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TECHNICAL SPECIFICATION

HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

CHECKING SYSTEM FOR EARTH FAULT OF LOW VOLTAGE USERS

JUNE 2021

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REFERENCES DOCUMENTS

IEC TR 60344
[Guide to the Calculation of Resistance of Plain and Coated Copper Conductors of Low-Frequency Cables and Wires]

1. SCOPE

Scope of this specification is to verify the limits in length of user power cables that, together with the protective conductor(s) will prevent the occurrence of dangerous touch voltage between exposed conductive parts and extraneous conductive parts, which can be reached contemporary and where the bonding, between them, could not be certainly ensured.

2. GENERAL

This specification shall be applied to:

- 400 V voltage users, to which the **Tables 1 to 8** are referred.
- Users fed and protected by following canalization:

a) three core unarmored cable and earth protective conductor (PE) incorporated in the same power cable,

b) three core cable and concentric PE conductor,

c) three core cable and separate PE conductor (*),

d) three core cable and incorporated PE conductor as per a) and b) with additional separate PE conductor (*).

- Following feeder protection:

a) by fuse

b) by automatic circuit breaker

- Distribution switchboard, at which the PE conductor is earthed; is located near the distribution transformer (in the same substation); for such reason no earth loop impedance of interconnection line between transformer and switchboard, has been considered in the calculations.

(*) This PE separate conductor is generally laid in the cable trench and / or cable tray and is used as a PE conductor common to all cables laid in the same trench and/or tray; trench with maximum width of 2m requiring only one PE conductor, for the calculation of earth loop impedance, the following distances of separate PE conductor from feeder cable have been considered:

- 0,5m and 2m for three core cable without incorporated PE conductor.
- 2m for three core cable with incorporated PE conductor (normal or concentric conductor) because for these types of cables the impedance variation from 0,5 to 2m is negligible.

3. CALCULATION CRITERIA

3.1. PROSPECTIVE TOUCH VOLTAGE

The touch voltage (V) which may occur during the earth fault of user circuit, is the voltage between user and earth, considering the voltage drop of feeder conductor up to user, determinate by the loop current, this value is obtained by the following relation:

$$V = Ie * Zpe = (Vo / Ze) * Zpe = Vo * (Zpe/ Ze)$$

In which:

V = touch voltage.

Ie = earth loop fault current.

Zpe = Protective conductor (PE) impedance (between user and earth).

Vo = phase-neutral voltage (230 V (*) when referred to 400 V system).

Ze = earth loop impedance.

The value of the protective touch voltage depends on the voltage of the system and on relationship between the impedance of the protective conductor(s) and phase conductor. The values of this ratio for each considered line are given on Table 9.1 to 9.4.

3.2. MAXIMUM OPERATING TIME AGAINST PROTECTIVE TOUCH VOLTAGE

The maximum operation time against prospective currents have been extracted referring to fixed installation equipment basis (50 V for 5 s), the values given by **IEC TR 60344.** These values are indicated on Tables **10 and 11** (first and second columns).

3.3. EARTH FAULT CURRENT

The maximum interrupting allowed time of circuit protection would permit determination of fault current on time current characteristics of considered protection.

Tables 10 and 11 indicate the value of these currents and the earth loop impedance (referred to 400 V system) for each considered protection rating (*).

(*) No voltage drops due to earth fault impedance of the circuit upstream the distribution switchboard has been considered.

3.4 EARTH LOOP IMPEDANCE

On the basis of the earth fault current, is possible to determinate the maximum limit of earth loop impedance which is:

$$Ze = Vo / Ie$$

By the earth loop impedance referred to one Km of line [Ze (Km)] indicated on **Tables 9.1 to 9.4** is possible to calculate the maximum allowable length for each type and size of line protected by fuse or Circuit Breaker of various possible ratings:

$$L(meters) = [Ze / (Ze(Km))] * 1000$$

4. ALTERNATIVE SOLUTION TO PREVENT DANGEROUS TOUCH VOLTAGES

If the length of cable under consideration will result more than one indicated on applicable **Tables 1 to 8** the following alternative solution to prevent the dangerous touch voltages, may be adopted:

a) reducing, if possible of line protection rating.

b) consideration of possible existing additional separated PE conductor.

