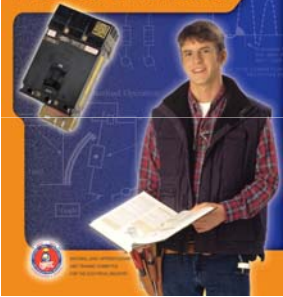


Some of these slides excerpted from

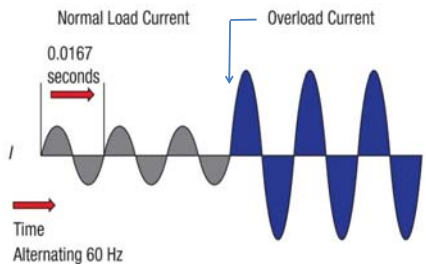
NJATC CODE AND PRACTICES 3 WORKBOOK

NJATC Code and Practices 3 Workbook



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OVERLOAD EXAMPLE



Normal Load Current

Overload Current

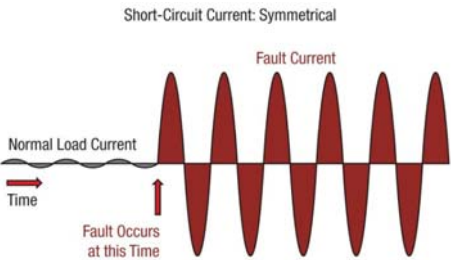
0.0167 seconds

Time Alternating 60 Hz

Normal current flows for an alternating 60-hertz circuit. When an overload occurs, the magnitude of the current increases.

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SHORT-CIRCUIT CURRENT: SYMMETRICAL



Short-Circuit Current: Symmetrical

Normal Load Current

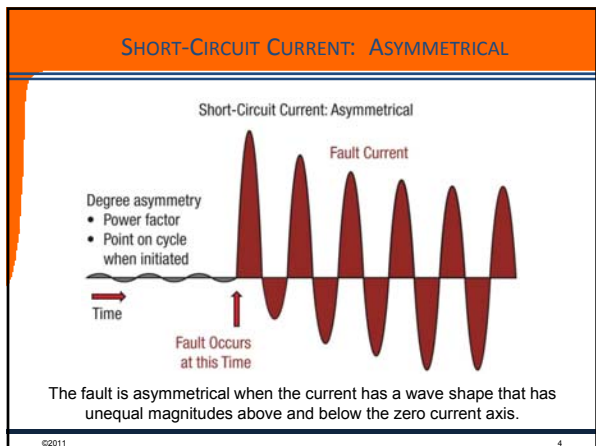
Fault Current

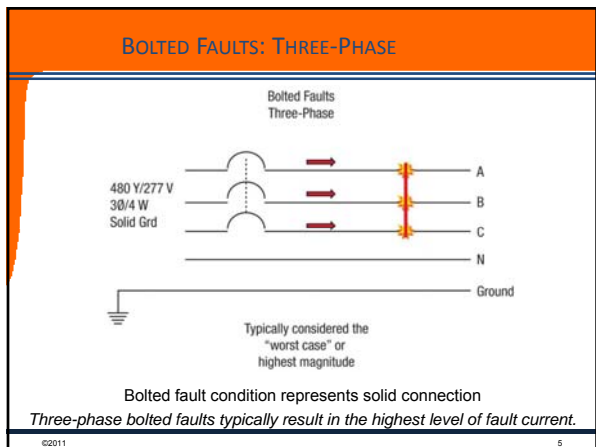
Time

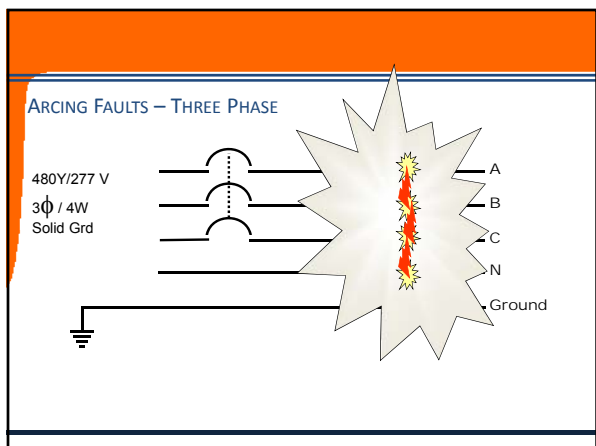
Fault Occurs at this Time

The fault is symmetrical when the current has a wave shape that has equal magnitudes above and below the zero current axis.


