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Selective Trip Coordination with Modern Molded Case Circuit Breakers

120-240V Revision 7
120-480V Revision 14

This Journal addresses selective trip coordination techniques that may be used to demonstrate compliance with the National Electrical Code (NEC) requirements for over current protective device selective trip coordination. The traditional technique of plotting the manufacturer's time current trip curves (TCC) for the devices under consideration is still a viable method when used properly. However, TCC plots are limited in their capability of accurately depicting selective trip coordination in the region of high levels of overcurrent that include the Instantaneous trip function of circuit breakers. This limited capability is the reason that circuit breaker manufacturers have developed alternate techniques including the coordination tables in this Journal.

In 2010 the National Electrical Manufacturers Association (NEMA) published ABP 1-2010, a white paper developed, as stated in the document Forward, " … in response to the requirements in the National Electrical Code for selective coordination in order to assist engineers in designing selectively coordinated power systems using low-voltage circuit breakers." This white paper is the most comprehensive presentation to date of information related to, and the interpretation of, the capabilities of low-voltage circuit breakers and techniques of their proper application to achieve desired levels of selective trip coordination. This Journal was developed in accordance with the principles presented in ABP 1-2010 and Siemens recommends this paper as reference for a more through understanding of the subject. NEMA ABP 1-2010 is available from 'www.nema.org' as a free download, and may be used in accordance with NEMA Copyright.

One important aspect of NEMA ABP 1-2010 is a discussion of the use of modern circuit breaker trip curves and the proper interpretation of TCC tolerance bands. Section 3.2 explains that due to the improved techniques employed in modern low-voltage circuit breakers, it is no longer necessary to allow white space between their trip curve bands to ensure selective coordination between them. Even if the outer edges of the bands touch, the included clearing times and tolerances ensure that the two devices will selectively coordinate. This principle is applied to circuit breaker pairs listed in the coordination tables below and is noted in Table Note #4 on the following pages.

Another important aspect of the published TCC is the minimum operating time shown. For many years it has been common practice in the electrical industry that the minimum time shown on the TCC is 0.01 seconds. This practice has been common on the part of many circuit breaker manufacturers, fuse manufacturers, and coordination software publishers. All TCC examples in ABP 1-2010 start at 0.01 seconds. In accordance with

that practice and in light of recent testing of circuit breakers, Siemens recommends that 0.01 seconds be the minimum time considered. Some older trip curves published originally under the "ITE" name and subsequently as "Siemens", show a minimum time of 0.001 seconds. These trip curves should be truncated at 0.01 seconds for selective trip coordination and application purposes.

The following Selective Trip Coordination Table shows the maximum values of short circuit current, at the downstream breaker, that will allow selective trip coordination between the two Siemens circuit breakers. As further industry experience in this area becomes available and further testing is conducted, updates to the table will be published. Please contact your Siemens representative for the latest information.

The following steps will assure the best use of the Selective Trip Coordination Table:

1. Conduct a short circuit study to determine the available fault current values at each level of the system where coordination is critical. This allows the most cost effective selection of breakers to achieve the necessary selective trip coordination. A higher available fault current value will necessitate a larger and more expensive upstream circuit breaker. Accurate short circuit current will also mean more accurate arc-flash energy calculations.

2. Trip coordination is assured up to the value shown in the "Branch Coordination Level" column. A short circuit study will be the best source of the maximum available fault current to be compared to the current value shown in this field. Selective trip coordination is assured where the maximum available fault current value is less than this "Branch Coordination Level". Faults occurring at the maximum calculated values are very rare so this is a conservative approach. The system designer may elect to consider other factors to balance the needs of system protection and coordination at various anticipated levels of current.

If the branch available fault current is not known, the main breaker maximum available fault current value may be used. This is a very conservative approach and may result in the least cost effective solution. For many systems the distribution transformer let-through value will provide a conservative available fault current for this use. The published data for the transformer should be consulted.

In many cases the minimum frame MCCB will only coordinate at relatively low levels of fault current. If the level of selective coordination between the two circuit breakers initially selected is insufficient for the available fault current at that point in the system, the tables may be used to find an alternate upstream circuit breaker that will allow a higher level of coordination. This will usually involve a larger frame size or different type of circuit breaker such as an insulated case or power breaker.

