the cables in raising the temperatures of the conduit, earth, or air surrounding the cables. For a given amount of heat generated by identical cables in apparently similar types of installations, the temperature rises of the conduits or earth may vary over a very wide range; and even for a given installation, the temperature rise may vary over a range of approximately 1.5 to 1 during a year, especially if there is a dry spell or a long period of hot weather.

If the calculations of load capabilities are based on adequate data on the actual thermal characteristics of the conduit, earth, etc., and if sufficient temperature surveys are made from time to time to locate high temperatures, and if remedial measures are applied where higher than contemplated temperatures are indicated, then the conductor temperatures can be calculated with a good degree of accuracy. In such cases the load capabilities may be determined with little or no allowance for uncertainty in the temperature rise of the conduit or other reference temperature over the ambient temperature.

Otherwise, allowances should be made to cover varying degrees of lack of knowledge of initial thermal conditions and to take care of unexpected increases in thermal characteristics of the medium in which the cable is to be installed. This has been done in connection with Note 1 and the tabulated temperatures. In cases where particularly adverse conditions are suspected, it may be advisable to reduce the temperature limits still further or to use relatively high values of thermal resistances for the conduit or soil, or both. (See Section 7(b).)

(b). The permissible maximum soil or duct temperature [see Section 7(c)] may prevent the full use of the recommended insulation temperature limits.

The soil will start to dry out as its temperature is increased which results in an increase in soil resistance and consequent further increases in soil and conductor temperatures. With moderate or low moisture contents, these increases may become intolerable. The magnitude of this tendency for the soil is partly dependent upon the soil temperature

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and the temperature gradient adjacent to the pipe, conduit, or buried cable. It is also a function of the time at the higher temperatures, depending on whether normal daily operation for many days or months is involved or emergency operation for a few hours or a few days. It depends on the kind and density of the soil, the depth below the surface of the ground, the nature of the ground surface, and the presence or proximity of moisture. Unless stable thermal resistivities of the soil and conduit are maintained, by supplying water or by other methods, if necessary, the loading should be limited to prevent the development of excessive temperatures.

(c). The daily flexing of the cable in the manholes or elsewhere caused by the temperature cycles may result in a life for lead sheaths which is much less than the expected cable life. A check should be made to ascertain that the training conditions do not impose such a limitation.

Where the offset between the center line of the duct and the center line of the joint is small, or the bending radii of the cable are small, or the total length between joint wipe and duct mouth is small, the effect of a given movement of the cable at the duct mouth in causing sheath cracks is increased. Where these characteristics are inferior to those considered good practice, allowable temperatures should be reduced, especially if the daily temperature ranges are large.

Precautions are especially necessary for large cables where the stiffness may cause large cable movement at the duct mouth and the large diameters cause greater strains in the sheath.

In some cases, the limitations discussed in this section may be substantially offset by the use of a suitable lead alloy as the sheath material, or by the use of triplex cable instead of 3-conductor cable.

(d). Operation at emergency temperatures may result in large cable movement with the result, e.g., that the joints may be pressed against the walls of the manholes in a conduit system with increased strains in the cable sheath in the manholes. Before the emergency temperature limits are used, the effects of the large movements on the joints and terminations should be considered, and suitable provisions made to avoid possible damage in service.

(e). Joints on solid-type cable lines filled with viscous or heavy compound may develop trouble at increased temperatures due to bulging or collapsing of the casing.

(f). The possibility of drainage of the impregnating oil in solid-type cable installed vertically or on steep slopes will increase as the temperature increases. In such cases consideration should be given to the design of the cable or accessories, or both.

(g). If solid-type cables are operated with reservoirs under positive pressure connected to joints, consideration should be given, when increasing operating temperatures, to the possibility of increased sheath expansion which might cause sheath bursting. Reduction of reservoir pressure may be considered as a compensating measure.

(h). For oil-filled cable lines, it is necessary to ascertain that the reservoir capacity is adequate for the recommended temperatures to prevent excessive pressures as well as the occurrence of pressures below the permissible limit when load is reduced or dropped.

(i). Impregnated-paper-insulated cable installed vertically or on steep slopes may be subject to excessive expansion of the lead sheath due to the internal hydrostatic pressure. For such installations and for all cables where the sheaths are subjected to positive internal pressure (oil-filled and gas-filled cables), the rates of expansion of the sheath will increase steeply with increases in sheath temperature; and the resultant life to bursting is appreciably shortened.

These limitations may be substantially reduced by the use of a suitable lead alloy for the sheath material or thicker sheath, or both, or by the use of sheath reinforcement.

(j). In locations where corrosion is a problem, increased sheath or pipe temperatures may increase the rate of chemical reaction and the number of failures due to corrosion.

(k). Coverings over pipes or sheaths may introduce a limitation to the use of high temperatures. The high-temperature characteristics of coverings should be checked. Also, the coverings, especially those in pipes, may decrease in electrical resistance at higher temperatures which will probably require increased current when cathodic protection is employed.

(l). Cable that has operated at appreciably less than its rated voltage with the correspondingly higher permissible temperatures may become unfit, so far as the insulation is concerned, to operate subsequently at its rated voltage. This applies more to solid-type cable than to the other types.

6. Operation and Maintenance

The recommended maximum temperatures are based on the assumption that the cable installation is in satisfactory condition and is subject to proper operation and adequate maintenance as outlined in the following:

(a). "Proper operation" is understood to include operation where the recommended maximum temperatures are approached or attained during each daily load cycle, but are not exceeded. As far as lead sheaths are concerned, it is assumed that there is only one general temperature cycle each day, unless provisions have been made for more frequent cycles. As has been previously indicated, if there is to be more or less continuous operation at a maximum temperature throughout the life of the installation, then this temperature should be somewhat less than the recommended maximum temperature.

(b). A moderate number of failures is to be expected. [For usual rates of failure of the different types of cable and accessories, see the annual reports on Cable Operation issued by the Edison Electric Institute (EEI).] If an excessive number of cable troubles results because of special circum-

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stances, which may include very heavy loading, it may well be necessary to decrease the loading in order to reduce the number of troubles to a reasonable level.

(c). It is expected that the cable installations will be subjected to periodic inspections to locate and remedy unsatisfactory conditions and incipient troubles. This includes examinations of the cables in manholes, in order to detect and repair sheath cracks caused by cyclic movement and to introduce measures to mitigate the effects of movement, to improve duct-mouth protection as needed, to check for proper supports, and in order to examine fittings, reservoirs, etc., for possible leaks and maladjustments.

(d). Periodic temperature measurements should be made (1) to detect unsatisfactory heat dissipating conditions due to the soil or due to other heat sources nearby and (2) to discover hot spots due to dielectric loss in deteriorated cable insulation. If possible, remedial measures should be taken. These measures would usually apply to the hottest locations in a line and may be of a temporary nature, such as forced cooling by water or air, or of a permanent nature, such as replacement of the cable with one having a larger conductor or replacement of the surrounding soil with material of lower thermal resistivity.

(e). It is recommended that oil from oil-filled and pipe-type cable lines be periodically sampled in order to check for possible signs of deterioration (indicated by color, acidity, resistivity, and power factor).

7. Determination of Load Capability

The load capabilities for a given installation may be determined by methods discussed in Chapter 10 of reference 10 and in reference 1. Such calculations require the knowledge or assumption of values for many factors or parameters. It is preferable to base calculations as much as possible on measured values of these factors, which may in some instances vary considerably. If specific information is not available, consideration of the following values and points is recommended:

(a). *Power Factor.* The power factor of the insulation usually increases as the cable ages. This becomes an increasingly critical factor at the higher operating voltages. It is recommended that the power factor values used be such as to represent conditions after many years of service. In general, the increased capability due to the lower power factors of new cable cannot be utilized since new installations usually are not subjected to full allowable load; one exception applies sometimes to lines directly involved with installations of new generating capacity. Older lines should receive special consideration.

The following values of power factor of insulation which is operated at 138 kv or less are recommended as typical values to be expected for present-day cables after they have been for many years in operation:

Conductor Temperature, C	Power Factor, Per Cent				
	Solid-Type Belted	Solid-Type 1-Conductor and Shielded	Low-Pressure Gas-Filled	Low-Pressure Oil-Filled	High-Pressure Pipe
60	2.0	1.5	1.5	0.4	0.4
80	4.0	3.0	3.0	0.6	0.6
100	7.0	5.0	5.0	0.9	0.9
115	10.0	7.0	7.0	1.3	1.3

Cable for operation at more than 138 kv requires very special consideration because of the large effect of power factor on load capability.

Aside from the inherent characteristics of cable as made, the manner of installation, including exposure of the cable insulation to air or moisture, and the type and materials in the accessories may affect the change in power factors of the insulation in service. In some cases, these factors can cause cable power factors higher than those in the preceding tabulation.

For cables of early vintages, the power factors may be much higher than those shown in the tabulation, especially for solid-type cable. In some cases, the power factor increases very steeply with increasing temperature and there is a possibility of failure due to cumulative heating, especially during emergency operation. For these cases lower temperature limits should be used.

(b). *Thermal Resistivity.* The thermal resistivity of soil in which cable is installed may vary greatly from place to place, and also with time at a given location. It is affected primarily by the type and density of the soil and the amount of moisture present. For a typical loam or clay containing normal amounts of moisture, the resistivity is usually somewhere in the range of 60–120 C per watt per cm^3. Under very favorable conditions the lower limit may be around 40 for some soils, and under adverse conditions, especially with low moisture content, which may exist, for example, in some sands, chalky soils, or cinders, the upper value may reach 300. For any given location over a period of a few years, the combined effects of heat, dissipated from the cable or other sources, and the climatic conditions may cause variations in the thermal resistivity of the soil by a range as large as 2 to 1.

Likewise, for example, for a 9-duct conduit not under water, the heating constant may vary from approximately 0.6 to 2.0 C rise in the middle idle duct per average watt of heat generated in 24 hours per foot of conduit. In most locations, the range is about 0.6 to 1.2.

In general, the assumptions used in making calculations should be those which apply for the time of the year when the maximum load occurs. If load capabilities are calculated for various seasons of the year, the assumptions used in each case should be those which apply for the portion of the season when its maximum load occurs. Thermal conditions are usually most critical in late summer and early autumn.

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Considerable valuable information on soil is given in reference 6.

(c). *Soil and Duct Temperatures.* Dissipation of heat through soils results in redistribution of moisture which under some conditions may noticeably affect the soil thermal resistivity. The limiting temperature for soil adjacent to cable lines, necessary to avoid undesirable increases in resistivity, have not yet been definitely determined, but the assumption of some value between 45 and 60 C has been considered good practice. Since the redistribution of moisture is a relatively slow process, temperatures 5 to 10 C higher are considered permissible for emergency operation, depending partly on the duration of the emergency. Temperatures well in excess of those cited have been reached safely in some places, while undesirable increases in resistivity have occurred in other places with lower temperatures.

For idle ducts in the middle of the cross section of conduits, the common limits are 50 to 60 C for normal operation, depending partly on the nearness and amount of the moisture in the soil; and approximately 10 C higher for emergency operation.

(d). *Ambient Earth Temperature.* The temperature of the ambient earth will vary with the location, season of the year, and depth. Usually the earth temperature increases directly with the depth in winter and decreases with depth in summer. At a depth of $3\frac{1}{2}$ feet, typical temperatures are as follows:

	Temperature, C	
	Summer	Winter
Northern part of United States	20 to 25	2 to 15
Southern part of United States	25 to 30	10 to 20

(e). *Sun and Wind.* In calculations of load capabilities of cables exposed to the sun, such as aerial cable and riser portions, consideration should be given to the inclusion of the effects of solar heating and wind, which may, however, offset each other.

AEIC Maximum Conductor Temperatures for Impregnated-Paper-Insulated Cable

General Notes

A. The temperatures in the following tables are 10 C below maximum conductor temperature limits which apply for the *actual* hottest portion of the line or circuit at any time.

B. These tabulated temperatures and associated notes are to be considered at the time of issuance of the Guide as replacements for similar information in the existing AEIC cable specifications. As the individual specifications are revised, it is expected that the new temperature limits will be inserted.

NOTE 1. These tabulated temperatures are recommended as permissible conductor temperatures for ampacity calculations when a value to represent the thermal characteristics of the installation is being assumed in the absence of knowledge of these characteristics adequate to establish their limits. Under these conditions, it is recognized that hot spots may exist with temperatures exceeding the values in the table by as much as 10 C.

