MODEL CB-PRO FUSED/CONTACTOR CIRCUIT BREAKER SYSTEM

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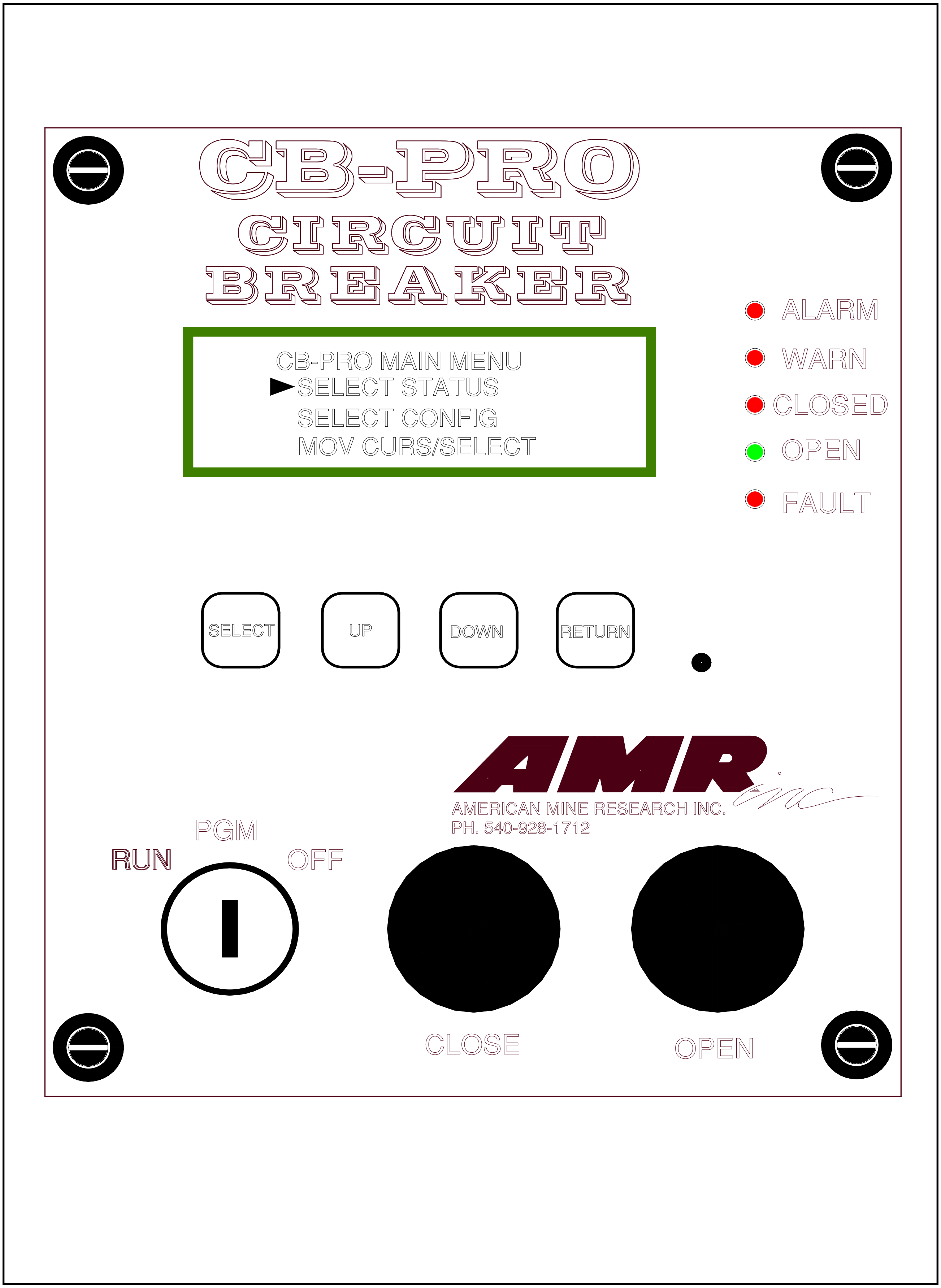
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RETURN
AMR inc
AMERICAN MINE RESEARCH INC.
PH. 540-928-1712
PGM
RUN
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1. Introduction

The first model of AMR's vacuum circuit breaker, the CB-1000-450, was designed for use in mining applications. It provides a more safe and reliable circuit protection system than the molded case circuit breaker used in power distributions centers. It can also be used as a belt or pump controller to replace the combination of the molded case circuit breaker, control contactor and overcurrent relay. Three more models of the CB-1000 were developed later, CB-1000-300, CB-1000-600, and CB-1000-800.

The CB-100 was developed next and it is a simplified version of the CB-1000. It does not have the ground monitor or the mine wide monitoring system interface. Currently, there are four models available. They are the:

- CB-100-300—(300 amperes continuous rating);
- CB-100-450—(450 amperes continuous rating);
- CB-100-600—(600 amperes continuous rating);
- CB-100-800—(800 amperes continuous rating).

The CB-200 was developed next. It is a modification of the CB-100 and was developed to satisify the need to provide control of lower currents. The three phase current transformers and the rating plug were re-designed to allow operation over the full load current range of 14 to 225 amperes.

The CB-PRO circuit breaker was developed to provide the user with an improved version of the CB-1000/100/200 series of circuit breakers. The same contactors and fuses that have proven themselves while used in the CB-1000/100/200 circuit breakers are also used in the CB-PRO circuit breaker.

The CB-PRO is composed of four primary components. These components consist of the contactor, fuses, voltage interface module and electronic control unit. The voltage interface module and electronic control unit differ from those used in the CB-1000/100/200 design. The electronic control unit has been improved by using a microprocessor to evaluate circuit parameters and compare them to easily set trip points.

The typical CB-PRO circuit protection panel will contain the following components:

- **Vacuum Bottle Contactor with control solenoid**
  The contactor switches three phase power to the load.
- **Current Limiting Fuses**
  The fuses limit three phase fault current and disconnects the load under extreme fault currents.
- **Phase Current Transformers**
  The current transformers monitor phase currents levels for thermal and magnetic trips.
- **Ground Fault Current Transformer**
  The ground fault current transformer monitors the three phase circuit for phase to ground conductor current leakage.
- **Voltage Interface Module**
  The voltage interface module measures the three phase voltages and monitors for open fuses and stuck contactor bottles. Also controls the current transformer output level to the Electronic Control Unit.
- **Cable Receptacle**
  The cable receptacle provides three phase power to the load.
- **Electronic Control Unit(ECU)**
  The ECU contains the hardware and firmware to monitor and control the three phase circuit.

The CB-PRO may have four configurations. The configuration is determined by the continuous current carrying capacity of the contactor and fuses. The three phase current transformer tap solid state switch is different for each configuration.

- **CB-PRO 225 and CB-PRO 300**

The CB-PRO 225 may be configured to operate over the full load current range of 10 amperes to 225 amperes. The CB-PRO 300 may be configured to operate over the full load current range of 10 amperes to 300 amperes. The contactor is a Joslyn -Clark 320 ampere contactor. The fuse (one for each phase) is a Bussman 600 ampere fuse. Three current transformers (one for each phase) and a three phase solid state switch allows the respective full current range to be covered.

- **CB-PRO 450**

The CB-PRO 450 may be configured to operate over the full load current range of 100 amperes to 450 amperes. The contactor is a ITT Jennings 450 ampere contactor. The fuse (one for each phase) is a Bussman 600 ampere fuse. Three current transformers (one for each phase) and a three phase solid state switch allows the 100 to 450 ampere range to be covered.

- **CB-PRO 550**

The CB-PRO 550 may be configured to operate over the full load current range of 100 amperes to 550 amperes. The contactor is a ITT Jennings 600 ampere contactor. The fuse (one for each phase) is a Bussman 700 ampere fuse. Three current transformers (one for each phase) and a three phase solid state switch allows the 100 to 550 ampere range to be covered.

- **CB-PRO 800**

The CB-PRO 800 may be configured to operate over the full load current range of 150 amperes to 800 amperes. The contactor is a Mitsubishi 800 ampere contactor. The fuse (one for each phase) is a Bussman 1000 ampere fuse. Three current transformers (one for each phase) and a three phase solid state switch allows the the 150 to 800 ampere range to be covered.

2. Features

- Covers the full load current range of 10 amperes to 800 amperes. Changing of current transformer taps is not necessary. A three phase solid state switch controlled by the Electronic Control Unit automatically controls the current transformer output level.
- Uses long life contactor backed up with high current interrupting fuse.
- User friendly interface with 4 line by 20 character LCD and 4 switch key pad.
- Status Menus provide the following information:
    1) Present Three Phase Voltage Values
    2) Present Three Phase Current Values
    3) Last Start Current Value

6) Full Load (Thermal) Current Trip Setting
7) Instantaneous (Magnetic) Current Trip Setting
8) Ground Fault Current Trip Setting
9) Phase Current Imbalance Trip Setting
10) Phase Under Voltage Trip Setting
11) Trip Delay Setting for Current Imbalance and Under Voltage
12) CB-PRO Address and Baud Rate Configuration
13) Display of Fault (Reason CB-PRO opened the circuit)
14) CB-PRO Front Panel Switch Status
15) Fuse and Contactor Bottle Status
16) Remote Open, Remote Reset and Remote Close Switch Status
17) Ground Monitor and Contactor Auxilliary Contact Status
18) Contactor Close Time
19) Date, Time and Value of Last Five Over Currents
20) Date, Time and Value of Last Five Ground Fault Currents
21) Perform Ground Fault Test
22) Present Date and Time
23) Date, Time and Value of Last Ten Faults

- Configuration Menus allow the following parameters to be modified:
    1) Select Contactor, Current Transformer and Current Transformer Range
    2) Select 115% Thermal Overload Time in seconds
    3) Set the CB-PRO Monitor System Address and Baud Rate
    4) Set Ground Fault Current Trip Value
    5) Set the Continuous (Thermal) Current Trip Value
    6) Set the Instantaneous (Magnetic) Current Trip Value
    7) Set the Percent Phase Current Imbalance Value
    8) Set the Percent Phase Under Voltage Value
    9) Set the Trip Delay for Phase Current Imbalance and Under Voltage
    10) Set Date and Time
    11) Enter and Change Configuration Passcodes
    12) Select the Three Phase Voltage Value
    13) Change the Close Delay Time

3. Specifications

3.1. CB-PRO Specifications

Control Voltage	90 VAC to 130 VAC
Three phase voltage	480 VAC to 1000 VAC
Interrupting Current	100,000 Amperes
Ambient Temperature	-40 degrees to +135 degrees Fahrenheit
Operation Life	1 Million
Long Time Thermal	Selectable with Motor Load I Trip Delay square t function. (See Current vs. Time Curves)
Thermal Trip Time Accuracy	+/- 10% From Current vs. Time Curves
Instantaneous (Mag) Trip Range	2X to 16X (X = Continuous Current)(See Current vs. Time Curves)
Magnetic Trip Accuracy	+/- 10% of Trip Setting
Ground Fault Protection	Adjustable from 1 Ampere to 25 Amperes in 0.1 Ampere Increments
Ground Fault Trip Accuracy	+/- 20% for setting between 1 and 2 Amperes. +/- 10% setting setting between 2.1 and 25 Amperes.
Low Control Voltage	Three Phase Circuit will open when Control Voltage is between 80 and 85 VAC.
Low Three Phase Voltage	Adjustable between 1% and 50%
Phase Current Imbalance	Adjustable between 1% and 50%
Delay for Low Phase Voltage	Adjustable between 1 and 5 seconds
Delay for Phase Current Imbalance	Adjustable between 1 and 5 seconds

3.2.1. CB-PRO 225 Specifications

Three Current Ranges Using One Current Transformer
10A-30A, 30A-90A, 100A-225A
NOTE: MOTOR CLASS = 10 FOR MAGNETIC RANGES

CURRENT RANGE	MAGNETIC RANGE
10A-30A(1 amp steps)	2X-16X(5 amp steps)
30A-90A(1 amp steps)	2X-16X(10 amp steps)
100A-200A(5 amp steps)	2X-16X(10 amp steps)
200A-225A(5 amp steps)	2X-12X(10 amp steps)

3.2.2. CB-PRO 225 Accepted System Components

The CB-PRO 225 must use the following components in order that the MSHA Acceptance be maintained. Assemble the following components using drawing 142-1025.

1) CB-PRO Control Unit (P/N 140-0173)
2) CB-PRO 300 Voltage Interface (P/N 140-0174-300)
3) Joslyn-Clark 320 AMP Contactor (P/N VC77U03515)
4) Receptacle - 225 AMP with appropriate voltage rating
5) Three Bussman 600 Fuses (P/N SPJ-6E600)
6) Ground Fault Current Transformer (P/N 130-0092)
7) Three Phase Current Transformers (P/N 130-0079)
8) Three Phase Conductor Cables - 1/0 minimum, 90 deg.Cent.
9) Fuse Insulator (P/N 125-0151)

3.2.3. CB-PRO 300 Specifications

Three Current Ranges Using One Current Transformer
10A-30A, 30A-90A, 100A-300A
NOTE: MOTOR CLASS = 10 FOR MAGNETIC RANGES

CURRENT RANGE	MAGNETIC RANGE
10A-30A(1 amp steps)	2X-16X(5 amp steps)
30A-90A(1 amp steps)	2X-16X(10 amp steps)
100A-200A(5 amp steps)	2X-16X(10 amp steps)
200A-250A(5 amp steps)	2X-12X(10 amp steps)
250A-300A(5 amp steps)	2X-10X(10 amp steps)

3.2.4. CB-PRO 300 Accepted System Components

The CB-PRO 300 must use the following components in order that the MSHA Acceptance be maintained. Assemble the following components using drawing 142-1022.

1) CB-PRO Control Unit (P/N 140-0173)
2) CB-PRO 300 Voltage Interface (P/N 140-0174-300)
3) Joslyn-Clark 320 AMP Contactor (P/N VC77U03515)
4) Receptacle - 400 AMP with appropriate voltage rating
5) Three Bussman 600 Fuses (P/N SPJ-6E600)
6) Ground Fault Current Transformer (P/N 130-0092)
7) Three Phase Current Transformers (P/N 130-0079)
8) Three Phase Conductor Cables - 4/0 minimum, 90 deg.Cent.

3.3.1. CB-PRO 450 Specifications

Two Current Ranges Using One Current Transformer
100A-300A and 150A-450A
NOTE: MOTOR CLASS = 10 FOR MAGNETIC RANGES

CURRENT RANGE	MAGNETIC RANGE
100A-200A(5 amp steps)	2X-16X(25 amp steps)
200A—250A(5 amp steps)	2X-12X(25 amp steps)
250A-300A(5 amp steps)	2X-10X(25 amp steps)
150A-200A(5 amp steps)	2X-16X(25 amp steps)
200A-250A(5 amp steps)	2X-12X(25 amp steps)
250A-300A(5 amp steps)	2X-10X(25 amp steps)
350A-400A(5 amp steps)	2X-8X(25 amp steps)
400A-450A(5 amp steps)	2X-7X(25 amp steps)

3.3.2. CB-PRO 450 Accepted System Components

The CB-PRO 450 must use the following components in order that the MSHA Acceptance be maintained. Assemble the following components using drawing 142-1023.

1) CB-PRO Control Unit (P/N 140-0173)
2) CB-PRO 450 Voltage Interface (P/N 140-0174-450)
3) Jennings 450 AMP Contactor (P/N RP-133-2335-00)
4) Receptacle - 500 AMP with appropriate voltage rating
5) Three Bussman 600 Fuses (P/N SPJ-6E600)
6) Ground Fault Current Transformer (P/N 130-0092)
7) Three Phase Current Transformers (P/N 130-0079)
8) Three Phase Conductor Cables - 444 MCM, 125 deg.Cent.
9) Two Phase Bussbars (P/N 125-0202)
10 Phase Bussbar (P/N 125-0203)
11) Three Heat Sinks (P/N 082-0005)

3.4.1. CB-PRO 550 Specifications

Two Current Ranges Using One Current Transformer
100A-300A and 200A-550A
NOTE: MOTOR CLASS = 10 FOR MAGNETIC RANGES

CURRENT RANGE	MAGNETIC RANGE
100A-200A(10 amp steps)	2X-16X(50 amp steps)
200A-250A(10 amp steps)	2X-15X(50 amp steps)
250A-300A(10 amp steps)	2X-12X(50 amp steps)
150A-200A(10 amp steps)	2X-16X(50 amp steps)
200A-250A(10 amp steps)	2X-15X(50 amp steps)
250A-300A(10 amp steps)	2X-12X(50 amp steps)
300A-350A(10 amp steps)	2X-10X(50 amp steps)
350A-400A(10 amp steps)	2X-8X(50 amp steps)
400A-450A(10 amp steps)	2X-7X(50 amp steps)
450A-500A(10 amp steps)	2X-6X(50 amp steps)
500A-550A(10 amp steps)	2X-5X(50 amp steps)

3.4.2. CB-PRO 550 Accepted System Components

The CB-PRO 550 must use the following components in order that the MSHA Acceptance be maintained. Assemble the following components using drawing 142-1024.

1) CB-PRO Control Unit (P/N 140-0173)
2) CB-PRO 550 Voltage Interface (P/N 140-0174-550)
3) Jennings 600 AMP Contactor (P/N RP-173-2315-00)
4) Receptacle - 600 AMP with appropriate voltage rating
5) Three Bussman 700 Fuses (P/N SPJ-6E700)
6) Ground Fault Current Transformer (P/N 130-0092)
7) Three Phase Current Transformers (P/N 130-0079)
8) Three Phase Conductor Cables - 444 MCM, 125 deg.Cent.
9) Three Phase Bussbar/Heat Sinks (P/N 271-0083)

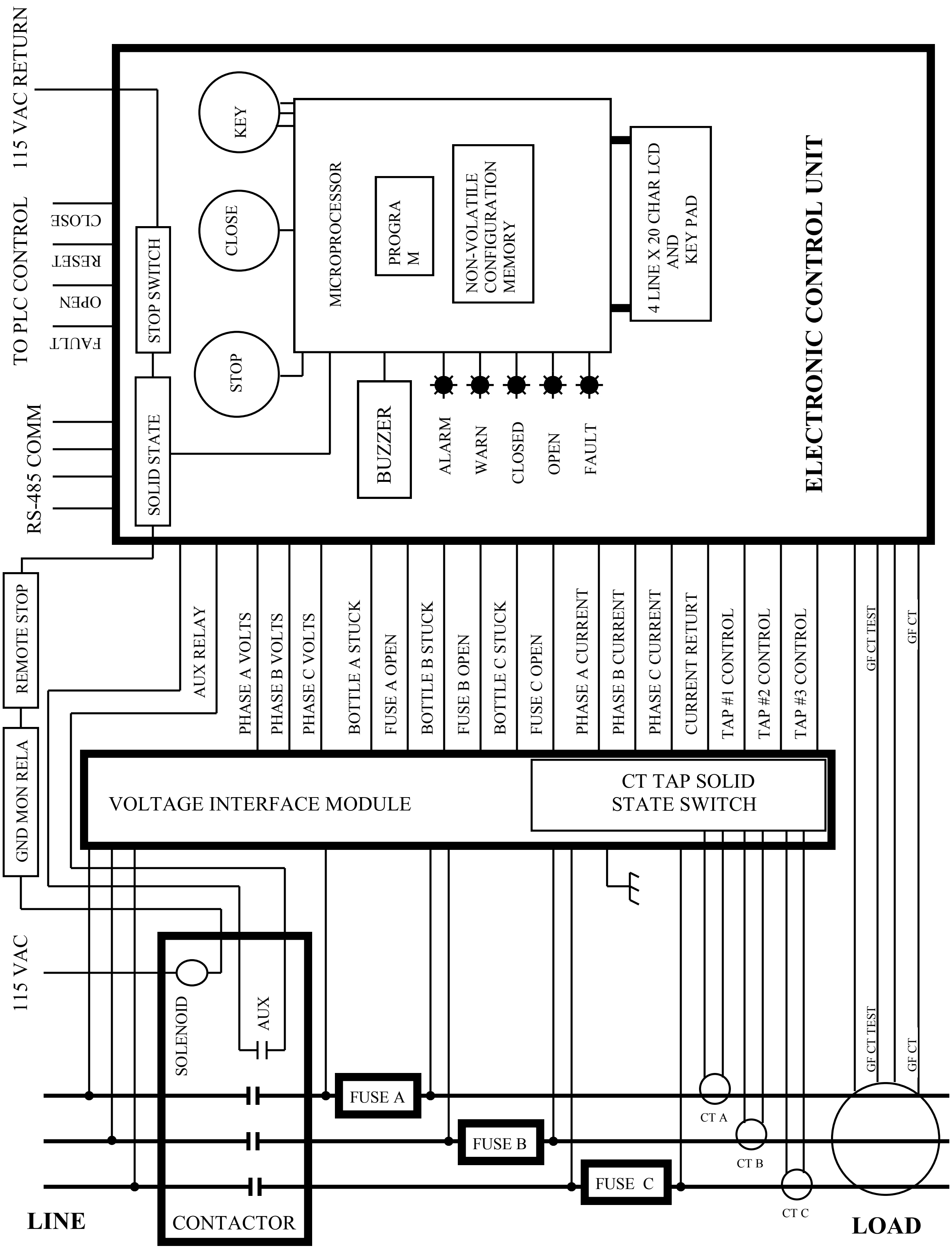


FIGURE 1, CB-PRO BLOCK DIAGRAM

4. Description

The CB-PRO is composed of four primary components. Refer to Figure 1, CBPRO Block Diagram. These components consist of the contactor, fuses, voltage interface module and electronic control unit. The contactor and fuses for all the configurations of the CB-PRO are the same as those used in the CB-1000/100/200 series of circuit breakers. The voltage interface module and electronic control unit differ from those used in the CB-1000/100/200 design.