Selective Trip Coordination Table

TABLE NOTES:

1. Coordination is assured up to the value of current shown in the "Branch Coordination Level" field.
2. If the available fault current at the branch is unknown, coordination is assured when the available fault current at the main is less than or equal to the value shown in the "Branch Coordination Level" field.
3. If the main breaker has an Instantaneous setting it must be set at maximum, branch Instantaneous must be set below “Branch Coordination Level” including bandwidth tolerances.
4. Coordination in the thermal range is also achieved, including instances where the tolerance bands touch but do not overlap. Electronic trip units must be adjusted for Long Time and Instantaneous functions (also Short Time if so equipped). As shipped, factory settings are at minimum values. Electronic trip mains must be adjusted to near maximums, standard trip curve coordination overlay techniques may be used for exact settings.
5. Applicable voltage range is marked for each chart.
6. In some cases the level of selectivity stated is for series rated pairs. When the same pair is used in a fully rated design, and if the level of selectivity given was higher than the fully rated AIC rating of the downstream device, selectivity is also assumed for levels up to the AIC rating of the downstream device for the same pair.
6. Consult literature for voltage and AIC ratings.

Breaker Type Key:

Breaker types are as shown in the table, except those called out specifically as ED, FD, JD, LD, LMD and MD. For those specific call outs:

'ED' includes the following types: ED4, ED6, HED4, CED6
'FD' includes the following types: FXD6-A, FD6-A, FD6, HFD6, HFXD6, CFD6
'JD' includes the following types: JXD2-A, JXD6-A, JD6-A, JD6, JXD6, HJD6-A, HJD6, HJXD6-A, HJXD6, CJD6-A
‘LD' includes the following types: LXD6-A, LD6-A, LD6, LXD6, HLXD6-A, HLD6-A, HLD6, HLXD6, CLD6-A
‘LMD’ includes the following types: LMD6, LMXD6, HLMD6, HLMXD6
‘MD’ includes the following types: MD6, MXD6, HMD6, HMXD6, CMD6

For VL family circuit breakers, unless the type designation in the table includes the rating level, all AIC level models for that type and frame are included. For example, ‘HFG’ would include only that AIC level, but ‘FG’ would apply to NFG, HFG, and LFG. If there is no trip unit reference, all trip unit types apply, i.e. 525, 545, 555, 576 and 586. If electronic only applies it is so noted, i.e. NG-545(555), and would include all electronic trip units.

* Electronic trip units are available in this type. When the type and size noted is used with an electronic trip unit, selective coordination is achieved as long as the thermal bands of the upstream and downstream devices do not overlap (they may touch), and the instantaneous is in the high setting.

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Main Amps	Main Breaker	Branch Coordination Level	1, 2, and 3 Pole Branch Breakers
100A	ED4, ED6 100A	1kA	15-60A BL, BLH, BLF, BLHF, BAF, BAFH, QP, QPH, QF, QFH, QAF, QAFH
	FD 175A	1.5kA	15-80A BL, BLH, BLF, BLHF, BAF, BAFH, QP, QPH, QF, QFH, QAF, QAFH
			15-70A ED
	FG-545,555,576,586 100A	3kA	15-100A BL, BLH, BLF, BLHF, BAF, BAFH, QP, QPH, QF, QFH, QAF, QAFH
			15-70A ED
150A	LDG	200kA	15-90A NGB, HGB, LGB, NGG
250A	LFG (225,250A)	200kA	15-125A NGB, HGB, LGB, NGG
	HHFD (225,250A)	200kA	15-125A NGB, HGB, LGB, NGG
	CFD6 (225,250A)	200KA	15-125A NGB, HGB, LGB, NGG
		100kA	15-30A BQD
	HFG (225,250A) *	100kA	15-125A QPH
	FD, FG 250A	3kA	15-100A BL, BLH, BLF, BLHF, BAF, BAFH, QP, QPH, QF, QFH, QAF, QAFH
	JD 250A		15-125A ED
	FG-545,555,576,586 70-250A		70-150A FD
400A	LJG	200kA	15-125A NGB, HGB, LGB, NGG
	CJD6 (350,400A)	200kA	15-125A NGB, HGB, LGB, NGG
	JD 400A	10kA	15-70A BL, BLH, BLF, BLHF, BAF, BAFH, QP, QPH, QF, QFH, QAF, QAFH
	LD 400A	8kA	80-100A BL, BLH, BLF, BLHF, BAF, BAFH, QP, QPH, QF, QFH, QAF, QAFH
	SJD 400A	3.6kA	15-125 ED
	JG 400A		70-250A FD
			200-250A JD
	SLD6-A	10kA	15-100A BL, BLH, BLF, BLHF, BAF, BAFH, QP, QPH, QF, QFH, QAF, QAFH
	600/400A	6.4kA	15-125 ED
			70-250A FD
			200-300A JD, LD
	WL 800/400A	65kA	15-125 ED
	FS1 Class L		70-250A FD
	LS Trip		200-250A JD, LD
		22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF
600A	CLD6 *	200kA	250A FD
	(500,600A)		15-125A NGB, HGB, LGB, NGG
	LLG *	200A	15-125A NGB, HGB, LGB, NGG
	LD (500,600A) *	65kA	60-225A QJ2-H
	LD	18kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
	LMXD6, LMD6	10kA	15-100A BL, BLF, BAF, QP, QF, QAF
	MXD6, MD6	5.4kA	15-125 ED
			70-250A FD
			200-300A JD, LD
	SLD6-A	18kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
	600A	10kA	15-100A BL, BLF, BAF, QP, QF, QAF
		6.4kA	15-125 ED
			70-250A FD
			200-300A JD, LD
	SMD6	22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
	800/600A	10kA	15-100A BL, BLF, BAF, QP, QF, QAF
			15-125 ED
			70-250A FD
			200-300A JD, LD
	WL 800/600A	65kA	15-125 ED4
	FS1 Class L		70-250A FD
	LS Trip		200-300A JD, LD
		22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF
	WL 800/600A	85kA	15-125 HED4
	FS2 Class L		70-250A HFD6, HFXD6
	LS Trip		200-300A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A
		22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, BAFH, QP, QF, QAF