NOTE 2. Temperatures 10 C above these tabulated values may be used in ampacity calculations when adequate knowledge of the over-all thermal characteristics of the cable environment is available.

NOTE 3. As a source of engineering information on the utilization of the temperatures covered by Notes 1 and 2, see the foregoing Guide.

Table I. Solid-Type Multiple-Conductor Belted Cable

Rated Voltage, Kv	Conductor Temperature, C	
	Normal Operation	Emergency Operation
1	85	105
2–9	80	100
10–15	75	95

Table II. Solid-Type Multiple-Conductor Shielded and Single-Conductor Cable

Rated Voltage, Kv	Conductor Temperature, C	
	Normal Operation	Emergency Operation
1–9	85	105
10–17	80	100
18–29	75	95
30–39	70	90
40–49	65	85
50–59	60	75
60–69	55	70

Table III. Low-Pressure Gas-Filled Cable

Rated Voltage, Kv	Conductor Temperature, C	
	Normal Operation	Emergency Operation
8–17	80	100
18–29	75	95
30–39	70	90
40–46	65	85

Table IV. Low-Pressure Oil-Filled and High-Pressure Pipe-Type Cable

Rated Voltage, Kv	Conductor Temperature, C		
	Normal Operation	100 Hours*	300 Hours*
15–17	85	105	100
18–39	80	100	95
40–162	75	95	90
163–230	70	90	85

* Use temperature limits which correspond to the expected maximum duration of any emergency operation.

Appendix III. Guide for Application of Maximum Insulation Temperatures at the Conductor for Rubber-, Thermoplastic-, Varnished-Cloth-, and Asbestos-Insulated Cables

1. Scope

This guide outlines definitions, assumptions, principles, and special considerations applying to the use of the maximum insulation temperatures at the

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conductor for normal operation for rubber-, thermoplastic-, varnished-cloth-, and asbestos-insulated cables.

Attention is drawn herein to precautions and limiting factors which should be taken into consideration when the specific temperatures for each type of insulation are applied. Full consideration of these points will lead, in some cases, to the use of lower limits than the maximum allowable temperatures for each type of insulation (see Section 3). Also, it may lead to the use of more conservative factors in calculating load capabilities.

This guide applies to insulated cables which are manufactured under the IPCEA Standards as listed in references 11–14 and are installed and operated in accordance with modern practices.

2. Definitions

The recommended insulation temperature limits apply to the highest conductor temperature of the line or circuit during regular daily loading. This temperature may be reached at any time during regular daily loading of a line. The loads in normal operation may vary between days of a given week, including a considerable decrease in load during week ends, and they may vary considerably during any year or from one year to the next.

3. Temperature Limits

The recommended maximum conductor temperature limits are the highest conductor temperatures attained by any part of the cable line under operating conditions.

Various factors should be taken into consideration in the application of these limits. These factors are given in detail in Appendix II, Sections 4 to 7 inclusive. It is to be appreciated that reference to the power factor and emergency temperatures pertaining to impregnated-paper cables are not applicable.

The values of ampacity given in the tables for a given set of conditions and the maximum conductor temperature for a given class of insulation are applicable when adequate knowledge of the over-all thermal characteristics of the cable environment is available. On the other hand, when the thermal characteristics of the installation are being assumed in the absence of knowledge of these characteristics adequate to establish their limits, values should be taken for an increased ambient temperature, which may be as much as 10 C higher than the normally assumed ambient temperature. This can be determined in accordance with Section II-B of the main text, for the assumed conditions and the higher ambient temperatures, and will result in ampacities for rubber- and thermoplastic-insulated cables on the same basis as values selected from the tables for paper-insulated cables.

Rubber

Natural 60 C. This insulation is suitable for operation at conductor temperatures not exceeding 60 C (140 F) and in dry locations only.* See Section 3.9 of Standard S-19-81.[11]

Natural 75 C. This insulation is suitable for use at conductor temperatures not exceeding 75 C (167 F) and in dry locations only.* See Section 3.12 of Standard S-19-81.[11]

Synthetic 60 C. This insulation is suitable for use at conductor temperatures not exceeding 60 C (140 F) and in dry locations only.* See Section 3.7 of Standard S-19-81.[11]

Synthetic, Moisture Resisting 60 C. This insulation is suitable for operation at conductor temperatures not exceeding 60 C (140 F) in dry or wet locations. See Section 3.8 of Standard S-19-81.[11]

Synthetic 75 C. This insulation is suitable for use at conductor temperatures not exceeding 75 C (167 F) and in dry locations only.* See Section 3.10 of Standard S-19-81.[11]

Synthetic, Heat Resisting 75 C or Moisture Resisting 60 C. This insulation is suitable for use at conductor temperatures not exceeding 75 C (167 F) for dry locations and 60 C (140 F) for wet locations. See Section 3.11 of Standard S-19-81.[11]

Synthetic, Heat and Moisture Resisting 75 C. This insulation is suitable for use at conductor temperatures not exceeding 75 C (167 F) and in dry or wet locations. See Section 3.13 of Standard S-19-81.[11]

Natural or Synthetic, Ozone Resisting. The conductor temperature shall not exceed 75 C (167 F) for voltages of 8,000 volts or less, grounded neutral or ungrounded neutral; and shall not exceed 70 C (158 F) for voltages of 8,001–28,000 volts grounded neutral, or 8,001–15,000 volts for ungrounded neutral and in dry or wet locations. See Section 3.14 of Standard S-19-81.[11]

Ozone-Resisting Butyl. The conductor temperature shall not exceed 85 C (185 F) for an operating voltage of 15,000 volts or less and shall not exceed 80 C (176 F) for an operating voltage above 15,000 volts, and in dry or wet locations. See Section 3.15 of Standard S-19-81.[11]

Synthetic 90 C. This insulation is suitable for use at conductor temperatures not exceeding 90 C (194 F) and in dry locations only,* for an operating voltage of 2,000 volts or less. See Section 3.16 of Standard S-19-81, Part 3, page 13, and Table 11, Part 3, page 3.[11]

Note: Ampacity tables covering 90C (194F) are also given for 8,000 volts and 15,000 volts, although at the time of publication IPCEA had not approved 90 C operation of any rubber or thermoplastic insulation at these voltages.

Thermoplastic

Polyvinyl Chloride 60 C. This insulation is intended for operation at conductor temperatures not exceeding 60 C (140 F) in dry or wet locations at a maximum voltage rating of 600 volts for power circuits. See Section 3.7 of Standard S-61-402.[12]

Polyvinyl Chloride 75 C. This insulation is intended for operation at conductor temperatures not exceeding 75 C (167 F), in dry or wet locations, at a maximum voltage rating of 600 volts for power circuits. See Section 3.8 of Standard S-61-402.[12]

* "Dry Locations" are those not normally subject to dampness or wetness (reference 9, article 100).

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Voltage Rating, Volts	Rubber Insulation						
	Maximum Temperature Rating of Insulation, C						
	60	65	70	75	80	85	90*
	Maximum Emergency Overload Temperatures, C						
0–2,000	85	85	—	95	—	105	110
2,001–5,000	—	—	—	95	—	105	110
5,001–8,000	—	—	—	90	—	100	105
8,001–15,000	—	—	85	—	—	100	105
15,001 and over	—	—	85	—	95	—	—

Voltage Rating, Volts	Thermoplastic Insulation	
	Maximum Temperature Rating of Insulation, C	
	60	75
	Maximum Emergency Overload Temperatures, C	
0–2,000	85	95
2,001–5,000	—	95
5,001–15,000	—	90

* See Page XVII, *Synthetic* 90 C, for limitation in the application of 90 C rubber insulation.

Polyethylene. This insulation is intended for operation at conductor temperatures not exceeding 75 C (167 F) and for rated voltages of 15,000 volts and less and in dry or wet locations. See Section 3.9 of Standard S-61-402.[12]

Varnished Cloth

The maximum conductor temperature for varnished-cloth cables is a function of the voltage. Table 33, page 39 of the IPCEA Standard S-62-375,[13] lists the temperature for a specific voltage. The ampacity tables give the temperature for which the current was calculated.

Asbestos-Varnished Cloth. Asbestos Braid (AVA); Asbestos-Varnished Cloth, Lead Sheath (AVL).

The conductor temperature has been taken as 110 C (230 F) for 1,000-volt cable.

These maximum temperatures should be used only after careful consideration of all the factors which have a bearing on the expected life and reliability of the installed line, as set forth in Appendix II, Section 5.

4. Emergency Overload Temperatures

Operation at the emergency overload temperatures tabulated here shall not exceed 100 hours per year. Such 100-hour overload periods shall not exceed five.

Varnished-Cloth Insulation. There are no emergency overload temperatures for varnished-cloth insulation included at the present time in the IPCEA Standards.

Asbestos Insulation. There are no emergency overload temperatures for asbestos insulation included at the present time in the IPCEA Standards.

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Correction: **The following corrections apply to both Vol I, Copper Conductors, and Vol II, Aluminum Conductors**

Usage of the tables has brought attention to the fact that the Ampacities for Triplexed Rubber Cables, directly buried, are in error when the load factors are 30, 50, and 75 percent.

Table A is to be used for pages 244, 246, 250, 252, 254, and 256

Table B is to be used for pages 245, 247, 249, 251, 253, and 257

On page 255, Table A applies to 8 kV and Table B applies to 15 kV.

TABLE A.

CORRECTION FACTORS FOR TRIPLEXED CONCENTRIC STRAND RUBBER INSULATED CABLES BURIED. AIEE-IPCEA AMPACITY TABLES 1 AND 2 CIRCUITS.

	RHO-60				RHO-90				RHO-120			
SIZE	30LF	50LF	75LF	100LF	30LF	50LF	75LF	100LF	30LF	50LF	75LF	100LF
					1 KV. CABLES.							
8	1.13	1.09	1.05	1.00	1.15	1.11	1.05	1.00	1.17	1.12	1.06	1.00
6	1.14	1.10	1.05	1.00	1.17	1.12	1.06	1.00	1.18	1.13	1.05	1.00
4	1.16	1.10	1.05	1.00	1.18	1.12	1.06	1.00	1.19	1.13	1.06	1.00
2	1.17	1.11	1.05	1.00	1.19	1.13	1.06	1.00	1.20	1.14	1.06	1.00
1	1.17	1.11	1.06	1.00	1.19	1.14	1.07	1.00	1.20	1.15	1.07	1.00
1/0	1.18	1.12	1.06	1.00	1.20	1.14	1.07	1.00	1.21	1.15	1.07	1.00
2/0	1.19	1.12	1.06	1.00	1.21	1.15	1.07	1.00	1.22	1.16	1.07	1.00
3/0	1.20	1.13	1.07	1.00	1.22	1.15	1.07	1.00	1.23	1.16	1.07	1.00
4/0	1.20	1.14	1.07	1.00	1.23	1.16	1.07	1.00	1.24	1.17	1.07	1.00
250	1.21	1.14	1.07	1.00	1.23	1.16	1.08	1.00	1.25	1.17	1.08	1.00
350	1.23	1.15	1.07	1.00	1.25	1.17	1.08	1.00	1.27	1.18	1.08	1.00
500	1.24	1.16	1.08	1.00	1.27	1.18	1.08	1.00	1.28	1.19	1.08	1.00
750	1.26	1.17	1.08	1.00	1.29	1.19	1.09	1.00	1.31	1.20	1.09	1.00
1000	1.28	1.18	1.08	1.00	1.31	1.20	1.09	1.00	1.33	1.21	1.09	1.00
					8 KV. CABLES.							
6	1.12	1.09	1.05	1.00	1.15	1.11	1.05	1.00	1.17	1.12	1.06	1.00
4	1.13	1.10	1.05	1.00	1.16	1.11	1.06	1.00	1.18	1.12	1.06	1.00
2	1.14	1.10	1.05	1.00	1.17	1.12	1.06	1.00	1.19	1.13	1.06	1.00
1	1.15	1.11	1.05	1.00	1.18	1.12	1.06	1.00	1.19	1.14	1.07	1.00
1/0	1.15	1.11	1.05	1.00	1.18	1.13	1.06	1.00	1.20	1.14	1.07	1.00
2/0	1.16	1.11	1.05	1.00	1.19	1.13	1.06	1.00	1.21	1.15	1.07	1.00
3/0	1.17	1.12	1.06	1.00	1.20	1.14	1.07	1.00	1.22	1.15	1.07	1.00
4/0	1.18	1.13	1.06	1.00	1.21	1.15	1.07	1.00	1.24	1.16	1.07	1.00
250	1.19	1.13	1.06	1.00	1.22	1.15	1.07	1.00	1.25	1.17	1.07	1.00
350	1.21	1.14	1.07	1.00	1.24	1.17	1.07	1.00	1.26	1.18	1.08	1.00
500	1.23	1.15	1.07	1.00	1.26	1.18	1.08	1.00	1.28	1.19	1.08	1.00
750	1.25	1.17	1.08	1.00	1.29	1.19	1.08	1.00	1.31	1.20	1.09	1.00
1000	1.27	1.18	1.08	1.00	1.31	1.20	1.09	1.00	1.33	1.21	1.09	1.00

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Table B is to be used for pages 245, 247, 249, 251, 253, and 257

On page 255, Table A applies to 8 kV and Table B applies to 15 kV.

