# Recommended Procedures

The following steps are recommended when conducting a selective coordination study.

**1. One-Line Diagram**

Obtain the electrical system one-line diagram that identifies important system components, as given below.

**a. Transformers**

Obtain the following data for protection and coordination information of transformers:

- KVA rating
- Inrush points
- Primary and secondary connections
- Impedance
- Damage curves
- Primary and secondary voltages
- Liquid or dry type

**b. Conductors -** Check phase, neutral, and equipment grounding. The one-line diagram should include information such as:

- Conductor size
- Number of conductors per phase
- Material (copper or aluminum)
- Insulation
- Conduit (magnetic or non-magnetic)

From this information, short circuit withstand curves can be developed. This provides information on how overcurrent devices will protect conductors from overload **and** short circuit damage.

**c. Motors**

The system one-line diagram should include motor information such as:

- Full load currents
- Horsepower
- Voltage
- Type of starting characteristic (across the line, etc.)
- Type of overload relay (Class 10, 20, 30)

Overload protection of the motor and motor circuit can be determined from this data.

**d. Fuse Characteristics**

Fuse Types/Classes should be identified on the one-line diagram.

**e. Circuit Breaker Characteristics**

Circuit Breaker Types should be identified on the one-line diagram.

**f. Relay Characteristics**

Relay Types should be identified on the one-line diagram.

**2. Short Circuit Study**

Perform a short circuit analysis, calculating maximum available short circuit currents at critical points in the distribution system (such as transformers, main switchgear, panelboards, motor control centers, load centers, and large motors and generators.) (Reference: Bussmann Bulletin, Engineering Dependable Protection - EDPI.)

**3. Helpful Hints**

**a. Determine the Ampere Scale Selection.** It is most convenient to place the time current curves in the center of the log-log paper. This is accomplished by multiplying or dividing the ampere scale by a factor of 10.

**b. Determine the Reference (Base) Voltage.** The best reference voltage is the voltage level at which most of the devices being studied fall. (On most low voltage industrial and commercial studies, the reference voltage will be 208, 240, or 480 volts). Devices at other voltage levels will be shifted by a multiplier based on the transformer turn ratio. The best reference voltage will require the least amount of manipulation. Modern computer programs will automatically make these adjustments when the voltage levels of devices are identified by the input data.

**c. Commencing the Analysis.** The starting point can be determined by the designer. Typically, studies begin with the main circuit devices and work down through the feeders and branches. (Right to left on your log-log paper.)

**d. Multiple Branches.** If many branches are taken off one feeder, and the branch loads are similar, the largest rated branch circuit should be checked for coordination with upstream devices. If the largest branch will coordinate, and the branch devices are similar, they generally will coordinate as well. (The designer may wish to verify other areas of protection on those branches, conductors, etc.)

**e. Don't Overcrowd the Study.** Many computer generated studies will allow a maximum of ten device characteristics per page.

**f. One-Line Diagram.** A one-line diagram of the study should be drawn for future reference.

# Examples of Selective Coordination Studies

The following pages will analyze in detail the system shown in Figure 11. It is understood that a short circuit study has been completed, and all devices have adequate interrupting ratings. A Selective Coordination Analysis is the next step.

This simple radial system will involve three separate time current curve studies, applicable to the three feeder/branches shown.