* Electronic trip units are available in this type. When the type and size noted is used with an electronic trip unit, selective coordination is achieved as long as the thermal bands of the upstream and downstream devices do not overlap (they may touch), and the instantaneous is in the high setting.

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800A	800A LMXD6, LMD6 MXD6, MD6 MG 800A	22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF
		7.2kA	15-125 ED
			70-250A FD
			200-400A JD, LD
	SMD6 800A NG 1200/800A	22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF 15-125 ED
			70-250A FD
			200-400A JD, LD 300-600A SLD6-A
	WL 800/800A FS1 Class L LS Trip	65kA	15-125 ED
			70-250A FD
			200-400A JD
			250-500A LD 300-600A SLD6-A
		22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF
	WL 800/800A FS2 Class L LS Trip	85kA	15-125 HED4
			70-250A HFD6, HFXD6
			200-400A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A
			250-450A HLD6-A, HLXD6-A
		22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF
1200A	CND6 * (900,1200A)	200kA	15-125A ED4
	1200A NXD6, ND6	18kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF
		9kA	15-125 ED
			70-250A FD
			200-400A JD
			450-600A LD
			500-700A LMD
			600-800A SMD6
	SND 1200A NG 1200A	22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF 15-125 ED
			70-250A FD
			200-400A JD
			450-600A LD
			500-700 LMD
			500-600A MD
			600-800A SMD6
	WL 1200/1200A FS1 Class L LS Trip	65kA	15-125 ED
			70-250A FD
			200-400A JD
			450-600A LD
		22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF
	WL 1200/1200A FS2 Class L LS Trip	85kA	15-125 HED4
			70-250A HFD6, HFXD6
			200-400A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A
			250-450A HLD6-A, HLXD6-A
		22kA	15-100A BLH, BLHF, BAFH, QPH, QFH, QAFH
		10kA	15-100A BL, BLF, BAF, QP, QF, QAF
1600A	CPD6 (1200,1600A)	200kA	250A FD 400-600A LD

* Electronic trip units are available in this type. When the type and size noted is used with an electronic trip unit, selective coordination is achieved as long as the thermal bands of the upstream and downstream devices do not overlap (they may touch), and the instantaneous is in the high setting.