TABLE B.

CORRECTION FACTORS FOR TRIPLEXED CONCENTRIC STRAND RUBBER INSULATED CABLES BURIED. AIEE-IPCEA AMPACITY TABLES 1 AND 2 CIRCUITS.

SIZE	RHO-60 30LF	50LF	75LF	100LF	RHO-90 30LF	50LF	75LF	100LF	RHO-120 30LF	50LF	75LF	100LF
15 KV. CABLES												
2	1.13	1.10	1.05	1.00	1.17	1.12	1.06	1.00	1.20	1.14	1.06	1.00
1	1.14	1.10	1.05	1.00	1.18	1.12	1.06	1.00	1.20	1.14	1.07	1.00
1/0	1.15	1.11	1.05	1.00	1.18	1.13	1.06	1.00	1.21	1.14	1.07	1.00
2/0	1.16	1.11	1.05	1.00	1.19	1.13	1.06	1.00	1.21	1.14	1.07	1.00
3/0	1.16	1.12	1.06	1.00	1.20	1.14	1.07	1.00	1.22	1.15	1.07	1.00
4/0	1.17	1.12	1.06	1.00	1.21	1.15	1.07	1.00	1.23	1.16	1.07	1.00
250	1.18	1.12	1.06	1.00	1.21	1.15	1.07	1.00	1.24	1.16	1.08	1.00
350	1.19	1.13	1.06	1.00	1.23	1.16	1.07	1.00	1.26	1.18	1.08	1.00
500	1.21	1.15	1.07	1.00	1.25	1.17	1.08	1.00	1.28	1.19	1.08	1.00
750	1.24	1.16	1.07	1.00	1.28	1.19	1.08	1.00	1.31	1.20	1.09	1.00
1000	1.26	1.17	1.08	1.00	1.30	1.20	1.09	1.00	1.33	1.21	1.09	1.00
25 KV. CABLES.												
1	1.13	1.09	1.05	1.00	1.17	1.12	1.06	1.00	1.19	1.13	1.06	1.00
1/0	1.13	1.10	1.05	1.00	1.17	1.12	1.06	1.00	1.20	1.14	1.07	1.00
2/0	1.14	1.10	1.05	1.00	1.18	1.13	1.06	1.00	1.21	1.14	1.07	1.00
3/0	1.15	1.11	1.05	1.00	1.19	1.13	1.06	1.00	1.22	1.15	1.07	1.00
4/0	1.16	1.12	1.05	1.00	1.19	1.14	1.06	1.00	1.23	1.16	1.07	1.00
250	1.16	1.12	1.06	1.00	1.21	1.15	1.07	1.00	1.24	1.16	1.07	1.00
350	1.18	1.13	1.06	1.00	1.22	1.16	1.07	1.00	1.25	1.17	1.07	1.00
500	1.20	1.14	1.07	1.00	1.24	1.16	1.08	1.00	1.27	1.18	1.08	1.00
750	1.22	1.15	1.07	1.00	1.27	1.18	1.08	1.00	1.30	1.20	1.09	1.00
1000	1.24	1.16	1.08	1.00	1.29	1.19	1.09	1.00	1.33	1.21	1.09	1.00

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 30LF	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 30LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 30LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0350 PF AND RHO 60	90	120
3 CABLES IN DUCT BANK 8 KV 85 C CONDUCTOR 20 C AMBIENT EARTH															
COPPER CONDUCTOR CONCENTRIC STRAND															
6	117	115	110	106	116	113	107	102	116	111	105	98	0.19	0.21	0.23
4	155	151	145	138	154	148	141	133	152	146	137	127	0.21	0.23	0.26
2	205	199	190	181	203	195	184	173	201	191	179	166	0.26	0.29	0.32
1	235	229	218	207	233	224	211	197	231	220	204	189	0.28	0.31	0.34
1/0	271	263	251	237	269	258	242	226	266	252	234	216	0.30	0.33	0.37
2/0	313	303	288	272	309	296	277	258	306	290	268	246	0.32	0.35	0.39
3/0	360	348	330	311	356	340	318	295	352	333	306	281	0.34	0.38	0.42
4/0	416	401	379	357	411	391	364	337	406	382	351	321	0.36	0.40	0.45
250	460	443	418	392	454	432	401	371	449	422	386	352	0.37	0.42	0.47
350	568	545	513	479	560	530	490	450	553	517	470	426	0.41	0.47	0.52
500	708	677	633	588	697	657	603	551	687	639	577	520	0.45	0.52	0.59
750	907	863	802	740	892	835	761	691	877	809	726	649	0.51	0.59	0.67
1000	1074	1018	941	865	1055	983	890	804	1036	950	847	754	0.55	0.64	0.74
1250	1221	1153	1061	972	1197	1111	1001	901	1175	1072	950	843	0.59	0.69	0.79
1500	1349	1269	1164	1062	1321	1221	1096	982	1295	1177	1038	917	0.62	0.73	0.85
1750	1459	1369	1252	1140	1427	1315	1177	1051	1398	1266	1113	981	0.65	0.77	0.89
2000	1559	1460	1332	1209	1525	1400	1249	1113	1491	1347	1180	1037	0.68	0.81	0.94
COPPER CONDUCTOR SEGMENTAL															
1000	1101	1043	964	886	1081	1007	912	824	1062	974	868	773	0.55	0.64	0.74
1250	1267	1196	1101	1008	1242	1152	1039	934	1218	1112	986	874	0.59	0.69	0.79
1500	1418	1335	1225	1117	1389	1284	1153	1033	1361	1238	1092	965	0.62	0.73	0.85
1750	1556	1461	1336	1216	1523	1403	1255	1122	1491	1351	1187	1046	0.65	0.77	0.89
2000	1686	1579	1440	1307	1648	1514	1350	1203	1613	1456	1275	1121	0.68	0.81	0.94
2250	1798	1680	1528	1384	1756	1609	1431	1272	1717	1545	1350	1183	0.71	0.84	0.98
2500	1906	1777	1613	1458	1860	1701	1508	1339	1817	1632	1421	1244	0.73	0.87	1.01
3000	2105	1956	1768	1592	2052	1868	1649	1458	2002	1789	1551	1352	0.77	0.93	1.08
6 CABLES IN DUCT BANK 8 KV 85 C CONDUCTOR 20 C AMBIENT EARTH															
COPPER CONDUCTOR CONCENTRIC STRAND															
6	115	110	103	96	114	107	99	90	112	104	95	85	0.24	0.28	0.31
4	152	145	135	125	149	140	128	117	147	136	123	110	0.27	0.31	0.35
2	200	190	176	162	196	183	167	151	193	178	159	142	0.34	0.39	0.45
1	230	218	201	185	226	210	191	172	222	204	181	162	0.36	0.42	0.48
1/0	264	250	230	211	260	241	218	196	255	233	207	184	0.39	0.45	0.52
2/0	304	287	263	241	299	276	248	223	293	267	236	209	0.41	0.49	0.56
3/0	350	329	301	274	343	316	283	253	336	305	268	237	0.44	0.52	0.60
4/0	404	378	345	313	395	363	323	288	386	349	306	269	0.48	0.57	0.66
250	446	416	379	343	436	399	355	316	426	384	336	294	0.50	0.60	0.69
350	549	510	461	415	536	487	430	381	523	467	406	353	0.55	0.67	0.78
500	682	630	565	506	664	600	525	462	647	573	493	428	0.62	0.75	0.88
750	870	797	709	630	845	756	656	573	820	720	614	528	0.71	0.87	1.02
1000	1027	935	826	731	995	884	762	662	964	840	711	609	0.78	0.96	1.14
1250	1163	1054	926	816	1125	993	852	737	1088	942	793	677	0.85	1.04	1.24
1500	1281	1156	1011	888	1237	1087	927	800	1195	1028	862	733	0.90	1.12	1.33
1750	1383	1243	1083	949	1333	1166	991	853	1286	1102	920	781	0.96	1.19	1.42
2000	1475	1321	1147	1002	1420	1237	1048	899	1368	1167	971	823	1.00	1.25	1.50
COPPER CONDUCTOR SEGMENTAL															
1000	1052	958	847	749	1019	905	781	678	988	860	729	624	0.78	0.96	1.14
1250	1207	1093	961	847	1167	1030	883	765	1129	977	823	702	0.85	1.04	1.24
1500	1348	1215	1063	934	1301	1143	975	841	1256	1081	906	771	0.90	1.12	1.33
1750	1475	1326	1156	1012	1423	1244	1057	910	1372	1175	981	833	0.96	1.19	1.42
2000	1595	1428	1240	1083	1536	1338	1133	972	1479	1262	1050	889	1.00	1.25	1.50
2250	1697	1515	1312	1143	1632	1417	1196	1024	1570	1335	1107	936	1.05	1.31	1.57
2500	1796	1599	1381	1201	1726	1493	1258	1075	1659	1406	1163	982	1.08	1.36	1.63
3000	1978	1752	1506	1305	1896	1632	1367	1165	1819	1533	1262	1062	1.16	1.46	1.75

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 30LF	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 30LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 30LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0350 PF AND RHO 60	90	120
9 CABLES IN DUCT BANK 8 KV 85 C CONDUCTOR 20 C AMBIENT EARTH															
COPPER CONDUCTOR CONCENTRIC STRAND															
6	114	107	99	91	112	104	94	85	110	101	90	80	0.27	0.32	0.36
4	150	141	129	118	147	136	122	110	144	132	117	103	0.31	0.36	0.41
2	197	184	167	152	193	177	158	141	189	171	151	133	0.39	0.45	0.52
1	226	211	191	173	221	203	180	161	217	196	172	151	0.42	0.49	0.56
1/0	260	242	218	198	254	232	206	183	249	224	195	171	0.45	0.53	0.60
2/0	299	277	249	225	292	266	234	207	286	256	222	194	0.48	0.57	0.65
3/0	344	318	284	256	335	304	267	235	328	292	253	220	0.51	0.61	0.70
4/0	396	364	325	291	386	348	304	267	377	334	287	249	0.56	0.66	0.77
250	437	401	356	319	425	382	333	292	415	367	315	272	0.58	0.70	0.81
350	537	490	432	384	521	465	403	351	508	445	379	326	0.65	0.79	0.91
500	666	603	528	466	645	571	490	425	627	545	460	394	0.74	0.89	1.04
750	847	760	659	578	818	716	609	525	793	682	570	485	0.85	1.04	1.22
1000	998	889	765	669	961	835	705	605	930	793	659	558	0.94	1.16	1.36
1250	1128	1000	856	745	1084	937	787	672	1048	887	733	619	1.02	1.26	1.49
1500	1241	1094	932	809	1191	1023	855	728	1149	967	795	669	1.09	1.35	1.60
1750	1338	1174	996	862	1281	1095	912	775	1235	1034	848	712	1.16	1.44	1.71
2000	1425	1246	1053	910	1363	1160	963	816	1312	1094	894	749	1.22	1.52	1.80
COPPER CONDUCTOR SEGMENTAL															
1000	1022	911	784	685	985	856	723	620	953	812	675	571	0.94	1.16	1.36
1250	1171	1037	888	773	1125	972	816	697	1087	920	760	642	1.02	1.26	1.49
1500	1305	1151	980	850	1252	1075	899	766	1208	1017	836	704	1.09	1.35	1.60
1750	1427	1253	1063	920	1367	1169	973	827	1317	1103	904	759	1.16	1.44	1.71
2000	1541	1347	1139	983	1473	1255	1041	883	1418	1183	966	810	1.22	1.52	1.80
2250	1638	1427	1202	1036	1564	1327	1098	929	1504	1249	1018	851	1.28	1.59	1.89
2500	1732	1505	1264	1088	1652	1397	1153	974	1587	1314	1068	892	1.32	1.65	1.97
3000	1903	1644	1375	1179	1812	1523	1251	1054	1737	1430	1157	964	1.42	1.78	2.12