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THREE-PHASE ARCING FAULT



A three-phase arcing fault 0.02 seconds after a screwdriver touched phase-to-ground

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TIME CURRENT CHARACTERISTIC CURVES

- Understanding how OCPDs respond to various levels of overcurrent (from light overloads to high level short-circuit currents).
- How to read time-current curves (TCCs) of an OCPD.

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TIME CURRENT CHARACTERISTIC CURVES

- For 100A fuse, different overcurrent scenarios
- The following slides will illustrate each scenario on a time-current curve

Scenario	Overcurrent Protective Device	Ammeter	Circuit Condition	OCPD Opening Time Current Characteristics
A	100 A	80	Normal Load Current	Carry Continuously
B	100 A	300	300 A Overload Current	Opens in 50 Seconds
C	100 A	500	500 A Overcurrent	Opens in 12 Seconds
D	100 A	1,500	1,500 A Fault Current	Opens in 0.01 Seconds
E	100 A	20,000	20,000 A Fault Current	Opens in Less Than 0.01 Seconds

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TIME CURRENT CHARACTERISTIC CURVES

Understanding the TCC

- TCC for 100A Class J fuse (dark solid line labeled)
- Logarithmic scales, not linear
- Horizontal axis: current axis (amperes)
- Vertical axis: time axis (seconds)

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TIME CURRENT CHARACTERISTIC CURVES

Overcurrent Protective Device

A

100 A

Ammeter

80

Circuit Condition

Normal Load Current

OCPD Opening Time Current Characteristics

Carry Continuously

Scenario A

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TIME CURRENT CHARACTERISTIC CURVES

Overcurrent Protective Device

B

100 A

Ammeter

300

Circuit Condition

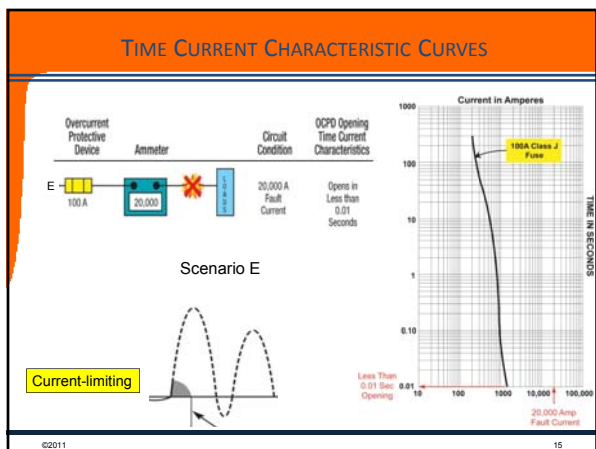
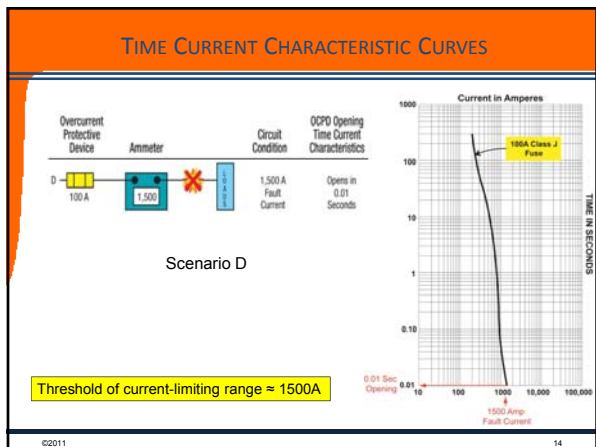
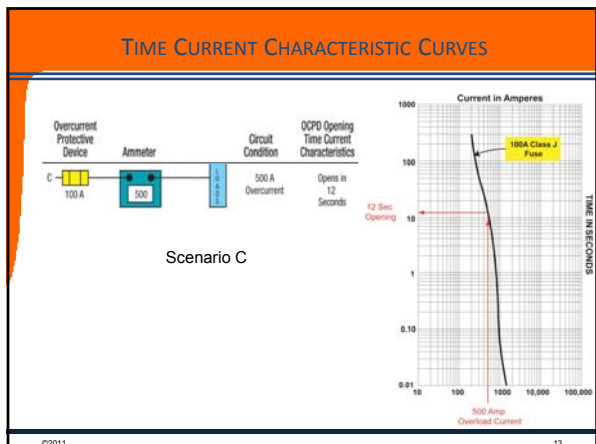
300 A Overload Current