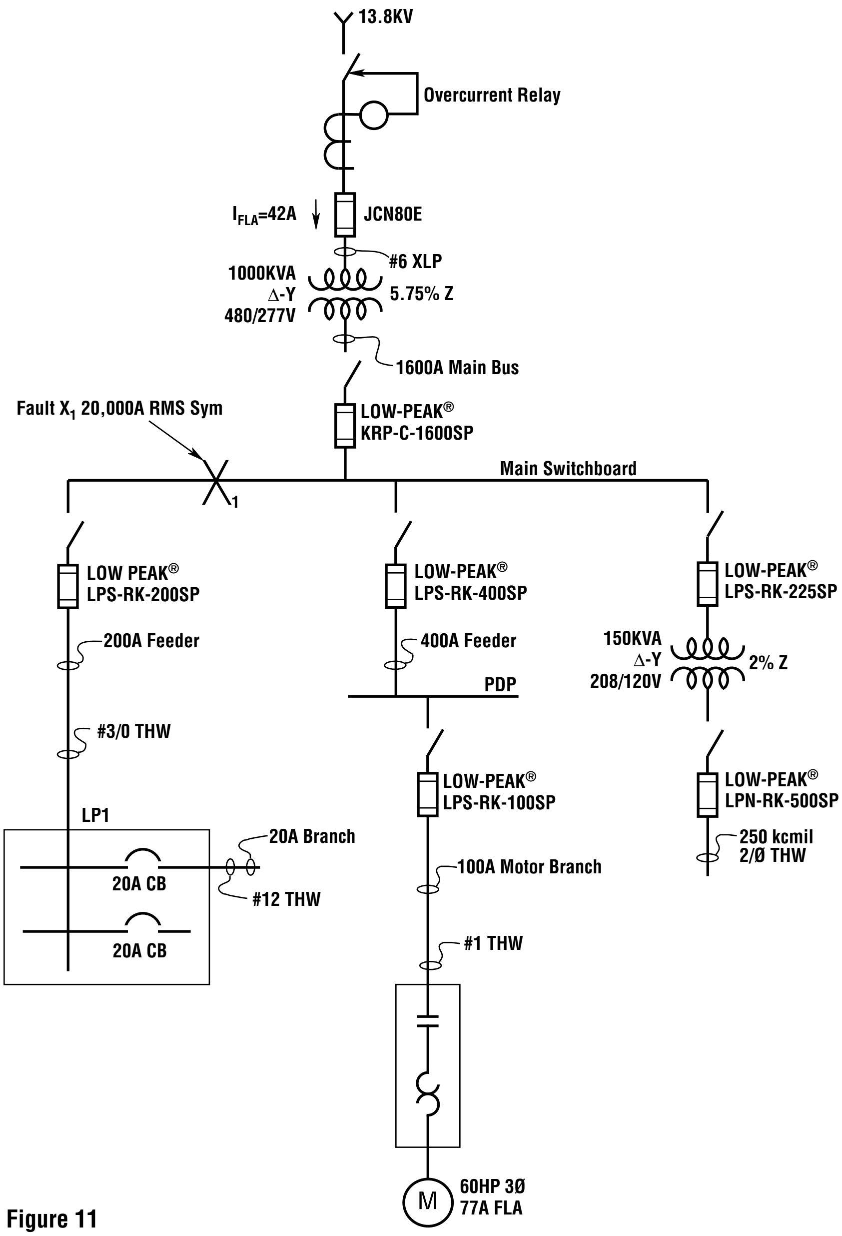



**Figure 11**

Example –

# Time Current Curve #1 (TCC1)

**Notes:**

**1.** TCC1 includes the primary fuse, secondary main fuse, 200 ampere feeder fuse, and 20 ampere branch circuit breaker from LP1.

**2.** Analysis will begin at the main devices and proceed down through the system.

**3.** Reference (base) voltage will be 480 volts, arbitrarily chosen since most of the devices are at this level.

**4.** Selective coordination between the feeder and branch circuit is not attainable for faults above 2500 amperes that occur on the 20 amp branch circuit, from LP1. Notice the overlap of the 200 ampere fuse and 20 ampere circuit breaker.

**5.** The required minimum ratio of 2:1 is easily met between the KRP-C-1600SP and the LPS-RK-200SP.

| Device ID | Description | Comments |
|---|---|---|
| 1 | 1000KVA XFMR Inrush Point | 12 x FLA @ .1 Seconds |
| 2 | 1000KVA XFMR Damage Curves | 5.75%Z, liquid filled (Footnote 1) (Footnote 2) |
| 3 | JCN 80E | E-Rated Fuse |
| 4 | #6 Conductor Damage Curve | Copper, XLP Insulation |
| 5 | Medium Voltage Relay | Needed for XFMR Primary Overload Protection |
| 6 | KRP-C-1600SP | Class L Fuse |
| 11 | LPS-RK-200SP | Class RK1 Fuse |
| 12 | 3/0 Conductor Damage Curve | Copper THW Insulation |
| 13 | 20A CB | Thermal Magnetic Circuit Breaker |
| 14 | #12 Conductor Damage Curve | Copper THW Insulation |