Depending upon economics:

a) Increasing of line size up for which the length indicated on **Tables 1 to 8,** at relevant protection rating, covers the effective installation length;

b) Adopting of suitable earth fault relay.

(*) The operating time current curves considered are:

a) for Fuses, referred to **ELOT EN 60269-2**

b) for Circuit Breakers, referred to SAGE module series.

TABLE 1

PE CONDUCTOR (NORMAL OR CONCENTRIC) INCORPORATED IN THE POWER CABLE PROTECTION WITH FUSES

FEEDER CABLE SIZE	CABLE LENGTH (m)																		REMARK!
	FUSE RATING (A)																		
	10	12	16	20	25	32	40	50	63	80	100	125	160	200	250				
3x2,5+2,5 T	120	86	60	52	37														
3x4+4 T	193	138	96	84	59	48													
3x6+6 T	291	207	145	126	89	72	58	43											
3x10+10 T	484	345	242	210	149	121	96	72	60										
3x16+16 T	768	548	384	333	237	192	153	115	96	76									
3x25+25 T		712	502	404	314	248	198	160	120	101	71								
3x35+25 T		826	583	469	365	288	230	185	140	117	83	64							
3x50+25 T		926	653	526	409	323	258	208	158	131	93	71	71						
3x70+35 T		1300	919	740	575	454	363	292	222	184	130	101	80	62					
3x95+50 T			1250	1008	784	618	495	398	302	251	178	137	110	85	64				
3x120+70 T						849	679	547	415	345	245	188	150	116	88				
3x150+95 T						1113	891	717	544	452	321	247	198	153	116				
3x185+95 T											348	268	214	166	126				
3x240+150 T											494	380	304	235	178				

TABLE 2

PE CONDUCTOR (NORMAL OR CONCENTRIC) INCORPORATED IN THE POWER CABLE PROTECTION WITH CIRCUIT BREAKERS

FEEDER CABLE SIZE	CABLE LENGTH (m)																		REMARKS
	CIRCUIT BREAKER RATING (A)																		
	20	25	32	40	50	63	80	100	125	160	200	250	320	400	500	630	800	001	
3x2,5+2,5 T	X	X	X																
3x4+4 T	X	X	X	X															
3x6+6 T	X	X	X	X	X														
3x10+10 T	220	176	137	110	88	68	55												
3x16+16 T	349	279	218	174	139	108	87	69											
3x25+25 T	641	441	345	276	220	171	138	110											
3x35+25 T		512	400	320	256	198	160	128	102										
3x50+25 T		574	448	359	287	222	179	143	114	89									
3x70+35 T		808	631	505	404	313	252	202	161	126	101								
3x95+50 T			859	687	550	426	343	275	220	171	137	110							
3x120+70 T				943	754	584	471	377	301	235	188	150	117	94	75	56	47	37	
3x150+95 T					990	767	618	495	396	309	247	198	154	123	99	74	61	49	
3x185+95 T						831	670	536	428	335	268	214	167	134	107	80	67	53	
3x240+150 T						1178	950	760	608	475	380	304	237	190	152	114	95	76	

NOTE: THE BOXES MARKED WITH X SHOWN THE CB RATINGS INDICATED IN THE HEAD OF COLUMN, WHICH GIVE NO PROTECTION AGAINST SHORT CIRCUIT TO THE REFERRED CABLE (S) (I^2t FLOWING THROUGH CB HIGHER THAN I^2t ALLOWED BY THE CABLE).

TABLE 3

PE CONDUCTOR (NORMAL OR CONCENTRIC) INCORPORATED IN THE POWER CABLE AND ADDITIONAL SEPARATE PE CONDUCTOR PROTECTION WITH FUSES