CABLE CONSTANTS

SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER

INSULATED CABLE IN DUCTS

8 KV 85 C CONDUCTOR

SIZE	OD	WD	RI	RSD	QS	RAC
COPPER CONDUCTOR CONCENTRIC STRAND						
6	0.596	0.020	3.189	5.312	1.000	505.94
4	0.654	0.023	2.726	4.978	1.000	317.63
2	0.686	0.030	2.097	4.812	1.000	200.71
1	0.723	0.033	1.914	4.632	1.000	158.86
1/0	0.764	0.036	1.746	4.449	1.000	125.65
2/0	0.820	0.040	1.592	4.220	1.000	99.94
3/0	0.871	0.044	1.450	4.032	1.000	79.30
4/0	0.933	0.048	1.307	3.824	1.000	62.96
250	0.976	0.052	1.225	3.692	1.000	53.39
350	1.092	0.060	1.060	3.377	1.000	38.21
500	1.235	0.070	0.906	3.056	1.000	27.01
750	1.429	0.084	0.755	2.707	1.001	18.36
1000	1.583	0.096	0.662	2.482	1.001	14.14
1250	1.729	0.107	0.598	2.301	1.002	11.66
1500	1.863	0.116	0.548	2.157	1.003	10.07
1750	1.977	0.125	0.510	2.047	1.004	8.98
2000	2.092	0.134	0.478	1.948	1.005	8.16
COPPER CONDUCTOR SEGMENTAL						
1000	1.583	0.096	0.662	2.482	1.001	13.46
1250	1.729	0.107	0.598	2.301	1.002	10.83
1500	1.863	0.116	0.548	2.157	1.003	9.11
1750	1.977	0.125	0.510	2.047	1.004	7.88
2000	2.092	0.134	0.478	1.948	1.006	6.98
2250	2.200	0.141	0.452	1.862	1.008	6.34
2500	2.294	0.147	0.433	1.794	1.010	5.80
3000	2.478	0.161	0.397	1.674	1.015	4.98

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 30LF	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 30LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 30LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0300 PF AND RHO 60	90	120
3 CABLES IN DUCT BANK 15 KV 80 C CONDUCTOR 20 C AMBIENT EARTH															
COPPER CONDUCTOR CONCENTRIC STRAND															
4	148	144	139	132	146	142	134	127	145	139	131	122	0.49	0.55	0.60
2	195	189	182	173	193	186	176	165	191	183	171	158	0.54	0.60	0.67
1	225	218	209	198	223	214	202	189	220	210	196	181	0.61	0.68	0.75
1/0	259	251	240	227	256	246	231	216	254	241	224	207	0.64	0.72	0.80
2/0	298	288	274	260	294	282	265	247	291	276	256	235	0.68	0.76	0.85
3/0	343	331	315	297	339	324	303	282	335	317	292	268	0.72	0.81	0.90
4/0	396	382	362	341	391	373	348	322	387	364	335	307	0.76	0.86	0.96
250	438	422	399	375	432	412	383	354	427	402	369	337	0.79	0.90	1.00
350	540	519	488	457	532	505	467	430	525	492	449	407	0.86	0.98	1.10
500	671	642	602	560	661	623	574	525	651	606	549	496	0.95	1.09	1.23
750	858	817	761	704	843	791	723	657	829	767	690	618	1.06	1.22	1.39
1000	1016	964	894	823	997	931	846	766	979	901	805	718	1.14	1.33	1.52
1250	1153	1090	1007	924	1130	1051	950	856	1108	1015	902	802	1.22	1.43	1.64
1500	1272	1199	1103	1009	1245	1154	1039	933	1220	1112	984	872	1.28	1.51	1.74
1750	1374	1292	1185	1081	1344	1242	1114	998	1315	1195	1054	931	1.34	1.59	1.83
2000	1466	1376	1258	1145	1433	1320	1181	1055	1401	1269	1115	982	1.40	1.66	1.92
COPPER CONDUCTOR SEGMENTAL															
1000	1042	989	916	844	1023	955	867	785	1004	924	825	736	1.14	1.33	1.52
1250	1197	1132	1045	959	1174	1091	987	889	1151	1054	937	832	1.22	1.43	1.64
1500	1339	1263	1162	1063	1312	1215	1094	983	1285	1171	1037	918	1.28	1.51	1.74
1750	1469	1381	1267	1156	1437	1327	1191	1067	1406	1277	1127	995	1.34	1.59	1.83
2000	1589	1492	1364	1241	1553	1431	1280	1144	1519	1376	1209	1065	1.40	1.66	1.92
2250	1692	1585	1446	1313	1652	1518	1354	1207	1614	1458	1278	1123	1.45	1.72	2.00
2500	1795	1678	1527	1384	1751	1606	1429	1271	1710	1540	1346	1181	1.50	1.79	2.07
3000	1980	1845	1672	1510	1929	1762	1560	1383	1881	1687	1467	1283	1.58	1.89	2.21
6 CABLES IN DUCT BANK 15 KV 80 C CONDUCTOR 20 C AMBIENT EARTH															
COPPER CONDUCTOR CONCENTRIC STRAND															
4	145	138	129	120	142	134	123	112	140	130	118	106	0.63	0.73	0.83
2	190	181	168	155	187	175	159	145	184	170	152	136	0.70	0.82	0.93
1	219	208	193	177	215	201	182	165	212	194	174	155	0.79	0.92	1.06
1/0	252	239	220	202	248	230	208	188	243	223	198	176	0.84	0.98	1.13
2/0	289	273	251	230	284	263	237	213	278	254	225	199	0.89	1.05	1.21
3/0	333	313	287	262	326	301	270	242	319	290	256	226	0.95	1.12	1.30
4/0	384	360	329	299	376	346	309	276	368	333	292	257	1.01	1.21	1.40
250	424	397	362	328	415	380	339	302	405	366	320	281	1.06	1.27	1.47
350	521	485	440	397	509	464	410	364	496	445	387	338	1.17	1.40	1.64
500	646	598	538	483	629	569	500	441	612	544	470	408	1.30	1.58	1.85
750	822	755	674	601	798	716	623	546	774	682	583	503	1.48	1.80	2.13
1000	970	886	785	696	939	837	724	630	909	795	675	580	1.62	1.99	2.36
1250	1097	997	879	777	1060	939	808	701	1024	890	752	643	1.75	2.15	2.56
1500	1207	1092	958	844	1164	1026	878	759	1123	970	816	696	1.86	2.30	2.74
1750	1301	1173	1026	900	1253	1100	938	809	1207	1038	870	740	1.96	2.43	2.90
2000	1385	1244	1085	950	1332	1165	990	852	1281	1098	916	778	2.05	2.56	3.05
COPPER CONDUCTOR SEGMENTAL															
1000	995	908	805	714	963	858	742	646	932	815	692	594	1.62	1.99	2.36
1250	1140	1036	913	807	1101	975	839	728	1064	924	781	668	1.75	2.15	2.56
1500	1271	1150	1010	889	1226	1081	925	800	1183	1022	859	733	1.86	2.30	2.74
1750	1391	1254	1096	962	1339	1176	1003	865	1290	1110	930	791	1.96	2.43	2.90
2000	1502	1349	1176	1030	1444	1263	1073	923	1389	1190	993	843	2.05	2.56	3.05
2250	1595	1429	1242	1085	1532	1335	1132	972	1472	1257	1046	886	2.14	2.67	3.19
2500	1689	1509	1308	1140	1621	1408	1189	1019	1555	1323	1098	929	2.23	2.78	3.34
3000	1857	1651	1424	1238	1778	1536	1292	1103	1703	1440	1190	1004	2.37	2.97	3.57

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 30LF	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 30LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 30LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD M .0300 PF AND M 60	90	W
9 CABLES IN DUCT BANK 15 KV 80 C CONDUCTOR 20 C AMBIENT EARTH															
COPPER CONDUCTOR CONCENTRIC STRAND															
4	143	134	123	113	140	130	117	105	138	126	112	99	0.72	0.84	0#
2	187	176	160	146	184	169	151	135	180	164	144	127	0.80	0.94	1#
1	216	202	183	166	211	194	173	154	207	187	164	144	0.91	1.07	1#
1/0	248	231	209	189	242	222	197	175	238	214	187	164	0.97	1.14	1#
2/0	284	264	238	215	278	253	224	198	272	244	212	185	1.03	1.23	1#
3/0	327	302	271	244	318	289	255	225	311	278	241	210	1.10	1.31	1#
4/0	377	347	310	278	367	331	290	256	358	318	274	238	1.18	1.42	1#
250	416	382	340	305	404	364	318	280	395	349	300	260	1.24	1.49	1#
350	510	466	412	367	495	443	384	336	482	424	361	312	1.38	1.66	1#
500	630	572	502	445	610	541	466	405	593	517	438	375	1.54	1.87	2#
750	800	720	626	551	772	678	579	500	748	645	541	461	1.77	2.16	2#
1000	942	842	727	637	906	791	670	576	876	749	625	530	1.95	2.39	2#
1250	1064	945	812	708	1021	885	746	638	985	837	694	587	2.11	2.59	3#
1500	1168	1033	883	768	1119	965	809	690	1078	911	751	634	2.25	2.78	3#
1750	1257	1108	943	818	1202	1032	862	734	1157	973	800	673	2.38	2.94	3#
2000	1337	1173	995	861	1276	1091	908	772	1226	1027	841	706	2.50	3.10	3#
COPPER CONDUCTOR SEGMENTAL															
1000	966	864	746	653	929	811	687	590	899	768	640	543	1.95	2.39	2#
1250	1105	982	843	736	1060	919	774	663	1023	869	721	609	2.11	2.59	3#
1500	1230	1088	930	809	1178	1016	852	727	1135	959	791	667	2.25	2.78	3#
1750	1344	1184	1008	874	1285	1103	922	785	1236	1040	855	719	2.38	2.94	3#
2000	1449	1272	1079	934	1384	1183	985	837	1329	1113	912	766	2.50	3.10	3#
2250	1538	1345	1138	983	1466	1249	1037	880	1407	1174	959	804	2.61	3.24	3#
2500	1627	1419	1196	1031	1549	1315	1088	922	1484	1234	1006	842	2.72	3.39	4#
3000	1785	1548	1299	1117	1695	1431	1179	996	1622	1341	1088	908	2.90	3.63	4#

CABLE CONSTANTS

SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

15 KV 80 C CONDUCTOR

SIZE	OD	WD	RI	RSD	QS	RAC
COPPER CONDUCTOR CONCENTRIC STRAND						
4	0.774	0.054	3.518	4.406	1.000	312.47
2	0.846	0.064	3.011	4.122	1.000	197.45
1	0.853	0.073	2.621	4.096	1.000	156.30
1/0	0.894	0.080	2.408	3.952	1.000	123.61
2/0	0.940	0.087	2.211	3.802	1.000	98.32
3/0	0.991	0.095	2.027	3.648	1.000	78.01
4/0	1.063	0.104	1.840	3.451	1.000	61.94
250	1.106	0.111	1.731	3.343	1.000	52.53
350	1.222	0.127	1.511	3.083	1.000	37.60
500	1.355	0.148	1.302	2.831	1.000	26.59
750	1.549	0.176	1.095	2.529	1.001	18.08
1000	1.713	0.199	0.966	2.320	1.001	13.93
1250	1.859	0.220	0.875	2.161	1.002	11.50
1500	1.993	0.239	0.805	2.033	1.004	9.95
1750	2.107	0.256	0.752	1.935	1.005	8.87
2000	2.222	0.272	0.707	1.846	1.006	8.09
COPPER CONDUCTOR SEGMENTAL						
1000	1.713	0.199	0.966	2.320	1.002	13.25
1250	1.859	0.220	0.875	2.161	1.003	10.66
1500	1.993	0.239	0.805	2.033	1.004	8.97
1750	2.107	0.256	0.752	1.935	1.005	7.76
2000	2.222	0.272	0.707	1.846	1.007	6.88
2250	2.320	0.287	0.671	1.776	1.009	6.25
2500	2.424	0.302	0.638	1.707	1.012	5.71
3000	2.608	0.328	0.588	1.598	1.019	4.91