4.1. CB-PRO Configurations

The CB-PRO may have five configurations. The configuration is determined by the continuous current carrying capacity of the contactor and fuses. The three phase current transformer tap solid state switch is different for each configuration.

4.1.1. CB-PRO 225

The CB-PRO 225 may be configured to operate over the full load current range of 10 amperes to 225 amperes. The contactor is a Joslyn-Clark 320 ampere contactor. The fuse (one for each phase) is a Bussman 600 ampere fuse. Three current transformers (one for each phase) and a three phase solid state switch allows the 10 to 225 ampere range to be covered.

4.1.2. CB-PRO 300

The CB-PRO 300 may be configured to operate over the full load current range of 10 amperes to 300 amperes. The contactor is a Joslyn-Clark 320 ampere contactor. The fuse (one for each phase) is a Bussman 600 ampere fuse. Three current transformers (one for each phase) and a three phase solid state switch allows the 10 to 300 ampere range to be covered.

4.1.3. CB-PRO 450

The CB-PRO 450 may be configured to operate over the full load current range of 100 amperes to 450 amperes. The contactor is a ITT Jennings 450 ampere contactor. The fuse (one for each phase) is a Bussman 600 ampere fuse. Three current transformers (one for each phase) and a three phase solid state switch allows 100 to 450 ampere range to be covered.

4.1.4. CB-PRO 550

The CB-PRO 550 may be configured to operate over the full load current range of 100 amperes to 550 amperes. The contactor is a ITT Jennings 600 ampere contactor. The fuse (one for each phase) is a Bussman 700 ampere fuse. Three current transformers (one for each phase) and a three phase solid state switch allows 100 to 550 ampere range to be covered.

4.1.5. CB-PRO 800

The CB-PRO 800 may be configured to operate over the full load current range of 150 amperes to 800 amperes. The contactor is a Mitsubishi 800 ampere contactor. The fuse (one for each phase) is a Bussman 1000 ampere fuse. Three current transformers (one for each phase) and a three phase solid state switch allows 150 to 800 ampere range to be covered.

4.2. Contactor

The contactor has proven itself to be a reliable device for controlling power to circuits even in the harsh environment of the coal mine. The contactor consists of vacuum bottle interrupters (one for each phase) that are held closed by applying 115 VAC to a solenoid. The vacuum bottle interrupters are required to carry the continuous current defined by the contactor rating and it must also interrupt fault currents in the 6000 ampere range. The interrupt ratings of the 320 ampere, 450 ampere, 600 ampere and 800 ampere contactors are 6000, 6000, 7000 and 13,000 respectively. All contactor vacuum bottle interrupters are rated for a minimum of 1500 VAC operation.

When the contactor is in the OPEN condition, the interrupters are monitored via the voltage interface module to insure that the interrupter contacts are not stuck. If a bottle is stuck, the electronic control unit will display a **STUCK BOTTLE FAULT** and the contactor is prohibited from closing. Several control switches (all in series) remove the 115 VAC from the solenoid to open the contactor interrupter bottles. These are the external cable ground continuity monitor contacts, the remote control stop switch, the CB-PRO front panel STOP switch and the CB-PRO solid state switch. An auxiliary contact that is operated from the same drive mechanism that operates the vacuum interrupter bottles is monitored by the microprocessor to confirm that the contactor is closed when it should be closed. If the contactor fails to close, the open command is then sent to the contactor solenoid.

4.3. Fuses

Since most power circuits to which the CB-PRO is applied have an available fault current level higher than the interrupt rating of the vacuum bottle interrupters, a fuse is used to increase the the CB-PRO interrupt rating. The fuses for all configurations of the CB-PRO are 1000 VAC rated, fast acting and the current limiting type. The fuses are equipped with buttons that pop out when the fuse is opened due to over current. The fuses are placed on the load side of the contactor. A window is placed on the power panel. This allows easy inspection to insure the fuses are in place. Fuses are monitored for an open condition via the voltage interface module to allow the electronic control unit to open the contactor and display a **FUSE OPEN FAULT.**

4.4. Contactor and Fuse Open Time Coordination

An important aspect of the operation of the CB-PRO circuit breaker is the coordination of the opening time of the fuse and the opening time of the contactor. Not only does the fuse increase the interrupt rating of the CB-PRO system, it also protects the vacuum bottle interrupters from clearing a fault current beyond their rating. In order that the vacuum bottle interrupters be protected, the fuse must always open before the contactor attempts to interrupt currents above its rating. A requirement of the MSHA A&CC design criteria is that the manufacturer present a worst case analysis of the opening time of the contactor and the selected fuse. This analysis is done using the fuse manufacturer's procedure for determining the fuse’s worst case opening time. Further, a safety factor of an additional 10% is added. The analysis must prove the fuse will always open first even at 90% contactor interrupt rating. Coordination tests are then performed to prove that the fuse will always open first. These tests are performed with a nearly resistive source impedance (97% power factor) to insure a symmetrical fault current is delivered to the fuse.

Note: See Figures 3 thru 24 for the current vs. open times for various CB-PRO configurations.

4.5. Phase Current Transformers

A current transformer for each phase provides an accurate voltage output to the electronic control unit. This output represents the magnitude and phase of the current. The current transformers are designed to not saturate and thus provide true linear representation of the phase current over the full range of CB-PRO operation. This over range capability insures that high level start-up currents and fault currents are accurately delivered to the electronic control unit for processing. Each current transformer output is connected to a solid state switch assembly that is controlled by the electronic control unit. This solid state switch assembly is located in the Voltage Interface Assembly. When the user configures the CB-PRO for a particular current range, the correct output from the solid state switch is delivered to the electronic control unit by tapping the CT output. As the user selects a higher current range, the solid state switch taps the CT output even more to provide the correct input to the electronic control unit. The solid state switch for the CB -PRO 225 has 3 outputs covering the range of 10 amperes to 225 amperes. The first output tap covers 10 amperes to 30 amperes. The second tap covers 30 amperes to 90 amperes. The third tap covers 100 amperes to 225 amperes. The solid state switch for the CB-PRO 300 has 3 outputs covering the range of 10 amperes to 300 amperes. The first output tap covers 10 amperes to 30 amperes. The second tap covers 30 amperes to 90 amperes. The third tap covers 100 amperes to 300 amperes. The solid state switch for the CB-PRO 450 has 2 outputs covering the range of 100 amperes to 450 amperes. The first output tap covers 100 amperes to 300 amperes. The second tap covers 150 amperes to 450 amperes. The solid state switch for the CB-PRO 550 has 2 outputs covering the range of 100 amperes to 550 amperes. The first output tap covers 100 amperes to 300 amperes. The second tap covers 200 amperes to 550 amperes. The CB-PRO electronic control unit can detect if one or two of the current transformers are open or disconnected by default since this would give the appearance of a phase current imbalance. If this condition exists, the control unit will open the contactor and display the **PHASE CURRENT IMBALANCE** fault.

4.6. Ground Fault Current Tranformer

A phase to ground current fault sensing current transformer is placed around all three phase conductors. This current transformer provides an output to the

The current transformer has an additional winding that allows testing of the ground fault sensing circuitry by the electronic control unit. The user selects the **GROUND FAULT TEST** function on the electronic control unit panel and the current is injected into the spare winding. The control unit measures the ground fault current transformer output, opens the circuit breaker and displays **GROUND FAULT** on the display.

4.7. Voltage Interface Module

The voltage interface module isolates the high voltage circuit from the low voltage circuit for the monitored or measured functions connected to the electronic control unit. Three phase voltage (480 VAC to 1000 VAC) is stepped-down and applied to the input of three precision isolation amplifiers contained in the interface module. The isolated voltage is then applied to the input of the electronic control unit where it is processed and available for display. Outputs from each phase fuse are connected to the voltage interface module. Opto-couplers measure voltage drop across each fuse. If this voltage drop is large enough (meaning the fuse is open), this voltage is transferred across the voltage barrier and delivered to the electronic control unit. The electronic control unit opens the circuit breaker and presents the **FUSE OPEN** fault on the display. Opto-couplers also measure voltage between the load side of the contactor and frame ground. If this voltage is large enough when the contactor is open (meaning the contactor interrupter is stuck), this voltage is transferred across the voltage barrier and delivered to the electronic control unit. The electronic control unit prevents the circuit breaker from closing and presents the **STUCK BOTTLE** fault on the display.

The Voltage Interface Module also houses the current tranformer tap solid state switch PC board assembly. This assembly consists of a resistive divider and solid state switch for each phase to automatically provide the correct output level to Electronic Control Unit.

4.9. Electronic Control Unit(ECU)

The electronic control unit is the processing center for all the CB-PRO monitor and control functions. The microprocessor evaluates analog and digital inputs from transducers, switches and the key pad and provides outputs to open/close the contactor and update the LCD display. The firmware that provides the instructions for the microprocessor is stored in an EPROM. Configuration parameters are stored in non-volatile memory to retain them when power is removed.

4.9.1. RS-485 Comm

The CB-PRO may be connected to a RS-485 serial interface communications line to provide monitor and control functions from a remote Master Station. Both two wire and four wire interfaces are serviced. Ask about communications protocols presently serviced.

4.9.2. PLC Monitor and Control

For less demanding monitor and control applications the CB-PRO may be connected to a PLC. Outputs to the PLC include a **FAULT** signal and an **OPEN** signal. Inputs from the PLC are **FAULT RESET** and **REMOTE CLOSE.**

4.9.3. Three Phase Voltage Measurement

Three AC voltages representing the magnitude and phase of the three AC line voltages are sampled by high speed analog to digital converters in the electronic control unit. Both the RMS and PEAK value of each phase voltage are determined and made available for LCD display. The phase of voltage is determined and is used to calculate the phase angle between voltage and current(power factor). Phase A voltage is used to synchronize the sampling of all the voltage and current inputs the electronic control unit. This is done to insure the sampling occurs at the same time during for each cycle. The RMS value of each phase voltages is compared to the value selected during configuration. If the voltage is less by the under voltage percentage (also selected during configuration), the electronic control unit will open the contactor and display the **LOW LINE VOLTAGE** fault.

4.9.4. Control Voltage Measurement

The control voltage (115 VAC) to power the contactor and electronic control unit is also monitored by the electronic control unit. If the voltage drops below 80 VAC the electronic control unit will open the contactor and display the

4.9.5. Three Phase Current Measurement

Three AC currents representing the magnitude and phase of the three AC load currents are sampled by high speed analog to digital converters in the electronic control unit. Both the RMS and PEAK value of each phase current are determined and made available for LCD display. The phase of each current is determined and is used to calculate the phase angle between voltage and current (power factor). The phase angle of each current with respect to its voltage is available for LCD display. The PEAK current value for each phase is made available for LCD display. The PEAK value of each phase current is compared to the value selected for the magnetic trip value during configuration. If the PEAK current is greater than the magnetic trip set value, the electronic control unit will open the contactor and display the **MAGNETIC OVER CURRENT** fault. The RMS value of each phase current is compared to the thermal trip set value (full load current value) selected during configuration. If the RMS value exceeds the thermal trip set value, a timer is started. If the current remains above the trip set value for a defined time, the electronic control unit will open the contactor and display the **THERMAL CURRENT** fault. The amount of time that the contactor is allowed to remain closed depends on the ratio of RMS current value to the magnetic trip set value. The smaller the ratio, the longer the contactor is allowed to remain closed. The thermal trip time is defined by a set of curves for each CB-PRO configuration. The curves also show that the thermal trip time is dependent on another factor called Motor Class. Motor Class is a number that defines the amount of time (in seconds) the CB-PRO will remain closed while an over current condition that is six times the thermal trip set point. For example, if the thermal trip set value is 100 amperes, the Motor Class is 10 and the over current value is 600 amperes, the circuit breaker will open in 10 seconds. See Figures 3 thru 24 for typical curves. During configuration (using the **OVRLD MENU**), the 115% Thermal Overload Time is displayed and selected.

4.9.6. Ground Fault Current Measurement

Ground fault current is measured in the same manner as phase currents. The RMS value is made available for LCD display. If the ground fault current value exceeds the ground fault current trip value defined during configuration, the electronic control unit will open the contactor and the **GROUND FAULT** message will be displayed. The ground

When the **GROUND FAULT TEST** menu is selected and the test initiated, the electronic control unit will deliver a current to an auxiliary winding on the ground fault current transformer. This current is measured as if it were a true phase to ground fault current. The electronic control unit opens the contactor and and the **GROUND FAULT** message is displayed.

4.9.7. Fuse Open Detection

Fuses are monitored for an open condition via the voltage interface module to allow the electronic control unit to open the contactor and display a **FUSE OPEN** fault.

4.9.8. Stuck Bottle Detection

When the contactor is in the OPEN condition, the interrupters are monitored via the voltage interface module to insure that the interrupter contacts are not stuck. If a bottle is stuck, the electronic control unit will display a **STUCK BOTTLE** fault and the contactor is prohibited from closing.

4.9.9. Auxiliary Contact Monitor

An auxiliary contact of the contactor is monitored by the microprocessor to confirm that the contactor is closed when it should be closed. If the contactor fails to close, the electronic control unit removes the close signal from the contactor solenoid and **AUXILIARY CONTACT** fault is displayed.

4.9.10. Solid State Switch

The electronic control unit uses two solid state switches to open and close the contactor. This redundant switch insures the contactor will open if one switch fails.

4.9.11. Ground Monitor Relay Contact, Remote Stop and Front Panel Stop Switch

Inputs are provided for a ground monitor relay contact and remote stop switch. These external inputs and the electronic control unit front panel stop switch are connected in series with the contactor solenoid control voltage to insure that the contactor is opened when any are opened.
In addition, all of the controls are monitored by the electronic control unit. The electronic control unit will remove the close signal from the solid state switch if either of the controls is opened and display the proper fault message.

4.912. Front Panel Controls and Indicators

The CB-PRO front panel controls and indicators have been selected to provide the user with all the information required to quickly analyze and control the CB-PRO operation without being overly complicated. A user friendly menu driven interface is provided by the four position keypad and a four line by 20 character LCD display. With a minimum of effort the user can quickly learn to retrieve information about the CB-PRO circuit status and perform the configuration of the CB-PRO.

4.9.12.1. LCD Display

A four line by 20 character LCD display provides information about the CB-PRO circuit status and configuration.

4.9.12.2. Keypad

A four position keypad along with the LCD display allows the user to move through the CB-PRO menu tree to gather status information about the operation and configuration for the particular circuit requirements to which the unit is applied. The four keys of the keypad are:

SELECT --This key is pressed to either select a function within a particular menu or select another menu.

UP --This key is pressed to move the cursor up within a particular menu or increment a trip value.

DOWN --This key is pressed to move the cursor down within a particular menu or decrement a trip value.

RETURN --This key is pressed to return to the previous menu selected.

4.9.12.3. Close Switch

The electronic control unit close switch is enclosed in a protective collar to prevent the switch from being depressed accidentally. In addition, the switch must be held closed for two seconds before the close sequence begins. The close sequence consists of an adjustable (0 to 10 second) warning period before the contactor actually closes. During this warning period an audible and visual indication is

4.9.12.4. Key Switch

A key switch located on the electronic control unit front panel is provided to allow the user to lock out operation of the CB-PRO circuit breaker system. In the **RUN** position of the switch, the contactor may be closed. In the **PGM** (PROGRAM) position, the CB-PRO configuration may be changed. In the **OFF** position, the contactor is prohibited from closing.

4.9.12.5. Open Switch

The electronic control unit front panel stop switch is connected in series with the contactor solenoid control voltage to insure that the contactor is opened when the stop switch is pushed. In addition, the front panel stop switch is monitored by the electronic control unit. The electronic control unit will remove the close signal from the contactor solenoid when the stop switch is pushed and the **STOP SWITCH** fault message is displayed.

4.9.12.6. LEDS

Five LEDS provide visual indication about the status of the CB-PRO circuit breaker.

ALARM - This LED is not used.

WARN - This LED is ON when the electronic control unit is preparing to close the contactor.

CLOSED- This LED is ON when the contactor is closed.

OPEN - This LED is ON when the contactor is open.

FAULT - This LED is ON when the contactor has been opened due to a fault condition.

4.9.13. Display Menus

The CB-PRO menus are arranged in a tree configuration with the **MAIN MENU** at the top. The main menu allows the user to select either the first page of **STATUS** information menus or the first page **CONFIGURATION** information menus. Each status page or configuration page contains a listing of more menus that may be accessed. The following is a listing of the menus with a functional description.

4.9.13.1. CB-PRO Main Menu

```
CB-PRO MAIN MENU
>SELECT STATUS
 SELECT CONFIG
 MOV CURS/SELECT
```

The MAIN MENU allows the user to select the first page of three status menus or the first page of two configuration menus.

To select STATUS or CONFIG, move the cursor using the UP/DOWN keys to the desired selection and press the SELECT key.

4.9.13.1.1. CB-PRO Status Menu Page 1

The CB-PRO currently has 20 status menus that provide the user with operational and status information about the circuit the unit is controlling.

```
    STATUS PAGE 1
>PHVOL  STCUR  SPHAN
 PHCUR  CTTAP  TRIP1
 PHANG  GFCUR  TRIP2
```

The first page of status menus contains nine menus.

1. PHVOL = Phase voltage values
2. PHCUR = Phase current values
3. PHANG = Phase angle (volt/curr)
4. STCUR = Value of last start current
5. CTTAP = Contactor/xformer select
6. GFCUR = Ground fault current value
7. SPHAN = Value of last start phs angl
8. TRIP1 = List of current trip values
9. TRIP2 = List of current trip values

To select one of the menus, move the cursor using the UP/DOWN keys to the desired selection and press the SELECT key.

Note: Page 2 of the Status Menus will automatically roll up when the DOWN key is pressed if the cursor is menu #9.

4.9.13.1.2. CB-PRO Phase Voltages Status Menu

PHASE VOLTAGES A 0995 RMS/1400 PK B 0995 RMS/1400 PK C 0995 RMS/1400 PK	The Phase Voltages Status Menu displays the RMS and Peak value for each phase voltage. To return to the first page of Status Menus, press the RETURN key

4.9.13.1.3. CB-PRO Phase Currents Status Menu

PHASE CURRENTS A 0100 RMS/0140 PK B 0100 RMS/0140 PK C 0100 RMS/0140 PK	The Phase Currents Status Menu displays the RMS and Peak value for each phase current. To return to the first page of Status Menus, press the RETURN key.

4.9.13.1.4. CB-PRO Phase Angle Status Menu

VOL/CUR PHASE ANGLE A 20 DEGREES LEAD B 20 DEGREES LEAD C 20 DEGREES LEAD	The Phase Angle Menu displays the phase angle between the voltage with respect to the current. To return to the first page of Status Menus, press the RETURN key.

4.9.13.1.5. CB-PRO Last Start Current Status Menu

LAST START CURRENT A 500 AMP PEAK B 500 AMP PEAK C 500 AMP PEAK	The Last Start Menu displays the peak value of the last start current. To return to the first page of Status Menus, press the RETURN key.

4.9.13.1.6. CB-PRO Circuit Configuration Status Menu

CIRCUIT CONFIG 320 AMP CONTACTOR 100 TO 300 AMP TAP OVERLOAD(SEC) 540	The Circuit Confuguration Menu displays selected contactor size, the current transformer tap current range, and the 115% Overload time in seconds To return to the first page of the Status Menus, press the RETURN key.