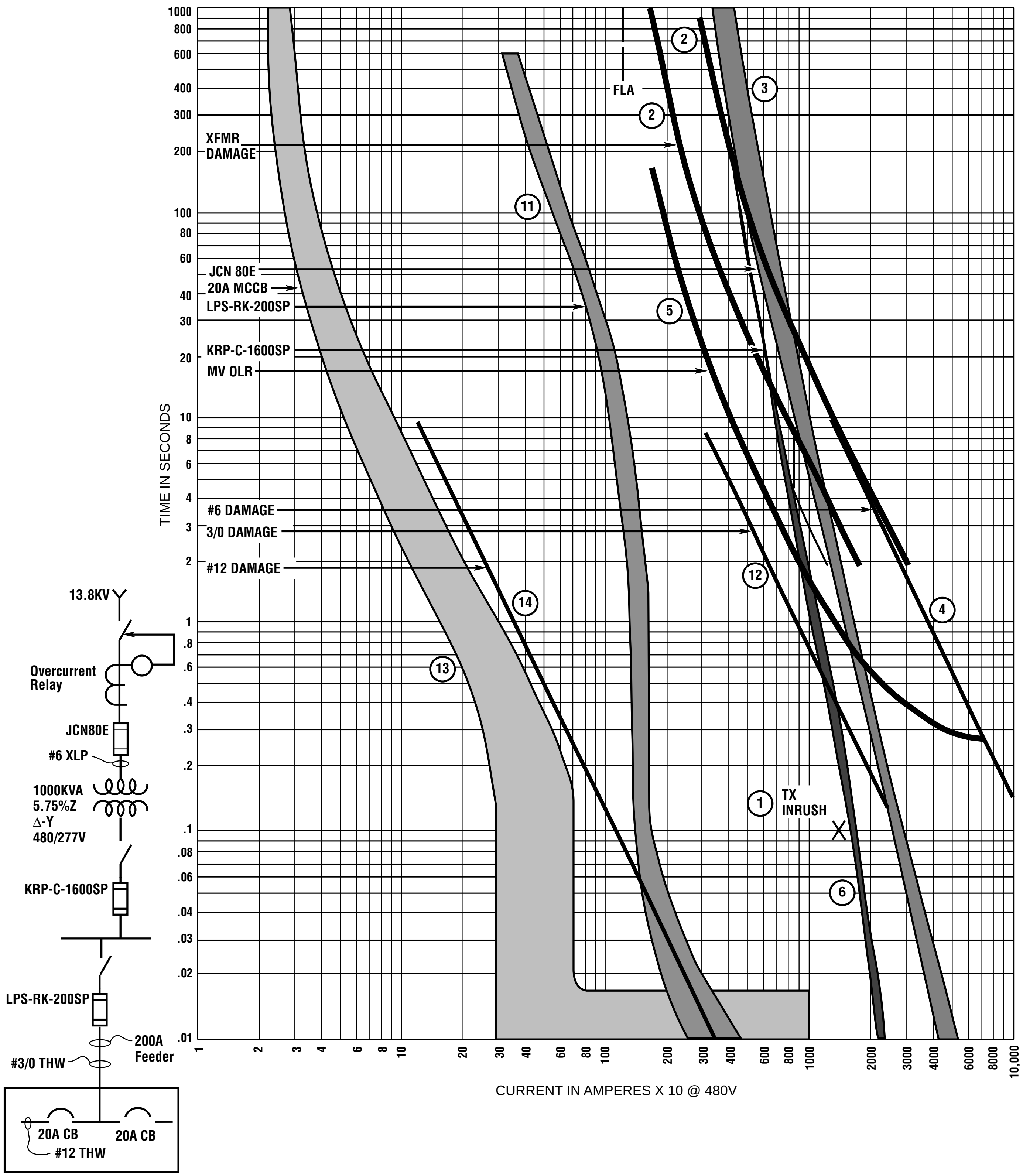
Footnote 1: Transformer damage curves indicate when it will be damaged, thermally and/or mechanically, under overcurrent conditions.

Transformer impedance, as well as primary and secondary connections, and type, all will determine their damage characteristics.

Footnote 2: A Δ-Y transformer connection requires a 15% shift, to the right, of the L-L thermal damage curve. This is due to a L-L secondary fault condition, which will cause 1.0 p.u. to flow through one primary phase, and .866 p.u. through the two faulted secondary phases. (These currents are p.u. of 3-phase fault current.)