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0250 PF AND RHO 60	90	120
3 CABLES IN DUCT BANK 25 KV 75 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
1	206	197	188	202	191	179	198	185	172	1.02	1.14	1.26
1/0	237	226	215	232	219	205	227	212	196	1.07	1.20	1.33
2/0	272	259	245	266	250	233	260	242	223	1.12	1.26	1.40
3/0	313	298	281	306	287	267	299	277	254	1.23	1.38	1.54
4/0	360	342	323	352	329	305	344	317	291	1.30	1.47	1.64
250	398	377	355	388	362	335	379	348	319	1.34	1.52	1.70
350	487	460	431	474	440	406	462	423	385	1.45	1.66	1.86
500	603	567	529	586	541	496	570	518	469	1.58	1.82	2.05
750	766	716	664	742	680	620	719	649	584	1.75	2.03	2.31
1000	903	839	775	872	795	721	843	756	677	1.89	2.20	2.52
1250	1019	944	869	982	891	806	948	846	754	2.00	2.35	2.69
1500	1118	1032	947	1076	973	877	1037	922	819	2.11	2.48	2.85
1750	1205	1109	1015	1157	1043	937	1114	986	874	2.20	2.60	3.00
2000	1283	1177	1074	1230	1105	990	1182	1043	922	2.29	2.71	3.13
COPPER CONDUCTOR SEGMENTAL												
1000	926	861	795	895	815	740	865	776	694	1.89	2.20	2.52
1250	1060	981	903	1021	927	838	986	880	784	2.00	2.35	2.69
1500	1180	1089	999	1135	1026	925	1094	972	864	2.11	2.48	2.85
1750	1291	1188	1087	1240	1117	1004	1193	1056	936	2.20	2.60	3.00
2000	1392	1278	1166	1335	1199	1075	1283	1132	1001	2.29	2.71	3.13
2250	1478	1353	1233	1416	1268	1134	1359	1196	1055	2.37	2.81	3.26
2500	1563	1428	1298	1495	1336	1193	1434	1259	1108	2.44	2.90	3.37
3000	1717	1562	1415	1638	1457	1296	1568	1370	1201	2.58	3.08	3.58
6 CABLES IN DUCT BANK 25 KV 75 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
1	196	182	168	190	173	156	184	164	147	1.32	1.55	1.78
1/0	225	208	192	217	197	178	210	187	167	1.40	1.64	1.89
2/0	257	238	218	248	224	202	239	213	189	1.47	1.74	2.01
3/0	296	272	249	284	256	230	274	242	215	1.62	1.93	2.23
4/0	340	311	284	326	292	261	313	276	244	1.73	2.06	2.39
250	374	342	311	358	320	286	344	303	266	1.80	2.15	2.50
350	456	414	375	436	387	344	418	365	319	1.97	2.37	2.77
500	561	507	456	534	471	416	510	442	385	2.18	2.63	3.09
750	708	634	567	671	586	515	638	548	474	2.45	2.99	3.53
1000	829	738	656	783	680	594	742	633	545	2.68	3.29	3.89
1250	932	825	731	877	757	659	829	704	604	2.87	3.54	4.20
1500	1018	898	793	956	822	713	902	762	652	3.05	3.76	4.48
1750	1093	960	845	1023	877	758	964	811	692	3.21	3.98	4.74
2000	1159	1015	891	1083	925	798	1019	854	727	3.35	4.17	4.98
COPPER CONDUCTOR SEGMENTAL												
1000	851	757	673	803	697	609	762	650	559	2.68	3.29	3.89
1250	969	857	760	911	787	685	862	731	628	2.87	3.54	4.20
1500	1074	947	836	1008	867	752	951	804	687	3.05	3.76	4.48
1750	1170	1028	905	1096	939	812	1033	869	741	3.21	3.98	4.74
2000	1258	1101	967	1176	1004	866	1106	927	789	3.35	4.17	4.98
2250	1332	1162	1019	1242	1057	910	1166	975	829	3.49	4.35	5.20
2500	1404	1222	1069	1308	1110	954	1226	1022	867	3.61	4.51	5.40
3000	1534	1329	1159	1424	1203	1031	1332	1105	935	3.85	4.82	5.79

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0250 PF AND RHO 60	90	120
9 CABLES IN DUCT BANK 25 KV 75 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
1	190	173	158	183	164	146	177	155	137	1.53	1.81	2.07
1/0	218	198	179	209	186	166	202	177	155	1.62	1.92	2.20
2/0	249	225	204	239	212	188	230	201	176	1.71	2.04	2.35
3/0	285	257	232	273	241	213	262	228	199	1.89	2.26	2.61
4/0	327	293	264	312	274	242	300	259	225	2.02	2.42	2.80
250	360	322	289	343	301	265	329	284	246	2.11	2.53	2.94
350	438	389	347	416	362	317	397	340	294	2.32	2.80	3.26
500	537	473	420	508	439	383	484	412	354	2.58	3.13	3.66
750	675	589	520	635	544	471	603	508	434	2.93	3.58	4.20
1000	788	683	600	738	628	541	699	585	497	3.22	3.95	4.65
1250	883	761	666	825	698	599	779	648	549	3.46	4.26	5.03
1500	962	826	721	897	756	647	845	700	592	3.68	4.55	5.38
1750	1031	882	767	958	804	687	901	744	627	3.89	4.81	5.70
2000	1091	930	807	1012	847	721	950	782	658	4.07	5.05	6.00
COPPER CONDUCTOR SEGMENTAL												
1000	808	701	616	758	644	555	717	600	510	3.22	3.95	4.65
1250	918	791	692	857	725	623	809	674	571	3.46	4.26	5.03
1500	1015	871	760	946	797	682	891	738	624	3.68	4.55	5.38
1750	1104	944	821	1026	861	735	965	797	672	3.89	4.81	5.70
2000	1184	1009	876	1099	919	783	1031	848	714	4.07	5.05	6.00
2250	1252	1063	921	1159	966	822	1086	891	749	4.25	5.28	6.27
2500	1318	1116	965	1218	1013	860	1140	933	783	4.41	5.49	6.53
3000	1436	1210	1043	1323	1095	927	1234	1006	842	4.71	5.88	7.01

CABLE CONSTANTS

SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

25 KV 75 C CONDUCTOR

SIZE	OD	WD	RI	RSD	QS	RAC
COPPER CONDUCTOR CONCENTRIC STRAND						
1	1.063	0.125	3.557	3.451	1.000	153.84
1/0	1.104	0.135	3.299	3.348	1.000	121.67
2/0	1.150	0.146	3.053	3.239	1.000	96.79
3/0	1.171	0.164	2.714	3.192	1.000	76.79
4/0	1.243	0.179	2.483	3.040	1.000	60.97
250	1.286	0.190	2.345	2.956	1.000	51.71
350	1.392	0.216	2.066	2.768	1.000	37.02
500	1.535	0.248	1.800	2.548	1.001	26.18
750	1.729	0.292	1.528	2.301	1.001	17.82
1000	1.893	0.329	1.355	2.127	1.002	13.74
1250	2.039	0.361	1.235	1.992	1.003	11.35
1500	2.163	0.390	1.143	1.891	1.005	9.83
1750	2.287	0.418	1.068	1.799	1.006	8.78
2000	2.402	0.443	1.007	1.722	1.008	8.00
COPPER CONDUCTOR SEGMENTAL						
1000	1.893	0.329	1.355	2.127	1.002	13.04
1250	2.039	0.361	1.235	1.992	1.004	10.50
1500	2.163	0.390	1.143	1.891	1.005	8.83
1750	2.287	0.418	1.068	1.799	1.007	7.65
2000	2.402	0.443	1.007	1.722	1.010	6.78
2250	2.500	0.466	0.957	1.661	1.013	6.17
2500	2.604	0.488	0.915	1.601	1.016	5.64
3000	2.788	0.529	0.843	1.504	1.024	4.85

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0220 PF AND RHO 60	90	120
3 CABLES IN DUCT BANK 37 KV 70 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
3/0	293	279	264	286	269	251	280	259	239	1.87	2.11	2.35
4/0	337	320	303	329	308	287	321	297	273	1.96	2.22	2.48
250	371	353	333	362	339	315	353	326	299	2.02	2.30	2.57
350	455	430	404	443	412	381	431	396	361	2.17	2.48	2.79
500	562	529	495	545	505	465	530	483	439	2.35	2.70	3.05
750	712	667	620	689	633	579	667	604	545	2.59	2.99	3.40
1000	836	780	723	807	739	673	780	703	631	2.77	3.23	3.69
1250	943	876	809	908	828	751	876	785	703	2.93	3.43	3.93
1500	1034	958	882	995	903	816	958	855	762	3.08	3.61	4.15
1750	1113	1028	944	1068	967	872	1027	914	813	3.21	3.78	4.35
2000	1180	1087	996	1131	1020	918	1086	963	854	3.32	3.93	4.54
COPPER CONDUCTOR SEGMENTAL												
1000	859	801	742	829	759	691	801	722	648	2.77	3.23	3.69
1250	981	912	842	945	861	781	912	817	731	2.93	3.43	3.93
1500	1092	1011	931	1050	953	862	1011	902	805	3.08	3.61	4.15
1750	1192	1101	1011	1145	1035	934	1100	979	870	3.21	3.78	4.35
2000	1285	1184	1084	1231	1111	999	1182	1048	930	3.32	3.93	4.54
2250	1363	1253	1145	1304	1174	1054	1251	1106	979	3.44	4.07	4.71
2500	1441	1321	1205	1377	1236	1107	1319	1163	1027	3.53	4.20	4.87
3000	1578	1442	1311	1505	1345	1200	1438	1262	1111	3.72	4.44	5.17
6 CABLES IN DUCT BANK 37 KV 70 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
3/0	276	255	234	265	240	216	256	227	201	2.47	2.94	3.40
4/0	317	291	266	304	273	245	292	258	228	2.61	3.12	3.62
250	349	320	292	334	300	268	321	283	249	2.71	3.24	3.77
350	425	388	352	406	362	322	388	340	299	2.95	3.54	4.14
500	522	473	427	496	439	389	473	412	360	3.24	3.92	4.59
750	657	590	529	621	545	480	590	508	441	3.62	4.41	5.20
1000	767	685	612	723	630	552	684	586	506	3.93	4.81	5.69
1250	860	765	680	808	701	612	762	650	559	4.20	5.16	6.13
1500	940	832	737	880	760	661	828	703	603	4.44	5.48	6.52
1750	1007	889	786	941	810	703	883	747	639	4.66	5.77	6.87
2000	1064	936	825	991	850	736	929	783	668	4.86	6.03	7.20
COPPER CONDUCTOR SEGMENTAL												
1000	788	704	628	742	647	567	702	602	520	3.93	4.81	5.69
1250	895	796	708	841	730	637	793	676	582	4.20	5.16	6.13
1500	992	878	778	929	802	698	874	742	636	4.44	5.48	6.52
1750	1079	952	841	1008	867	753	946	800	685	4.66	5.77	6.87
2000	1158	1019	898	1079	926	802	1011	852	728	4.86	6.03	7.20
2250	1225	1074	945	1139	974	842	1065	895	763	5.05	6.29	7.51
2500	1290	1129	991	1197	1021	881	1118	937	797	5.22	6.51	7.79
3000	1405	1223	1070	1300	1103	948	1209	1009	855	5.54	6.94	8.33