4.9.13.1.7. CB-PRO Ground Fault Current Status Menu

```
GROUND FLT CURRENT
   0.1     AMPERES
  HISTORY MAXIMUM
   5.5     AMPERES
```

The Ground Fault Current Menu displays the present value and historical value of ground fault current. To return to the first page of Status Menus, press the RETURN key

4.9.13.1.8. CB-PRO Last Start Phase Angle Status Menu

```
LAST START PHAS ANG
 A PHASE  30  DEGREES
 B PHASE  30  DEGREES
 C PHASE  30  DEGREES
```

The Last Start Phase Angle Menu displays the phase angle between the voltage with respect to the current for the last motor start. To return to the first page of Status Menus, press the RETURN key.

4.9.13.1.9. CB-PRO Trip Settings 1 Status Menu

```
   TRIP SETTINGS 1
 THERMAL    0100 AMP
 MAGNETIC  0800 AMP
 GND FAULT 4.00 AMP
```

The Trip Setting 1 Menu displays the thermal current trip value, the magnetic current trip value, and the ground fault current trip value. To return to the first page of Status Menus, press the RETURN key.

4.9.13.1.10. CB-PRO Trip Settings 2 Status Menu

```
    TRIP SETTINGS 2
PHASE CUR IMBAL  30%
UNDER VOLTAGE    30%
TRIP DELAY       3.0 SEC
```

The Trip Setting 2 Menu displays the phase current imbalance trip %, the under voltage trip %, and the trip delay for these two faults. To return to the first page of Status Menus, press the RETURN key.

4.9.13.1.11. CB-PRO Status Menu Page 2

```
   STATUS PAGE 2
>COMM  FUBOT  CLSTM
 FAULT  REMS1   LSTCR
 FPSWC REMS2  LSTGF
```

The second page of status menus contains nine menus.

1. COMM = Comm status
2. FAULT = Reason CB-PRO opened
3. FPSWC = Front panel switch status
4. FUBOT = Fuse/Bottle status
5. REMS1 = Status of remote switches
6. REMS2 = Status of remote switches
7. CLSTM = Total close time
8. LSTCR = Last over current value
9. LSTGF = Last ground fault value

To select one of the menus, move the cursor using the UP/DOWN keys to the desired selection and press the SELECT key.

Note: Page 3 of the Status Menus will automatically roll up when the DOWN key is pressed if the cursor is menu #9.

4.9.13.1.12. CB-PRO Communications Status Menu

```
  COMM STATUS
 COMM            OK
  ADDRESS       007
  BAUD RATE  38.4K
```

The Comm Status Menu displays the communication status of the CB-PRO he with the master, the CB-PRO address, comm channe baud rate. To return to the second page of Status Menus, press the RETURN key.

4.9.13.1.13. CB-PRO Breaker Fault Type Status Menu

```
 BREAKER FAULT TYPE
    GROUND FAULT
    TO RESET FAULT
    SELECT/RETURN
```

The Breaker Fault Type Menu displays the fault or reason the CB-PRO opened the contactor. To clear the fault, press any KEYPAD key.

4.9.13.1.14. CB-PRO Front Panel Switches Status Menu

```
FRNT PANL SWIT STAT
 CLOSE SW      OPEN
OPEN   SW     CLOSED
  KEY SW        RUN
```

The Front Panel Switch Status Menu displays the status of the CLOSE push button switch, the OPEN or STOP mushroom switch, and the KEY switch. To return to the second page of Status Menus, press the RETURN key.

4.9.13.1.15. CB-PRO Fuse and Contactor Bottle Status Menu

```
FUSE/BOTTLE STATUS
A(FUS  OK  /BOTL  OK   )
B(FUS  OK  /BOTL  OK   )
C)FUS  OK  /BOTL  OK   )
```

The Fuse/Bottle Status Menu displays the condition of the fuse and contactor bottle for each phase. To return to the second page of Status Menus, press the RETURN key.

4.9.13.1.16. CB-PRO Remote Control Switches #1 Status Menu

```
REMOTE CONTROL #1
OPEN SW        CLOSED
RESET SW       OPEN
CLOSE SW       OPEN
```

The Remote Control #1 Status Menu displays the status of the remote open, reset, and close switches. To return to second page of Status Menus, press the RETURN key.

4.9.13.1.17. CB-PRO Remote Control Switches #2 Status Menu

```
REMOTE CONTROL #2
GND MONITOR  CLOSED
SPARE        CLOSED
AUX CONTACT  CLOSED
```

The Remote Control #2 Status Menu displays the status of the ground monitor, spare, and auxilliary contacts. To return to the second page of Status Menus, press the RETURN key.

4.9.13.1.18. CB-PRO Contactor Close Time Status Menu

```
TOTAL CLOSE TIME

    HOURS  00500.82
```

The Close Time Menu displays the number of hours the contactor has been closed. To return to the second page of Status Menus, press the RETURN key.

4.9.13.1.19. CB-PRO Last Overcurrent Status Menu

```
  LAST OVR CUR  #0  ^
MO/DA/YR   HR:MN:SC
10   21   98    16  04   43
VALUE     01292 AMP
```

The Last Over Current Status Menu displays the date, time, and value of the last **FIVE** over current conditions that opened the CB-PRO contactor. To display all **FIVE** over current dates, times, and values; press the UP key. TO return to the second page of Status Menus, press the RETURN key.

4.9.13.1.20. CB-PRO Last Ground Fault Current Status Menu

```
  LAST GND FLT  #0  ^
MO/DA/YR   HR:MN:SC
10   16   98    10  03   43
 VALUE     08.2 AMP
```

The Last Ground Fault Status Menu displays the date, time, and value of the last **FIVE** ground fault conditions that opened the CB-PRO contactor. To display all **FIVE** ground fault current dates, times, and values; press the UP key. TO return to the second page of Status Menus, press the RETURN key.

4.9.13.1.21. CB-PRO Status Menu Page 3

```
    STATUS PAGE 3
>GFTST  STA01  STA04
 DTIME STA02  STA05
 LSTFL  STA03  STA06
```

The third page of status menus contains one menu and eight spares.

1. GFTST = Ground fault test
2. DTIME = Date and Time
3. LSTFL = Last 10 Faults of any type
4. STA01 thru STA06. = Future spares

To select one of the menus, move the cursor using the UP/DOWN keys to the desired selection and press the SELECT key.

4.9.13.1.22. CB-PRO Ground Fault Test Status Menu

4.9.13.1.23. CB-PRO Date and Time Status Menu

```
 GROUND FAULT TEST
START GND FLT TEST
TO PERFORM TEST
  SELECT/RETURN
```

The Ground Fault Test Status Menu allows the CB-PRO to perform a test of the ground fault current transformer and electronics. To begin the test, press the SELECT key and then RETURN key. The display will show the test is in progress. To end the test, press the RETURN key again. To return to the second page of the Status Menus, press the RETURN key.

```
  CURRENT DATE/TIME
DATE 10-16-98
 TIME  15:42:24
       RETURN
```

The Current Date/Time Status Menu displays the date and time. To return to the second page of the Status Menus, press the RETURN key.

4.9.13.1.24. CB-PRO Last Fault Status Menu

```
  LAST FAULT  #0  ^
MO/DA/YR   HR:MN:SC
10   21   98    16  04   43
MAG CUR/CABLE SHORT
```

The Last Fault Status Menu displays the date, time, and name of the fault for the last **TEN** faults of any type. To display all **TEN** faults**,** dates and times; press the UP key. TO return to the second page of Status Menus, press the RETURN key.

4.9.13.2. CB-PRO Configuration Menus

To begin the configuration process of the CB-PRO use the MAIN MENU and move the cursor to SELECT CONFIG. Press the SELECT key and the PASS CODE MENU will be displayed.

NOTE: The front panel KEY switch must be in the program (PGM)position before the CB-PRO will allow configuration changes.

4.9.13.2.1. CB-PRO Enter/Change Pass Code Configuration Menu

```
   PASS CODE MENU
> ENTER PASSCODE
CHANGE PASSCODE
INC/DEC/SELECT/RETN
```

This menu is displayed when the configuration series of menus is selected from the MAIN MENU. This menu allows the user to enter the passcode so that the configuration menus may be accessed or the pass code may be changed. If the CHANGE PASSCODE selection is made, the user must first enter the current passcode before the passcode may be changed. Use the INC/DEC keys to move the cursor. Press the SELECT key to make the selection. To return to the second page of Config Menus, press the RETURN key.

4.9.13.2.2. CB-PRO Enter Pass Code Configuration Menu

```
 ENTER PASS CODE
0123456789
^          (ENTRY  1)
 INC/DEC/SELECT/RETN
```

This menu is used to enter the passcode before access to the configuration menus or changing the passcode is allowed.

The passcode consists of four numbers that are entered by moving the cursor (^) to each number using the INC/DEC keys and pressing the SELECT key. As each number is selected, the ENTRY number is incremented. When the fourth number is entered, press the SELECT key again. If the four numbers that were entered are the same as the passcode, page 1 of the configuration menus will be displayed or the CHANGE PASS CODE menu will be displayed. To return to the PASS CODE MENU, press the RETURN key.

4.9.13.2.3. CB-PRO Change Pass Code Configuration Menu

```
CHANGE PASS CODE
0123456789
^            (ENTRY  1)
INC/DEC/SELECT/RETN
```

This menu is used to change the passcode. The passcode consists of four numbers that are entered by moving the cursor (^) to each number using the INC/DEC keys and pressing the SELECT key. As each number is selected, the ENTRY number is incremented. When the four numbers are entered, press the SELECT key again. The passcode is now saved. To return to the PASS CODE MENU, press the RETURN key.

4.9.13.2.4. CB-PRO Configuration Menu Page 1

The CB-PRO currently has 16 configuration menus that allow the user to configure the CB-PRO to the circuit the unit is controlling.

```
   CONFIG PAGE 1
>CRXFM  COMM  MAGTP
  ZROCT  GFTRP  IMBAL
  OVRLD THRTP  UNVOL
```

The first page of configuration contains nine menus.

1. CRXFM = Select contactor/xformer
2. ZROCT = Calibrate CT's
3. OVRLD = Selects overload time
4. COMM = Configure comm port
5. GFTRP = Set Gnd Fault trip level
6. THRTP = Set thermal current trip
7. MAGTP = Set magnet current trip
8. IMBAL = Set % current imbal trip
9. UNVOL = Set % phase volt trip

To select one of the menus, move the cursor using the UP/DOWN keys to the desired selection and press the SELECT key.

Note: Page 2 of the Config Menus will automatically roll up when the DOWN key is pressed if the cursor is menu #9.

4.9.13.2.5. CB-PRO Contactor and CT Configuration Menu

```
 CONTACTOR & CT TAP
320 AMP CONTACTOR
100 TO 300 AMP TAP
 INC/DEC    SELECT
```

The Contactor and CT Tap Menu allows the user to configure the CB-PRO electronic control unit to match the contactor and current transformer hardware used to monitor and control the circuit. It is important for proper operation of the CB-PRO that the control unit configuration match the hardware. The contactor selections available are 320 ampere, 450 ampere, and 600 ampere. The 320 ampere contactor has two current ranges available, 10 to 225 amperes and 10 to 300 amperess. Each current range has three CT taps. The 10 to 225 ampere range (10 to 30 ampere, 30 to 90 ampere, and 100 to 225 ampere). The 10 to 300 ampere range (10 to 30 ampere, 30 to 90 ampere, and 100 to 300 ampere). The 450 ampere contactor has two CT taps (100 to 300 ampere and 150 to 450 ampere). The 600 ampere contactor has two CT taps (100 to 300 ampere and 200 to 550 ampere). Use the INC/DEC key to move through the contactor and current transformer selections. Use the SELECT key to select the desired configuration. To return to the first page of Config Menus, press the RETURN key.

4.9.13.2.6. CB-PRO Zero Currents Configuration Menu

```
  ZERO CURRENTS
>PHA   PHB   PHC   GF
 000    000   000    0.0
SELECT/INC/DEC/RETN
```

This menu is used by AMR technicans to remove minor offsets in the current amplifiers. It should not be used by unqualified personnel. To return to the first page of Config Menus, press the RETURN key.

4.9.13.2.7. CB-PRO Select Motor Overload Time Config. Menu

```
MOTOR OVERLOAD TIME
@ 115% THERMAL RATE
   TIME IN SEC      540
    INC/DEC     SELECT
```

The Motor Overload Time Menu is used to select the long time delay trip time in seconds for 115% overload current conditions. See page 16 of the electronic control unit description for a discussion of motor overload curves. To return to the first page of Config Menus, press the RETURN key.

4.9.13.2.8. CB-PRO Communications Configuration Menu

```
COMMUNICATIONS
>BAUD 38.4K  ENAB NO
 ADDRESS 008
 CURSR INC/DEC SELET
```

The Communications Config Menu allows the electronic control unit to be configured as a monitor system remote. Data that is displayed on the CB-PRO front panel is sent to a mine monitoring system master station over the RS-485 communication link. To select the baud rate, address, or enable the CB-PRO: move the cursor to the desire function by using the INC/DEC keys and then press the SELECT key. After the function has been selected, use the INC/DEC key to toggle the baud rate between 4800 and 38400 baud, enable or disable communicatons, or change the address. After the function change has occurred, use the SELECT key to save the change. To return to the first page of Config Menus, press the RETURN key.

4.9.13.2.9. CB-PRO Set Ground Fault Current Trip Config Menu

```
GROUND FAULT TRIP

    4.0  AMPS
  INC/DEC  SELECT
```

The Ground Fault Trip Menu allows the user to set the ground fault trip current between 1.0 amperes and 25 amperes in 0.1 ampere increments. Use the INC/DEC key to change the display to the desired current value. Use the SELECT key to save the value. To return to the first page of Config Menus, press the RETURN key.

4.9.13.2.10. CB-PRO Set Thermal Current Trip Config Menu

```
THERMAL TRIPSET

   100  AMPS
INC/DEC   SELECT
```

The Thermal Tripset Menu is used to set the full load or thermal current value that provides thermal over load protection for the circuit controlled by the CB-PRO. Use the INC/DEC key to change the display to the desired value. Use the SELECT key to save the value. To return to the first page of Config Menus, press the RETURN key.

4.9.13.2.11. CB-PRO Set Magnetic Current Trip Config Menu

MAGNETIC TRIPSET

600 AMPS
INC/DEC SELECT

The Magnetic Tripset Menu is used to set the instantaneous or magnetic current trip value to provide trailing cables short circuit protection for the circuit controlled by the CB-PRO. Use the INC/DEC key to change the display to the desired value. Use the SELECT key to save the value. To return to the first page of Config Menus, press the RETURN key.

4.9.13.2.12. CB-PRO Set Phase Current Imbal Trip Config Menu

% PHASE CURR IMBAL

20%
INC/DEC SELECT

The Percent Phase Current Imbalance Menu is used to set the percent difference that is allowed between the phase currents before the CB-PRO opens the circuit breaker contactor. To change the value, use the INC/DEC key. To save the value, use the SELECT key. To return to the first page of Config Menus, press the RETURN key.

4.9.13.2.13. CB-PRO Set % Undervoltage Trip Config Menu

% UNDER VOLTAGE

20%
INC/DEC SELECT

The Percent Under Voltage Menu is used to set the percentage the three phase voltage is allowed to drop before the the CB-PRO opens the circuit breaker contactor. To change the value, use the INC/DEC key. To save the value, use the SELECT key. To return to the first page of Config Menus, press the RETURN key.

4.9.13.2.14. CB-PRO Configuration Menu Page 2

```
  CONFIG PAGE 2
>TRPDL  PHSVL  CLSDL
 SETIM   ENTPC  CON01
 PASCD  CHGPC CON02
```

The second page contains six configuration and three spare menus.

1. TRPDL = Set delay for some faults.
2. SETIM = Set Date and Time.
3. PASCD = Passcode menu.
4. PHSVL = Select phase voltage.
5. ENTPC = Enter passcode menu.
6. CHGPC = Change passcode menu.
7. CLSDL = Change close delay time.
8. CON01-CON02 = Spares.

To select one of the menus, move the cursor using the UP/DOWN keys to the desired selection and press the SELECT key.

4.9.13.2.15. CB-PRO Delay For % Trips Configuration Menu

```
DELAY FOR % TRIPS

      3.0  SECS
 INC/DEC    SELECT
```

The Delay For % Trips Menu is used to set the delay in seconds before the CB-PRO will open the contactor for % current imbalance and % undervoltage faults. Use the INC/DEC key to change the display to the desired value. Use the SELECT key to save the value. To return to the second page of Config Menus, press the RETURN key.

4.9.13.2.16. CB-PRO Set Date and Time Configuration Menu

```
   SET DATE/TIME
MO/DA/YR  HR:MN:SC
10   21    98   15   26  45
SELECT/INC/DEC/RETN
```

This menu is used to set the real time clock. This clock is used to time stamp over current and ground faults. To set the month, day, year, etc., first move the blinking cursor to the particular item to be set using the UP/DOWN keys on the keypad. With the cursor placed at the desired item, push the SELECT key. Now, use the UP/DOWN keys to change the value of the item selected. When the value is equal to the desired value, press the SELECT key to save the value. Again, move the blinking cursor to the next item to be changed and repeat the above process. To return to page 2 of the Config Menu, press the RETURN key.

4.9.13.2.17. CB-PRO Select Phase Voltage Configuration Menu

```
SELECT PHASE VOLTS
     480  VOLTS

INC/DEC/SELECT/RETN
```

This menu is used to select the three phase voltage value. The values available are: 000 (used for testing with no voltage available), 480, 575, and 995. To change the voltage displayed use the INC/DEC keys. To save the displayed voltage use the SELECT key. To return to page 2 of the Config Menu, press the RETURN key.

4.9.13.2.18. CB-PRO Select Contactor Close Delay Time

```
 DELAY FOR CLOSE

    5.0 SECS
INC/DEC    SELECT
```

This menu is used to select the contactor close time after the close switch is released. The close delay time range is 0 to 5 seconds. To change the time displayed use the INC/DEC keys. To save the displayed voltage use the SELECT key. To return to page 2 of the Config Menu, press the RETURN key.

5. Operation

5.1. Fuse/Contactor Fault Disconnect Coordination

Since the vacuum contactor is limited to disconnecting faults that are less than its interrupt rating (usually between 5000 and 7000 amperes), coordination of the disconnect time between the vacuum bottles and the fuses is crucial to the protection of the vacuum bottles and the prevention of nuisance fuse disconnects. The CB-PRO Electronic Control Unit is designed to always open the vacuum bottle contactor before the fuses open for faults less than the contactor interrupt rating. Fault currents above the interrupt rating of the contactor generate a fuse disconnect time that is faster than the contactor opening time, thus protecting the vacuum contactor bottles. Figures 3 thru 24 show the coordination of the disconnect times between the fuses and vacuum bottle contactor for various full load current and fault current conditions.

5.2. CB-PRO Configuration

Before closing the CB-PRO contactor for the first time, the Electronic Control Unit should be configured to match the contactor being used and also be configured to match the particular circuit protection parameters to which the CB-PRO is being applied. Follow the steps below to configure the CB-PRO:

- Use the Contactor and CT Tap Configuration Menu to select either the 320,450, 600 or 800 amp contactor that is being controlled by the CB-PRO Electronic Control Unit.

- Use the Contactor and CT Tap Configuration Menu to select the current transformer tap range that matches the continuous or full load current of the circuit the CB-PRO circuit breaker is protecting.

  Use the Motor Overload Menu to select the thermal trip time in seconds the CB-PRO Electronic Control Unit will open the contactor for an overload current that is 115% of the thermal trip setting.
  NOTE: This value is usually set to 540 seconds.

- Use the Communications Menu to set the CB-PRO baud rate and address.

- Use the Ground Fault Trip Menu to set the Ground Fault Trip level.

- Use the Thermal Tripset Menu to set the circuit full load current value.

- Use the Magnetic Tripset Menu to set the instantaneous current trip value.

- Use the % Phase Current Imbalance Menu to set the percent current imbalance value. **NOTE:** Usually set to 30%.

- Use the % Under Voltage Menu to set the percent under voltage value. **NOTE:** Usually set to 30%.

- Use the Delay For % Trips Menu to set the delay in seconds for the percent current imbalance and under voltage faults. **NOTE:** Usually set to 3.

- Use the Select Phase Volage Menu to select the three phase voltage value that matches the circuit voltage.