FEEDER CABLE SIZE ($N \times mm^2$)	SEPARATE EARTH CONDUCTOR (mm^2)	CABLE LENGTH (m)																		REMARKS
		FUSE RATING (A)																		
		10	12	16	20	25	32	40	50	63	80	100	125	160	200	250	Amps			
3x2,5+2,5T	35	412	324	251	206	162														
	70	413	324	252	206	162														
3x4+4T	35	637	500	389	318	250	194	145												
	70	666	523	406	333	261	203	151												
3x64CT	35	919	721	560	459	360	280	209												
	70	975	765	595	487	382	297	221												
3xlO+10T	35	1423	1117	868	711	558	434	323	277	21										
	70	1541	1210	940	770	605	470	350	300	23										
3x16+16T	35	1618	1190	871	708	536	432	350	268	21	174									
	70	2285	1794	1394	1142	897	697	520	445	34	273									
3x25+25T	35		1673	1224	996	753	608	492	376	30	244	17								
	70		1878	1373	1117	845	682	552	422	34	274	19								
3x35+25T	35		1739	1191	1006	765	608	478	382	30	239	17	130							
	70		2310	1690	1375	1040	840	680	520	42	338	24	190							
3x50+25T	35		1565	1096	953	677	548	438	329	27	219	14	119	99						
	70		2350	1610	1360	1034	822	646	517	41	323	23	176	141						
3x70+35T	35		1675	1314	1142	812	657	525	394	32	262	17	143	119	89					
	70		2208	1547	1344	956	773	618	464	38	309	21	168	140	10					
3x95+50T	35			1243	1000	778	614	491	396	30	250	17	136	109	84	64				
	70			1757	1527	1086	878	702	527	43	351	23	191	159	11	91				
3x120+70T	35						681	545	439	33	277	19	151	121	93	71				
	70						964	771	578	48	385	26	210	175	13	100				
3x150+95T	35						731	585	471	35	297	21	162	130	10	76				
	70						987	790	592	49	394	26	215	179	13	102				
3x185+95T	35											21	166	133	10	78				
	70											28	230	192		144				
3x240+150T	35											23	179	143	11	84				
	70											26	206	164	12	96				

TABLE 4

PE CONDUCTOR (NORMAL OR CONCENTRIC) INCORPORATED IN THE POWER CABLE AND ADDITIONAL SEPARATE PE CONDUCTOR PROTECTION WITH AUTOMATIC CIRCUIT BREAKERS

FEEDER CABLE SIZE ($Nzmm^2$)	SEPARATE EAARTH CONDUCTOR (mm^2)	CABLE LENGTH (m) — CIRCUIT BREAKER RATING (A)																			REMARKS
		20	25	32	40	50	63	80	100	125	160	200	250	320	400	500	630	800	1000	Amp	
3x2,5+2,5T	35	X	X	X																	
	70	X	X	X																	
3x4+4T	35	X	X	X	X																
	70	X	X	X	X																
3x6+6T	35	X	X	X	X	X															
	70	X	X	X	X	X															
3xlO+10T	35	411	327	256	205	163	130	102													
	70	445	354	277	222	177	141	111													
3xl6+16T	35	515	412	322	257	206	159	128	103	82											
	70	661	525	411	330	262	209	165	131	108											
3x25+25T	35	724	579	452	362	289	224	181	144	115											
	70	813	731	508	406	325	252	203	162	130											
3x35+25T	35				434	347	269	217	173	139	108										
	70				500	400	310	250	200	160	125										
3x50+25T	35					398	309	249	199	159	124	99									
	70					470	364	293	235	188	146	117									
3x70+35T	35					477	370	298	238	191	149	119	95								
	70					562	436	351	281	225	175	140	112								
3x95+50T	35					546	423	341	273	218	170	136	109	85							
	70					638	495	399	319	255	199	159	127	99							
3xl20+70T	35						469	378	303	242	189	151	121	94	75	60	45	37	30		
	70						543	438	350	280	219	175	140	109	87	70	52	43	35		
3xl50+95T	35						504	406	325	260	203	162	130	101	81	65	48	40	32		
	70						556	448	359	287	224	179	143	112	89	71	53	44	35		
3xl85+95T	35							417	333	267	208	166	133	104	83	66	50	41	33		
	70							480	384	307	240	192	153	120	96	76	57	48	38		
3x240+150T	35							449	359	287	224	179	143	112	89	71	53	44	35		
	70							515	412	329	257	206	164	128	103	82	61	51	41		

NOTE: THE BOXES MARKED WITH X SHOWN THE CB RATINGS INDICATED IN THE HEAD OF COLUMN, WHICH GIVE NO PROTECTION AGAINST SHORT CIRCUIT TO THE REFERRED CABLE (S) (I^2t FLOWING THROUGH CB HIGHER THAN I^2t ALLOWED BY THE CABLE).

