CIRCUIT BREAKER SHORT-CIRCUIT TEST RESPONSE DATA AND ANALYSIS

Short-circuit test data cited above has been assembled from random, "in-situ" field tests conducted at receptacle outlets protected by 15 and 20 amp/120-volt branch circuit breakers installed in dwelling units located in several different geographic areas of the US. The test data presented has been selected because the contributors of the data verified on supplying it that all tests were gathered from existing and occupied residences. The data has been copied from the recorded instrument data logged by professional users of a test instrument who were performing the tests in the course of their regular business in the homes of their customers. This data presents the electronically recorded available short-circuit current and short-circuit response time in milliseconds for each short-circuit test of an installed circuit breaker. All tests were conducted "in-situ" from an outlet chosen at random on the circuit protected by the circuit breaker-under-test. Recorded amplitude and duration of a fault test provide the data necessary to calculate the I2T conductor heating value for each test and compare the I2T values found in the test sample to the method for determinir

The data has been separated into two groups:

· The first group is identified as Magnetic responses. This group includes any circuit breaker response time shorter than 17 milliseconds (approximating 1-cycle), which corresponds to the specified clearing time for the magnetic response of all major manufacturers of standard thermal/magnetic circuit breakers per their published time-current characteristics.

·The second group is identified as Thermal responses, which consists of any circuit breaker response time longer than 17 milliseconds (approximating 1-cycle).

Analysis of this I^2T conductor heating data indicates that three general conditions exist regarding the performance of installed circuit breakers. Analysis compares test results to withstand ratings established in the ICEA Publication P32-382 using the methodology laid out by Soares book and referred to above:

1. The highest value of I^2T conductor heating in any magnetic response (20,358 amps-squared-seconds) is less than ½ the insulation withstand rating (47,000 amps-squared-seconds) for a #14 AWG/75C insulated conductor. This wide margin of safety between the highest I^2T heating recorded in a magnetic response and the maximum safe limit indicates that when a circuit breaker's magnetic response is triggered in response to a fault condition, the instantaneous (1-cycle) clearing time of the magnetic response almost certainly will prevent overheating and possible degradation of conductor insulation.

2. The value of I^2T conductor heating in 18% of the thermal responses exceeds the insulation withstand rating for a #14 AWG/75C insulated conductor, suggesting according to Soares that conductor insulation may be damaged by overheating in these instances, creating potentially unsafe conditions in the circuit when the circuit is re-energized subsequent to the localized repair of the faulted condition.

3. The highest value of I^2T heating among the thermal responses is nearly double the insulation withstand rating for a #14 AWG/75C insulated conductor (88,804 amps-squared-seconds). A significant number (35%) of the tests exceeding the withstand rating did so by at least 150% of the withstand rating.

CIRCUIT BREAKER SHORT-CIRCUIT RESPONSES and CONDUCTOR HEATING		
Number of 15-20A/120-volt receptacle outlets in sample:		**1017**
CIRCUIT BREAKER RESPONSE SUMMARY DATA		
MAGNETIC RESPONSES: < 17 milliseconds	**438**	**43%**
THERMAL RESPONSES: => 17 milliseconds	**579**	**57%**
NOTE: Using the reference sources cited below, **47,000** is calculated to be the value of I^2T representing the limit of conductor heating for #14 cable insulated to 75 C, above which the potential for insulation damage exists.		
HIGHEST I^2T VALUE OF ANY MAGNETIC RESPONSE: (amps squared x seconds)		**20,358**
HIGHEST I^2T VALUE FOR A THERMAL RESPONSE: (amps squared x seconds)		**88,804**
POTENTIAL INSULATION DAMAGE: # OF THERMAL RESPONSES > CALCULATED SAFE LIMIT SHOWN AS % OF THERMAL RESPONSES	**104**	**18%**
Source data: Soares' Book on Grounding and Bonding (2004 Ed.), Chapter 11 (Clearing Ground-faults and Short Circuits), Pages 203-207, esp. Figure 11-14 (courtesy ICEA) "5-Second Withstand Ratings for Insulated Conductors..." row 1, column 4		