- Use the Close Delay Time Menu to select the time between the release of the Close Switch and the contactor closing.

5.3. Using Status Menus to Confirm Configuration

Any time the configuration of the CB-PRO has been changed the changes should be verified by using the appropriate Status Menus.

- Use the Circuit Config Status Menu to verify the contactor type, current transformer tap and overload time selected.

- Use the Trip Settings #1 Menu to verify the full load (thermal) current, instantaneous (magnetic) current and ground fault current trip settings.

- Use the Trip Settings #2 Menu to verify the phase current imbalance percent, undervoltage percent and trip delay settings.

5.4. Reset of Faults

When the CB-PRO Electronic Control Unit detects a fault condition, it causes the contactor to open. The Breaker Fault Type Menu immediately appears on the LCD display and the Fault LED is turned ON. To close the contactor after a fault has been detected, the fault must first be cleared. To clear a fault with the Breaker Fault Type Menu displayed, press any of the four keys on the keypad. The fault LED will extinguish and the contactor may now be closed. If the Fault LED is ON and the Breaker Fault Type Menu is not displayed, then the Breaker Fault Type Menu must first be displayed by selecting it from the Status Menus Page 2 menu.

5.5. Closing the Contactor

To close the contactor the Electronic Control Unit Fault LED must first be OFF. See section 5.4. Reset of Faults. Push the Electronic Control Unit Front Panel Close Switch and hold for approximately 2 seconds until the Audible Alarm and Warn LED come ON. The Electronic Control Unit will execute a Pre-Close Warning for the length of the delay close time selectd (0 to 10 seconds)and then close the contactor.

5.6. Caution

If the Stuck Bottle Fault or the Fuse Open Fault is displayed, be sure to lock out the circuit and turn OFF the incoming power to the power center before troubleshooting the power center. Turn OFF the incoming power center power before checking or changing fuses.

6. Installation

The CB-PRO Circuit Breaker System is MSHA accepted as a **"no less effective device"** compared to the traditional molded case circuit breaker. The acceptance and performance of the the CB-PRO as a circuit interrupting and protection device is predicated on the proper installation of all components of the circuit breaker system. Below is a list of components for each of the CB-PRO Circuit Breaker Systems.

6.1.CB-PRO 225 and CB-PRO 300 Components

Electronic Control Unit Assembly—(140-0173)
Voltage Interface Assembly—(140-0174-300)
CT Tap Solid State Switch PCB Assembly—(253-0339-300)
Contactor—(280-0070)Joslyn-Clark VC77U03515 320 AMP
Fuse—(160-0029)Bussman SPJ-6E600 600 AMP
Phase Current Transformer—(130-0079)
Ground Fault Transformer—(130-0092)
Optional Communications PCB Assembly—(253-0325)
Three Phase Power Cable
CB-PRO 225 1/0 or larger, 90 deg, C.
CB-PRO 300 4/0 or larger, 90 deg. C.
Fuse Heat Sink—None Required
Fuse Insulator (P/N 125-0151)

6.1.1. CB-PRO 225 and CB-PRO 300 Power Components Connection

◊ Refer to Figure 2, CB-PRO Interconnect Diagram. The contactor for the CB-PRO **may** be placed on the back of a standard, removable power center panel using the available mounting holes. If it is desired to install the system in the power center excluding the removable power panel, then mount the contactor on the bottom of the power center close to the power output receptacle so as to minimize power cable length from the contactor to the receptacle.

◊ Use the appropriate three phase power cable as defined above to make connections from the three phase power buss to the contactor line side. Before tightening the contactor line side cable hardware, attach an appropriate length of #16 AWG, 1000 Volt Rated wire to each contactor line side terminal. The wire length should be sufficient to reach from each fuse to the Voltage Interface Module. These wires will be used to monitor the three

◊ Install the appropriate three phase power circuit fuses as defined above on the **load side** of the contactor.
NOTE: The fuses must be mounted such that they are clearly visable through a window mounted on the power center panel. Before tightening the fuse mounting hardware, attach an appropriate length of #16 AWG, 1000 Volt Rated wire to each fuse terminal. The wire length should be sufficient to reach from each fuse to the Voltage Interface Module. These wires will be used to monitor for open fuse and stuck bottle conditions.

◊ Use the appropriate three phase power cable as defined above to make connections from the load side of each fuse to the power receptacle. Place a phase current transformer around each phase conductor on the **load side** and place a ground fault current transformer on the **load side** around all three phase conductors before tighting the cable/fuse/contactor/receptacle hardware.

6.2.CB-PRO 450 Components

Electronic Control Unit Assembly—(140-0173)
Voltage Interface Assembly—(140-0174-450)
CT Tap Solid State Switch PCB Assembly—(253-0339-450)
Contactor—(280-0004)ITT Jennings RP133-2335-00 450 AMP
Fuse—(160-0029)Bussman SPJ6E600 600 AMP
Phase Current Transformer—(130-0079)
Ground Fault Transformer—(130-0092)
Optional Communications PCB Assembly—(253-0325)
Three Phase Power Cable—444 MCM or larger, 125 deg.C.
Fuse Heat Sink—(125-0207)
Buss Bar (125-0203)

6.2.1. CB-PRO 450 Power Components Connection

◊ Refer to Figure 2, CB-PRO Interconnect Diagram. The contactor for the CB-PRO 450 **may** be placed on the back of a standard, removable power center panel using the available mounting holes. If it is desired to install the system in the power center excluding the removable power panel, then mount the contactor on the bottom of the power center close to the power output receptacle so as to minimize power cable length from the contactor to the receptacle.

◊ Use the appropriate three phase power cable as defined above to make connections from the three phase power buss to the contactor line side. Before tightening the contactor line side cable hardware, attach an appropriate length of #16 AWG, 1000 Volt Rated wire to each contactor line side terminal. The wire length should be sufficient to reach from each fuse to the Voltage Interface Module. These wires will be used to monitor the three phase voltages.

◊ Install the three phase buss bars defined in the CB-PRO 450 Components list. The buss bars are necessary and are required to maintain the MSHA acceptance of the CB-PRO 450 Circuit Breaker System. They serve to seperate the fuses to improve voltage-breakdown and they assist in removing heat from the fuses.

◊ Install the appropriate three phase power circuit fuses defined above on the top of each phase buss bar. **NOTE: The fuses must be mounted as such so that they are clearly visable through a window mounted on the power center panel.**Place the heat sink (125-0207) on top of each fuse terminal (side nearest the load side of the contactor). Before tightening the fuse mounting hardware, attach an appropriate length of #16 AWG, 1000 Volt Rated wire to each fuse terminal. The wire length should be sufficient to reach from each fuse to the Voltage Interface Module. These wires will be used to monitor for open fuse and stuck bottle conditions.

6.3.CB-PRO 550 Components

Electronic Control Unit Assembly—(140-0173)
Voltage Interface Assembly—(140-0174-550)
CT Tap Solid State Switch PCB Assembly—(253-0339-550)
Contactor—(280-0087) ITT Jennings RP173-2315-00 600 AMP
Fuse—(160-0022)Bussman SPJ-6E700 700 AMP
Phase Current Transformer—(130-0079)
Ground Fault Transformer—(130-0092)
Optional Communications PCB Assembly—(253-0325)
Three Phase Power Cable—444 MCM or larger, 125 deg.C.
Fuse Heat Sink—(271-0083)

6.3.1. CB-PRO 550 Power Components Connection

◊ Refer to Figure 2, CB-PRO Interconnect Diagram. Because the contactor for the CB-PRO 550 is too large and heavy to be placed on the back of a standard, removable power center panel, the contactor should be mounted in the bottom of the power center close to the power output receptacle. This will minimize power cable length from the contactor to the receptacle.

◊ Use the appropriate three phase power cable as defined above to make connections from the three phase power buss to the contactor line side. Before tightening the contactor line side cable hardware, attach an appropriate length of #16 AWG, 1000 Volt Rated wire to each contactor line side terminal. The wire length should be sufficient to reach from each fuse to the Voltage Interface Module. These wires will be used to monitor the three phase voltages.

Place the heat sink (271-0083) on each phase of the load side of the contactor.

◊ Install the appropriate three phase power circuit fuses defined above on the top of each phase buss bar. **NOTE: The fuses must be mounted as such so that they are clearly visable through a window mounted on the power center panel.** Before tightening the fuse mounting hardware, attach an appropriate length of #16 AWG, 1000 Volt Rated wire to each fuse terminal. The wire length should be sufficient to reach from each fuse to the Voltage Interface Module. These wires will be used to monitor for open fuse and stuck bottle conditions.

6.4.CB-PRO Monitor and Control Components Connection

◊ Place the Voltage Interface Assembly near the contactor too minimize the wire length between the power line connections and the Voltage Interface Assembly.

◊ Install the Electronic Control Unit on the power center panel such that the user will have easy access to all indicators and controls.

- Connect the three wires attached to the contactor line side terminals (used to monitor of all three phase voltages) to the Voltage Interface Assembly TB1 positions 1 through 3 (phase A to 1, phase B to 2, phase C to 3).

- Connect phase A fuse wires (used to monitor open fuse and stuck contactor bottle) to the Voltage Interface Assembly TB2 positions 1 and 2. Connect the wire attached to the contactor load side of the fuse terminal to TB2-1 and the wire attached to load side of the fuse terminal to TB2-2.

- Connect phase B fuse wires (used to monitor open fuse and stuck contactor bottle) to the Voltage Interface Assembly TB2 positions 3 and 4. Connect the wire attached to the contactor load side of the fuse terminal to TB2-3 and the wire attached to load side of the fuse terminal to TB2-4.

- Connect phase C fuse wires (used to monitor open fuse and stuck contactor bottle) to the Voltage Interface Assembly TB2 positions 5 and 6. Connect the wire attached to the contactor load side of the fuse terminal to TB2-5 and the wire attached to load side of the fuse terminal to TB2-6.

- Connect a #16 AWG wire from an appropriate frame ground connection on the contactor to the Voltage Interface Assembly TB2-7.

- Connect phase A current transformer output wires to the CT Tap Solid State Switch (mounted in the Voltage Interface Assembly) connector J2-11 and 12.

- Connect phase B current transformer output wires to the CT Tap Solid State Switch (mounted in the Voltage Interface Assembly) connector J2-7 and 8.

- Connect phase C current transformer output wires to the CT Tap Solid State Switch (mounted in the Voltage Interface Assembly) connector J2-2 and 3.

◊ Connect ground fault current transformer test input wires (#20 AWG White) to the Electronic Control Unit connector P2-8 and P2-9 positions.

◊ Use a wire of size #16 AWG thru #20 AWG to connect the CT Tap Solid State Switch connector J2 to the Electronic Control Unit connectors P1 and P2 as follows:

From CT Tap Solid State Switch to Electronic Control Unit

J2-13————————————————————-P1-5
J2-9————————————————————--P1-6
J2-4————————————————————--P1-7
J2-5—————————————————————-P1-8
J2-10————————————————————-P1-9
J2-6————————————————————--P1-10
J2-1—————————————————————-P2-3

◊ Use wires of size #16 AWG thru #20 AWG to connect the Voltage Interface Module connector J1 to the Electronic Control Unit connectors P1 and P4 as follows:

From Voltage Interface Module to Electronic Control Unit

J1-5—————————————————————-P1-1
J1-4————————————————————--P1-2
J1-3————————————————————--P1-3
J1-10————————————————————-P4-1
J1-11————————————————————-P4-2
J1-9————————————————————--P4-3
J1-8-—————————————————————P4-4
J1-7——————————————————-——-P4-5
J1-6————————————————————--P4-6
J1-1————————————————————--P4-7

From Voltage Interface Module to Solid State Switch

J1-2—————————————————————-J2-5

◊ Use a #16 AWG Black wire to connect 115 VAC Line to the Electronic Control Unit connector position P2-5.

◊ Use a #16 AWG White wire to connect 115 VAC Return to the Electronic Control Unit connector position P2-6.

◊ Use a #16 AWG Green wire to connect Frame Ground to the

◊ Use a #16 AWG White wire to connect the return side of the contactor control diode bridge to the Electronic Control Unit connector position P3-10.

◊ Use a #16 AWG White wire to connect 115 VAC Return to one side of the Ground Monitor Relay normally open contact.

◊ Use a #16 AWG White wire to connect 115 VAC Return to the Electronic Control Unit connector position P3-6.

◊ Use a #16 AWG White wire to connect the other side of the Ground Monitor Relay normally open contact to the Electronic Control Unit connector position P3-7.

◊ If a Remote Stop Switch is used to open the CB-PRO Circuit Breaker System, use #16 AWG White wire to connect the stop switch to the Electronic Control Unit connector posistions P3-7 and P3-8.

◊ If a Remote Stop Switch is not used, use a #16 AWG White wire to jumper the Electronic Control Unit connector positions P3-7 to P3-8.

◊ Use a #16 AWG White wire to jumper the Electronic Control Unit connector positions P3-1 to P3-9.

◊ Use a pair of #16 AWG White wires to connect a set of contactor normally open auxiliary contacts to the Electronic Control Unit connector positions P3-2 to P3-3.

◊ The CB-PRO may also be opened using a set of dry, normally open contacts connected to the Spare Contact inputs of the Electronic Control Unit connector positions P3-4 and P3-5.

◊ Use a #16 AWG Green wire to connect the contactor frame ground to the power center frame ground.

◊ To provide a Fault output to a PLC (0 to 5VDC) connect the PLC to the Electronic Control Unit connector position P4-9.

◊ To remotely Reset Faults and Remotely Close the CB-PRO from a PLC, the PLC must provide outputs of 0 to 5VDC. Connect the PLC RESET/CLOSE RETURN to the Electronic Control Unit connector position P5-10. Connect the PLC CLOSE output to the Electronic Control Unit connector position P5-9. Connect the PLC RESEToutput to the Electronic Control Unit connector position P5-8.

◊ If used, connect the 2-wire RS-485 communications (+) wire to the Electronic Control Unit connector position P5 -1. Connect 2-wire RS-485 communications (-) wire to the Electronic Control Unit connector position P5-2.

7. Troubleshooting

7.1. CB-PRO LCD Fault Menu Display Message

Use the CB-PRO LCD display Fault Menu Message as an indication of the reason the CB-PRO Electronic Control Unit caused the contactor to open. Note: ECU means Electronic Control Unit.

FAULT MENU MESSAGE	**DESCRIPTION OF MESSAGE**
A BOTTLE STUCK	Phase A contactor bottle is stuck.
A FUSE OPEN	Phase A fuse is open.
AUX CONTACT OPEN	The contactor has failed to close or stay closed.
B BOTTLE STUCK	Phase B contactor bottle is stuck.
B FUSE OPEN	Phase B Fuse is open.
BREAKER FAULT RESET	The fault has been reset.
C BOTTLE STUCK	Phase C contactor bottle is stuck.
C FUSE OPEN	Phase C fuse is open
CURRENT IMBAL	A phase current imbalance exceeded the setting.
GROUND FAULT	Phase to ground current leakage exceeded setting.
GROUND MONITOR	Cable ground monitor opened the contactor.
KEY SWITCH	The CB-PRO front panel “KEY” switch is OFF.
MAGETIC CURRENT	An instantaneous fault current exceeded setting.
MAG CUR/CABLE SHORT	Fault current caused by cable short.
MC-4000 MSTR OPEN	Contactor opened by MC-4000 Monitor System.
NO BREAKER FAULT	The fault has been reset.
OPEN SWITCH	The CB-PRO front panel “STOP” switch is pushed.
REMOTE OPEN	The “REMOTE OPEN” switch opened the contactor.
SPARE CTRL OPEN	The user defined “SPARE” opened the contactor.
STUCK CLOSE SWITCH	The CB-PRO front panel “CLOSE” switch has failed.
THERMAL CURRENT	Continuous current exceeded level/time limits.

7.2. More Troubleshooting

Use the CB-PRO LCD display Fault Menu as an indication of the reason the CB-PRO Electronic Control Unit caused the contactor to open. Use the table below as a aid in determining the cause of other problems. Note: ECU means Electronic Control Unit.

SYMPTOM	POSSIBLE CAUSE
ECU LCD and LEDs are OFF.	1) Lost 115 VAC control power. 2) Loose ECU Front Panel Cover. 3) Blown ECU control power fuse. 4) Bad ECU.
Contactor closes but opens with AUX CONTACT fault.	1) Blown contactor control power fuse. 2) Bad Elect. Control Unit. 3) Bad contactor coil. 4) Bad or misadjusted contactor auxiliary contact.
Contactor opens and ECU displays LOW CONTROL VOLTAGE fault.	1) Low three phase or control voltage. 2) Bad Voltage Interface Monitor. 3) Bad ECU.
Contactor opens and ECU displays LOW LINE VOLTAGE fault.	1) Low three phase or lost one phase. 2) Bad Voltage Interface Monitor. 3) Bad ECU.
Contactor opens and ECU displays CURRENT IMBAL fault.	1) Lost one of the input voltages. 2) One of the power circuit fuses opened. 3) Loose power circuit connection. 4) Low phase voltage. 5) Loose CT or CT Tap Solid State Switch connection. 6) Bad Solid State Switch. 7) Bad ECU.
Contactor opens and ECU displays MAG CUR/CABLE SHORT fault.	1) Power circuit cable short. 2) Magnetic Trip Setting to low.
Contactor opens and ECU displays THERMAL(TIME = XXX) fault.	1) Increase the Thermal Overload Time. **NOTE: CHANGING THE THERMAL TIME CAUSES THE MAGNETIC TRIP VALUE TO DEFAULT TO 2X THE THERMAL VALUE. RESET THE MAGNETIC TRIP VALUE.**
Contactor opens and ECU displays GROUND FAULT fault.	1) Power cable phase conductor to ground conductor leakage.