TABLE 5

SEPARATE PE CONDUCTOR AT 0.5 m OF POWER CABLE PROTECTION WITH FUSES

FEEDER CABLE SIZE (Nxmm²)	SEPARATE EARTH CONDUCTOR (mm²)	CABLE LENGTH (m) FUSE RATING (A)																		REMARKS
		10	12	16	20	25	32	40		63	80	100	125	160	200	250	Amps			
3x2,5	35	409	321	249	204	160														
	70	422	331	257	211	165														
3x4	35	625	490	381	312	245	190	142												
	70	657	516	401	328	258	200	149												
3x6	35	881	691	537	440	345	268	200												
	70	947	744	578	473	372	289	215												
3x10	35	1016	747	546	444	336	271	220	168	135										
	70	1444	1133	880	*111*	566	440	328	261	220										
3x16	35	1185	862	590	498	379	301	237	189	150	118									
	70	1562	1149	840	684	517	417	338	258	208	168									
3x25	35	1176	839	588	511	363	249	235	176	147	117	80								
	70	1750	1270	870	735	560	445	350	280	222	175	127								
3x35	35		945	662	575	410	330	265	195	165	130	90	70							
	70		1137	797	692	492	398	318	240	200	160	108	85							
3x50	35			594	479	372	294	235	190	143	120	85	65	52						
	70			866	752	535	433	346	259	216	173	118	94	78						
3x70	35				512	398	314	251	202	153	127	90	69	55	43					
	70				810	576	466	372	279	233	186	127	101	84	63					
3x95	35				535	416	328	262	211	160	133	94	72	58	45	34				
	70				648	504	398	318	256	194	161	115	88	70	54	41				
3x120	35							268	216	164	136	97	74	59	46	35				
	70							324	261	198	164	117	90	72	55	42				
3x150	35									167	139	99	76	61	47	35				
	70									201	167	119	91	73	56	43				
3x185	35										140	100	76	61	47	36				
	70										169	120	92	74	57	43				
3x240	35											101	78	62	48	36				
	70											121	93	74	57	43				

TABLE 6

SEPARATE PE CONDUCTOR AT 0,5 m OF POWER CABLE PROTECTION WITH AUTOMATIC CIRCUIT BREAKERS

FEEDER CABLE SIZE ($Nzmm^2$)	SEPARATE EAARTH CONDUCTOR (mm^2)	CABLE LENGTH (m) — CIRCUIT BREAKER RATING (A)																			REMARKS
		20	25	32	40	50	63	80	100	125	160	200	250	320	400	500	630	800	1000	Amp	
3X2,5	35	X	X	X																	
	70	X	X	X																	
3X4	35	X	X	X	X																
	70	X	X	X	X																
3X6	35	X	X	X	X	X															
	70	X	X	X	X	X															
3X10	35	323	258	202	161	129	100	80													
	70	417	332	259	208	166	132	104													
3X16	35	431	344	269	215	172	133	107	86	68											
	70	497	398	310	248	199	154	124	99	79											
3X25	35	534	427	334	267	213	165	133	106	85											
	70	636	509	398	318	254	197	159	127	101											
3X35	35				301	240	186	150	120	96	75										
	70				362	289	224	181	144	115	90										
3X50	35					261	202	163	130	104	81	65									
	70					314	244	196	157	125	98	78									
3X70	35					279	216	174	139	111	87	69	55								
	70					338	262	211	169	135	105	84	67								
3X95	35					291	226	182	145	116	91	72	58	45							
	70					353	274	221	176	141	110	88	70	55							
3X120	35						231	186	149	119	93	74	59	46	37	29	22	18	14		
	70						279	225	180	144	112	90	72	56	45	36	27	22	18		
3X150	35							190	152	122	95	76	61	47	38	30	22	19	15		
	70							229	183	146	114	91	73	57	45	36	27	22	28		
3X185	35									123	96	76	61	48	38	30	23	19	15		
	70									148	115	92	74	57	46	37	27	23	18		
3X240	35										97	78	62	48	39	31	23	19	15		
	70										116	93	74	58	46	37	28	23	18		

NOTE: THE BOXES MARKED WITH X SHOWN THE CB RATINGS INDICATED IN THE HEAD OF COLUMN, WHICH GIVE NO PROTECTION AGAINST SHORT CIRCUIT TO THE REFERRED CABLE (S) (I^2t FLOWING THROUGH CB HIGHER THAN I^2t ALLOWED BY THE CABLE).