Example –

# Time Current Curve #1 (TCC1)



Example –

# Time Current Curve #2 (TCC2)

**Notes:**

**1.** TCC2 includes the primary fuse, secondary main fuse, 400 ampere feeder fuse, 100 ampere motor branch fuse, 77 ampere motor and overload relaying.

**2.** Analysis will begin at the main devices and proceed down through the system.

**3.** Reference (base) voltage will be 480 volts, arbitrarily chosen since most of the devices are at this level.

| Device ID | Description | Comment |
|---|---|---|
| 1 | 1000KVA XFMR Inrush Point | 12 x FLA @ .1 seconds |
| 2 | 1000KVA XFMR Damage Curves | 5.75%Z, liquid filled (Footnote 1) (Footnote 2) |
| 3 | JCN 80E | E-Rated Fuse |
| 4 | #6 Conductor Damage Curve | Copper, XLP Insulation |
| 5 | Medium Voltage Relay | Needed for XFMR Primary Overload Protection |
| 6 | KRP-C-1600SP | Class L Fuse |
| 21 | LPS-RK-100SP | Class RK1 Fuse |
| 22 | Motor Starting Curve | Across the Line Start |
| 23 | Motor Overload Relay | Class 10 |
| 24 | Motor Stall Point | Part of a Motor Damage Curve |
| 25 | #1 Conductor Damage Curve | Copper THW Insulation |

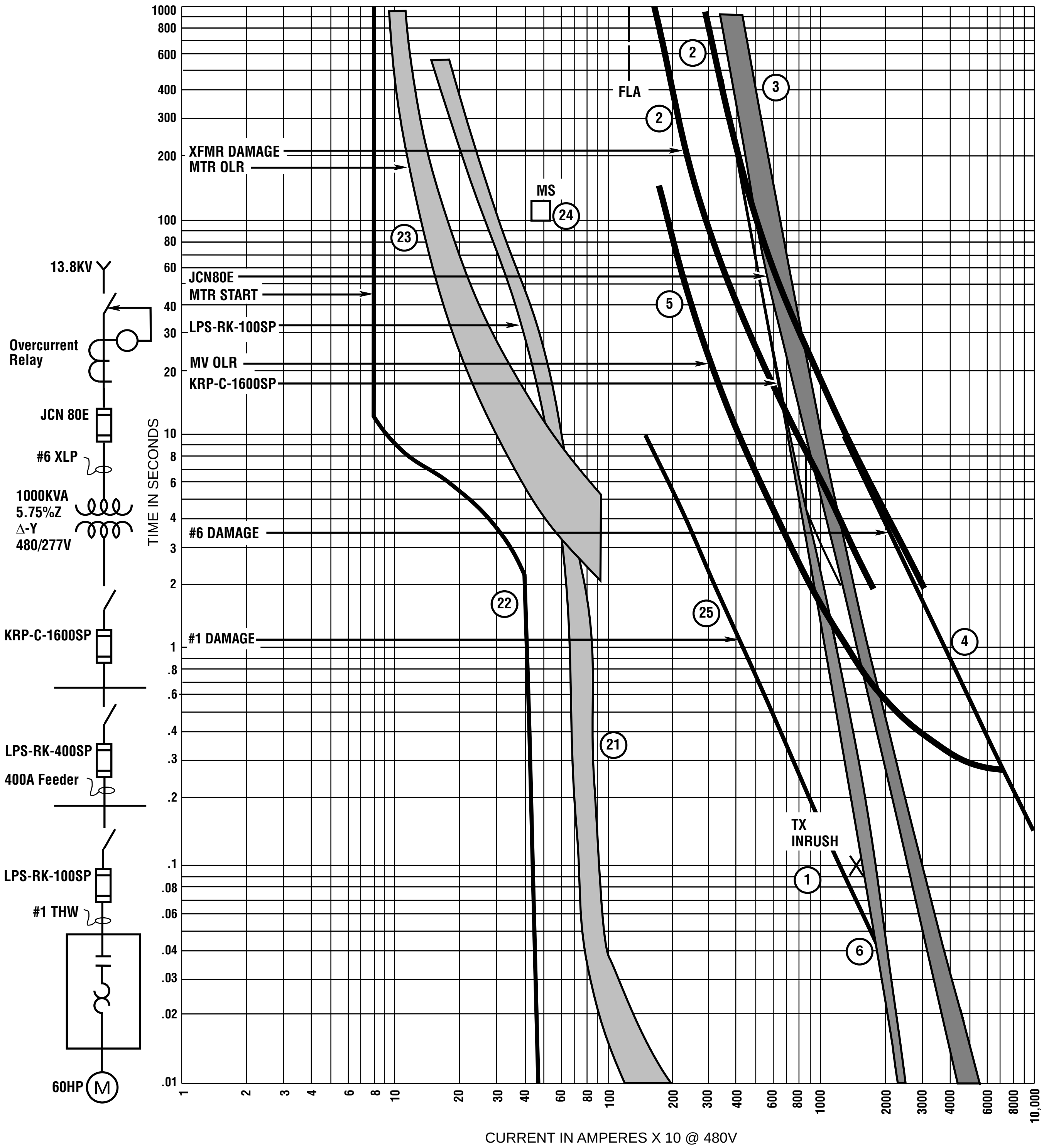
Footnote 1: Transformer damage curves indicate when it will be damaged, thermally and/or mechanically, under overcurrent conditions.