OCPD Opening Time Current Characteristics

Opens in 50 Seconds

Scenario B

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TYPICAL CLEARING TIMES FOR LV FUSES

Considerations for Fuse Clearing Times

- Maintenance generally not issue
- Can vary by fuse UL class
- Can vary by amp rating
- Can vary by vintage

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BRANCH CIRCUIT BREAKERS

Circuit Breaker Types which are Branch Circuit OCPDs		
Device Type	Acceptable Devices	IEEE Std 1015—2006 IEEE Blue Book
UL489 Circuit Breakers	Molded Case Circuit Breakers (MCCBs)	A circuit breaker that is assembled as an integral unit in a supporting and enclosing housing of insulating material.
	Insulated Case Circuit Breakers (ICCBs)	A circuit breaker that is assembled as an integral unit in a supporting and enclosing housing of insulating material and with a stored energy mechanism.
UL1066 Circuit Breakers	Low-Voltage Power Circuit Breakers (LVPCBs)	A mechanical switching device, capable of making, carrying, and breaking currents under normal circuit conditions and making and carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short circuit. Rated 1,000 VAC or below, or 300 VDC and below. Also referred to as an air frame circuit breaker.

Three Types Branch Circuit CBs

- MCCBs
- ICCBs
- LVPCBs

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MCCB FRAME SIZES AND AMPERE RATINGS

Molded Case Circuit Breakers

1	Frame	F	J	K	L	MDL	N	R
2	Ampere Range	15-225	70-250	70-400	300-600	400-800	400-1200	800-2500
3	IR kA rms @ 480Vac	14	35	35	35	50	50	65
		35	65	65	65	65	65	100
		65	100	100	100		100	
4	Trip Unit	T/M FF	T/M FA	T/M FA	T/M FA	T/M FA	Electronic	Electronic
				Electronic	Electronic	Electronic		

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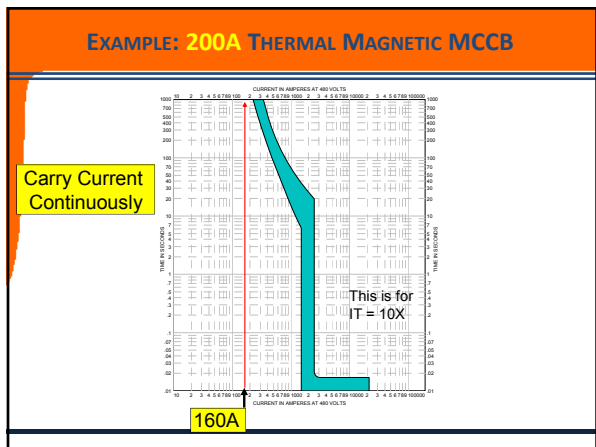
TYPICAL CB OPENING TIMES

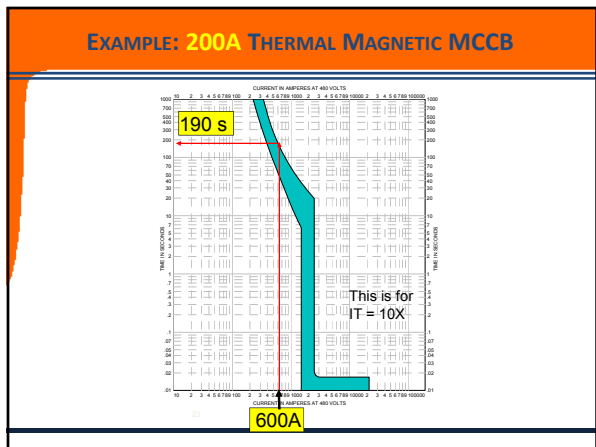
2002 IEEE 1584 Guide for Calculating Arc Flash Hazard
Table 1—Power circuit breaker operating times^a