TABLE 7

SEPARATE PE CONDUCTOR AT 2 m OF POWER CABLE PROTECTION WITH FUSES

FEEDER CABLE SIZE (Nxmm²)	SEPARATE EARTH CONDUCTOR (mm²)	CABLE LENGTH (m) FUSE RATING (A)																		REMARKS
		10	12	16	20	25	32	40	50	63	80	100	125	160	200	250	Amps			
3x2,5	35	408	320	248	204	122														
	70	421	331	257	210	165														
3x4	35	620	486	378	310	243	189	141												
	70	653	513	398	326	256	192	148												
3x6	35	869	682	530	434	341	265	197												
	70	934	733	570	467	366	285	216												
3x10	35	990	728	533	433	328	264	214	164	13										
	70	1097	807	590	480	363	293	237	181	14										
3x16	35	1131	823	563	476	362	288	226	181	14	113									
	70	1474	1084	793	645	488	394	319	244	19	158									
3x25	35	1100	785	550	478	340	275	220	165	13	110	75								
	70	1598	1162	796	672	511	406	319	255	20	159	11								
3x35	35		862	604	525	373	302	241	181	15	120	82	65							
	70		1012	709	616	438	354	283	212	17	140	96	77							
3x50	35			535	431	335	264	211	170	13	107	76	58	47						
	70			758	659	465	379	303	227	18	150	10	82	68						
3x70	35					355	279	223	180	13	113	80	62	50	38					
	70					415	328	262	211	16	133	95	72	58	45					
3x95	35						290	230	187	14	118	83	64	50	40	30				
	70						338	270	218	16	137	97	75	60	46	35				
3x120	35							235	190	14	120	85	65	52	40	30				
	70							274	220	16	140	99	75	60	47	35				
3x150	35								193	14	122	85	65	53	41	30				
	70								223	17	140	10	75	60	47	36				
3x185	35									14	122	87	67	53	41	31				
	70									17	140	10	77	62	48	36				
3x240	35									15	124	88	68	54	42	31				
	70									17	142	10	78	62	48	36				

TABLE 8

SEPARATE PE CONDUCTOR AT 2 m OF POWER CABLE PROTECTION WITH AUTOMATIC CIRCUIT BREAKERS

FEEDER CABLE SIZE ($Nzmm^2$)	SEPARATE EARTH CONDUCTOR (mm^2)	CABLE LENGTH (m) — CIRCUIT BREAKER RATING (A)																		REMARKS
		20	25	32	40	50	63	80	100	125	160	200	250	320	400	500	630	800	1000	Amp	
3x2,5	35	X	X	X																	
	70	X	X	X																	
3x4	35	X	X	X	X																
	70	X	X	X	X																
3x6	35	X	X	X	X	X															
	70	X	X	X	X	X															
3x10	35	315	252	197	157	126	97	78													
	70	349	279	218	174	139	108	87													
3x16	35	411	329	257	205	164	127	102	82	65											
	70	469	375	293	234	187	145	117	93	75											
3x25	35	500	400	312	250	200	155	125	100	80											
	70	581	465	363	290	232	180	145	116	93											
3x35	35	549	439	343	274	219	170	137	109	87	68										
	70	645	516	403	322	258	200	161	129	103	80										
3x50	35			367	294	235	182	147	117	94	73	58									
	70			431	344	275	213	172	137	110	86	68									
3x70	35			388	310	248	192	155	124	99	77	62	49								
	70			456	364	291	226	182	145	116	91	72	58								
3x95	35				322	258	200	161	129	103	80	64	51	40							
	70				375	300	233	187	150	120	93	75	60	46							
3x120	35						203	164	131	105	82	65	52	41	32	26	19				
	70						236	190	152	122	95	76	61	47	38	30	22				
3x150	35							166	133	106	83	66	53	41	33	26	20				
	70							192	153	123	96	76	61	48	38	30	23				
3x185	35								134	113	83	67	53	41	33	26	20	16			
	70								155	124	96	77	62	48	38	31	23	19			
3x240	35									108	85	68	54	42	34	27	20	17			
	70									125	97	78	62	48	39	31	23	19			