8. Spare Parts

Amr Part Number	Description
140-0173	Electronic Control Unit
140-0174-300	CB-PRO 300 Voltage Interface Assembly
140-0174-450	CB-PRO 450 Voltage Interface Assembly
140-0174-550	CB-PRO 550 Voltage Interface Assembly
253-0319	Back Panel PCB Assembly
253-0323	Front Panel PCB Assembly
253-0325	Communications PCB Assembly
253-0339-300	CB-PRO 300 Solid Stage Switch PCB
253-0339-450	CB-PRO 450 Solid Stage Switch PCB
253-0339-550	CB-PRO 550 Solid Stage Switch PCB
130-0079	Phase Current Transformer
130-0092	Ground Fault Current Transformer (300 Amp Applications)
130-0094	Ground Fault Current Transformer (450 & 550 Amp Applications)
160-0029	Bussman 600 Amp Fuse
160-0022	Bussman 700 Amp Fuse
271-0081	Front Panel Assembly
195-0196	Ribbon Cable Assembly

FIGURE 3,

CB-PRO 300 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 100 AMPERES

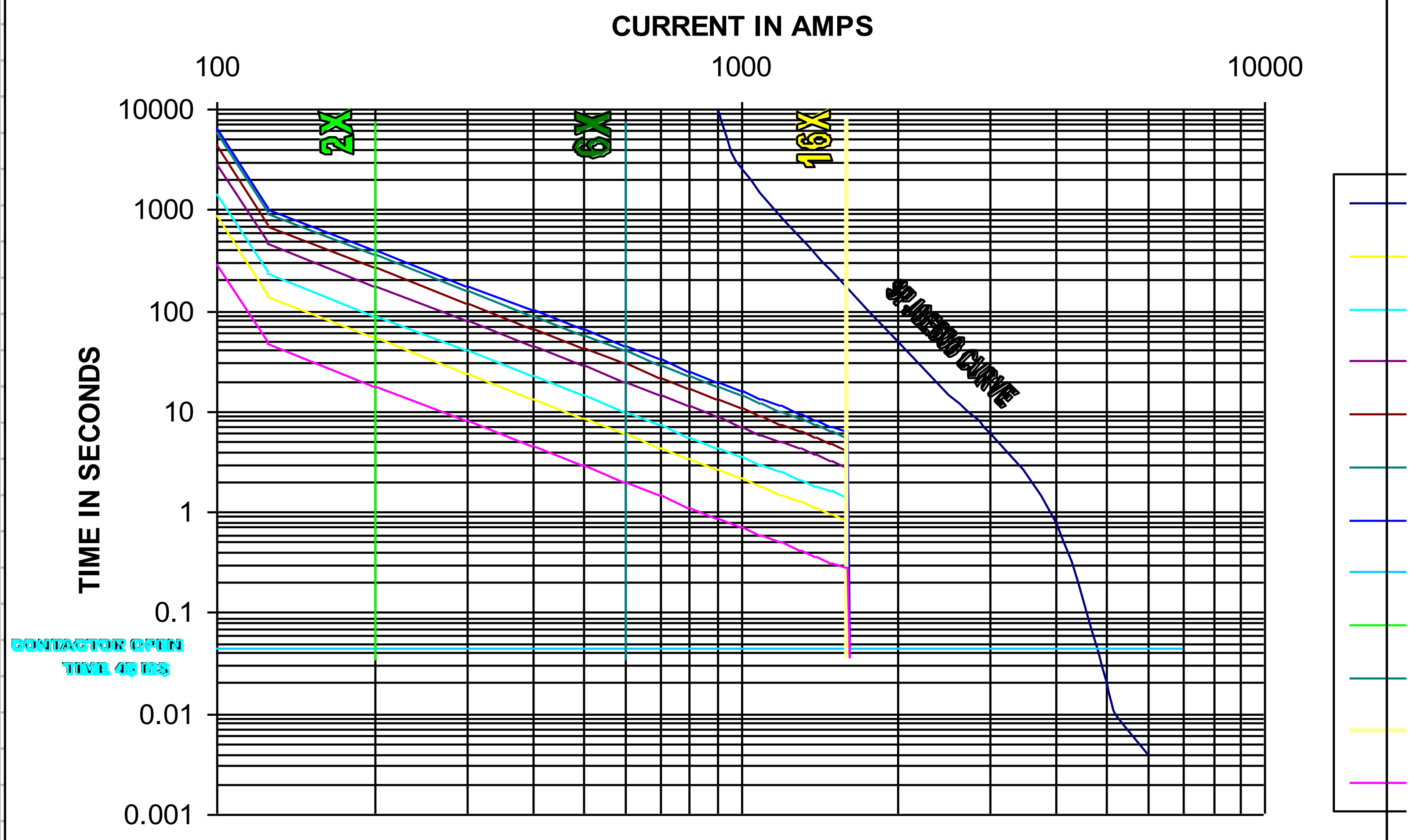


FIGURE 4,

CB-PRO 300 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 150 AMPERES

CURRENT IN AMPS

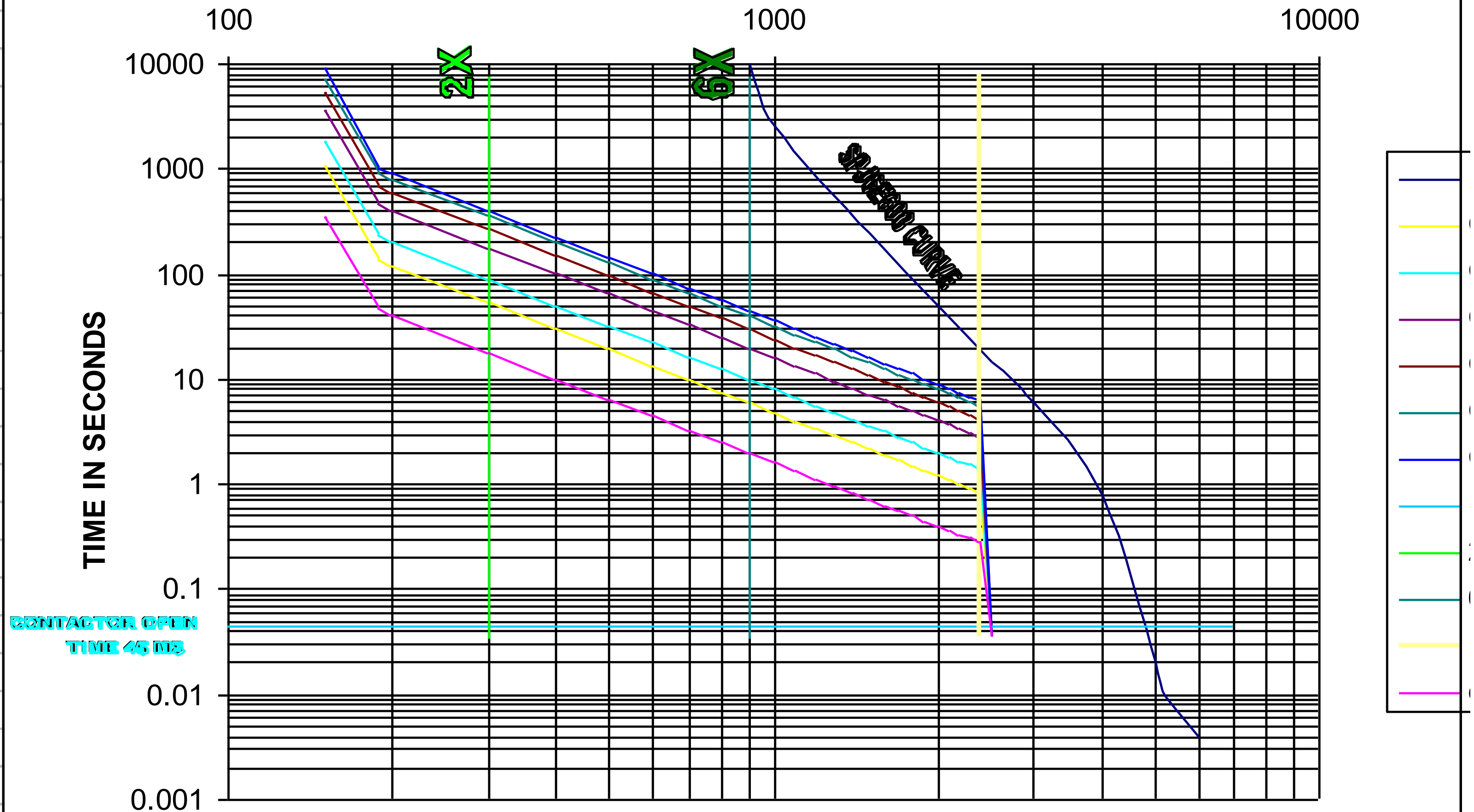


FIGURE 5,

CB-PRO 300 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 200 AMPERES

CURRENT IN AMPS

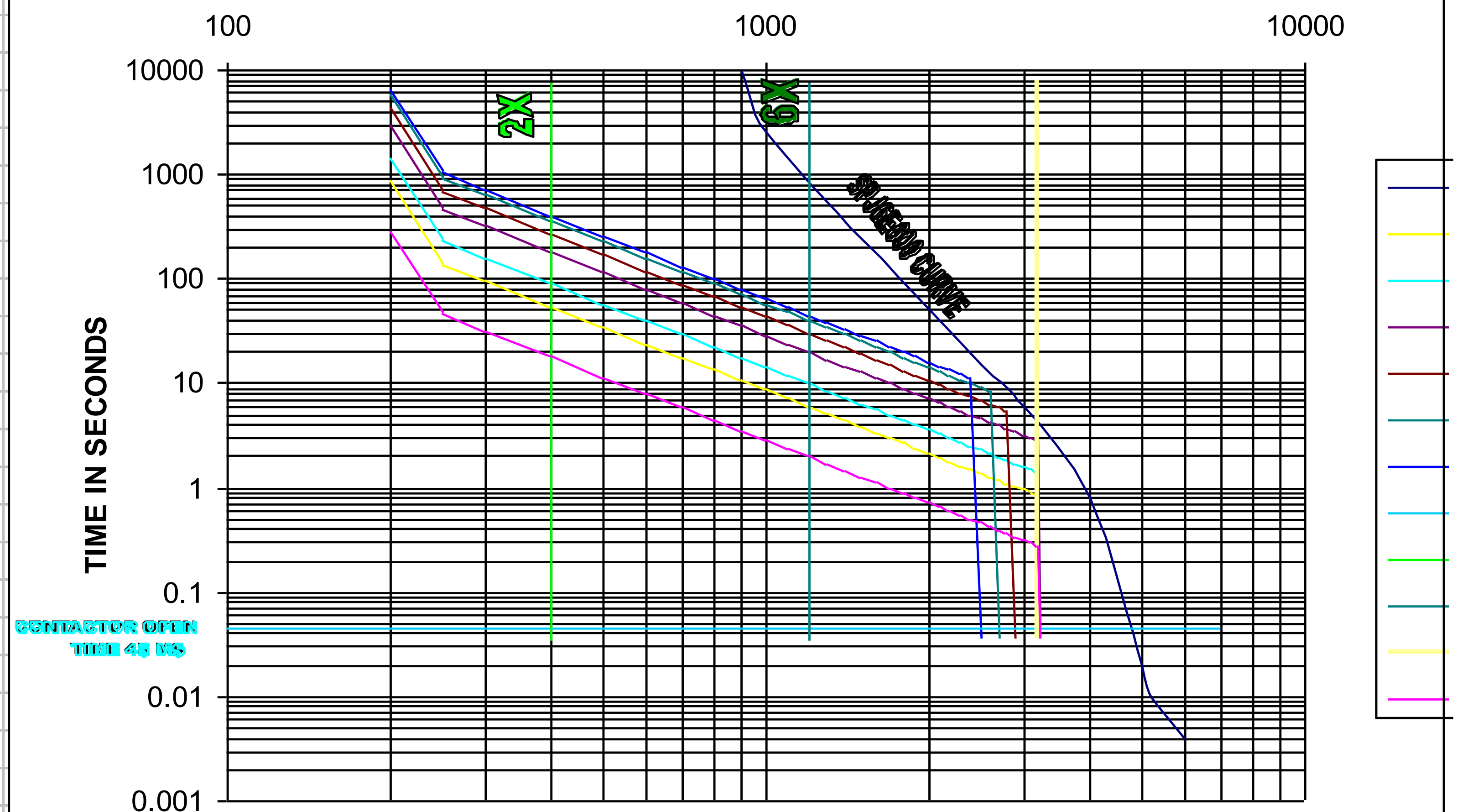


FIGURE 6,

CB-PRO 300 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 250 AMPERES

CURRENT IN AMPS

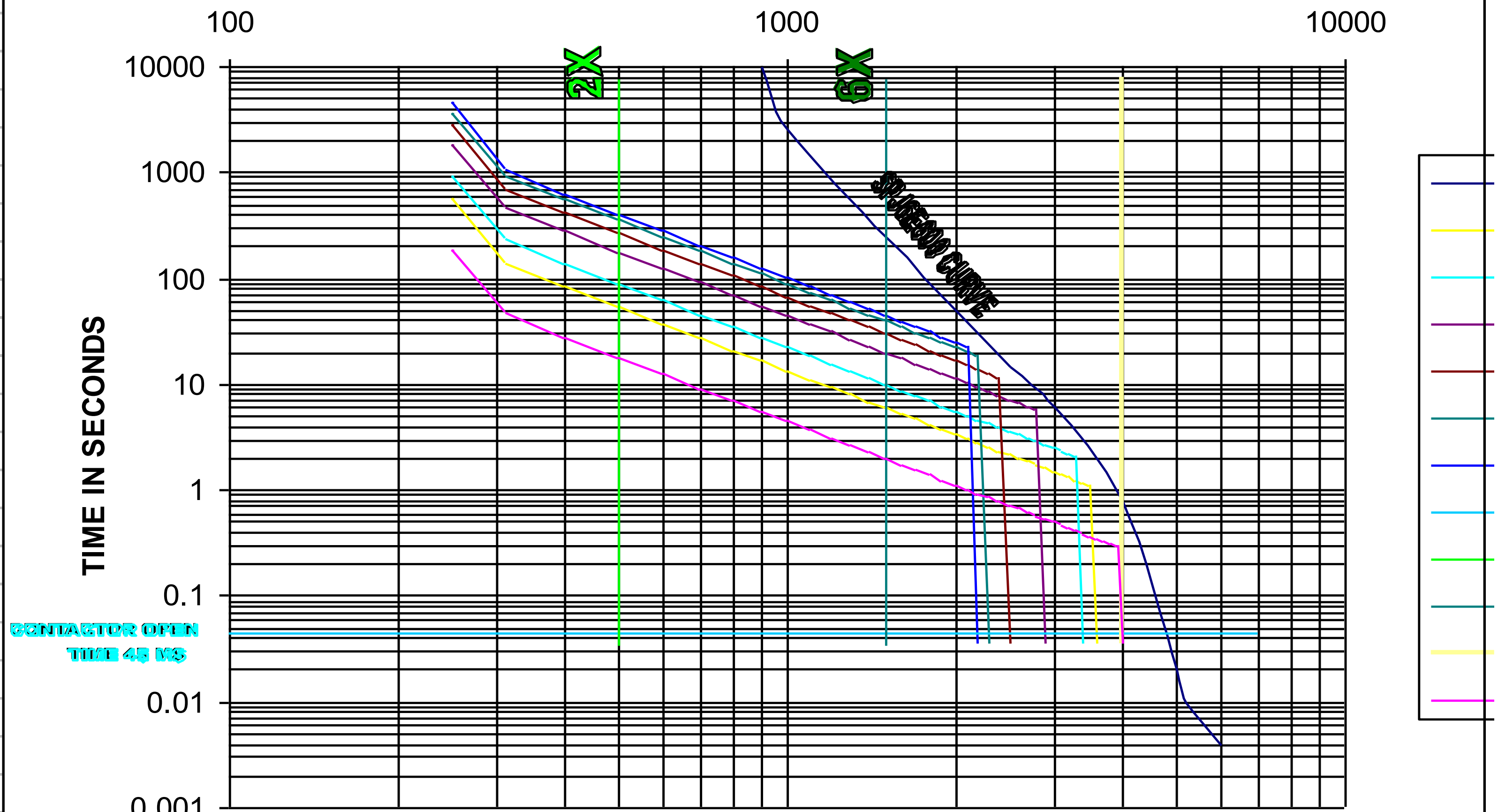


FIGURE 7,

CB-PRO 300 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 300 AMPERES

CURRENT IN AMPS

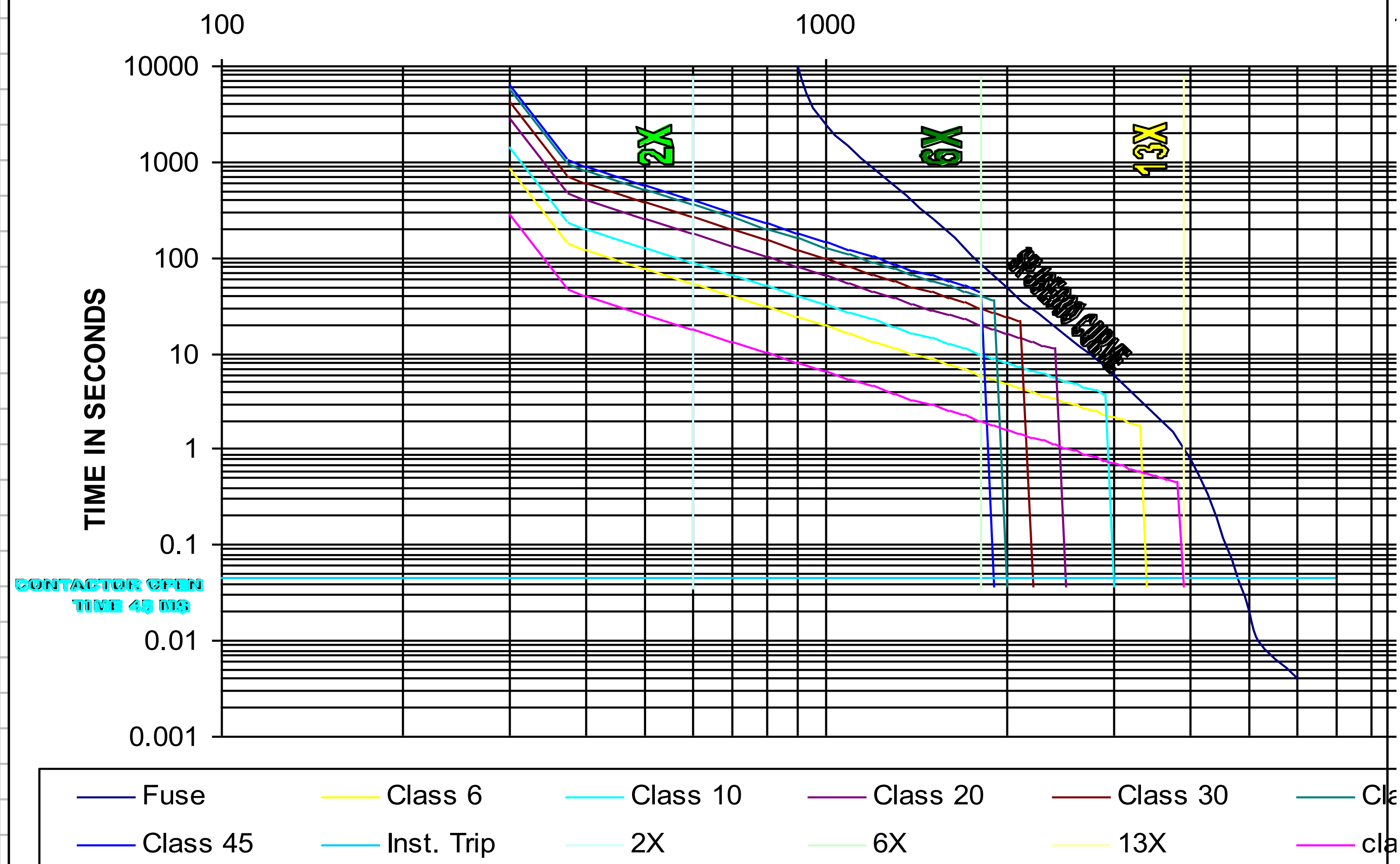
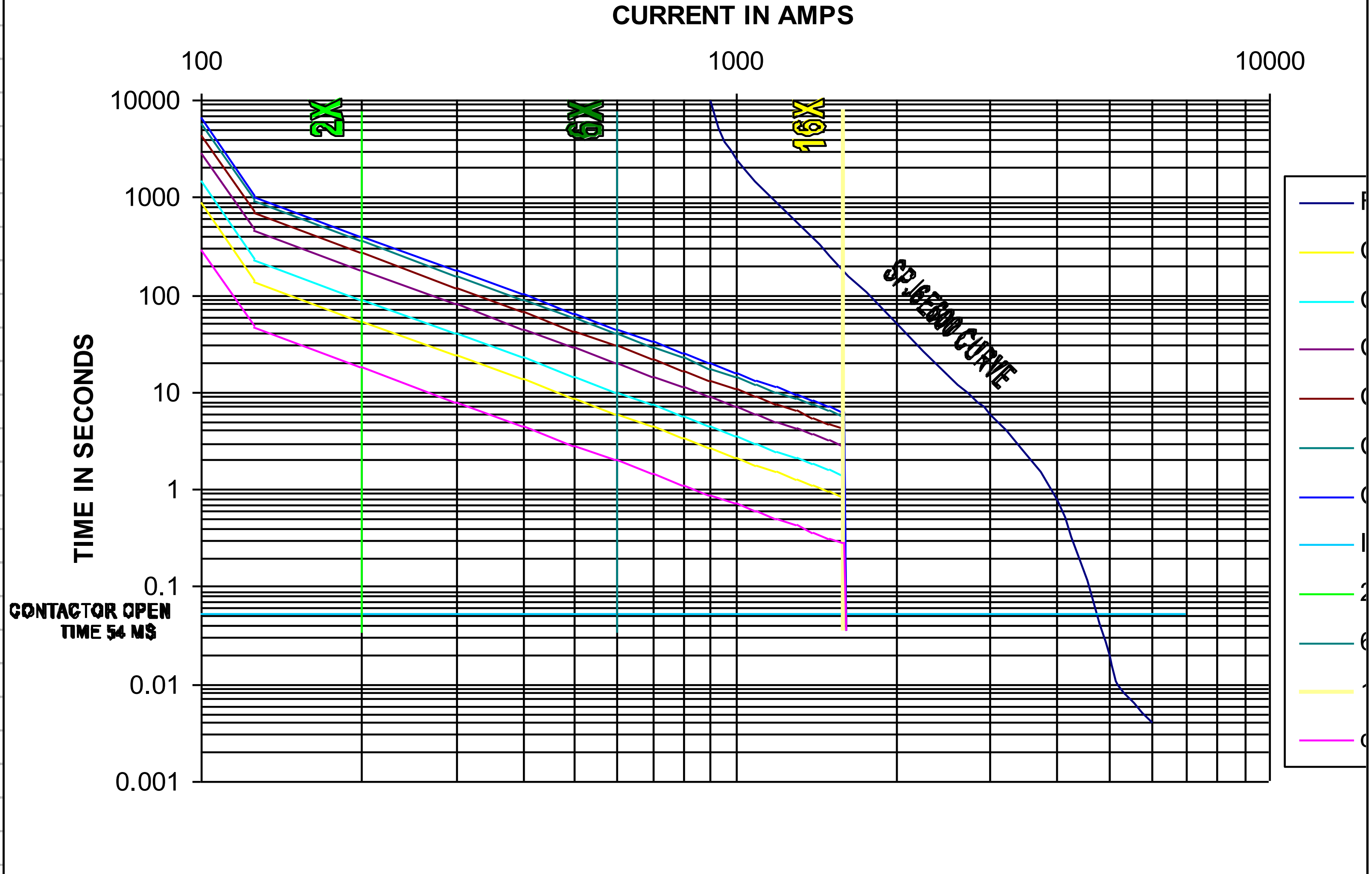