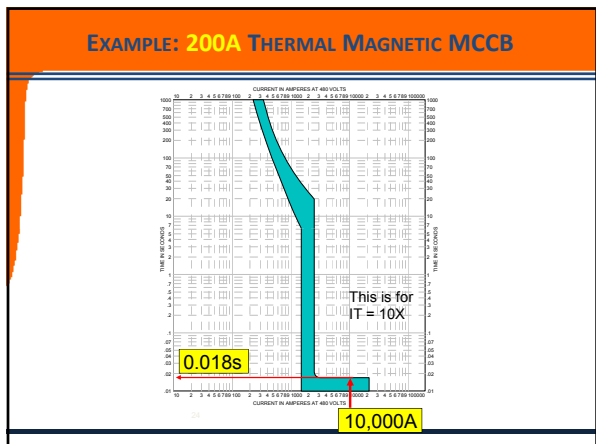
Circuit breaker rating and type	Opening time at 60 Hz (cycles)	Opening time (seconds)
Low voltage (molded case) (< 1000 V) (integral trip)	1.5	0.025
Low voltage (insulated case) (< 1000 V) power circuit breaker (integral trip or relay operated)	3.0	0.050
Medium voltage (1-35 kV)	5.0	0.080
Some high voltage (> 35 kV)	8.0	0.130

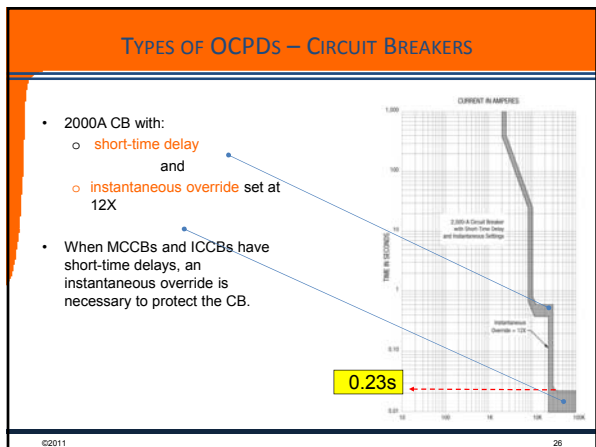
^aThis table does not include the external relay trip times.

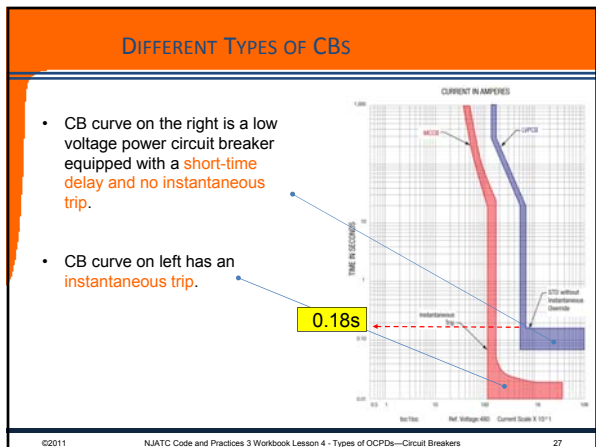
Qualifier: LV CBs with instantaneous trip

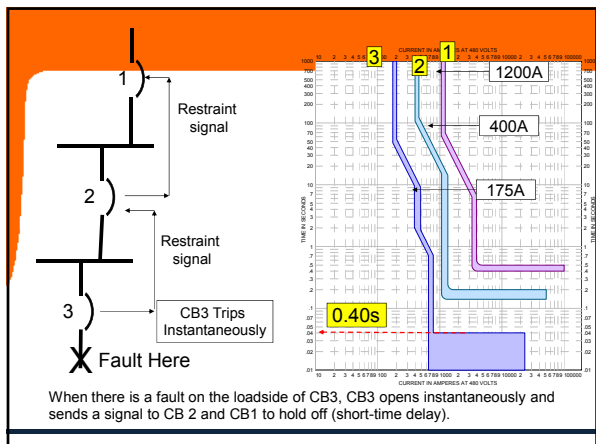












TYPICAL OPENING TIMES FOR SOME CIRCUIT BREAKERS

150A (F Frame, Thermal Mag):	0.02 sec or less in instantaneous range
400A (J & K Frame, Thermal Mag or Elect Trip)	0.02 sec or less in instantaneous range (Short time delay available up to instantaneous override of 10X) Zone selective interlocking available 400A frame and above (0.04 sec.)
600A (L Frame, Thermal Mag, Elect Trip or Optimum Trip Unit)	0.02 sec or less in instantaneous range (typically 10X max) (Short time delay available up to instantaneous override of 10X)
1200A (N Frame, Elect Trip)	0.03 sec or less in instantaneous range (typically 8X max) (Short time delay available up to instantaneous override of 8X)
2500A (R Frame, Elect Trip)	0.05 sec or less in instantaneous range (typically 10X max) (Short time delay available up to instantaneous override of 10X)