NOTE: THE BOXES MARKED WITH X SHOWN THE CB RATINGS INDICATED IN THE HEAD OF COLUMN, WHICH GIVE NO PROTECTION AGAINST SHORT CIRCUIT TO THE REFERRED CABLE (S) (I^2t FLOWING THROUGH CB HIGHER THAN I^2t ALLOWED BY THE CABLE).

TABLE 9.1

EARTH LOOP AND PROTECTIVE CONDUCTOR IMPEDANCES WITH PE INCORPORATED IN POWER CABLE

FEEDER CABLE SIZE (N x mm²)	**Zpe (Ω)**	**Ze (Ω)**	**Zpe / Ze**
3 x 2,5 + 2,5 T	9,08	18,16	0,5
3 x 4 x 4 T	5,68	11,36	0,5
3 x 6 +6 T	3,78	7,56	0,5
3xIO+10T	2,27	4,54	0,5
3xI6+16T	1,432	2,864	0,5
3 x 25 + 25 T	0,907	1,81	0,502
3x35 + 25T	0,907	1,56	0,58
3 x 50 + 25 T	0,907	1,392	0,65
3x70 + 35T	0,655	0,99	0,66
3 x 95 + 50 T	0,484	0,727	0,665
3x120 + 70 T	0,336	0,530	0,633
3x150 + 95 T	0,243	0,404	0,601
3x185 + 95 T	0,243	0,373	0,651
3x240+150 T	0,161	0,263	0,612

TABLE 9.2

EARTH LOOP AND PROTECTIVE CONDUCTOR IMPEDANCES WITH PE INCORPORATED IN POWER CABLE AND ADDITIONAL SEPARATE PE CONDUCTOR

FEEDER CABLE SIZE (N x mm^2)	EARTH CONDUCTOR (mm^2)	Zpe (Ω)	Ze (Ω)	Zpe / Ze
3 x 2,5 + 2,5 T	35	0,652	9,69	0,067
	70	0,386	9,68	0,039
3 x 4 + 4 T	35	0,631	6,27	0,1
	70	0,38	6	0,063
3 x 6 + 6 T	35	0,61	4,35	0,14
	70	0,376	4,1	0,091
3xIO+10 T	35	0,562	2,81	0,2
	70	0,362	2,595	0,139
3xI6+16 T	35	0,512	1,94	0,26
	70	0,348	1,75	0,198
3 x 25 + 25 T	35	0,456	1,38	0,33
	70	0,392	1,23	0,26
3 x 35 + 25 T	35	0,456	1,15	0,396
	70	0,328	1	0,328
3 x 50 + 25 T	35	0,456	1,003	0,454
	70	0,328	0,851	0,385
3 x 70 + 35 T	35	0,414	0,837	0,494
	70	0,312	0,711	0,438
3 x 95 + 50 T	35	0,378	0,732	0,516
	70	0,297	0,626	0,474
3 x 120 + 70 T	35	0,339	0,66	0,51
	70	0,278	0,57	0,48
3 x 150 + 95 T	35	0,312	0,615	0,507
	70	0,264	0,557	0,47
3 x 185 + 95 T	35	0,312	0,599	0,52
	70	0,26	0,52	0,5
3 x 240+ 150 T	35	0,288	0,556	0,51
	70	0,248	0,485	0,51