FIGURE 8,

CB-PRO 450 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 100 AMPERES



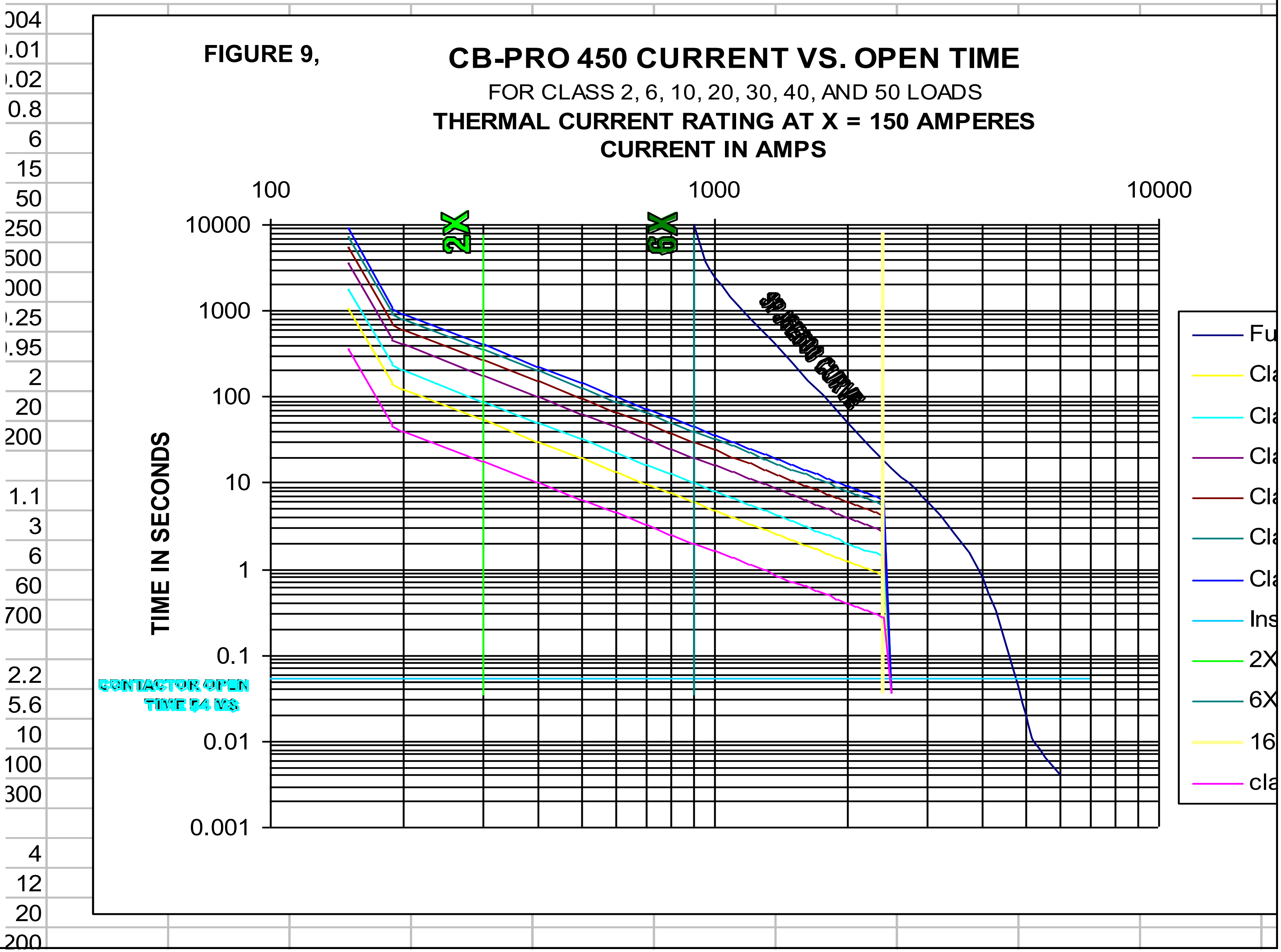


FIGURE 9,
CB-PRO 450 CURRENT VS. OPEN TIME
FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS
THERMAL CURRENT RATING AT X = 150 AMPERES
CURRENT IN AMPS
100
1000
10000
TIME IN SECONDS
10000
1000
100
10
1
0.1
0.01
0.001
2X
6X
CONTACTOR OPEN
TIME 54 MS
Fu
Cla
Cla
Cla
Cla
Cla
Cla
Ins
2X
6X
16
cla