DETAILED TEST RESULTS					DETAILED TEST RESULTS				
Test	Voltage Drop @ Outlet	Available Fault Current	Breaker Response Time	I^2T	Test	Voltage Drop @ Outlet	Available Fault Current	Breaker Response Time	I^2T
#	PERCENT	AMPS	MILLISECONDS	$AMPS^2$-SECS	#	PERCENT	AMPS	MILLISECONDS	$AMPS^2$-SECS
1	10.5	135	1141	**20,795**	74	9.0	160	1108	**28,365**
2	10.5	139	1299	**25,098**	75	9.0	163	807	**21,441**
3	10.5	140	1083	**21,227**	76	9.0	164	849	**22,835**
4	10.4	134	1933	**34,709**	77	9.0	167	16	**446**
5	10.3	140	1199	**23,500**	78	8.9	157	883	**21,765**
6	10.3	143	1174	**24,007**	79	8.9	157	891	**21,962**
7	10.3	144	1150	**23,846**	80	8.9	157	1225	**30,195**
8	10.3	145	1200	**25,230**	81	8.9	157	1182	**29,135**
9	10.2	146	1458	**31,079**	82	8.9	157	908	**22,381**
10	10.1	149	1081	**23,999**	83	8.9	157	1224	**30,170**
11	10.1	151	883	**20,133**	84	8.9	157	908	**22,381**
12	10.0	137	958	**17,981**	85	8.9	158	1232	**30,756**
13	10.0	152	867	**20,031**	86	8.9	161	791	**20,504**
14	10.0	152	866	**20,008**	87	8.9	164	816	**21,947**
15	9.9	140	1149	**22,520**	88	8.9	165	791	**21,535**
16	9.9	141	965	**19,185**	89	8.9	166	66	**1,819**
17	9.9	143	1016	**20,776**	90	8.9	167	583	**16,259**
18	9.9	149	908	**20,159**	91	8.9	167	616	**17,180**
19	9.9	151	1074	**24,488**	92	8.8	158	891	**22,243**
20	9.9	153	875	**20,483**	93	8.8	158	1232	**30,756**
21	9.8	139	925	**17,872**	94	8.8	159	883	**22,323**
22	9.8	142	1782	**35,932**	95	8.8	159	1232	**31,146**
23	9.8	149	9	**200**	96	8.8	160	899	**23,014**
24	9.8	149	1482	**32,902**	97	8.8	160	883	**22,605**
25	9.8	152	8	**185**	98	8.8	160	1225	**31,360**
26	9.8	153	2400	**56,182**	99	8.8	160	1200	**30,720**
27	9.8	156	866	**21,075**	100	8.8	160	891	**22,810**
28	9.7	141	950	**18,887**	101	8.8	161	1283	**33,257**
29	9.7	142	950	**19,156**	102	8.8	163	1316	**34,965**
30	9.7	142	941	**18,974**	103	8.8	163	1108	**29,438**
31	9.7	143	900	**18,404**	104	8.8	164	1124	**30,231**
32	9.7	151	875	**19,951**	105	8.8	164	1125	**30,258**
33	9.7	154	82	**1,945**	106	8.8	165	783	**21,317**
34	9.6	143	933	**19,079**	107	8.8	168	966	**27,264**
35	9.6	145	941	**19,785**	108	8.8	168	16	**452**
36	9.5	146	191	**4,071**	109	8.8	168	808	**22,805**
37	9.5	147	1041	**22,495**	110	8.8	173	16	**479**
38	9.5	157	942	**23,219**	111	8.8	174	2516	**76,174**
39	9.5	159	766	**19,365**	112	8.7	159	257	**6,497**
40	9.4	150	1815	**40,838**	113	8.7	161	1241	**32,168**
41	9.4	151	899	**20,498**	114	8.7	162	1341	**35,193**
42	9.4	156	774	**18,836**	115	8.7	163	1233	**32,760**
43	9.4	156	783	**19,055**	116	8.7	165	1033	**28,123**
44	9.4	156	684	**16,646**	117	8.7	165	1024	**27,878**
45	9.4	157	576	**14,198**	118	8.7	165	1025	**27,906**
46	9.4	158	675	**16,851**	119	8.7	170	833	**24,074**
47	9.3	151	1184	**26,996**	120	8.7	174	1033	**31,275**
48	9.3	155	1225	**29,431**	121	8.7	174	825	**24,978**
49	9.3	156	791	**19,250**	122	8.7	174	1033	**31,275**
50	9.3	157	808	**19,916**	123	8.6	162	891	**23,383**
51	9.3	158	1817	**45,360**	124	8.6	166	1075	**29,623**
52	9.3	159	1299	**32,840**	125	8.6	167	1041	**29,032**
53	9.3	159	775	**19,593**	126	8.6	168	1133	**31,978**
54	9.3	163	866	**23,009**	127	8.6	168	741	**20,914**
55	9.2	156	791	**19,250**	128	8.6	168	1033	**29,155**
56	9.2	158	817	**20,396**	129	8.6	168	750	**21,168**
57	9.2	158	799	**19,946**	130	8.6	168	1016	**28,676**
58	9.2	159	825	**20,857**	131	8.6	168	1008	**28,450**
59	9.2	159	807	**20,402**	132	8.6	168	957	**27,010**
60	9.2	159	783	**19,795**	133	8.6	170	3011	**87,018**
61	9.2	160	825	**21,120**	134	8.6	176	725	**22,458**
62	9.2	161	1316	**34,112**	135	8.5	171	825	**24,124**
63	9.2	162	2608	**68,444**	136	8.5	171	1042	**30,469**
64	9.2	162	2750	**72,171**	137	8.5	171	1033	**30,206**
65	9.2	167	2835	**79,065**	138	8.5	171	1033	**30,206**
66	9.1	161	800	**20,737**	139	8.4	171	976	**28,539**
67	9.1	161	791	**20,504**	140	8.4	171	917	**26,814**
68	9.1	162	774	**20,313**	141	8.4	173	600	**17,957**
69	9.1	163	391	**10,388**	142	8.4	173	967	**28,941**
70	9.1	164	8	**215**	143	8.4	180	616	**19,958**
71	9.0	156	866	**21,075**	144	8.3	172	675	**19,969**
72	9.0	157	883	**21,765**	145	8.3	174	925	**28,005**
73	9.0	158	875	**21,844**	146	8.3	175	600	**18,375**

Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T $AMPS^2$-SECS	Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T $AMPS^2$-SECS
147	8.3	176	916	**28,374**	222	7.6	200	657	**26,280**
148	8.3	177	634	**19,863**	223	7.6	200	1641	**65,640**
149	8.3	179	916	**29,350**	224	7.6	200	1916	**76,640**
150	8.3	179	16	**513**	225	7.5	191	607	**22,144**
151	8.3	180	426	**13,802**	226	7.5	193	466	**17,358**
152	8.3	182	1158	**38,358**	227	7.5	194	483	**18,178**
153	8.3	182	724	**23,982**	228	7.5	195	483	**18,366**
154	8.3	182	717	**23,750**	229	7.5	199	533	**21,107**
155	8.3	182	1158	**38,358**	230	7.5	200	674	**26,960**
156	8.2	172	9	**266**	231	7.5	200	658	**26,320**
157	8.2	177	933	**29,230**	232	7.5	200	666	**26,640**
158	8.2	177	924	**28,948**	233	7.5	200	741	**29,640**
159	8.2	177	657	**20,583**	234	7.5	201	733	**29,614**
160	8.2	178	583	**18,472**	235	7.5	202	665	**27,135**
161	8.2	178	950	**30,100**	236	7.4	194	16	**602**
162	8.2	179	591	**18,936**	237	7.4	196	475	**18,248**
163	8.2	179	908	**29,093**	238	7.4	198	458	**17,955**
164	8.2	179	924	**29,606**	239	7.4	199	924	**36,591**
165	8.2	180	650	**21,060**	240	7.4	199	466	**18,454**
166	8.1	177	925	**28,979**	241	7.4	207	8	**343**
167	8.1	180	583	**18,889**	242	7.4	212	433	**19,461**
168	8.1	180	934	**30,262**	243	7.4	214	433	**19,830**
169	8.1	184	425	**14,389**	244	7.3	197	25	**970**
170	8.1	185	416	**14,238**	245	7.3	198	475	**18,622**
171	8.0	182	650	**21,531**	246	7.3	199	8	**317**
172	8.0	184	983	**33,280**	247	7.3	199	475	**18,810**
173	8.0	186	583	**20,169**	248	7.3	201	1791	**72,358**
174	8.0	192	16	**590**	249	7.3	202	458	**18,688**
175	7.9	185	925	**31,658**	250	7.3	202	458	**18,688**
176	7.9	185	907	**31,042**	251	7.3	205	483	**20,298**
177	7.9	189	516	**18,432**	252	7.3	208	50	**2,163**
178	7.9	190	575	**20,758**	253	7.3	213	816	**37,021**
179	7.9	199	1483	**58,728**	254	7.2	201	1866	**75,388**
180	7.8	190	583	**21,046**	255	7.2	201	449	**18,140**
181	7.8	194	683	**25,705**	256	7.2	203	466	**19,203**
182	7.8	194	658	**24,764**	257	7.2	203	466	**19,203**
183	7.7	184	42	**1,422**	258	7.2	213	17	**771**
184	7.7	189	491	**17,539**	259	7.1	215	641	**29,630**
185	7.7	194	633	**23,824**	260	7.1	215	641	**29,630**
186	7.7	194	674	**25,367**	261	7.1	215	1365	**63,097**
187	7.7	194	675	**25,404**	262	7.0	209	16	**699**
188	7.7	194	674	**25,367**	263	7.0	213	533	**24,182**
189	7.7	194	516	**19,420**	264	7.0	213	25	**1,134**
190	7.7	194	525	**19,759**	265	7.0	215	41	**1,895**
191	7.7	194	366	**13,775**	266	7.0	215	1433	**66,240**
192	7.7	195	791	**30,078**	267	7.0	217	616	**29,007**
193	7.7	195	674	**25,629**	268	7.0	217	1166	**54,906**
194	7.7	195	690	**26,237**	269	7.0	217	391	**18,412**
195	7.7	195	841	**31,979**	270	7.0	218	400	**19,010**
196	7.7	196	742	**28,505**	271	7.0	221	1216	**59,391**
197	7.7	196	1825	**70,109**	272	7.0	221	1216	**59,391**
198	7.7	197	841	**32,638**	273	7.0	222	566	**27,895**
199	7.7	198	25	**980**	274	7.0	222	566	**27,895**
200	7.7	198	25	**980**	275	6.9	217	25	**1,177**
201	7.6	188	25	**884**	276	6.9	218	633	**30,083**
202	7.6	188	150	**5,302**	277	6.9	220	416	**20,134**
203	7.6	193	9	**335**	278	6.9	220	566	**27,394**
204	7.6	195	33	**1,255**	279	6.9	220	558	**27,007**
205	7.6	197	1884	**73,116**	280	6.9	220	491	**23,764**
206	7.6	197	1108	**43,000**	281	6.9	220	566	**27,394**
207	7.6	197	667	**25,886**	282	6.9	220	399	**19,312**
208	7.6	197	958	**37,179**	283	6.9	221	566	**27,644**
209	7.6	197	516	**20,025**	284	6.9	221	492	**24,030**
210	7.6	197	516	**20,025**	285	6.9	221	392	**19,146**
211	7.6	198	525	**20,582**	286	6.9	221	1325	**64,714**
212	7.6	198	667	**26,149**	287	6.9	222	566	**27,895**
213	7.6	198	666	**26,110**	288	6.8	205	409	**17,188**
214	7.6	198	674	**26,423**	289	6.8	208	441	**19,079**
215	7.6	198	666	**26,110**	290	6.8	212	16	**719**
216	7.6	198	516	**20,229**	291	6.8	212	25	**1,124**
217	7.6	198	391	**15,329**	292	6.8	220	408	**19,747**
218	7.6	199	683	**27,047**	293	6.8	220	391	**18,924**
219	7.6	199	758	**30,018**	294	6.8	221	10	**488**
220	7.6	199	657	**26,018**	295	6.8	221	575	**28,084**
221	7.6	199	733	**29,028**					

Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS	Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS
296	6.8	221	400	**19,536**	370	6.3	238	16	
297	6.8	221	401	**19,585**	371	6.3	238	16	**906**
298	6.8	222	583	**28,733**	372	6.3	240	293	**16,877**
299	6.8	223	516	**25,660**	373	6.3	240	16	**922**
300	6.8	223	25	**1,243**	374	6.3	241	9	**523**
301	6.8	223	16	**796**	375	6.3	241	16	**929**
302	6.8	223	566	**28,147**	376	6.3	242	550	**32,210**
303	6.8	223	25	**1,243**	377	6.3	243	9	**531**
304	6.8	223	566	**28,147**	378	6.3	243	466	**27,517**
305	6.8	224	24	**1,204**	379	6.3	243	508	**29,997**
306	6.8	225	25	**1,266**	380	6.3	247	541	**33,006**
307	6.8	226	426	**21,758**	381	6.3	247	541	**33,006**
308	6.8	226	826	**42,189**	382	**6.2**	233	341	**18,513**
309	6.8	226	558	**28,500**	383	6.2	238	26	**1,473**
310	6.8	226	483	**24,670**	384	6.2	239	241	**13,766**
311	6.8	226	482	**24,619**	385	6.2	241	400	**23,232**
312	6.8	226	650	**33,199**	386	6.2	245	16	**960**
313	6.8	231	500	**26,681**	387	6.2	245	8	**480**
314	6.8	231	500	**26,681**	388	6.2	245	16	**960**
315	6.7	213	58	**2,631**	389	6.2	245	33	**1,981**
316	6.7	217	524	**24,675**	390	6.2	248	391	**24,048**
317	6.7	218	816	**38,780**	391	6.1	238	350	**19,825**
318	6.7	225	16	**810**	392	6.1	240	358	**20,621**
319	6.7	225	16	**810**	393	6.1	242	474	**27,759**
320	6.7	225	583	**29,514**	394	6.1	243	350	**20,667**
321	6.7	225	408	**20,655**	395	6.1	247	291	**17,754**
322	6.7	225	25	**1,266**	396	6.1	247	16	**976**
323	6.7	225	575	**29,109**	397	6.1	248	285	**17,529**
324	6.7	225	25	**1,266**	398	6.1	248	16	**984**
325	6.7	226	400	**20,430**	399	6.1	248	408	**25,094**
326	6.7	227	741	**38,183**	400	6.1	249	16	**992**
327	6.7	227	583	**30,041**	401	6.1	249	9	**558**
328	6.7	227	575	**29,629**	402	6.1	249	9	**558**
329	6.7	227	566	**29,165**	403	6.1	250	483	**30,188**
330	6.7	227	41	**2,113**	404	6.1	250	441	**27,563**
331	6.7	227	566	**29,165**	405	6.1	250	158	**9,875**
332	6.7	227	399	**20,560**	406	6.1	250	391	**24,438**
333	6.7	229	566	**29,682**	407	6.1	252	316	**20,067**
334	6.7	230	482	**25,498**	408	6.1	253	16	**1,024**
335	6.7	230	482	**25,498**	409	6.1	253	458	**29,316**
336	6.7	237	1176	**66,055**	410	6.1	260	975	**65,910**
337	6.6	215	8	**370**	411	6.0	239	350	**19,992**
338	6.6	216	25	**1,166**	412	6.0	242	16	**937**
339	6.6	219	16	**767**	413	6.0	242	16	**937**
340	6.6	223	525	**26,108**	414	6.0	243	16	**945**
341	6.6	226	1712	**87,442**	415	6.0	247	8	**488**
342	6.6	228	16	**832**	416	6.0	248	8	**492**
343	6.6	228	400	**20,794**	417	6.0	252	359	**22,798**
344	6.6	228	400	**20,794**	418	6.0	252	691	**43,881**
345	6.6	228	1673	**86,969**	419	6.0	252	475	**30,164**
346	6.6	229	641	**33,615**	420	6.0	253	16	**1,024**
347	6.6	229	524	**27,479**	421	6.0	253	377	**24,131**
348	6.6	229	583	**30,573**	422	6.0	253	16	**1,024**
349	6.6	229	583	**30,573**	423	6.0	253	109	**6,977**
350	6.6	230	16	**846**	424	6.0	254	16	**1,032**
351	6.6	230	16	**846**	425	6.0	254	9	**581**
352	6.6	231	482	**25,720**	426	6.0	254	16	**1,032**
353	6.6	231	25	**1,334**	427	6.0	254	242	**15,613**
354	6.6	231	25	**1,334**	428	6.0	254	383	**24,710**
355	**6.6**	233	575	**31,216**	429	6.0	255	401	**26,075**
356	**6.6**	234	501	**27,433**	430	6.0	256	466	**30,540**
357	6.5	215	466	**21,541**	431	6.0	256	391	**25,625**
358	6.5	215	449	**20,755**	432	6.0	256	9	**590**
359	6.5	219	33	**1,583**	433	6.0	257	458	**30,250**
360	**6.5**	233	16	**869**	434	6.0	258	841	**55,980**
361	6.5	235	558	**30,816**	435	6.0	265	865	**60,745**
362	6.5	235	608	**33,577**	436	5.9	242	16	**937**
363	6.5	237	16	**899**	437	5.9	245	16	**960**
364	6.4	220	225	**10,890**	438	5.9	245	16	**960**
365	6.4	229	8	**420**	439	5.9	246	416	**25,175**
366	6.3	227	208	**10,718**	440	5.9	252	8	**508**
367	**6.3**	233	16	**869**	441	5.9	258	10	**666**
368	**6.3**	234	1066	**58,370**	442	5.9	259	391	**26,229**
369	6.3	237	33	**1,854**	443	5.9	263	691	**47,796**

Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS	Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS
444	5.9	263	325	**22,480**	518	5.4	280	709	**55,586**
445	5.9	268	10	**718**	519	5.4	282	8	**636**
446	5.9	268	434	**31,172**	520	5.4	282	16	**1,272**
447	5.8	248	16	**984**	521	5.4	283	10	**801**
448	5.8	248	525	**32,290**	522	5.4	285	91	**7,391**
449	5.8	251	8	**504**	523	5.4	286	266	**21,758**
450	5.8	251	16	**1,008**	524	5.4	288	567	**47,029**
451	5.8	251	391	**24,633**	525	5.4	292	616	**52,523**
452	5.8	251	9	**567**	526	5.4	292	9	**767**
453	5.8	251	16	**1,008**	527	5.4	292	616	**52,523**
454	5.8	254	8	**516**	528	5.4	293	10	**858**
455	5.8	261	335	**22,821**	529	5.4	293	707	**60,695**
456	5.8	261	25	**1,703**	530	5.3	278	9	**696**
457	5.8	262	1278	**87,727**	531	5.3	281	35	**2,764**
458	5.8	263	774	**53,537**	532	5.3	283	8	**641**
459	5.8	263	1008	**69,722**	533	5.3	284	8	**645**
460	5.8	264	658	**45,860**	534	5.3	284	966	**77,914**
461	5.8	265	16	**1,124**	535	5.3	285	8	**650**
462	5.8	267	600	**42,773**	536	5.3	285	8	**650**
463	5.8	268	51	**3,663**	537	5.3	285	8	**650**
464	5.8	268	917	**65,863**	538	5.3	288	16	**1,327**
465	5.8	268	9	**646**	539	5.3	290	357	**30,024**
466	5.8	275	8	**605**	540	5.3	295	18	**1,566**
467	5.7	253	16	**1,024**	541	5.3	295	18	**1,566**
468	5.7	255	525	**34,138**	542	5.2	278	141	**10,897**
469	5.7	259	466	**31,260**	543	5.2	287	41	**3,377**
470	5.7	259	9	**604**	544	5.2	288	10	**829**
471	5.7	262	16	**1,098**	545	5.2	288	9	**746**
472	5.7	262	9	**618**	546	5.2	288	8	**664**
473	5.7	262	9	**618**	547	5.2	289	8	**668**
474	5.7	271	377	**27,687**	548	5.2	289	52	**4,343**
475	5.7	271	16	**1,175**	549	5.2	289	16	**1,336**
476	5.7	271	940	**69,035**	550	5.2	289	16	**1,336**
477	5.7	272	909	**67,251**	551	5.2	290	8	**673**
478	5.7	272	33	**2,441**	552	5.2	290	8	**673**
479	5.6	258	16	**1,065**	553	5.2	291	8	**677**
480	5.6	267	474	**33,791**	554	5.2	291	9	**762**
481	5.6	267	9	**642**	555	5.2	291	8	**677**
482	5.6	267	9	**642**	556	5.2	293	10	**858**
483	5.6	267	366	**26,092**	557	5.2	295	9	**783**
484	5.6	267	9	**642**	558	5.2	298	8	**710**
485	5.6	267	9	**642**	559	5.2	300	16	**1,440**
486	5.6	267	9	**642**	560	5.2	301	16	**1,450**
487	5.6	267	391	**27,874**	561	5.2	301	17	**1,540**
488	5.6	268	8	**575**	562	5.1	291	8	**677**
489	5.6	269	991	**71,710**	563	5.1	294	8	**691**
490	5.6	271	332	**24,382**	564	5.1	295	8	**696**
491	5.6	271	9	**661**	565	5.1	295	8	**696**
492	5.6	271	16	**1,175**	566	5.1	295	8	**696**
493	5.6	271	9	**661**	567	5.1	295	16	**1,392**
494	5.6	274	9	**676**	568	5.1	298	8	**710**
495	5.6	275	757	**57,248**	569	5.1	298	8	**710**
496	5.6	278	16	**1,237**	570	5.1	300	16	**1,440**
497	5.6	279	525	**40,867**	571	5.1	301	650	**58,891**
498	5.6	279	525	**40,867**	572	5.1	301	8	**725**
499	5.6	287	626	**51,563**	573	5.1	302	10	**912**
500	5.5	270	375	**27,338**	574	5.1	304	16	**1,479**
501	5.5	270	9	**656**	575	5.1	306	16	**1,498**
502	5.5	274	8	**601**	576	5.1	306	16	**1,498**
503	5.5	282	391	**31,094**	577	5.1	307	8	**754**
504	5.5	283	483	**38,683**	578	5.1	307	8	**754**
505	5.5	283	8	**641**	579	5.1	307	16	**1,508**
506	5.5	287	817	**67,295**	580	5.1	307	8	**754**
507	5.5	292	792	**67,529**	581	5.1	308	559	**53,029**
508	5.4	272	10	**740**	582	5.1	308	559	**53,029**
509	5.4	274	9	**676**	583	5.1	311	10	**967**
510	5.4	274	9	**676**	584	5.1	312	168	**16,354**
511	5.4	274	9	**676**	585	5.0	291	158	**13,380**
512	5.4	274	9	**676**	586	5.0	294	18	**1,556**
513	5.4	275	9	**681**	587	5.0	295	9	**783**
514	5.4	275	9	**681**	588	5.0	295	8	**696**
515	5.4	275	141	**10,663**	589	5.0	295	41	**3,568**
516	5.4	277	733	**56,242**	590	5.0	298	8	**710**
517	5.4	277	8	**614**	591	5.0	298	8	**710**

Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS	Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS
592	5.0	300	8	**720**	666	4.4	343	225	**26,471**
593	5.0	301	8	**725**	667	4.4	344	8	**947**
594	5.0	301	8	**725**	668	4.4	348	16	**1,938**
595	5.0	301	8	**725**	669	4.4	349	392	**47,746**
596	5.0	301	8	**725**	670	4.4	351	8	**986**
597	5.0	304	10	**924**	671	4.4	351	8	**986**
598	5.0	304	8	**739**	672	4.4	352	8	**991**
599	5.0	305	566	**52,652**	673	4.4	352	8	**991**
600	5.0	309	8	**764**	674	4.4	357	8	**1,020**
601	5.0	310	33	**3,171**	675	4.4	357	9	**1,147**
602	5.0	310	9	**865**	676	4.4	357	266	**33,901**
603	5.0	311	10	**967**	677	4.4	360	574	**74,390**
604	5.0	314	251	**24,748**	678	4.4	360	574	**74,390**
605	5.0	314	251	**24,748**	679	4.4	362	383	**50,190**
606	5.0	314	557	**54,918**	680	4.4	362	383	**50,190**
607	4.9	298	9	**799**	681	4.4	364	8	**1,060**
608	4.9	306	8	**749**	682	4.4	365	257	**34,239**
609	4.9	308	8	**759**	683	4.4	365	302	**40,234**
610	4.9	308	8	**759**	684	4.3	342	10	**1,170**
611	4.9	309	191	**18,237**	685	4.3	345	8	**952**
612	4.9	312	898	**87,415**	686	4.3	345	8	**952**
613	4.9	314	8	**789**	687	4.3	345	8	**952**
614	4.9	314	10	**986**	688	4.3	349	8	**974**
615	4.9	317	35	**3,517**	689	4.3	349	8	**974**
616	4.9	321	616	**63,473**	690	4.3	352	8	**991**
617	4.9	321	608	**62,649**	691	4.3	353	10	**1,246**
618	4.9	321	8	**824**	692	4.3	353	8	**997**
619	4.9	322	616	**63,869**	693	4.3	353	8	**997**
620	4.9	324	8	**840**	694	4.3	353	416	**51,837**
621	4.9	324	8	**840**	695	4.3	353	8	**997**
622	4.9	329	435	**47,085**	696	4.3	353	8	**997**
623	4.8	315	8	**794**	697	4.3	353	10	**1,246**
624	4.8	318	864	**87,371**	698	4.3	359	8	**1,031**
625	4.8	318	864	**87,371**	699	4.3	362	9	**1,179**
626	4.8	322	50	**5,184**	700	4.3	363	16	**2,108**
627	4.8	323	24	**2,504**	701	4.3	363	16	**2,108**
628	4.8	328	591	**63,582**	702	4.3	365	158	**21,050**
629	4.8	328	591	**63,582**	703	4.3	365	158	**21,050**
630	4.8	328	9	**968**	704	4.3	365	424	**56,487**
631	4.8	330	75	**8,168**	705	4.3	365	424	**56,487**
632	4.8	330	75	**8,168**	706	4.3	366	16	**2,143**
633	4.8	332	582	**64,150**	707	4.3	366	10	**1,340**
634	4.7	312	9	**876**	708	4.3	368	8	**1,083**
635	4.7	313	24	**2,351**	709	4.3	372	91	**12,593**
636	4.7	316	8	**799**	710	4.3	377	8	**1,137**
637	4.7	319	859	**87,413**	711	4.2	354	8	**1,003**
638	4.7	325	309	**32,638**	712	4.2	355	8	**1,008**
639	4.7	330	8	**871**	713	4.2	358	8	**1,025**
640	4.7	330	8	**871**	714	4.2	358	8	**1,025**
641	4.7	335	591	**66,325**	715	4.2	365	133	**17,719**
642	4.6	315	9	**893**	716	4.2	365	133	**17,719**
643	4.6	325	9	**951**	717	4.2	367	199	**26,803**
644	4.6	328	485	**52,178**	718	4.2	368	276	**37,377**
645	4.6	329	16	**1,732**	719	4.2	371	16	**2,202**
646	4.6	330	16	**1,742**	720	4.2	374	8	**1,119**
647	4.6	330	8	**871**	721	4.2	375	9	**1,266**
648	4.6	331	8	**876**	722	4.2	375	9	**1,266**
649	4.6	337	8	**909**	723	4.2	385	291	**43,133**
650	4.6	338	425	**48,554**	724	4.2	393	8	**1,236**
651	4.6	345	9	**1,071**	725	4.1	356	8	**1,014**
652	4.5	333	8	**887**	726	4.1	371	16	**2,202**
653	4.5	339	16	**1,839**	727	4.1	372	16	**2,214**
654	4.5	346	9	**1,077**	728	4.1	373	10	**1,391**
655	4.5	348	8	**969**	729	4.1	376	10	**1,414**
656	4.5	348	10	**1,211**	730	4.1	379	16	**2,298**
657	4.5	348	24	**2,906**	731	4.1	383	9	**1,320**
658	4.5	352	526	**65,174**	732	4.1	383	555	**81,412**
659	4.5	353	374	**46,604**	733	4.1	388	382	**57,508**
660	4.4	335	8	**898**	734	4.1	388	8	**1,204**
661	4.4	340	8	**925**	735	4.1	390	8	**1,217**
662	4.4	340	8	**925**	736	4.0	382	243	**35,460**
663	4.4	340	8	**925**	737	4.0	383	435	**63,810**
664	4.4	342	8	**936**	738	4.0	388	10	**1,505**
665	4.4	342	8	**936**	739	4.0	391	8	**1,223**

Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS	Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS
740	4.0	394	182	**28,253**	814	3.4	470	8	**1,767**
741	4.0	398	10	**1,584**	815	3.4	470	16	**3,534**
742	4.0	398	16	**2,534**	816	3.4	471	149	**33,054**
743	4.0	398	10	**1,584**	817	3.4	478	8	**1,828**
744	4.0	398	16	**2,534**	818	3.3	462	10	**2,134**
745	3.9	377	10	**1,421**	819	3.3	473	174	**38,929**
746	3.9	385	16	**2,372**	820	3.3	473	10	**2,237**
747	3.9	391	124	**18,957**	821	3.3	473	10	**2,237**
748	3.9	394	149	**23,130**	822	3.3	476	8	**1,813**
749	3.9	396	32	**5,018**	823	3.3	477	8	**1,820**
750	3.9	399	474	**75,461**	824	3.3	483	124	**28,928**
751	3.9	401	275	**44,220**	825	3.3	483	191	**44,558**
752	3.9	402	10	**1,616**	826	3.3	483	10	**2,333**
753	3.9	402	410	**66,258**	827	3.3	487	8	**1,897**
754	3.9	402	241	**38,947**	828	3.3	487	8	**1,897**
755	3.9	403	357	**57,980**	829	3.3	499	8	**1,992**
756	3.9	403	332	**53,920**	830	3.2	494	16	**3,905**
757	3.9	403	218	**35,405**	831	3.1	479	10	**2,294**
758	3.9	405	166	**27,228**	832	3.1	491	274	**66,056**
759	3.9	407	8	**1,325**	833	3.1	498	91	**22,568**
760	3.9	411	33	**5,574**	834	3.1	500	18	**4,500**
761	3.9	411	33	**5,574**	835	3.1	510	10	**2,601**
762	3.8	403	24	**3,898**	836	3.1	513	16	**4,211**
763	3.8	403	16	**2,599**	837	3.1	513	8	**2,105**
764	3.8	405	16	**2,624**	838	3.1	514	182	**48,084**
765	3.8	407	16	**2,650**	839	3.1	518	10	**2,683**
766	3.8	411	16	**2,703**	840	3.1	528	166	**46,278**
767	3.8	415	8	**1,378**	841	3.0	512	334	**87,556**
768	3.8	416	10	**1,731**	842	3.0	520	10	**2,704**
769	3.8	418	10	**1,747**	843	3.0	521	16	**4,343**
770	3.8	420	8	**1,411**	844	3.0	521	8	**2,172**
771	3.8	426	174	**31,577**	845	3.0	531	8	**2,256**
772	3.7	410	16	**2,690**	846	3.0	531	8	**2,256**
773	3.7	418	24	**4,193**	847	3.0	531	268	**75,566**
774	3.7	419	410	**71,980**	848	3.0	533	10	**2,841**
775	3.7	422	8	**1,425**	849	3.0	535	16	**4,580**
776	3.7	425	10	**1,806**	850	3.0	536	8	**2,298**
777	3.7	425	132	**23,843**	851	3.0	536	8	**2,298**
778	3.7	428	8	**1,465**	852	3.0	539	8	**2,324**
779	3.7	431	224	**41,610**	853	3.0	549	8	**2,411**
780	3.7	433	291	**54,559**	854	2.9	514	157	**41,479**
781	3.7	433	10	**1,875**	855	2.9	532	16	**4,528**
782	3.7	433	10	**1,875**	856	2.9	538	16	**4,631**
783	3.7	434	132	**24,863**	857	2.9	538	10	**2,894**
784	3.7	440	266	**51,498**	858	2.9	538	8	**2,316**
785	3.7	444	282	**55,592**	859	2.9	539	10	**2,905**
786	3.6	420	8	**1,411**	860	2.9	542	16	**4,700**
787	3.6	423	191	**34,175**	861	2.9	542	10	**2,938**
788	3.6	426	10	**1,815**	862	2.9	542	10	**2,938**
789	3.6	433	8	**1,500**	863	2.9	547	10	**2,992**
790	3.6	434	8	**1,507**	864	2.9	552	8	**2,438**
791	3.6	434	10	**1,884**	865	2.9	553	124	**37,920**
792	3.6	436	107	**20,340**	866	2.9	563	8	**2,536**
793	3.6	436	10	**1,901**	867	2.8	534	307	**87,543**
794	3.6	439	216	**41,628**	868	2.8	561	16	**5,036**
795	3.6	443	210	**41,212**	869	2.8	572	10	**3,272**
796	3.5	436	16	**3,042**	870	2.8	576	99	**32,846**
797	3.5	440	10	**1,936**	871	2.8	582	16	**5,420**
798	3.5	441	16	**3,112**	872	2.8	583	8	**2,719**
799	3.5	441	8	**1,556**	873	2.8	583	257	**87,351**
800	3.5	441	8	**1,556**	874	2.7	572	10	**3,272**
801	3.5	444	10	**1,971**	875	2.7	573	16	**5,253**
802	3.5	448	10	**2,007**	876	2.7	585	16	**5,476**
803	3.5	449	8	**1,613**	877	2.7	586	99	**33,996**
804	3.5	451	8	**1,627**	878	2.7	586	16	**5,494**
805	3.5	454	16	**3,298**	879	2.7	586	10	**3,434**
806	3.5	455	91	**18,839**	880	2.7	587	10	**3,446**
807	3.5	457	16	**3,342**	881	2.7	587	10	**3,446**
808	3.5	457	16	**3,342**	882	2.7	591	24	**8,383**
809	3.5	457	10	**2,088**	883	2.7	591	8	**2,794**
810	3.5	458	235	**49,295**	884	2.7	591	251	**87,670**
811	3.4	438	10	**1,918**	885	2.7	593	16	**5,626**
812	3.4	458	216	**45,309**	886	2.7	599	16	**5,741**
813	3.4	460	8	**1,693**	887	2.6	583	16	**5,438**

Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS
888	2.6	590	16	**5,570**
889	2.6	603	16	**5,818**
890	2.6	603	16	**5,818**
891	2.6	622	91	**35,206**
892	2.5	626	10	**3,919**
893	2.5	631	16	**6,371**
894	2.5	631	24	**9,556**
895	2.5	632	8	**3,195**
896	2.5	637	16	**6,492**
897	2.5	644	8	**3,318**
898	2.4	649	208	**87,610**
899	2.4	649	208	**87,610**
900	2.4	656	16	**6,885**
901	2.4	658	202	**87,459**
902	2.4	658	16	**6,927**
903	2.4	658	16	**6,927**
904	2.4	664	8	**3,527**
905	2.4	670	195	**87,536**
906	2.4	678	8	**3,677**
907	2.4	678	16	**7,355**
908	2.4	678	16	**7,355**
909	2.4	685	8	**3,754**
910	2.3	668	82	**36,590**
911	2.3	669	8	**3,580**
912	2.3	694	182	**87,658**
913	2.3	698	82	**39,951**
914	2.3	699	74	**36,156**
915	2.3	699	16	**7,818**
916	2.3	702	16	**7,885**
917	2.3	702	8	**3,942**
918	2.3	722	10	**5,213**
919	2.3	722	8	**4,170**
920	2.3	722	10	**5,213**
921	2.3	723	8	**4,182**
922	2.2	720	57	**29,549**
923	2.2	723	82	**42,864**
924	2.2	723	8	**4,182**
925	2.2	723	32	**16,727**
926	2.2	728	16	**8,480**
927	2.2	733	9	**4,836**
928	2.2	741	16	**8,785**
929	2.2	750	8	**4,500**
930	2.2	750	8	**4,500**
931	2.1	739	16	**8,738**
932	2.1	748	8	**4,476**
933	2.1	749	16	**8,976**
934	2.1	749	16	**8,976**
935	2.1	749	16	**8,976**
936	2.1	749	16	**8,976**
937	2.1	765	16	**9,364**
938	2.1	766	16	**9,388**
939	2.1	766	74	**43,420**
940	2.1	775	8	**4,805**
941	2.1	775	8	**4,805**
942	2.1	776	8	**4,817**
943	2.1	776	8	**4,817**
944	2.1	784	8	**4,917**
945	2.0	781	16	**9,759**
946	2.0	781	49	**29,888**
947	2.0	781	57	**34,768**
948	2.0	782	74	**45,253**
949	2.0	794	8	**5,043**
950	2.0	804	16	**10,343**
951	2.0	805	8	**5,184**
952	2.0	815	8	**5,314**
953	2.0	823	10	**6,773**
954	2.0	824	16	**10,864**
955	2.0	826	66	**45,030**
956	1.9	821	88	**59,316**
957	1.9	825	8	**5,445**
958	1.9	833	8	**5,551**
959	1.9	835	16	**11,156**
960	1.9	836	8	**5,591**
961	1.9	836	8	**5,591**

Test #	Voltage Drop @ Outlet PERCENT	Available Fault Current AMPS	Breaker Response Time MILLISECONDS	I^2T AMPS^2-SECS
962	1.9	855	16	**11,696**
963	1.9	870	8	**6,055**
964	1.9	870	8	**6,055**
965	1.9	872	8	**6,083**
966	1.8	867	49	**36,833**
967	1.8	878	49	**37,773**
968	1.8	890	8	**6,337**
969	1.8	892	16	**12,731**
970	1.8	900	41	**33,210**
971	1.8	905	8	**6,552**
972	1.8	931	8	**6,934**
973	1.7	904	16	**13,075**
974	1.7	917	8	**6,727**
975	1.7	934	16	**13,958**
976	1.7	945	98	**87,516**
977	1.7	945	98	**87,516**
978	1.7	956	9	**8,225**
979	1.7	970	8	**7,527**
980	1.7	970	16	**15,054**
981	1.7	970	8	**7,527**
982	1.7	970	8	**7,527**
983	1.7	972	24	**22,675**
984	1.7	972	24	**22,675**
985	1.7	986	8	**7,778**
986	1.7	986	8	**7,778**
987	1.7	1005	8	**8,080**
988	1.6	987	16	**15,587**
989	1.6	1001	16	**16,032**
990	1.6	1001	16	**16,032**
991	1.6	1014	16	**16,451**
992	1.6	1016	16	**16,516**
993	1.6	1020	16	**16,646**
994	1.6	1022	32	**33,423**
995	1.6	1036	16	**17,173**
996	1.6	1036	16	**17,173**
997	1.6	1036	16	**17,173**
998	1.5	1039	8	**8,636**
999	1.5	1051	24	**26,510**
1000	1.5	1052	16	**17,707**
1001	1.5	1073	8	**9,211**
1002	1.5	1073	8	**9,211**
1003	1.5	1111	29	**35,795**
1004	1.4	1128	16	**20,358**
1005	1.4	1150	8	**10,580**
1006	1.4	1192	62	**88,094**
1007	1.4	1192	62	**88,094**
1008	1.3	1255	8	**12,600**
1009	1.3	1280	11	**18,022**
1010	1.3	1280	11	**18,022**
1011	1.3	1314	9	**15,539**
1012	1.1	1456	0	**0**
1013	1.1	1456	0	**0**
1014	1.1	1459	0	**0**
1015	1.1	1459	0	**0**
1016	1.1	1467	41	**88,236**
1017	1.1	1490	40	**88,804**