TABLE 9.3

EARTH LOOP AND PROTECTIVE CONDUCTOR IMPEDANCES WITH PE SEPARATE CONDUCTOR AT 0,5 m OF POWER CABLE

FEEDER CABLE SIZE (N x mm^2)	EARTH CONDUCTOR (mm^2)	Zpe (Ω)	Ze (Ω)	Zpe / Ze
3x2,5	35	0,828	9,77	0,08
	70	0,59	9,46	0,06
3x4	35	0,828	6,4	0,129
	70	0,59	6,08	0,09
3x6	35	0,828	4,54	0,18
	70	0,59	4,22	0,139
3x10	35	0,828	3,09	0,26
	70	0,59	2,77	0,212
3x16	35	0,828	2,32	0,35
	70	0,59	2,01	0,29
3x25	35	0,828	1,87	0,44
	70	0,59	1,57	0,375
3x35	35	0,828	1,66	0,498
	70	0,59	1,38	0,42
3x50	35	0,828	1,53	0,54
	70	0,59	1,27	0,46
3x70	35	0,828	1,43	0,57
	70	0,59	1,18	0,5
3x95	35	0,828	1,37	0,6
	70	0,59	1,13	0,52
3x120	35	0,828	1,34	0,61
	70	0,59	1,11	0,53
3x150	35	0,828	1,31	0,63
	70	0,59	1,09	0,54
3x185	35	0,828	1,3	0,63
	70	0,59	1,08	0,54
3x240	35	0,828	1,28	0,64
	70	0,59	1,07	0,55

TABLE 9.4

EARTH LOOP AND PROTECTIVE CONDUCTOR IMPEDANCES WITH PE SEPARATE CONDUCTOR AT 2 m OF POWER CABLE

FEEDER CABLE SIZE (N x mm^2)	EARTH CONDUCTOR (mm^2)	Zpe (Ω)	Ze (Ω)	Zpe / Ze
3x2,5	35	0,905	9,8	0,092
	70	0,688	9,48	0,072
3x4	35	0,905	6,45	0,14
	70	0,688	6,12	0,112
3x6	35	0,905	4,6	0,19
	70	0,688	4,28	0,16
3x10	35	0,905	3,17	0,28
	70	0,688	2,86	0,24
3x16	35	0,905	2,43	0,37
	70	0,688	2,13	0,32
3x25	35	0,905	2	0,45
	70	0,688	1,72	0,4
3x35	35	0,905	1,82	0,49
	70	0,688	1,55	0,44
3x50	35	0,905	1,7	0,53
	70	0,688	1,45	0,47
3x70	35	0,905	1,61	0,57
	70	0,688	1,37	0,502
3x95	35	0,905	1,55	0,58
	70	0,688	1,33	0,51
3x120	35	0,905	1,52	0,59
	70	0,688	1,31	0,52
3x150	35	0,905	1,5	0,6
	70	0,688	1,3	0,52
3x185	35	0,905	1,49	0,6
	70	0,688	1,29	0,53
3x240	35	0,905	1,47	0,61
	70	0,688	1,28	0,53

TABLE 10

PROSPECTIVE VOLTAGE AND OPERATING TIME: PROTECTION FUSE CURRENT AND RELEVANT EARTH LOOP IMPEDANCE

PROSPECTIVE TOUCH VOLTAGE (V)	MAXIMUM OPERATING TIME (s)	V/Vo=Zpe/Ze	FUSE RATING (A)																						REMARKS
			10		12		16		20		25		32		40		50		63		80		100		
			I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	
50	5	0,227	55	4	70	3,14	90	2,44	110	2	140	1,57	180	1,22	240	0,91	280	0,78	360	0,61	460	0,478	600	0,36	
75	1	0,341	70	3,14	95	2,31	130	1,69	160	1,375	210	1,04	260	0,84	320	0,68	420	0,52	520	0,42	650	0,338	900	0,24	
90	0,5	0,409	80	2,75	110	2	160	1,37	190	1,157	250	0,88	310	0,7	400	0,55	500	0,44	620	0,35	800	0,275	1100	0,2	
110	0,2	0,5	100	2,2	140	1,57	200	1,1	230	0,956	320	0,86	400	0,55	500	0,44	650	0,33	800	0,275	1000	0,22	1400	0,15	
150	0,1	0,682	125	1,76	170	1,29	240	0,91	300	0,733	380	0,57	480	0,45	600	0,36	750	0,29	1000	0,22	1200	0,183	1600	0,13	
220	0,05	1	160	1,37	210	1,04	300	0,73	380	0,578	470	0,46	600	0,36	750	0,29	900	0,24	1200	0,18	1500	0,146	2000	0,11	