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TYPICAL OPENING TIMES FOR SOME CIRCUIT BREAKERS

Current Limiting Circuit Breaker (Both Types):
(Current-Limiting CB must be tested, listed, and marked as such)

100A Current-R-Limiter (Slot motor design):	0.03 cycles or less 1/2 cycle or less about 20,000A or more
400A Current-R-Limiter (Slot motor design):	0.03 cycles or less 1/2 cycle or less about 30,000A or more
100A Tri-Pac (fused limiter design):	0.017 cycles or less 1/2 cycle or less about 7000A or more
400A Tri-Pac (fused limiter design):	0.017 cycles or less 1/2 cycle or less about 10,000A or more

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TYPICAL OPENING TIMES FOR SOME CIRCUIT BREAKERS

Insulated Case Circuit Breaker (SPB w/Digitrip Unit):
w/short time delay - Up to 30 Cycles, until to instantaneous override.

w/instantaneous override - 0.05 sec (3 cycles)

Instantaneous override:

400-800:	25kA
1200:	35kA
1600-3000:	35-51kA
4000-5000:	65-85kA

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TYPICAL OPENING TIMES FOR SOME CIRCUIT BREAKERS

Low Voltage Drawout Circuit Breaker (DS w/Digitrip Trip Unit):
w/out Instantaneous Trip - Up to 30 Cycles, depending upon the short time delay setting.

w/Instantaneous Trip (no short time delay): 0.07 sec (between 4-5 cycles)

w/fused limiter (DSL): half cycle or less (in current limiting range, fault would need to be approx 12-15 times limiter rating)

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TYPICAL OPENING TIMES FOR SOME CIRCUIT BREAKERS

Considerations for CB Opening Times

- Depends on condition of maintenance
- Can vary by manufacturer
- Can vary by type
- Can vary by frame size
- Can vary on options and settings
- Can vary by vintage
 - Older circuit breakers may be slower operating designs (even if CB is in original operation condition)

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Table 130.7(C)(15)(a)	Fuse Class Amp Rating		Molded Case Circuit Breaker Max. Frame†		Insulated Case CB Max. Frame†	LV Power CB Max. Frame†
	Fuse UL Class	Max. Amp Rating	Non-Current-Limiting Largest Frame	Current-Limiting		
<p>Panelboards or other equipment rated 240 V and below</p> <p>Parameters:</p> <p>Maximum of 25 kA short circuit current available.</p> <p>maximum of 0.03 sec (2 cycle) fault clearing time.</p> <p>minimum 18 in. working distance</p> <p>Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 29 in.</p>	J (LPJ or JKS) RKL (LPN-RK) RKS (FRS-R) L (KRP-C)	600A* 600A* 600A* 1600A	1200A	600A	None	None
<p>Panelboards or other equipment rated 240 V and up to 480 V</p> <p>Parameters:</p> <p>Maximum of 25 kA short circuit current available.</p> <p>maximum of 0.03 sec (2 cycle) fault clearing time.</p> <p>minimum 18 in. working distance</p> <p>Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 29 in.</p>	J (LPJ or JKS) RKL (LPS-RK) RKS (FRS-R) L (KRP-C)	600A* 600A* 600A* 1600A	1200A	600A	None	None
<p>600 V class motor control centers (MCCs)</p> <p>Parameters:</p> <p>Maximum of 65 kA short circuit current available.</p> <p>maximum of 0.03 sec (2 cycle) fault clearing time.</p> <p>minimum 18 in. working distance</p> <p>Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 33 in.</p>	J (LPJ or JKS) RKL (LPS-RK) RKS (FRS-R) L (KRP-C)	600A* 600A* 600A* 4000A	1200A	600A	None	None
<p>600 V class motor control centers (MCCs)</p> <p>Parameters:</p> <p>Maximum of 42 kA short circuit current available.</p> <p>maximum of 0.13 sec (20 cycle) fault clearing time.</p> <p>minimum 18 in. working distance</p> <p>Potential arc flash boundary with exposed energized conductors or circuit parts using above parameters: 165 in.</p>	J (LPJ or JKS) RKL (LPS-RK) RKS (FRS-R) L (KRP-C)	600A* 600A* 600A* 2000A	2500A	600A	5000A w/IT set at ≤ 43kA 5000A w/STD set ≤ 20 cycles	5000A w/IT set at ≤ 43kA 5000A STD set at ≤ 20 cycles