FIGURE 10,

CB-PRO 450 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 200 AMPERES

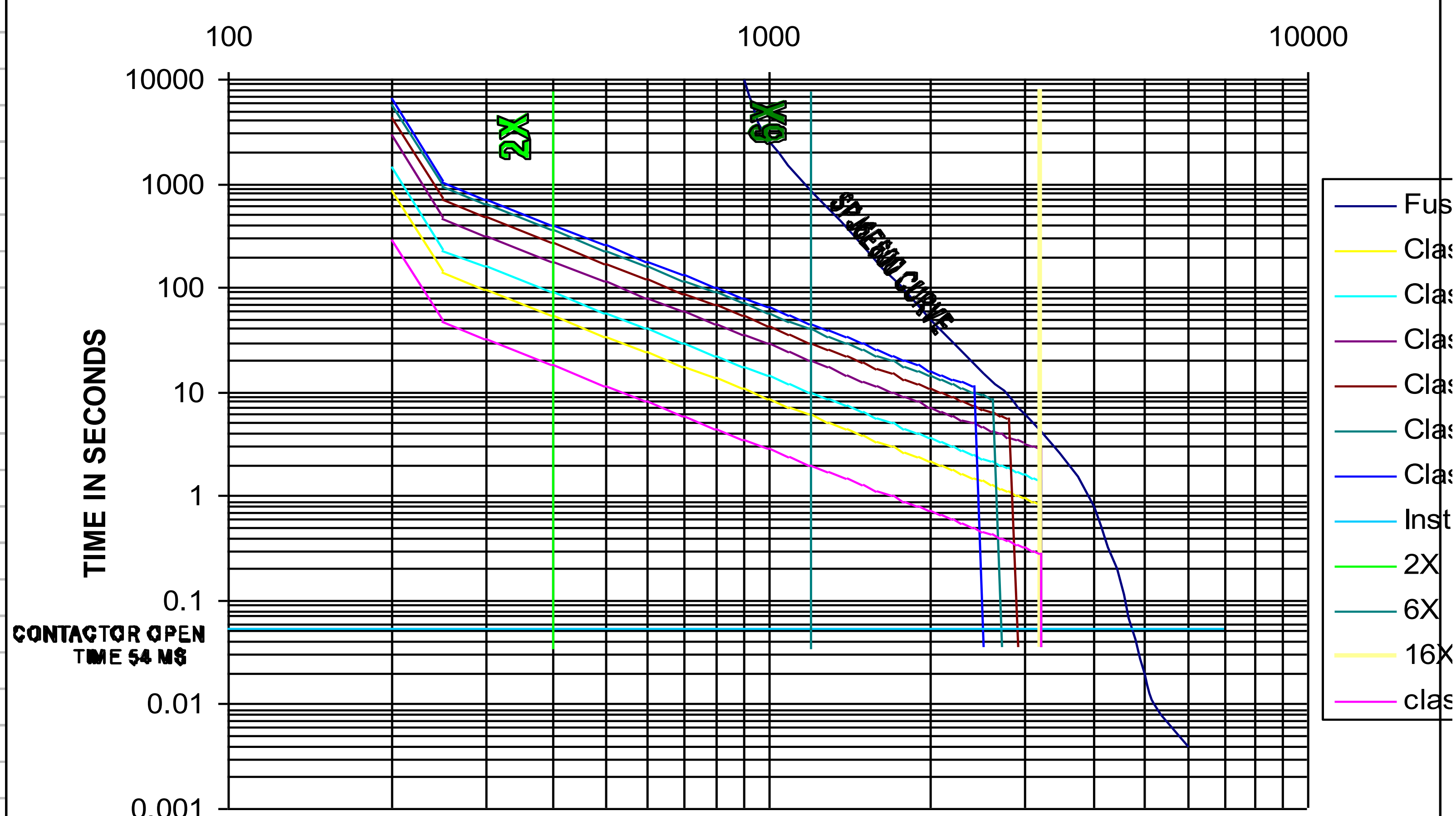


FIGURE 11,

CB-PRO 450 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 250 AMPERES

CURRENT IN AMPS

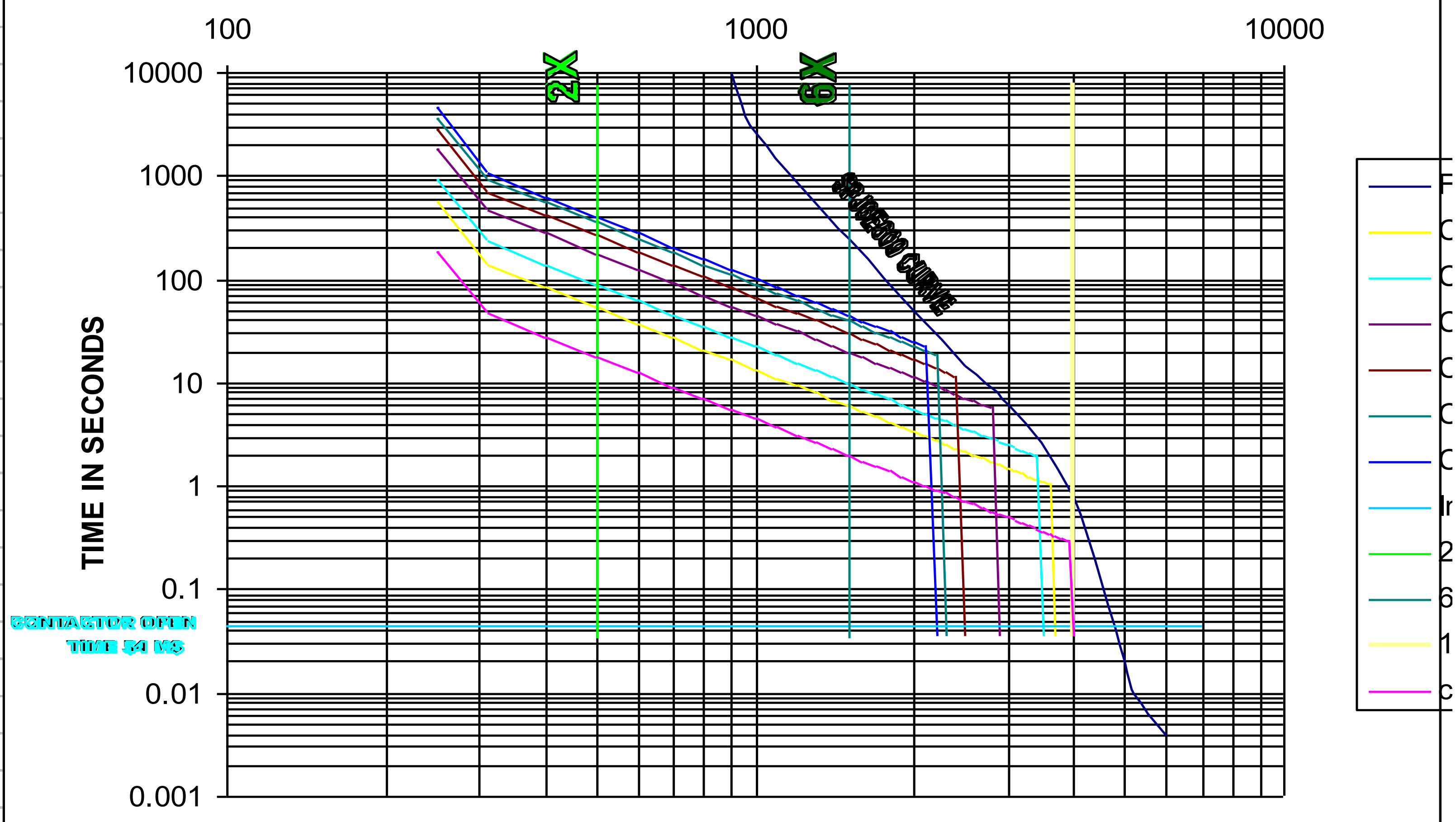


FIGURE 12,

CB-PRO 450 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 300 AMPERES

CURRENT IN AMPS

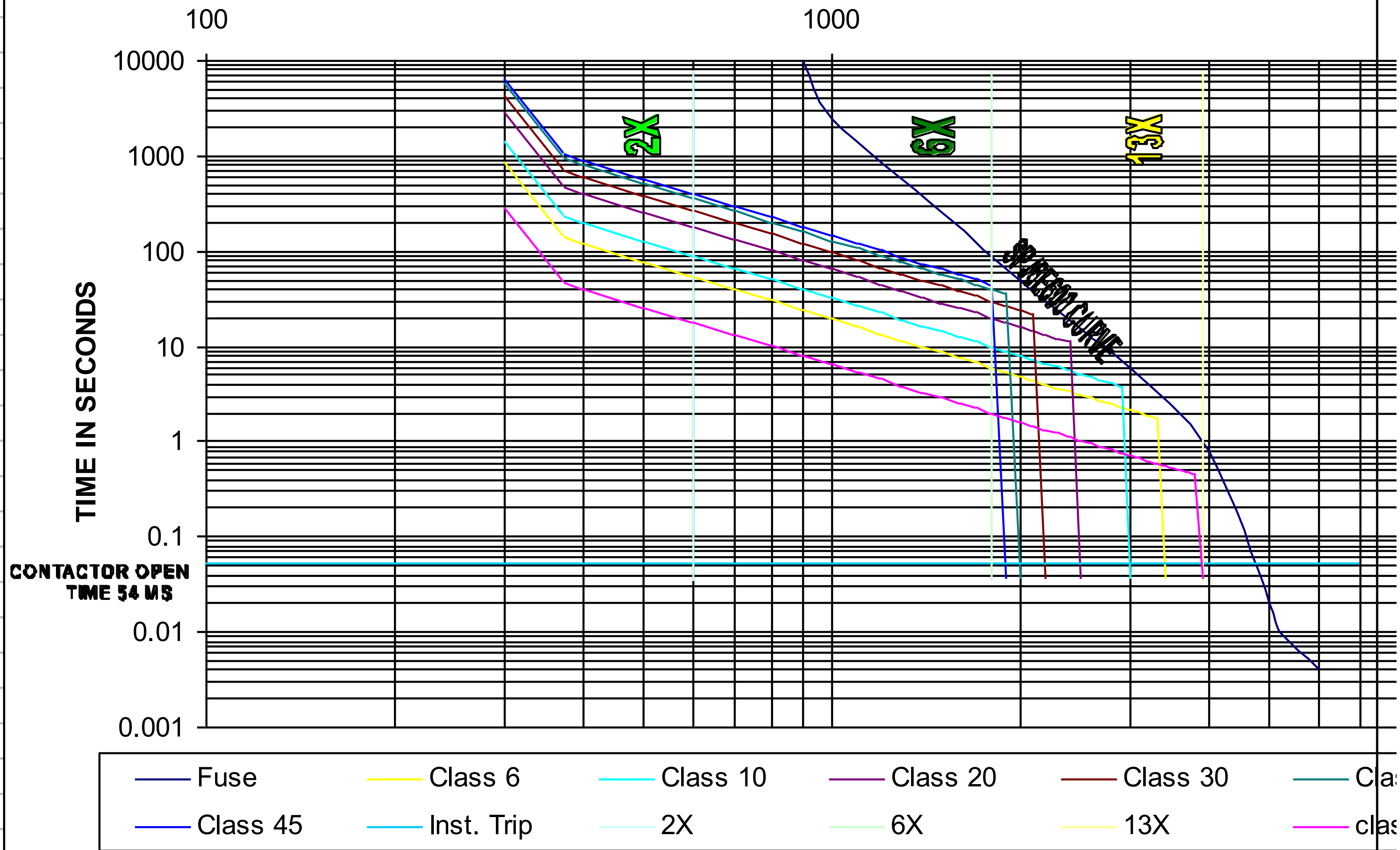


FIGURE 13,

CB-PRO 450 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 350 AMPERES

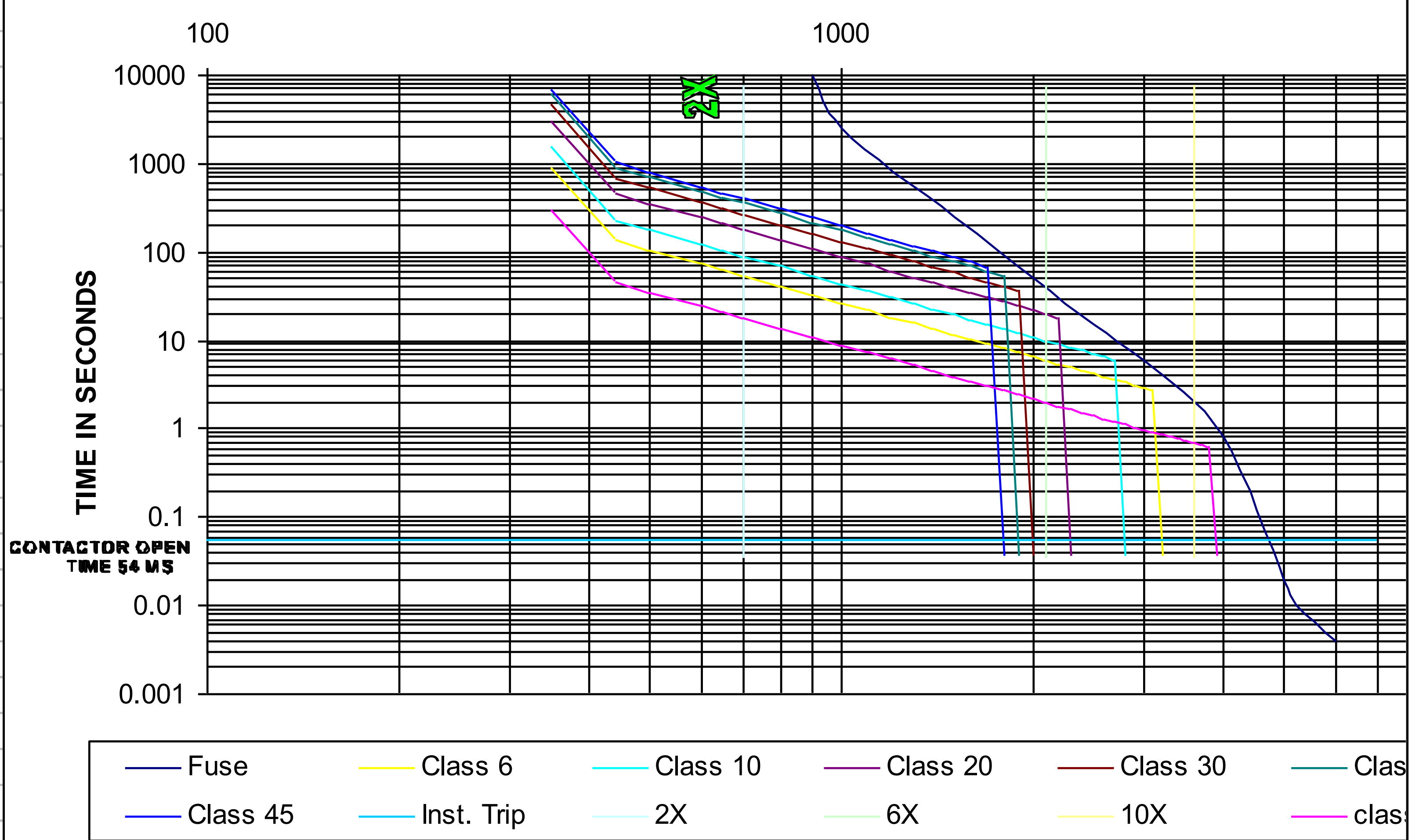


FIGURE 14,

CB-PRO 450 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 400 AMPERES

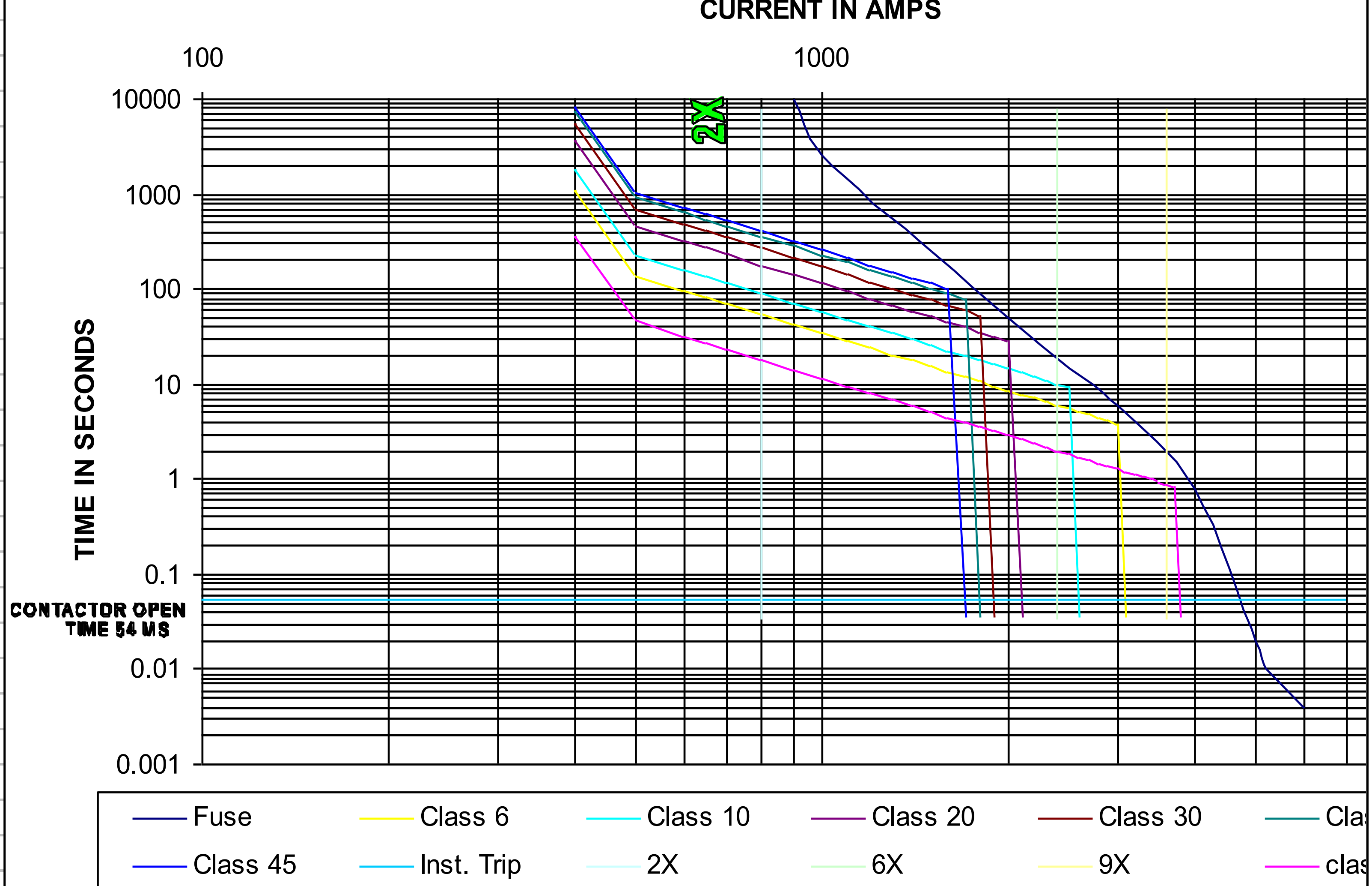


FIGURE 15,

CB-PRO 450 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 450 AMPERES

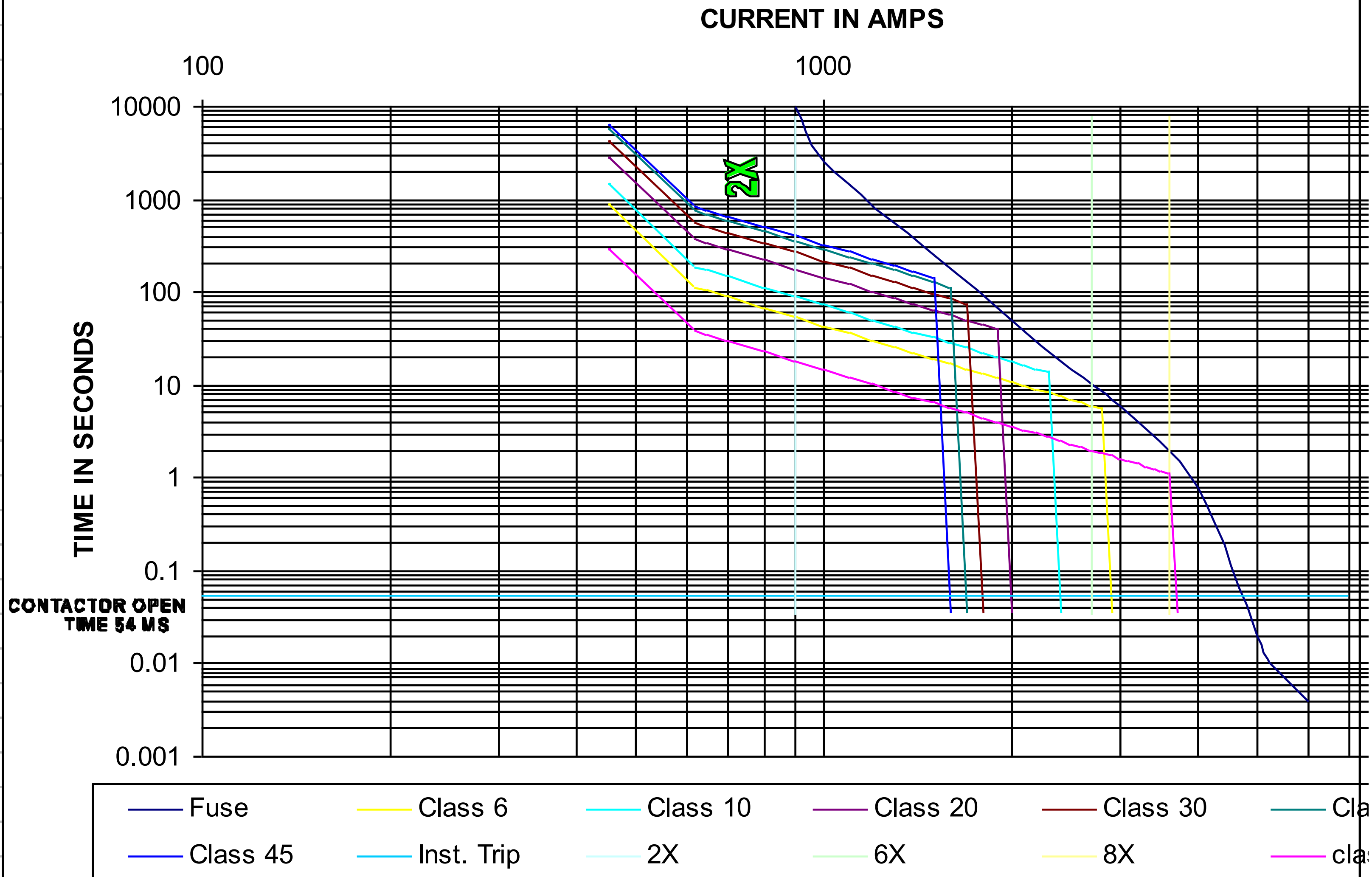
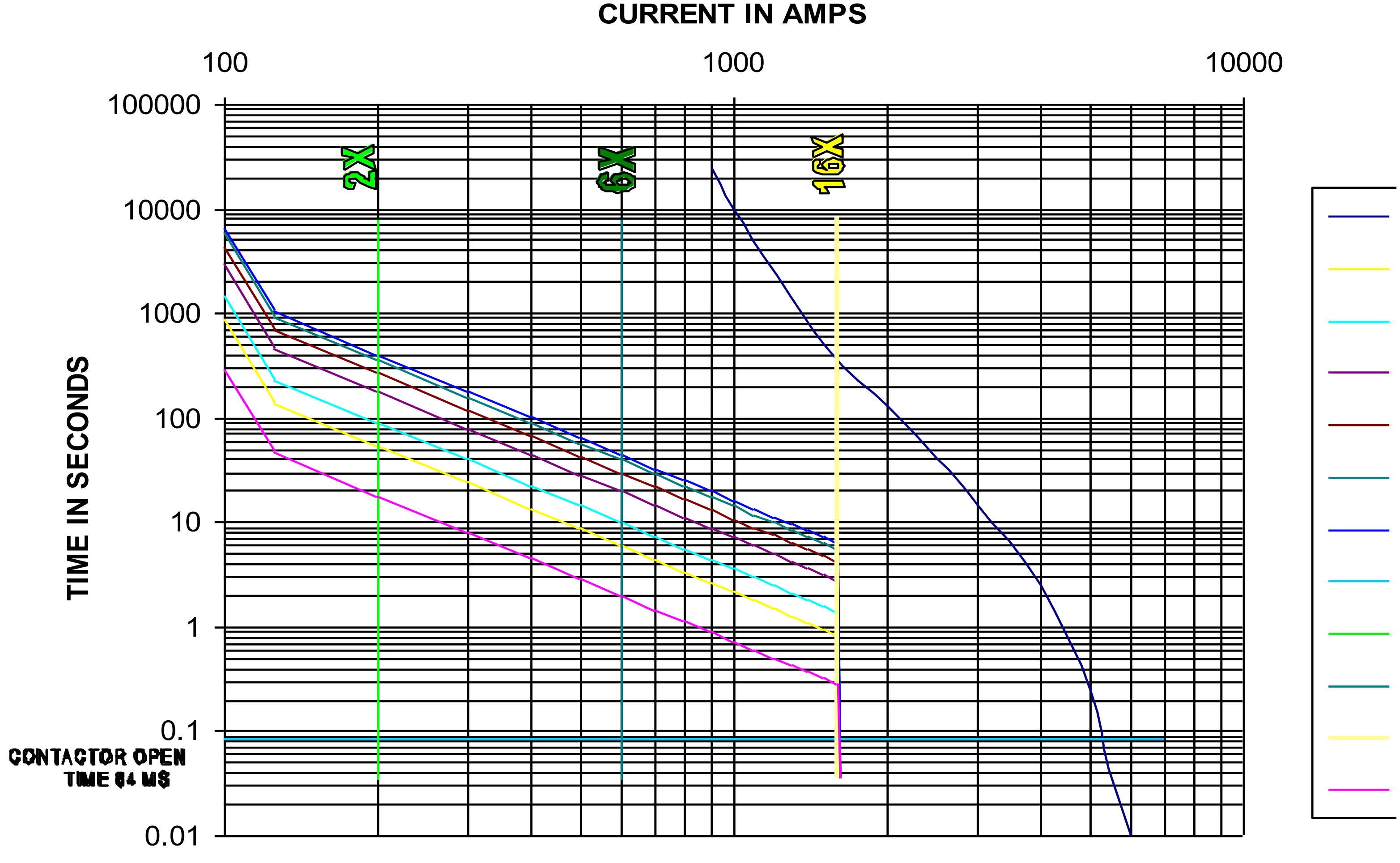


FIGURE 16,

CB-PRO 550 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 100 AMPERES



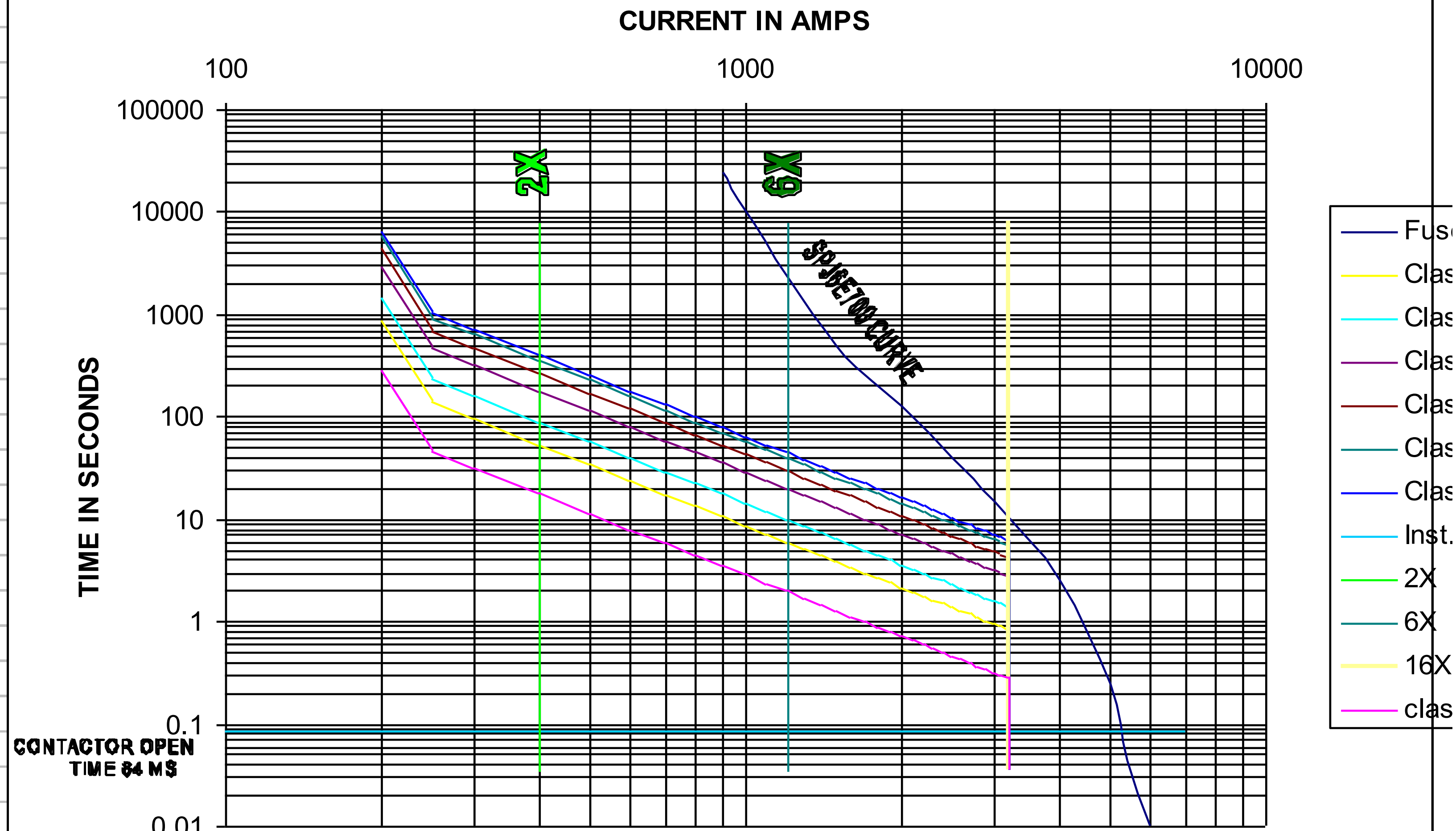
0.01
.045
0.25
2.5
15
40
130
500
000
000
0.25
0.95
2
20
200
1.1
3
6
60
700
2.2
5.6
10
100
300
4
12
20
200

FIGURE 17,

CB-PRO 550 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 200 AMPERES



0.01
.045
0.25
2.5
15
40
130
500
000
5000
0.25
0.95
2
20
200
1.1
3
6
60
700
2.2
5.6
10
100
1300
4
12
20
200

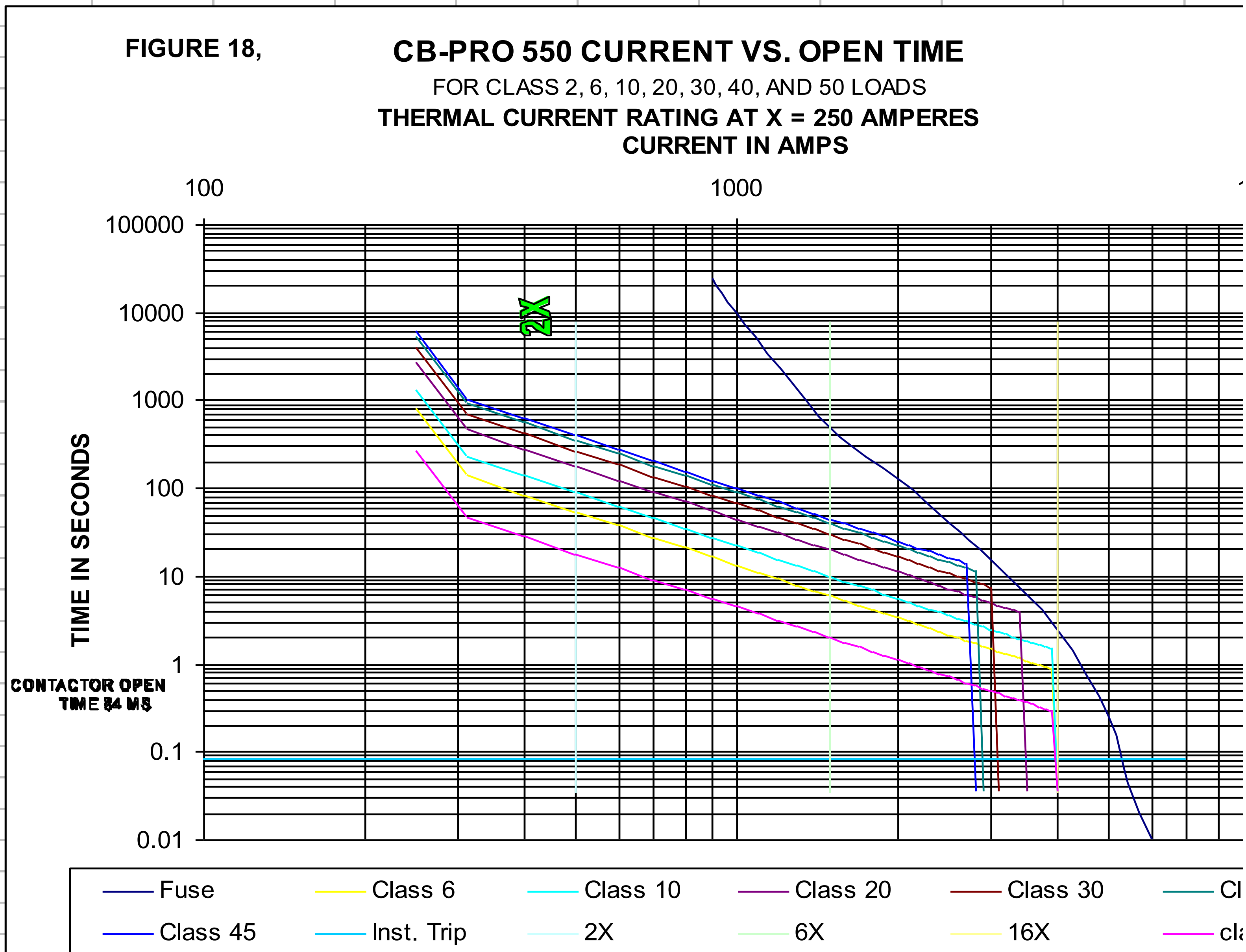


FIGURE 18,
CB-PRO 550 CURRENT VS. OPEN TIME
FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS
THERMAL CURRENT RATING AT X = 250 AMPERES
CURRENT IN AMPS
100
1000
TIME IN SECONDS
100000
10000
1000
100
10
1
0.1
0.01
2X
CONTACTOR OPEN
TIME 84 MS
Fuse
Class 6
Class 10
Class 20
Class 30
Class 45
Inst. Trip
2X
6X
16X