For continuation of Table 10 for High Fuse Ratings see Next Page

Notes: **I =** **PROTECTION OPERATING CURRENT (A) AT CONSIDERED TIME i.e. "Ie" MAXIMUM EARTH LOOP FAULT CURRENT)**

Ze = **MAXIMUM EARTH LOOP IMPEDANCE (Ω)**

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TABLE 10 (Continuation)

PROSPECTIVE VOLTAGE AND OPERATING TIME: PROTECTION FUSE CURRENT AND RELEVANT EARTH LOOP IMPEDANCE

PROSPECTIVE TOUCH VOLTAGE (V)	MAXIMUM OPERATING TIME (s)	V/Vo=Zpe/Ze	FUSE RATING (A)																						REMARKS
			125		160		200		250																
			I	Ze	I	Ze	I	Ze	I	Ze															
50	5	0,227	800	0,275	1000	0,22	1900	0,17	1700	0,13															
75	1	0,341	1150	0,19	1450	0,15	1900	0,11	2500	0,088															
90	0,5	0,409	1400	0,15	1750	0,12	2300	0,095	3000	0,073															
110	0,2	0,5	1700	0,12	2200	0,1	2900	0,075	3800	0,075															
150	0,1	0,682	2100	0,1	2600	0,08	3500	0,062	4600	0,047															
220	0,05	1	2600	0,08	3200	0,06	4200	0,052	5500	0,04															

Notes: **I =** **PROTECTION OPERATING CURRENT (A) AT CONSIDERED TIME i.e. "Ie" MAXIMUM EARTH LOOP FAULT CURRENT)**

Ze = **MAXIMUM EARTH LOOP IMPEDANCE (Ω)**

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TABLE 11

PROSPECTIVE VOLTAGE AND OPERATING TIME: PROTECTION CIRCUIT BREAKER CURRENT AND RELEVANT EARTH LOOP IMPEDANCE

PROSPECTIVE TOUCH VOLTAGE (V)	MAXIMUM OPERATING TIME (s)	V/Vo=Zpe/Ze	FUSE RATING (A)																REMARKS
			20		25		32		40		50		63		80		100		
			I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	I	Ze	
50	5	0,227	190	1,157	237,5	0,92	304	0,72	380	0,578	475	0,46	598	0,367	760	0,289	950	0,23	
75	1	0,341	220	1	275	0,8	352	0,625	440	0,5	550	0,4	693	0,31	880	0,25	1100	0,2	
90	0,5	0,409																	
110	0,2	0,5																	
150	0,1	0,682																	
220	0,05	1																	

For continuation of Table 11 for High Fuse Ratings see Next Page

Notes: **I =** **PROTECTION OPERATING CURRENT (A) AT CONSIDERED TIME i.e. "Ie" MAXIMUM EARTH LOOP FAULT CURRENT)**

Ze = **MAXIMUM EARTH LOOP IMPEDANCE (Ω)**

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TABLE 11 (Continuation)

PROSPECTIVE VOLTAGE AND OPERATING TIME: PROTECTION CIRCUIT BREAKER CURRENT AND RELEVANT EARTH LOOP IMPEDANCE

PROSPECTIVE TOUCH VOLTAGE (V)	MAXIMUM OPERATING TIME (s)	V/Vo=Zpe/Ze	125		160		200		250		320		400		500		630		800		1000		REMARKS
			I	Ze	I	Ze	I	Ze	I	Ze													
50	5	0,227	1150	0,19	1472	0,149	2200	0,1	2700	0,08	3520	0,062	4400	0,05	5500	0,04	6930	0,03	8800	0,25	1100	0,02	
75	1	0,341	1375	0,16	1760	0,125																	
90	0,5	0,409																					
110	0,2	0,5																					
150	0,1	0,682																					
220	0,05	1																					

Notes: I = PROTECTION OPERATING CURRENT (A) AT CONSIDERED TIME i.e. "Ie" MAXIMUM EARTH LOOP FAULT CURRENT)

Ze =MAXIMUM EARTH LOOP IMPEDANCE (Ω)