Transformer impedance, as well as primary and secondary connections, and type, all will determine their damage characteristics.

Footnote 2: A Δ-Y transformer connection requires a 15% shift, to the right, of the L-L thermal damage curve. This is due to a L-L secondary fault condition, which will cause 1.0 p.u. to flow through one primary phase, and .866 p.u. through the two faulted secondary phases. (These currents are p.u. of 3-phase fault current.)

Example –

# Time Current Curve #2 (TCC2)



Example –

# Time Current Curve #3 (TCC3)

**Notes:**

**1.** TCC3 includes the primary fuse, secondary main fuse, 225 ampere feeder/transformer primary and secondary fuses.

**2.** Analysis will begin at the main devices and proceed down through the system.

**3.** Reference (base) voltage will be 480 volts, arbitrarily chosen since most of the devices are at this level.

**4.** Relative to the 225 ampere feeder, coordination between primary and secondary fuses is not attainable, noted by overlap of curves.

**5.** Overload and short circuit protection for the 150 KVA transformer is afforded by the LPS-RK-225SP fuse.

| Device ID | Description | Comment |
|---|---|---|
| 1 | 1000KVA XFMR Inrush Point | 12 x FLA @ .1 seconds |
| 2 | 1000KVA XFMR Damage Curves | 5.75%Z, liquid filled (Footnote 1) (Footnote 2) |
| 3 | JCN 80E | E-Rated Fuse |
| 4 | #6 Conductor Damage Curve | Copper, XLP Insulation |
| 5 | Medium Voltage Relay | Needed for XFMR Primary Overload Protection |
| 6 | KRP-C-1600SP | Class L Fuse |
| 31 | LPS-RK-225SP | Class RK1 Fuse |
| 32 | 150 KVA XFMR Inrush Point | 12 x FLA @.1 Seconds |
| 33 | 150 KVA XFMR Damage Curves | 2.00% Dry Type (Footnote 3) |
| 34 | LPN-RK-500SP | Class RK1 Fuse |
| 35 | 2-250kcmil Conductors Damage Curve | Copper THW Insulation |

Footnote 1: Transformer damage curves indicate when it will be damaged, thermally and/or mechanically, under overcurrent conditions.