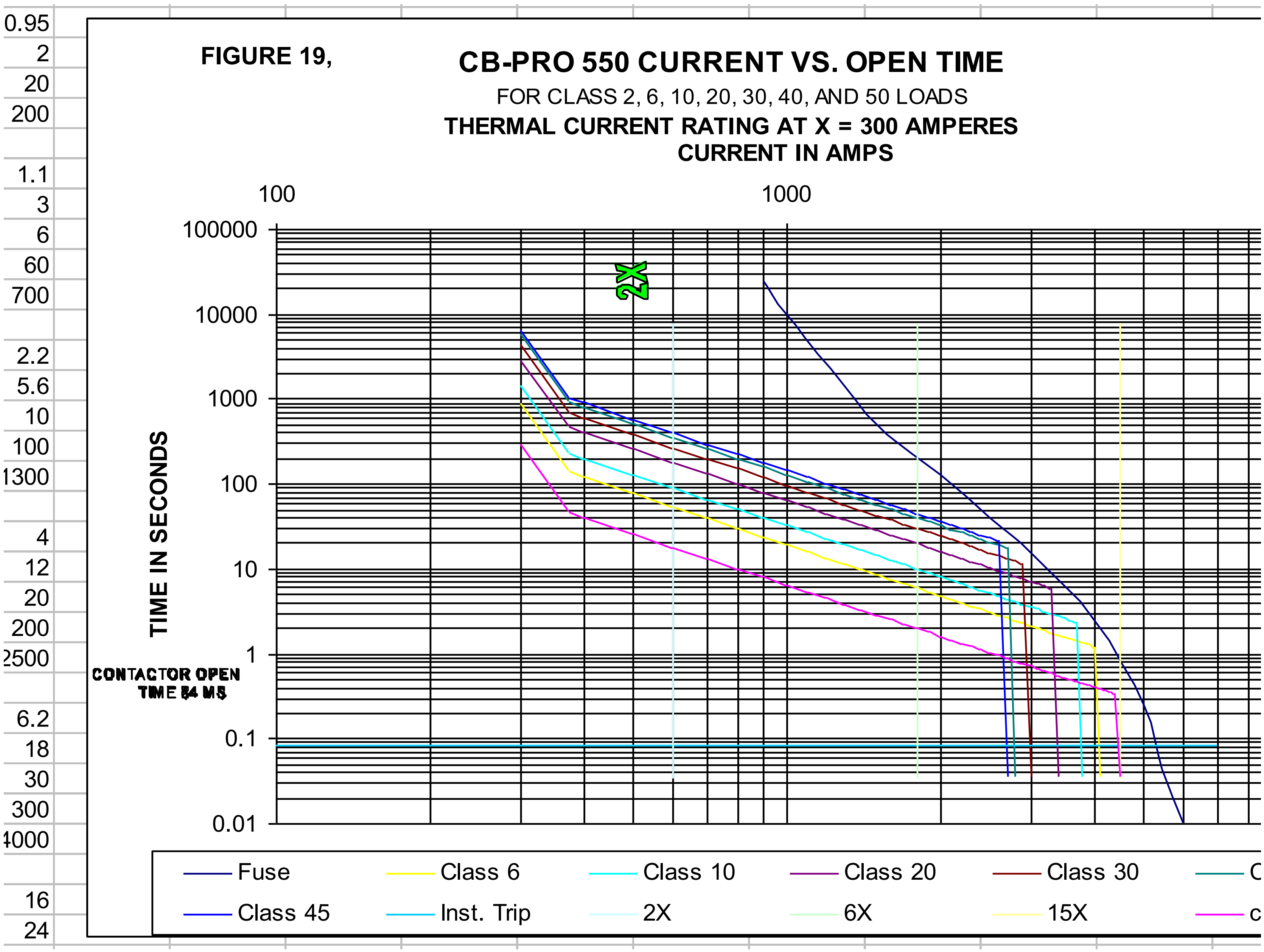


FIGURE 19,
CB-PRO 550 CURRENT VS. OPEN TIME
FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS
THERMAL CURRENT RATING AT X = 300 AMPERES
CURRENT IN AMPS
100
1000
TIME IN SECONDS
100000
10000
1000
100
10
1
0.1
0.01
CONTACTOR OPEN TIME 54 MS
2X
Fuse
Class 6
Class 10
Class 20
Class 30
Class 45
Inst. Trip
2X
6X
15X
0.95
2
20
200
1.1
3
6
60
700
2.2
5.6
10
100
1300
4
12
20
200
2500
6.2
18
30
300
4000
16
24

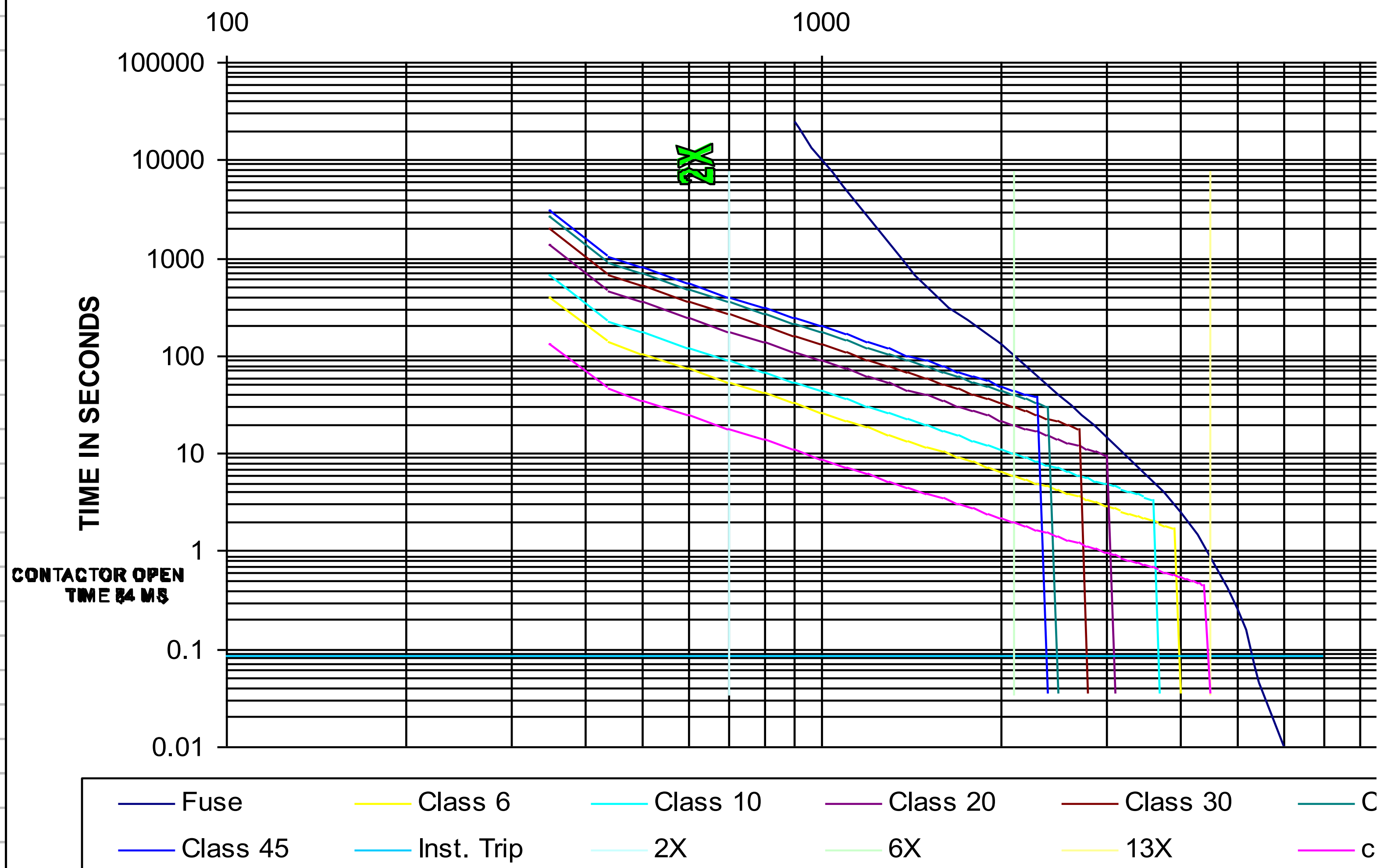
FIGURE 20,

CB-PRO 550 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 350 AMPERES

CURRENT IN AMPS



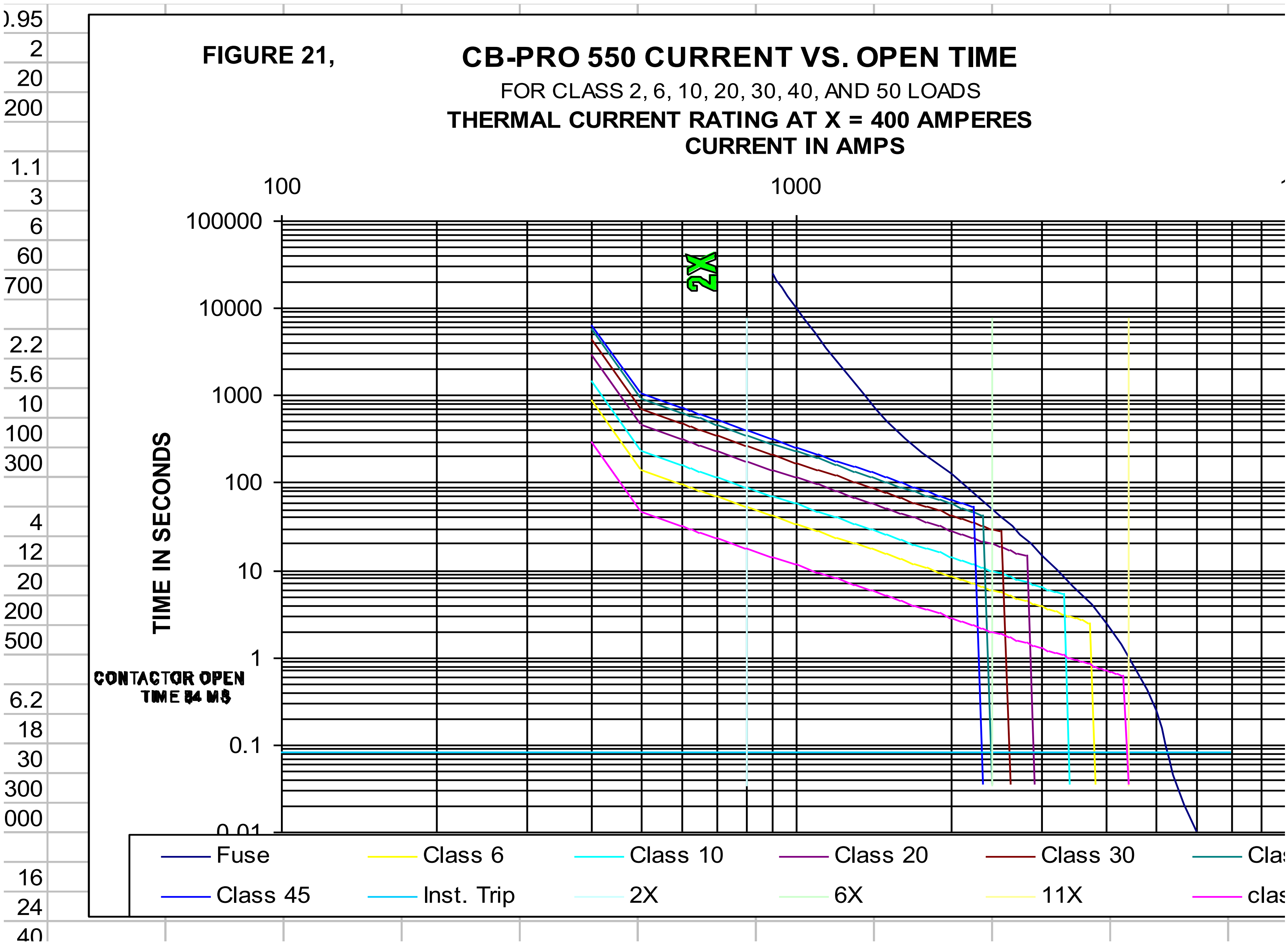


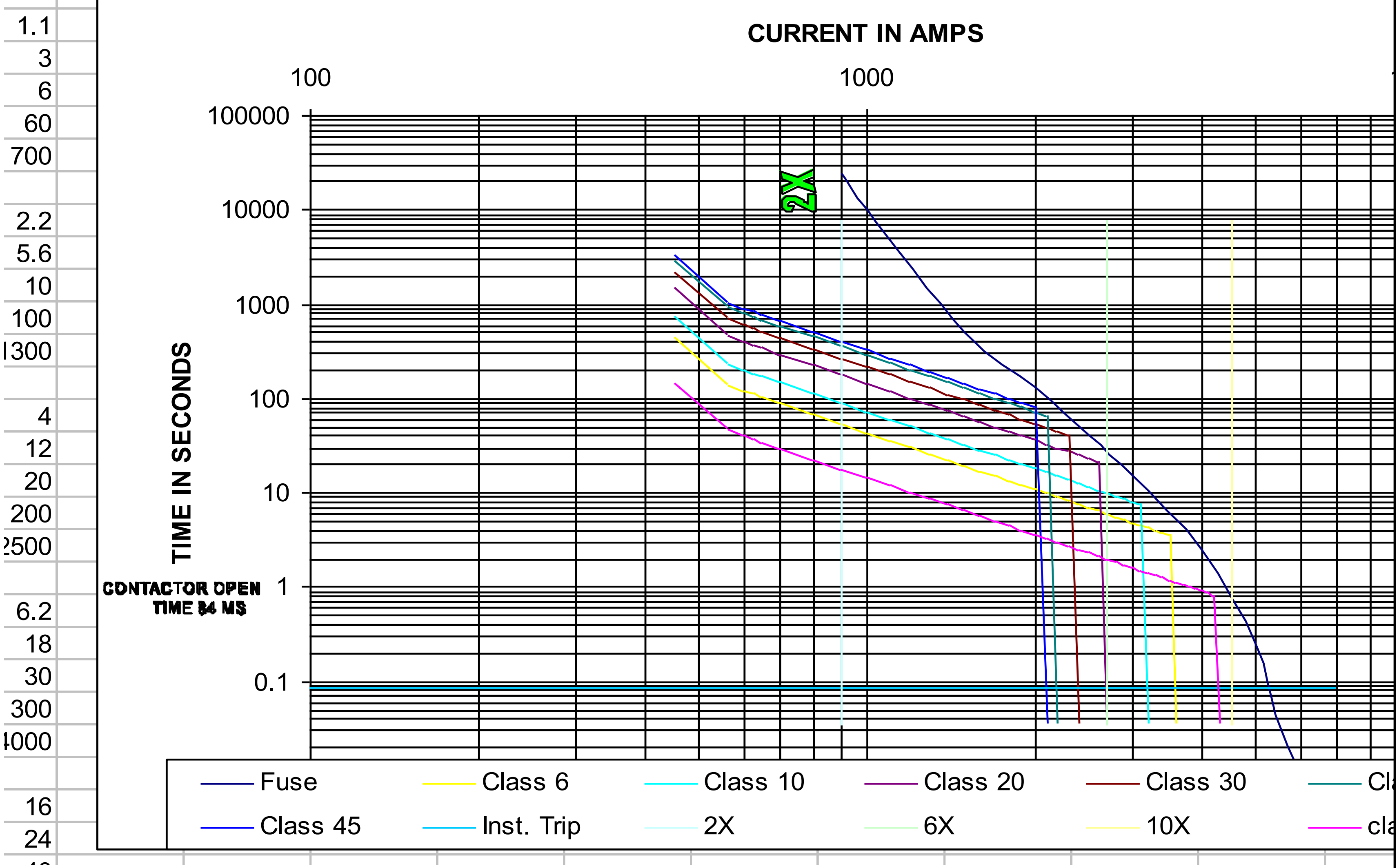
FIGURE 21,
CB-PRO 550 CURRENT VS. OPEN TIME
FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS
THERMAL CURRENT RATING AT X = 400 AMPERES
CURRENT IN AMPS
100
1000
TIME IN SECONDS
100000
10000
1000
100
10
1
0.1
0.01
2X
CONTACTOR OPEN
TIME 54 MS
Fuse
Class 6
Class 10
Class 20
Class 30
Class 45
Inst. Trip
2X
6X
11X

FIGURE 22,

CB-PRO 550 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 450 AMPERES



0.95
2
20
200
1.1
3
6
60
700
2.2
5.6
10
100
1300
4
12
20
200
2500
6.2
18
30
300
4000
16
24

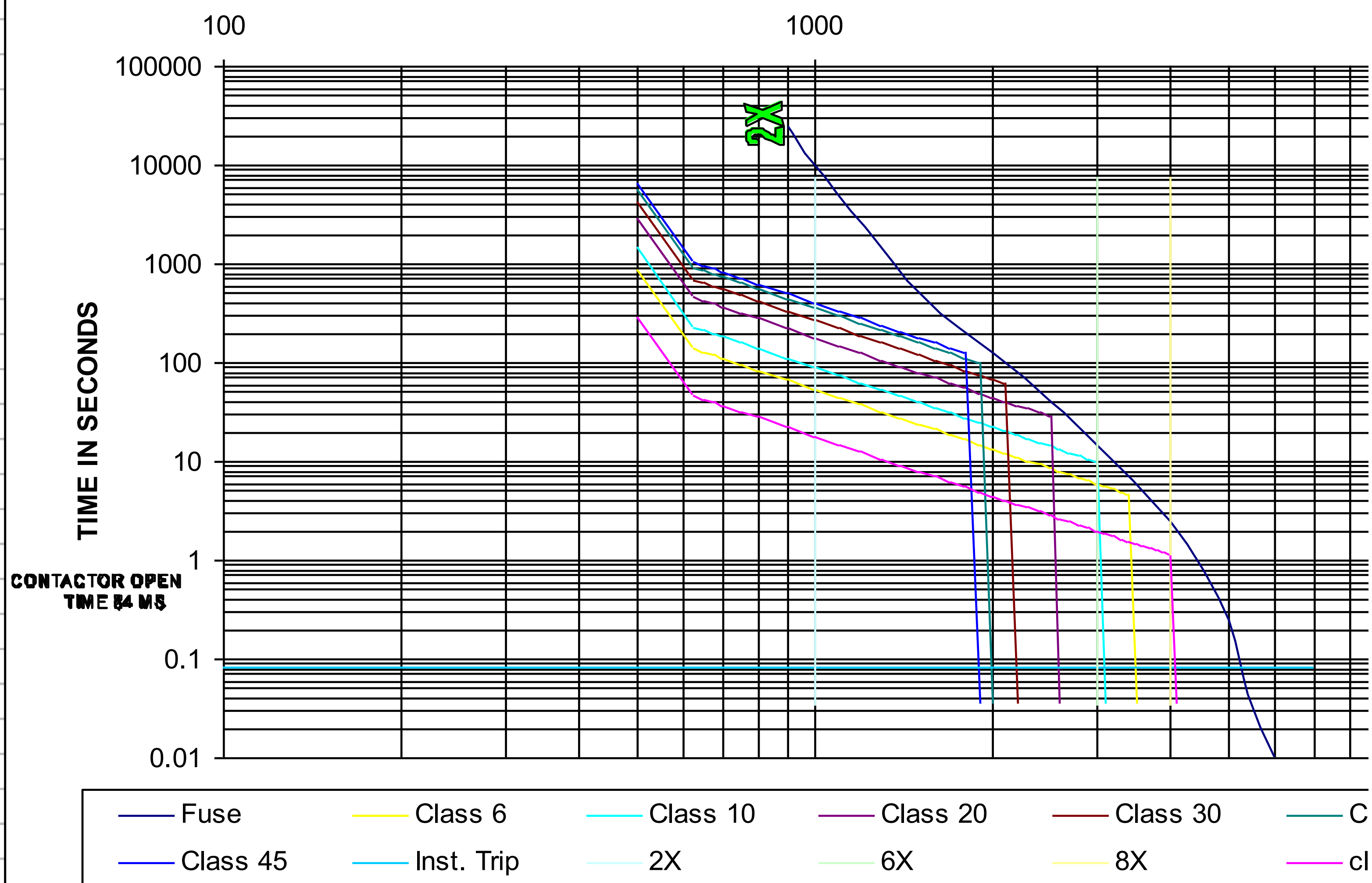
FIGURE 23,

CB-PRO 550 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 500 AMPERES

CURRENT IN AMPS



0.95
2
20
200
1.1
3
6
60
700
2.2
5.6
10
100
300
4
12
20
200
2500
6.2
18
30
300
1000
16
24

FIGURE 24,

CB-PRO 550 CURRENT VS. OPEN TIME

FOR CLASS 2, 6, 10, 20, 30, 40, AND 50 LOADS

THERMAL CURRENT RATING AT X = 550 AMPERES