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0220 PF AND RHO 60	90	120
9 CABLES IN DUCT BANK 37 KV 70 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
3/0	267	241	218	255	226	200	244	213	187	2.88	3.44	3.98
4/0	305	274	247	291	257	227	279	242	211	3.06	3.67	4.25
250	336	301	271	319	281	248	306	264	230	3.18	3.82	4.44
350	408	363	325	387	338	297	369	317	275	3.48	4.19	4.88
500	499	441	393	471	409	357	448	382	329	3.84	4.66	5.44
750	625	548	485	587	505	438	555	470	402	4.32	5.27	6.19
1000	727	634	558	680	581	502	641	539	460	4.71	5.77	6.80
1250	814	705	619	758	644	555	713	596	507	5.05	6.22	7.34
1500	886	765	669	823	696	598	772	643	545	5.36	6.62	7.82
1750	948	815	711	878	740	634	821	681	576	5.64	6.98	8.26
2000	999	856	745	923	776	663	862	712	601	5.90	7.31	8.67
COPPER CONDUCTOR SEGMENTAL												
1000	747	651	573	698	597	516	659	554	472	4.71	5.77	6.80
1250	847	734	644	789	670	577	742	620	527	5.05	6.22	7.34
1500	936	807	706	869	735	631	815	678	575	5.36	6.62	7.82
1750	1015	873	762	940	793	679	880	730	617	5.64	6.98	8.26
2000	1088	931	811	1005	844	722	938	776	655	5.90	7.31	8.67
2250	1148	980	852	1058	886	756	986	813	685	6.14	7.63	9.06
2500	1207	1028	892	1110	928	790	1033	849	714	6.36	7.91	9.41
3000	1311	1111	960	1201	999	848	1113	911	765	6.78	8.46	10.07

CABLE CONSTANTS

SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

37 KV 70 C CONDUCTOR

SIZE	OD	WD	RI	RSD	QS	RAC
COPPER CONDUCTOR CONCENTRIC STRAND						
3/0	1.391	0.252	3.413	2.769	1.000	75.57
4/0	1.463	0.273	3.146	2.654	1.000	60.01
250	1.506	0.288	2.986	2.590	1.000	50.90
350	1.622	0.324	2.654	2.431	1.000	36.44
500	1.755	0.369	2.332	2.272	1.001	25.78
750	1.949	0.430	2.000	2.073	1.002	17.55
1000	2.113	0.481	1.789	1.930	1.003	13.55
1250	2.259	0.526	1.636	1.819	1.005	11.20
1500	2.393	0.567	1.518	1.727	1.007	9.70
1750	2.507	0.604	1.425	1.656	1.009	8.66
2000	2.622	0.638	1.348	1.591	1.012	7.93
COPPER CONDUCTOR SEGMENTAL						
1000	2.113	0.481	1.789	1.930	1.003	12.84
1250	2.259	0.526	1.636	1.819	1.005	10.34
1500	2.393	0.567	1.518	1.727	1.008	8.70
1750	2.507	0.604	1.425	1.656	1.010	7.54
2000	2.622	0.638	1.348	1.591	1.014	6.68
2250	2.720	0.671	1.282	1.538	1.017	6.08
2500	2.824	0.701	1.227	1.487	1.022	5.56
3000	3.008	0.758	1.135	1.403	1.031	4.79

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0180 PF AND RHO 60	90	120
3 CABLES IN DUCT BANK 46 KV 65 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
4/0	316	301	285	309	290	270	301	279	257	2.17	2.46	2.75
250	349	331	313	340	318	296	332	306	282	2.24	2.54	2.84
350	426	404	380	415	387	358	404	371	340	2.39	2.73	3.07
500	526	496	465	510	474	437	496	453	413	2.58	2.96	3.35
750	665	624	582	644	593	544	624	566	512	2.82	3.27	3.71
1000	781	730	677	754	691	631	728	658	592	3.02	3.51	4.01
1250	880	819	758	847	774	704	817	734	658	3.18	3.72	4.27
1500	963	894	825	926	842	764	891	798	713	3.34	3.92	4.50
1750	1036	959	882	994	902	815	955	852	760	3.47	4.09	4.71
2000	1098	1014	931	1052	952	858	1009	898	798	3.59	4.24	4.89
COPPER CONDUCTOR SEGMENTAL												
1000	803	750	696	775	711	648	749	676	608	3.02	3.51	4.01
1250	916	853	789	882	806	733	851	765	686	3.18	3.72	4.27
1500	1018	945	872	979	891	807	942	843	754	3.34	3.92	4.50
1750	1112	1029	947	1067	968	875	1025	915	815	3.47	4.09	4.71
2000	1197	1105	1014	1146	1037	935	1100	979	870	3.59	4.24	4.89
2250	1269	1169	1071	1214	1095	986	1163	1032	915	3.71	4.39	5.07
2500	1340	1232	1126	1280	1152	1035	1225	1084	960	3.81	4.53	5.24
3000	1466	1343	1223	1397	1252	1120	1334	1175	1036	4.01	4.78	5.55
6 CABLES IN DUCT BANK 46 KV 65 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
4/0	298	274	251	285	257	231	274	243	215	2.90	3.46	4.02
250	327	301	275	313	282	253	300	266	235	3.00	3.59	4.17
350	398	364	331	380	339	303	363	319	281	3.25	3.91	4.56
500	489	444	401	464	412	366	442	386	338	3.55	4.29	5.03
750	614	553	497	580	511	450	550	476	414	3.95	4.81	5.67
1000	716	641	574	674	590	518	637	547	474	4.27	5.23	6.19
1250	802	715	638	752	655	573	709	606	523	4.55	5.60	6.64
1500	874	776	690	817	709	618	768	654	562	4.80	5.93	7.05
1750	936	829	734	873	754	656	819	694	596	5.03	6.23	7.42
2000	989	872	771	920	792	687	860	727	623	5.24	6.50	7.76
COPPER CONDUCTOR SEGMENTAL												
1000	736	659	590	692	606	532	654	562	487	4.27	5.23	6.19
1250	835	745	664	784	682	597	738	631	544	4.55	5.60	6.64
1500	924	821	729	864	749	653	812	691	595	4.80	5.93	7.05
1750	1005	889	788	937	809	704	879	745	639	5.03	6.23	7.42
2000	1078	951	840	1003	863	749	938	793	678	5.24	6.50	7.76
2250	1139	1002	883	1057	907	786	987	832	710	5.43	6.76	8.08
2500	1198	1052	925	1110	950	821	1034	869	741	5.62	7.00	8.38
3000	1303	1138	998	1203	1024	882	1116	934	794	5.96	7.45	8.93

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

9 CABLES IN DUCT BANK 46 KV 65 C CONDUCTOR 20 C AMBIENT EARTH

SIZE	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0180 PF AND RHO 60	90	120
COPPER CONDUCTOR CONCENTRIC STRAND												
4/0	287	258	233	273	241	214	261	227	198	3.40	4.07	4.72
250	315	283	255	299	264	233	286	248	216	3.52	4.23	4.91
350	382	341	306	362	317	279	345	297	258	3.84	4.63	5.39
500	467	414	370	440	383	335	418	358	309	4.21	5.10	5.96
750	584	513	455	547	472	411	517	439	377	4.71	5.75	6.75
1000	678	593	523	633	543	470	596	503	430	5.12	6.28	7.39
1250	758	659	580	705	601	519	661	555	473	5.48	6.73	7.95
1500	824	713	625	763	648	558	714	597	507	5.80	7.15	8.46
1750	880	759	664	813	688	591	759	632	535	6.09	7.53	8.92
2000	927	797	696	855	721	617	796	660	558	6.36	7.87	9.33
COPPER CONDUCTOR SEGMENTAL												
1000	697	609	538	651	558	483	613	517	442	5.12	6.28	7.39
1250	789	686	604	734	626	540	689	578	492	5.48	6.73	7.95
1500	871	754	661	807	685	590	755	631	536	5.80	7.15	8.46
1750	945	814	712	873	738	634	815	678	575	6.09	7.53	8.92
2000	1011	868	758	932	785	673	867	719	608	6.36	7.87	9.33
2250	1066	913	795	980	824	704	910	753	636	6.61	8.20	9.73
2500	1120	957	832	1027	861	735	952	785	662	6.85	8.51	10.11
3000	1214	1032	894	1108	924	787	1024	840	706	7.28	9.07	10.80

CABLE CONSTANTS

SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

46 KV 65 C CONDUCTOR

SIZE	OD	WD	RI	RSD	QS	RAC
COPPER CONDUCTOR CONCENTRIC STRAND						
4/0	1.633	0.304	3.581	2.417	1.000	59.04
250	1.676	0.319	3.408	2.364	1.000	50.08
350	1.782	0.357	3.045	2.242	1.001	35.86
500	1.925	0.404	2.693	2.096	1.001	25.38
750	2.119	0.468	2.322	1.925	1.002	17.29
1000	2.283	0.522	2.085	1.802	1.004	13.35
1250	2.429	0.568	1.914	1.704	1.006	11.05
1500	2.553	0.611	1.780	1.629	1.009	9.58
1750	2.677	0.650	1.673	1.561	1.012	8.57
2000	2.792	0.686	1.587	1.502	1.015	7.84
COPPER CONDUCTOR SEGMENTAL						
1000	2.283	0.522	2.085	1.802	1.004	12.64
1250	2.429	0.568	1.914	1.704	1.007	10.18
1500	2.553	0.611	1.780	1.629	1.010	8.57
1750	2.677	0.650	1.673	1.561	1.013	7.43
2000	2.792	0.686	1.587	1.502	1.018	6.59
2250	2.890	0.719	1.513	1.456	1.022	5.99
2500	2.994	0.752	1.447	1.409	1.027	5.48
3000	3.178	0.811	1.343	1.334	1.039	4.73

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0150 PF AND RHO 60	90	120
3 CABLES IN DUCT BANK 69 KV 55 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
500	443	419	394	428	399	370	415	381	349	3.77	4.33	4.89
750	557	525	492	538	498	459	519	474	430	4.09	4.73	5.37
1000	652	612	570	627	578	530	603	548	496	4.34	5.05	5.75
1250	731	684	636	701	644	589	673	609	549	4.56	5.32	6.09
1500	798	745	690	764	699	637	732	659	593	4.75	5.57	6.38
1750	856	796	736	817	746	678	781	702	629	4.93	5.79	6.66
2000	905	841	775	863	786	712	823	737	659	5.09	6.00	6.91
COPPER CONDUCTOR SEGMENTAL												
1000	671	630	587	645	595	545	621	564	510	4.34	5.05	5.75
1250	763	714	664	732	673	615	703	636	573	4.56	5.32	6.09
1500	846	790	732	810	741	675	776	699	628	4.75	5.57	6.38
1750	921	857	792	880	803	730	841	755	677	4.93	5.79	6.66
2000	989	918	847	943	858	778	900	806	720	5.09	6.00	6.91
2250	1047	970	893	996	904	818	949	847	755	5.24	6.19	7.14
2500	1103	1019	937	1047	949	856	996	887	790	5.38	6.36	7.36
3000	1201	1107	1013	1138	1026	923	1078	956	848	5.63	6.69	7.76
6 CABLES IN DUCT BANK 69 KV 55 C CONDUCTOR 20 C AMBIENT EARTH												
COPPER CONDUCTOR CONCENTRIC STRAND												
500	408	373	339	385	344	307	364	320	281	5.18	6.26	7.34
750	509	462	417	478	423	375	449	391	341	5.70	6.94	8.17
1000	591	533	479	551	486	429	516	446	388	6.12	7.49	8.84
1250	659	592	530	612	536	472	570	491	425	6.49	7.96	9.43
1500	716	640	572	662	578	507	614	526	455	6.81	8.39	9.96
1750	764	680	606	703	612	535	650	555	479	7.11	8.78	10.45
2000	804	714	635	738	640	558	680	579	498	7.38	9.14	10.89
COPPER CONDUCTOR SEGMENTAL												
1000	609	549	494	568	500	441	531	459	400	6.12	7.49	8.84
1250	688	618	554	639	560	493	595	512	444	6.49	7.96	9.43
1500	759	678	606	702	612	537	651	558	482	6.81	8.39	9.96
1750	822	732	652	757	658	576	699	597	515	7.11	8.78	10.45
2000	878	780	693	806	699	610	742	632	543	7.38	9.14	10.89
2250	925	820	727	847	732	637	777	660	566	7.64	9.47	11.30
2500	971	858	759	885	763	663	810	686	587	7.87	9.79	11.70
3000	1049	923	813	952	816	706	865	729	622	8.31	10.37	12.42