Voltage range 120-480 Vac. Rev. 14

Main Amps	Main Breaker	Branch Coordination Level	1, 2, and 3 Pole Branch Breakers
125A	CED6	200kA	15-20A NGB, HGB, LGB, NGG
175A	FD 175A	1.5kA	15-70A ED, NEB, NEG, BQD, CQD
250A	FD 250A JD 250A	2.4kA	15-125A ED, NEB, NEG 50-150A DG, 70-150A FD, FG
	FD6 (225,250A)	35kA	15-125 NGB, HGB, LGB, NGG
	LFG (225,250A) *	100kA	15-125A NGB, HGB, LGB, NGG
	HFD6 (225, 250A)	100kA	15-30 BQD (1P)
		65kA	15-100A BQD 15-125A ED4
		50kA	15-125A NGB, HGB, LGB, NGG
	HHFD (225, 250A)	100kA	15-125A NGB, HGB, LGB, NGG
	CFD6 (225, 250A)	200kA	15-30A BQD (15-100A BQD, 1P) 15-50A ED4 (15-100A ED4, 1P) 15-125A NGB, HGB, LGB, NGG 15-125A HED4
		150kA	15-125 ED4
		100kA	15-100A BQD
400A	JD (350,400A) *	35kA	15-125 NGB, HGB, LGB, NGG
	HJD6 (350,400A) *	65kA	15-90 NGB, HGB, LGB, NGG
		42kA	15-125 NGB, HGB, LGB, NGG
	HHJD (350,400A) *	65kA	15-125A NGB, HGB, LGB, NGG
	HJG *	65kA	15-30A NGB, HGB, LGB, NGG
	CJD6 (350,400A) *	100kA	100-125A NGB, HGB, LGB, NGG
		150kA	15-90 NGB, HGB, LGB, NGG
	SHJD6-A 400A SCJD6-A 400A	3.6kA	15-125 ED, NEB, NEG, BQD, CQD 50-150A DG, 70-250A FD, FG 200A JD
	SLD6-A 600/400A SHLD6-A 600/400A SCLD6-A 600/400A LG 525,545,555,576,586 600/400A LD, HLD 400A	6.4kA	15-125 ED, NEB, NEG, BQD, CQD 70-250A FD 200A JD, 300A SJD6-A, SHJD6-A
	NG-545,555,576,586 1000/400A	10kA	15-125 ED, NEB, NEG, BQD, CQD 70-250A FD 200A JD
	WL 800/400A FS1 Class S LS Trip	65kA	15-125 HHED6, HEB, HEG 70-250A HFD6, HFXD6 200-250A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A
		35kA	15-125 NEB, NEG 70-250A FD 200-250A JD6-A, JXD6-A, LD6, LXD6
		42kA	15-125 HED4
		25kA	15-125A ED6
		14kA	15-100A BQD, CQD

* Electronic trip units are available in this type. When the type and size noted is used with an electronic trip unit, selective coordination is achieved as long as the thermal bands of the upstream and downstream devices do not overlap (they may touch), and the instantaneous is in the high setting.

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Main Amps	Main Breaker	Branch Coordination Level	1, 2, and 3 Pole Branch Breakers
600A	LD6 (500,600A) *	65kA	15-100A ED4 (1P)
	HLD6 (500,600A) *	50kA	15-50A HED4
		65kA	15-100A ED4 (1P)
	HHLD6 (500,600A) *	65kA	15-125A NGB, HGB, LGB, NGG
		100kA	15-100A ED4 (1P)
	CLD6 (500,600A) *	200kA	70-250A FD
		150kA	15-100A ED4 (1P)
		100kA	15-125A NGB, HGB, LGB, NGG
	HLG *	65kA	15-125A NGB, HGB, LGB, NGG
	LD, HLD, CLD 600A LMD, HLMD 600A MD, HMD, CMD 600	5.4kA	15-125 ED4 (2,3P), NEB, NEG, BQD, CQD 70-250A FD 200-300A JD6-A, JXD6-A, LD6, LXD6
	SLD6-A 600A SHLD6-A 600A SCLD6-A 600A MG-525 800/600A	6.4kA	15-125A ED4, NEB, NEG 70-250A FD 200-300A JD6-A, JXD6-A, LD6, LXD6 400A SJD6-A, 500A SLD6-A
	SMD6 800/600A SHMD6 800/600A SCMD6 800/600A NG-545,555,576,586 1000/600A	10kA	15-125 ED4, NEB, NEG 70-250A FD 200-300A JD, LD 400A SJD6-A, SHJD6-A 500A SLD6-A, SHLD6-A
	WL 800/600A FS1 Class S 745 LS Trip	65kA	15-125 HHED6, HEB, HEG 70-250A HFD6, HFXD6 200-300A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A
		35kA	15-125 NEB, NEG 70-250A FD6 200-250A JD6-A, JXD6-A, LD6, LXD6
		42kA	15-125 HED4
		25kA	15-125A ED6
		14kA	15-100A BQD, CQD
	WL 800/600A FS2 Class H 745 LS Trip	85kA	70-250A HHFD6, HHFXD6 200-400A HHJD6-A, HHJXD6-A 250-300 HHLD6-A, HHLXD6-A
		65kA	15-125 HHED6, HEB, HEG 70-250A HFD6, HFXD6 200-300A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A
		35kA	15-125 NEB, NEG 70-250A FD 200-300A JD, LD
		42kA	15-125 HED4
		25kA	15-125A ED6
		14kA	15-100A BQD, CQD

* Electronic trip units are available in this type. When the type and size noted is used with an electronic trip unit, selective coordination is achieved as long as the thermal bands of the upstream and downstream devices do not overlap (they may touch), and the instantaneous is in the high setting.