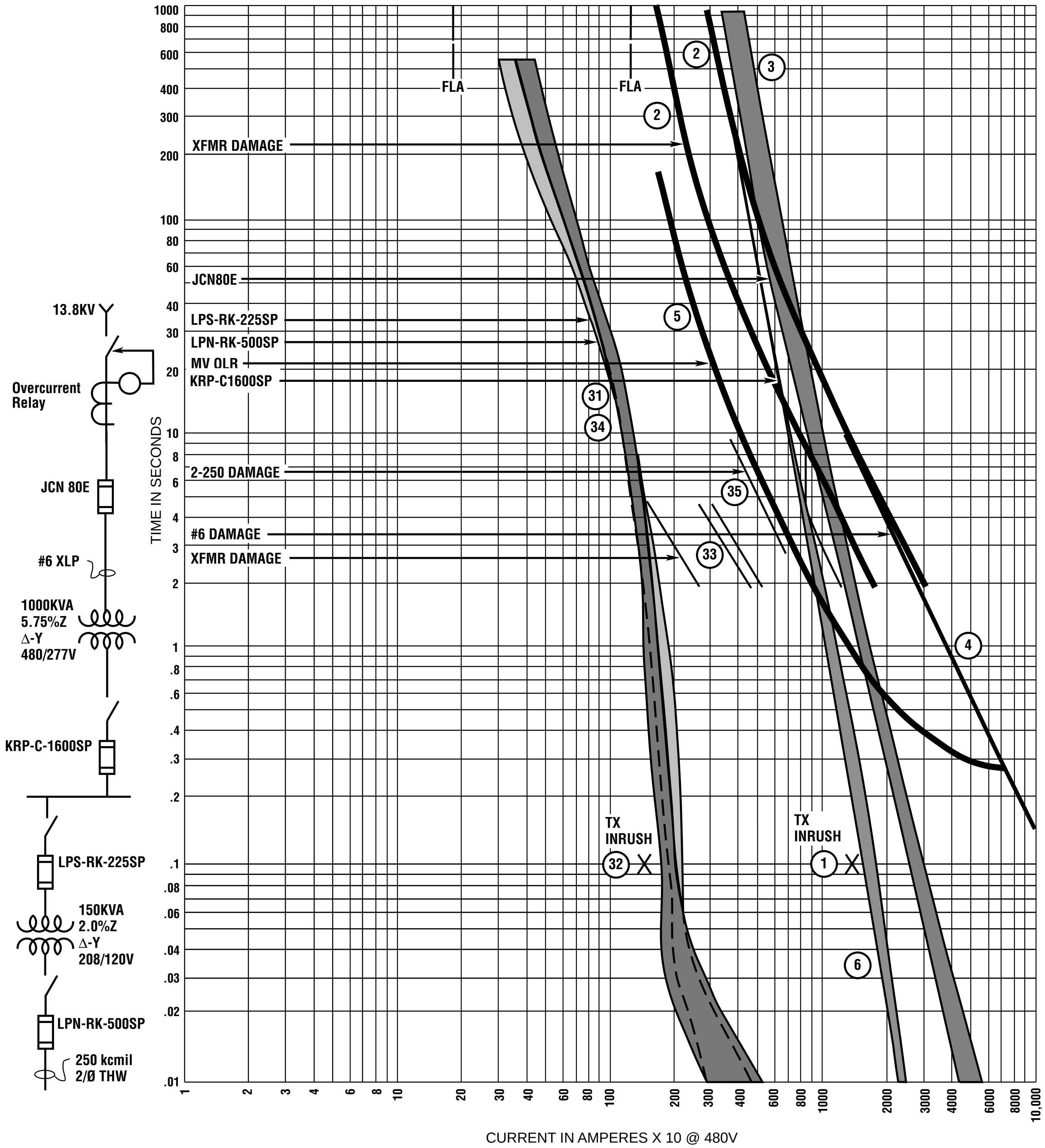
Transformer impedance, as well as primary and secondary connections, and type, all will determine their damage characteristics.

Footnote 2: A Δ-Y transformer connection requires a 15% shift, to the right, of the L-L thermal damage curve. This is due to a L-L secondary fault condition, which will cause 1.0 p.u. to flow through one primary phase, and .866 p.u. through the two faulted secondary phases. (These currents are p.u. of 3-phase fault current.)

Footnote 3: Damage curves for a small KVA (<500KVA) transformer, illustrate thermal damage characteristics for Δ-Y connected. From right to left, these reflect damage characteristics, for a line-line fault, 3Ø fault, and L-G fault condition.

Example –

# Time Current Curve #3 (TCC3)



# Conclusions

Unnecessary power OUTAGES, such as the BLACKOUTS we so often experience, can be stopped by isolating a faulted circuit from the remainder of the system through the proper selection of MODERN CURRENT-LIMITING FUSES.

Time-Delay type current-limiting fuses can be sized close to the load current and still hold motor-starting currents or other harmless transients, thereby ELIMINATING nuisance OUTAGES.

The SELECTIVITY GUIDE on page 10 may be used for an easy check on fuse selectivity regardless of the short-circuit current levels involved. Where medium and high voltage primary fuses are involved, the time-current characteristic curves of the fuses in question should be plotted on standard NEMA log-log graph paper for proper study.

The time saved by using the SELECTIVITY GUIDE will allow the electrical systems designer to pursue other areas for improved systems design.