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SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO-60 50LF	RHO-60 75LF	RHO-60 100LF	RHO-90 50LF	RHO-90 75LF	RHO-90 100LF	RHO-120 50LF	RHO-120 75LF	RHO-120 100LF	DELTA TD FOR .0150 PF AND RHO 60	90	120
				9 CABLES IN DUCT BANK 69 KV 55 C CONDUCTOR 20 C AMBIENT EARTH								
				COPPER CONDUCTOR CONCENTRIC STRAND								
500	388	346	310	362	317	279	340	293	254	6.14	7.44	8.69
750	481	426	380	446	387	339	416	356	307	6.80	8.28	9.71
1000	556	489	434	512	442	385	475	403	347	7.33	8.97	10.55
1250	617	540	478	566	486	421	522	441	378	7.80	9.57	11.28
1500	668	582	513	609	521	451	560	471	402	8.21	10.10	11.93
1750	710	617	542	645	549	474	590	494	421	8.59	10.60	12.54
2000	745	645	566	674	572	493	614	513	436	8.94	11.05	13.09
				COPPER CONDUCTOR SEGMENTAL								
1000	572	503	447	527	455	396	489	415	357	7.33	8.97	10.55
1250	644	564	499	591	507	440	545	461	394	7.80	9.57	11.28
1500	708	617	544	646	552	477	593	499	426	8.21	10.10	11.93
1750	764	664	583	694	591	510	635	532	453	8.59	10.60	12.54
2000	814	705	618	736	625	538	671	560	476	8.94	11.05	13.09
2250	855	738	646	770	652	560	699	582	494	9.26	11.47	13.60
2500	895	770	673	803	678	581	726	603	510	9.57	11.87	14.09
3000	962	824	717	857	720	615	769	636	536	10.14	12.61	14.99

CABLE CONSTANTS

SINGLE CONDUCTOR SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

69 KV 55 C CONDUCTOR

SIZE	OD	WD	RI	RSD	QS	RAC
			COPPER CONDUCTOR CONCENTRIC STRAND			
500	2.355	0.587	3.479	1.752	1.003	24.55
750	2.549	0.671	3.040	1.632	1.005	16.75
1000	2.713	0.741	2.753	1.542	1.008	12.96
1250	2.859	0.802	2.543	1.470	1.012	10.75
1500	2.993	0.858	2.380	1.410	1.016	9.33
1750	3.107	0.909	2.246	1.362	1.020	8.35
2000	3.222	0.955	2.136	1.317	1.025	7.65
			COPPER CONDUCTOR SEGMENTAL			
1000	2.713	0.741	2.753	1.542	1.008	12.23
1250	2.859	0.802	2.543	1.470	1.013	9.85
1500	2.993	0.858	2.380	1.410	1.018	8.30
1750	3.107	0.909	2.246	1.362	1.023	7.20
2000	3.222	0.955	2.136	1.317	1.030	6.39
2250	3.320	0.999	2.044	1.281	1.036	5.82
2500	3.424	1.041	1.961	1.245	1.045	5.33
3000	3.608	1.117	1.827	1.186	1.063	4.60

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THREE CONDUCTOR BELTED SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO 60 50 LF	RHO 60 75 LF	RHO 60 100 LF	RHO 90 50 LF	RHO 90 75 LF	RHO 90 100 LF	RHO 120 50 LF	RHO 120 75 LF	RHO 120 100 LF	DELTA TD FOR .0400 PF AND RHO 60	90	120
						COPPER CONDUCTOR						
						1 CABLE IN DUCT BANK 8 KV 80 C CONDUCTOR 20 C AMBIENT EARTH						
6	80	78	76	79	77	74	78	75	72	0.33	0.35	0.37
4	105	102	99	103	100	96	102	98	94	0.35	0.38	0.40
2	137	133	129	135	131	125	134	128	122	0.38	0.41	0.43
1	157	153	148	156	150	144	154	147	140	0.39	0.42	0.45
1/0	181	176	170	179	172	164	176	169	160	0.40	0.43	0.46
2/0	206	200	194	204	196	187	201	192	181	0.51	0.55	0.59
3/0	237	230	222	234	225	214	231	220	208	0.54	0.59	0.63
4/0	274	266	256	270	259	246	267	253	238	0.57	0.63	0.67
250	304	294	282	299	286	271	295	279	262	0.60	0.66	0.71
350	374	361	345	368	351	330	362	341	319	0.67	0.74	0.80
500	464	446	425	456	432	405	448	420	390	0.77	0.85	0.92
750	590	564	535	578	544	507	566	527	487	0.93	1.04	1.14
1000	693	659	622	677	634	588	662	612	562	1.14	1.29	1.41
						3 CABLES IN DUCT BANK 8 KV 80 C CONDUCTOR 20 C AMBIENT EARTH						
6	77	73	69	75	70	65	73	68	62	0.42	0.47	0.53
4	100	95	89	98	91	84	95	87	80	0.45	0.52	0.58
2	130	123	115	127	118	108	124	113	103	0.49	0.56	0.63
1	150	141	131	146	135	124	142	129	117	0.51	0.59	0.66
1/0	172	161	150	167	154	141	162	147	133	0.53	0.61	0.69
2/0	196	183	170	190	174	159	184	167	150	0.68	0.78	0.89
3/0	225	210	194	218	199	181	211	190	171	0.73	0.85	0.96
4/0	259	241	222	250	228	207	242	217	195	0.78	0.91	1.04
250	286	265	244	276	251	227	267	239	213	0.83	0.97	1.11
350	350	323	295	337	304	274	325	289	256	0.94	1.10	1.27
500	431	395	359	414	371	331	398	350	309	1.10	1.30	1.50
750	542	493	445	518	459	408	497	432	378	1.37	1.64	1.90
1000	631	570	511	601	528	466	574	495	431	1.71	2.06	2.41
						6 CABLES IN DUCT BANK 8 KV 80 C CONDUCTOR 20 C AMBIENT EARTH						
6	72	66	60	70	62	56	67	59	52	0.56	0.66	0.77
4	94	86	78	90	81	72	87	76	67	0.61	0.73	0.85
2	122	111	100	117	104	92	112	98	85	0.67	0.81	0.95
1	140	127	114	134	118	104	128	111	97	0.70	0.85	1.00
1/0	160	144	129	153	134	118	146	126	110	0.74	0.89	1.05
2/0	182	163	146	173	152	133	165	142	123	0.94	1.14	1.34
3/0	208	186	166	198	172	151	189	162	140	1.02	1.24	1.46
4/0	239	212	189	226	196	171	215	184	158	1.10	1.35	1.60
250	263	233	207	249	215	187	236	201	172	1.18	1.45	1.72
350	320	281	248	301	259	224	285	241	206	1.36	1.67	1.99
500	391	341	299	366	312	268	346	289	246	1.60	1.99	2.38
750	486	420	365	453	381	326	425	352	297	2.04	2.56	3.07
1000	561	480	415	520	434	369	485	398	335	2.59	3.26	3.93
						9 CABLES IN DUCT BANK 8 KV 80 C CONDUCTOR 20 C AMBIENT EARTH						
6	70	63	56	67	59	52	64	56	48	0.65	0.78	0.90
4	91	81	72	87	76	66	83	71	62	0.72	0.86	1.00
2	118	104	93	112	97	85	107	91	79	0.79	0.96	1.12
1	134	119	105	128	110	96	122	104	89	0.83	1.01	1.18
1/0	153	135	119	145	125	109	139	118	101	0.88	1.07	1.25
2/0	174	152	135	165	141	123	157	133	114	1.12	1.36	1.60
3/0	199	173	153	188	160	139	179	150	128	1.22	1.48	1.74
4/0	227	197	173	214	182	157	204	170	145	1.32	1.62	1.90
250	250	216	189	235	199	171	223	186	158	1.42	1.74	2.05
350	303	260	226	284	239	204	268	222	188	1.64	2.02	2.39
500	369	313	272	344	287	244	324	266	223	1.94	2.41	2.86
750	457	384	330	423	349	295	396	322	269	2.50	3.12	3.72
1000	524	436	373	482	395	332	450	363	302	3.18	3.99	4.77

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THREE CONDUCTOR BELTED SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO 60 50 LF	RHO 60 75 LF	RHO 60 100 LF	RHO 90 50 LF	RHO 90 75 LF	RHO 90 100 LF	RHO 120 50 LF	RHO 120 75 LF	RHO 120 100 LF	DELTA TD FOR .0340 PF AND RHO 60	DELTA TD FOR .0340 PF AND RHO 90	DELTA TD FOR .0340 PF AND RHO 120
						COPPER CONDUCTOR						
						1 CABLE IN DUCT BANK 15 KV 75 C CONDUCTOR 20 C AMBIENT EARTH						
4	102	99	96	101	97	93	99	96	91	0.77	0.83	0.88
2	133	129	125	131	127	121	129	124	118	0.83	0.89	0.95
1	152	148	143	150	145	139	149	142	135	0.85	0.93	0.99
1/0	174	169	164	172	166	158	170	162	154	0.93	1.02	1.08
2/0	199	193	187	197	189	180	194	185	175	0.96	1.05	1.12
3/0	228	221	214	225	216	206	222	211	199	0.99	1.08	1.16
4/0	262	254	244	258	247	235	254	241	227	1.22	1.33	1.43
250	290	280	269	285	273	258	281	266	250	1.27	1.39	1.50
350	355	342	328	349	333	314	343	324	303	1.38	1.52	1.64
500	438	421	402	429	408	383	422	396	369	1.52	1.69	1.84
750	552	528	502	540	510	476	530	494	457	1.75	1.96	2.13
1000	645	615	582	630	592	550	616	572	526	1.97	2.22	2.43
						3 CABLES IN DUCT BANK 15 KV 75 C CONDUCTOR 20 C AMBIENT EARTH						
4	97	92	86	95	88	81	92	85	77	1.01	1.16	1.30
2	126	119	111	123	114	104	119	109	99	1.10	1.26	1.42
1	145	136	127	140	130	119	137	124	112	1.14	1.32	1.50
1/0	165	155	144	160	147	135	156	141	127	1.26	1.45	1.65
2/0	188	176	164	183	168	153	177	160	144	1.31	1.52	1.73
3/0	215	201	186	209	191	174	202	182	163	1.36	1.58	1.81
4/0	246	229	212	238	217	197	230	207	185	1.67	1.95	2.23
250	272	252	232	262	238	216	253	227	202	1.76	2.06	2.35
350	331	306	280	319	288	259	307	273	243	1.95	2.29	2.63
500	405	373	339	389	349	313	374	330	291	2.19	2.59	3.00
750	507	462	418	484	430	383	463	405	355	2.57	3.07	3.57
1000	587	532	478	558	493	436	532	461	403	2.95	3.54	4.16
						6 CABLES IN DUCT BANK 15 KV 75 C CONDUCTOR 20 C AMBIENT EARTH						
4	91	83	75	87	78	69	84	73	64	1.38	1.66	1.94
2	118	107	96	112	99	88	108	94	82	1.51	1.83	2.14
1	135	122	109	128	113	100	123	106	92	1.59	1.93	2.27
1/0	153	138	124	146	128	113	139	120	104	1.75	2.14	2.51
2/0	175	157	140	166	145	127	158	136	118	1.84	2.24	2.65
3/0	199	178	159	189	164	144	179	154	133	1.92	2.36	2.79
4/0	226	202	179	214	186	162	203	173	149	2.37	2.91	3.44
250	249	221	196	235	203	177	223	189	163	2.51	3.09	3.66
350	302	266	235	283	244	211	267	226	193	2.81	3.48	4.14
500	366	321	282	343	292	252	322	270	230	3.21	3.99	4.77
750	453	393	342	421	355	305	393	327	276	3.83	4.80	5.76
1000	520	447	387	480	402	343	446	368	310	4.45	5.61	6.75
						9 CABLES IN DUCT BANK 15 KV 75 C CONDUCTOR 20 C AMBIENT EARTH						
4	88	78	70	83	73	64	80	68	59	1.63	1.96	2.29
2	113	100	89	107	93	81	102	87	75	1.79	2.17	2.54
1	129	114	101	122	105	92	116	99	85	1.89	2.30	2.70
1/0	147	129	114	139	119	104	132	112	96	2.09	2.55	2.99
2/0	167	146	129	157	135	117	150	126	108	2.20	2.69	3.16
3/0	190	165	146	179	153	132	170	143	122	2.31	2.83	3.33
4/0	215	187	164	202	172	148	191	160	136	2.85	3.49	4.11
250	236	204	179	221	188	162	209	175	148	3.02	3.71	4.38
350	285	245	214	266	224	192	251	208	176	3.40	4.20	4.97
500	345	294	255	320	268	228	301	247	208	3.90	4.84	5.76
750	424	358	308	391	324	274	365	297	249	4.69	5.85	6.97
1000	484	405	347	443	364	307	412	333	278	5.48	6.86	8.20