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Main Amps	Main Breaker	Branch Coordination Level	1, 2, and 3 Pole Branch Breakers
800A	LMD, HLMD 800A MD, HMD 800A CMD 800A	7.2kA	15-125 ED, NEB, NEG, BQD, CQD 70-250A FD 200-400A JD, LD
	SMD6 800A SHMD6 800A SCMD6 800A NG-545,555,576,586 1000/800A	10kA	15-125 ED 70-250A FD 200-400A JD, LD 400A SJD6-A, SHJD6-A 300-600A SLD6-A, SHLD6-A
	WL 800/800A FS1 Class S 745 LS Trip	65kA	15-125 HHED6, HEB, HEG 70-250A HFD6, HFXD6 200-400A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A 250-500A HLD6-A, HLXD6-A 300-600A SHLD6-A, SCLD6-A
		35kA	15-125 NEB, NEG 70-250A FD 200-400A JD 250-500 LD 250-600 SLD6-A, SHLD6-A
		42kA	15-125 HED4
		25kA	15-125A ED6
		14kA	15-100A BQD, CQD
	WL 800/800A FS2 Class L 745 LS Trip	85kA	70-250A HHFD6, HHFXD6 200-400A HHJD6-A, HHJXD6-A 250-300 HHLD6-A, HHLXD6-A
		65kA	15-125 HHED6, HEB, HEG 70-250A HFD6, HFXD6 200-300A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A 300-600A SHLD6-A, SCLD6-A
		35kA	15-125 NEB, NEG 70-250A FD 200-400A JD 250-500 LD 250-600 SLD6-A, SHLD6-A
		42kA	15-125 HED4
		25kA	15-125A ED6
		14kA	15-100A BQD, CQD

Voltage range 120-480 Vac. Rev. 14

Main Amps	Main Breaker	Branch Coordination Level	1, 2, and 3 Pole Branch Breakers
1000A	SND6 1000A SHND6 1000A SCND6 1000A NG 545,555,576,586 1000A	10kA	15-125 ED
			70-250A FD
			200-400A JD, SJD6, SHJD6-A
			450-600A LD, SLD6, SHLD6-A
			500-700 LMD
			500-600A MD
			600-800A SMD6, SHMD6, MG 545,555,576,586 800-1000A SND6, SHND6, NG 545,555,576,586
1200A	CND (900,1200A)	200kA	15-125A ED4 (1P)
	ND, HND 1200A CND 1200A	9kA	15-125 ED
			70-250A FD
			200-400A JD
			450-600A LD
			500-600A LMD
			600-800A SMD6, SHMD6, MG 545,555,576,586
	SND6 1200A SHND6 1000A SCND6 1000A NG 545,555,576,586 1200A	10kA	15-125 ED
			70-250A FD
			200-400A JD, SJD6, SHJD6-A
			450-600A LD, SLD6, SHLD6-A
			500-700 LMD
			500-600A MD
			600-800A SMD6, SHMD6, NG 545,555,576,586 800-1000A SND6, SHND6, NG 545,555,576,586
	WL 1200/1200A FS1 Class S 745 LS Trip	65kA	15-125 HHED6, HEB, HEG
			70-250A HFD6, HFXD6
			200-400A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A
			250-600A HLD6-A, HLXD6-A
			300-600A SHLD6-A
			500-700 HLMD
			500-700A HMD
			600-800A SHMD6
		35kA	15-125 NEB, NEG
			70-250A FD
			200-400A JD
			250-600 LD
			250-600 SLD6-A
			500-700 LMD
			500-700A MD
			600-800A SMD6, SHMD6
		42kA	15-125 HED4
		25kA	15-125A ED6, NGB, HGB, LGB, NGG, NGG
		14kA	15-100A BQD, CQD
	WL 1200/1200A FS2 Class L 745 LS Trip	85kA	70-250A HHFD6, HHFXD6
			200-400A HHJD6-A, HHJXD6-A
			250-600 HHLD6-A, HHLXD6-A
			600-800A SCMD6
		65kA	15-125 HHED6, HEB, HEG
			70-250A HFD6, HFXD6
			200-400A HJD6-A, HJDX6-A, HLD6-A, HLXD6-A
			300-600A SHLD6-A
			500-700 HLMD
			500-700A HMD
			600-800A SHMD6, SCMD6
		35kA	15-125 NEB, NEG
			70-250A FD
			200-400A JD
			250-600 LD
			250-600 SLD6-A, SHLD6-A
			500-700 LMD
			500-700A MD
			600-800A SMD6, SHMD6, NG-545,555,576,586
		42kA	15-125 HED4
		25kA	15-125A ED6, NGB, HGB, LGB, NGG
		14kA	15-100A BQD, CQD