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CABLE CONSTANTS

THREE CONDUCTOR BELTED SOLID TYPE IMPREGNATED PAPER

INSULATED CABLE IN DUCTS

COPPER CONDUCTOR

8 KV 80 C CONDUCTOR

SIZE	OD	WD	RI	RSD	QS	RAC
6	1.139	0.019	6.839	9.794	1.000	498.13
4	1.253	0.021	6.172	9.061	1.001	312.76
2	1.382	0.024	5.557	8.353	1.001	197.68
1	1.478	0.026	5.235	7.894	1.002	156.49
1/0	1.566	0.028	4.958	7.516	1.003	123.81
2/0	1.443	0.036	3.896	8.056	1.003	98.43
3/0	1.527	0.040	3.562	7.679	1.004	78.12
4/0	1.646	0.044	3.245	7.202	1.006	62.05
250	1.725	0.048	3.003	6.917	1.008	52.64
350	1.908	0.057	2.565	6.336	1.013	37.74
500	2.130	0.070	2.123	5.750	1.023	26.78
750	2.434	0.093	1.618	5.103	1.043	18.36
1000	2.691	0.121	1.252	4.660	1.065	14.31

15 KV 75 C CONDUCTOR

4	1.583	0.050	7.370	7.447	1.001	307.85
2	1.722	0.057	6.684	6.927	1.002	194.56
1	1.818	0.061	6.318	6.609	1.003	154.02
1/0	1.842	0.069	5.849	6.534	1.003	121.85
2/0	1.941	0.073	5.545	6.241	1.005	96.97
3/0	2.061	0.078	5.258	5.920	1.007	76.99
4/0	1.919	0.097	4.260	6.304	1.008	61.07
250	2.007	0.104	3.996	6.060	1.010	51.81
350	2.190	0.120	3.518	5.609	1.016	37.13
500	2.412	0.141	3.038	5.145	1.028	26.34
750	2.707	0.175	2.497	4.635	1.049	18.06
1000	2.974	0.208	2.115	4.254	1.076	14.06

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THREE CONDUCTOR SHIELDED SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO 60 50 LF	RHO 60 75 LF	RHO 60 100 LF	RHO 90 50 LF	RHO 90 75 LF	RHO 90 100 LF	RHO 120 50 LF	RHO 120 75 LF	RHO 120 100 LF	DELTA TD FOR .0350 PF AND RHO 60	90	120
					COPPER CONDUCTOR							
				1 CABLE IN DUCT BANK 8 KV 85 C CONDUCTOR 20 C AMBIENT EARTH								
6	92	89	87	91	88	84	90	86	81	0.30	0.32	0.34
4	120	117	113	119	114	109	117	112	106	0.33	0.36	0.38
2	157	152	147	155	148	141	153	145	137	0.41	0.45	0.48
1	181	175	168	178	171	162	176	167	157	0.43	0.47	0.51
1/0	208	201	193	205	196	185	202	191	179	0.46	0.50	0.54
2/0	232	224	215	228	218	206	225	213	200	0.52	0.57	0.61
3/0	265	256	246	261	249	235	257	243	228	0.55	0.60	0.65
4/0	306	295	282	301	286	269	296	279	260	0.58	0.64	0.69
250	337	325	310	332	315	296	326	306	286	0.61	0.67	0.72
350	412	395	377	404	383	359	397	372	345	0.66	0.74	0.80
500	506	484	459	496	468	436	486	453	419	0.73	0.81	0.88
750	634	604	570	620	581	539	607	562	517	0.82	0.92	1.00
1000	735	697	657	717	670	619	701	646	592	0.89	1.00	1.10
				3 CABLES IN DUCT BANK 8 KV 85 C CONDUCTOR 20 C AMBIENT EARTH								
6	87	82	77	85	79	72	83	75	68	0.39	0.45	0.51
4	114	107	99	111	102	93	108	97	88	0.44	0.51	0.57
2	148	138	128	144	131	119	139	125	112	0.55	0.64	0.72
1	170	158	146	165	150	136	160	143	128	0.59	0.69	0.78
1/0	195	181	166	189	171	155	182	163	145	0.63	0.74	0.84
2/0	218	202	186	210	191	173	203	182	162	0.71	0.82	0.94
3/0	249	230	211	240	217	196	232	207	184	0.76	0.88	1.01
4/0	286	263	241	275	248	223	265	235	208	0.81	0.95	1.09
250	314	289	264	302	272	244	292	258	228	0.85	1.00	1.15
350	382	350	317	367	328	292	353	310	273	0.95	1.12	1.29
500	466	424	383	446	396	352	428	373	327	1.06	1.26	1.46
750	580	524	470	552	487	430	528	457	398	1.21	1.46	1.70
1000	668	601	536	635	556	489	606	521	452	1.34	1.61	1.89
				6 CABLES IN DUCT BANK 8 KV 85 C CONDUCTOR 20 C AMBIENT EARTH								
6	82	74	66	78	69	61	75	65	56	0.54	0.65	0.76
4	106	95	85	101	89	78	97	83	72	0.61	0.74	0.87
2	137	122	109	130	113	99	124	106	92	0.77	0.94	1.10
1	157	140	124	149	129	113	142	121	104	0.83	1.01	1.20
1/0	180	159	141	170	147	127	161	137	117	0.89	1.10	1.30
2/0	200	177	157	189	164	142	180	153	131	1.00	1.22	1.44
3/0	228	201	178	215	185	161	204	173	148	1.08	1.32	1.56
4/0	261	229	202	246	211	182	233	196	167	1.16	1.43	1.69
250	286	251	221	269	230	199	255	214	182	1.23	1.52	1.80
350	346	301	264	324	275	237	306	255	216	1.38	1.71	2.05
500	420	363	316	392	330	283	368	305	258	1.57	1.96	2.34
750	517	443	384	480	402	342	450	370	311	1.82	2.29	2.76
1000	592	505	435	548	456	386	512	419	351	2.03	2.56	3.09
				9 CABLES IN DUCT BANK 8 KV 85 C CONDUCTOR 20 C AMBIENT EARTH								
6	78	69	61	74	64	56	71	61	52	0.63	0.77	0.89
4	102	89	79	96	83	72	92	78	66	0.72	0.88	1.03
2	131	114	100	124	105	91	118	99	84	0.92	1.12	1.31
1	150	130	114	141	120	103	134	112	95	0.99	1.21	1.43
1/0	171	147	129	161	136	117	152	127	107	1.07	1.31	1.55
2/0	190	164	144	179	152	130	170	142	120	1.19	1.46	1.71
3/0	217	186	163	203	172	147	193	160	135	1.29	1.58	1.87
4/0	247	212	184	231	194	166	219	181	153	1.40	1.72	2.03
250	271	231	201	253	212	181	239	197	166	1.49	1.83	2.16
350	326	277	239	304	253	215	287	235	197	1.68	2.08	2.46
500	395	332	286	366	303	256	344	280	234	1.91	2.38	2.83
750	484	404	346	447	367	309	419	338	282	2.24	2.80	3.34
1000	553	458	391	509	415	348	475	382	317	2.50	3.14	3.76

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THREE CONDUCTOR SHIELDED SOLID TYPE IMPREGNATED PAPER INSULATED CABLE IN DUCTS

SIZE	RHO 60 50 LF	RHO 60 75 LF	RHO 60 100 LF	RHO 90 50 LF	RHO 90 75 LF	RHO 90 100 LF	RHO 120 50 LF	RHO 120 75 LF	RHO 120 100 LF	DELTA TD FOR .0300 PF AND RHO 60	90	120
						COPPER CONDUCTOR						
						1 CABLE IN DUCT BANK 15 KV 80 C CONDUCTOR 20 C AMBIENT EARTH						
4	118	114	110	116	112	106	115	109	103	0.74	0.80	0.86
2	154	149	143	151	145	138	149	142	133	0.81	0.89	0.95
1	176	170	163	173	166	157	171	162	152	0.92	1.00	1.08
1/0	202	195	187	199	190	179	196	185	173	0.97	1.06	1.14
2/0	228	220	211	224	214	202	220	208	195	1.06	1.17	1.26
3/0	261	251	241	256	244	230	252	238	222	1.12	1.24	1.33
4/0	299	288	275	294	279	262	289	271	253	1.19	1.31	1.41
250	330	317	303	324	307	288	318	299	278	1.23	1.37	1.48
350	402	385	366	394	372	348	386	361	335	1.35	1.50	1.63
500	491	469	445	481	453	422	471	438	404	1.48	1.65	1.80
750	612	583	550	598	560	519	585	541	497	1.65	1.86	2.04
1000	708	671	632	690	644	594	674	620	567	1.79	2.02	2.22
						3 CABLES IN DUCT BANK 15 KV 80 C CONDUCTOR 20 C AMBIENT EARTH						
4	111	104	96	108	99	90	105	94	85	0.99	1.15	1.30
2	145	135	124	140	127	116	135	121	109	1.11	1.29	1.47
1	165	153	141	160	145	131	154	138	123	1.26	1.47	1.68
1/0	189	175	161	182	165	149	176	157	140	1.34	1.57	1.80
2/0	213	197	181	205	186	168	198	176	157	1.47	1.72	1.97
3/0	243	225	205	234	211	190	226	200	178	1.57	1.84	2.11
4/0	278	256	233	267	240	215	257	227	201	1.67	1.97	2.27
250	306	281	256	294	263	236	282	249	220	1.76	2.07	2.39
350	370	338	307	355	316	282	340	298	262	1.94	2.31	2.67
500	450	409	369	430	381	338	411	358	313	2.17	2.59	3.01
750	557	503	451	529	466	411	505	436	379	2.48	2.98	3.48
1000	639	574	512	606	530	465	576	495	428	2.72	3.29	3.86
						6 CABLES IN DUCT BANK 15 KV 80 C CONDUCTOR 20 C AMBIENT EARTH						
4	103	92	83	98	86	75	93	80	69	1.39	1.69	1.99
2	133	119	106	126	110	96	120	102	88	1.56	1.91	2.26
1	152	135	119	143	124	108	136	116	99	1.79	2.20	2.60
1/0	173	153	135	163	141	122	155	131	112	1.92	2.36	2.80
2/0	195	172	152	183	158	137	174	147	126	2.10	2.58	3.06
3/0	222	195	172	208	179	155	197	166	142	2.25	2.78	3.30
4/0	252	221	194	237	202	175	223	188	160	2.42	3.00	3.57
250	277	242	212	259	221	190	244	204	174	2.56	3.17	3.78
350	333	289	253	311	263	226	292	243	206	2.86	3.57	4.27
500	402	347	302	374	314	269	350	289	244	3.23	4.05	4.86
750	493	422	365	456	380	324	425	348	293	3.74	4.72	5.68
1000	562	478	412	517	429	364	480	392	328	4.16	5.26	6.35
						9 CABLES IN DUCT BANK 15 KV 80 C CONDUCTOR 20 C AMBIENT EARTH						
4	99	86	76	93	80	69	89	75	64	1.65	2.01	2.36
2	127	110	97	119	102	88	113	95	81	1.87	2.29	2.70
1	144	125	109	135	115	99	128	107	91	2.15	2.64	3.11
1/0	164	141	124	154	130	112	146	121	103	2.31	2.84	3.35
2/0	185	159	139	173	146	125	163	136	115	2.53	3.10	3.66
3/0	210	180	157	196	165	141	185	153	129	2.72	3.35	3.95
4/0	238	203	177	222	186	159	209	172	145	2.93	3.62	4.29
250	261	222	193	243	203	173	228	188	158	3.10	3.84	4.55
350	313	265	229	290	241	204	272	222	186	3.49	4.33	5.15
500	377	316	272	347	287	242	325	264	220	3.96	4.93	5.88
750	460	383	328	422	345	290	392	316	263	4.60	5.77	6.90
1000	522	432	368	477	388	325	442	355	294	5.13	6.45	7.73

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