Fusing Equipment
Reference Data
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COOPER POWER SERIES

Pad-mounted transformer fusing philosophies

General

This document was created as a supplement to Eaton's Cooper Power™ series products standard catalog sections. The fusing philosophies described in this document have been used for many years to create fuse selection and coordination tables for Eaton's Cooper Power series fuses used in pad-mounted transformer applications. The information provided in this document is meant as a guide only. The equipment specifier has the ultimate responsibility for the fuse selection as well as fuse coordination. There are typically options to consider when making those selections and it is therefore important that the selection criteria behind published tables is understood. Please contact your Eaton representative for any questions related to this document.

Dual sensing (358C--), dual element (108C--) & high amp Bay-O-Net (361C--)

Step 1. **Inrush** – Selected fuse's minimum melt should withstand 12 x transformer full load current for .1 seconds.

Step 2. **Cold Load –** Selected fuse's minimum melt should withstand 3 x transformer full load current for 10 seconds (optional requirement for transformers).

Step 3. **Long-time Loading–Recommendation:** Selected fuse provides approximately 200% of transformer full load for 2 hours and 160% of transformer full load for 7 hours with:

1. Transformer preloaded to 75% of nameplate
2. Outside ambient temperature of 35 °C

(Examination of calculated long-time curves at 2 and 7 hours will indicate where the selected fuse will melt, per initial conditions as a percent of load.)

Step 4. Select fuse to satisfy Steps 1, 2, and 3.

Current sensing Bay-O-Net fuse – (353C--)

Step 1. **Inrush** – Selected fuse's minimum melt should withstand 12 x transformer full load current for .1 seconds.

Step 2. **Cold Load** – Selected fuse's minimum melt should withstand 3 x transformer full load current for 10 seconds (optional requirement for transformers.)

Step 3. **Loading Recommendation:** Minimum melt of the selected fuse at 300 seconds shall be at least 3 to 4 times transformer rated current.

3 x rated current for tin elements (353C4 thru 12)

4 x rated current for copper elements (353C14 thru 17)

This allows for twice (normal) nameplate rating continuously.

Step 4. Select a fuse to satisfy Steps 1, 2, and 3.

38 kV Bay-O-Net Fuse - (380C--)

Step 1. **Inrush** – Selected fuse's minimum melt should withstand 12 x transformer full load current for .1 seconds.

Step 2. **Cold Load** – Selected fuse's minimum melt should withstand 3 x transformer full load current for 10 seconds (optional requirement for transformers).

Step 3. **Loading Recommendation:** Minimum melt of the selected fuse at 300 seconds shall be at least 2 to 3 times transformer rated current

2.5 x rated current for (380C06 thru 12)

2 x rated current for (380C14)

Step 4. Select a fuse to satisfy Steps 1, 2, and 3.

Powering Business Worldwide

Current sensing cartridge fuse – (718C--, 719C--)

Step 1. **Inrush** – Selected fuse's minimum melt should withstand 12 x transformer full load current for .1 seconds.

Step 2. **Cold Load** – Selected fuse's minimum melt should withstand 3 x transformer full load current for 10 seconds (optional requirement for transformers.)

Step 3. **Loading Recommendation:** Minimum melt of the selected fuse at 300 seconds shall be at least 3 to 4 times transformer rated current.

3 x rated current for tin elements (718C–, 719C thru 12)

4 x rated current for copper elements (718C, 719C16 – 18)

This allows for twice (normal) nameplate rating continuously.

Step 4. Select fuse to satisfy Steps 1, 2, and 3.

Dual sensing cartridge fuse – (628C--, 629C--, 722C--, 723C--)

Step 1. **Inrush** – Selected fuse's minimum melt should withstand 12 x transformer full load current for .1 seconds.

Step 2. **Cold Load** – Selected fuse's minimum melt should withstand 3 x transformer full load current for 10 seconds (optional requirement for transformers.)

Step 3. **Loading Recommendation:** Minimum melt of the selected fuse at 300 seconds shall be at least 4 times transformer rated current.

Step 4. Faults in excess of interrupting capacity of cartridge fuse are cleared by backup device.

Step 5. Select a fuse to satisfy Steps 1, 2, 3 and 4.

Current sensing cartridge fuses with secondary breakers – (718C--, 719C--)

Step 1. **Inrush** – Selected fuse's minimum melt should withstand 12 x transformer full load current for .1 seconds.

Step 2. **Cold Load** – Selected fuse's minimum melt should withstand 3 x transformer full load current for 10 seconds (optional requirement for transformers.)

Step 3. **Fuse Must Coordinate with Secondary Breaker** – The minimum melt curve of the cartridge fuse should lie to the right of the total operating curve of the selected breaker when converted to the same base (secondary breaker operating curve must be converted to the primary side of the transformer – Ratio = transformer primary voltage/ transformer secondary voltage).

Step 4. Select fuse to satisfy Steps 1, 2, and 3.

Backup current-limiting fuse with Bay-O-Net fuse – (ELSP in series with Bay-O-Net fuse)

Step 1. Select the low current clearing Bay-O-Net fuse (358C–) per the philosophy set down in section Current Sensing (353C–) Dual Sensing (358C–), Dual Element (108C–) and High Amp Bay-O-Net (361C–), 38 kV Bay-O-Net (380C–).

Step 2. Select a current limiting fuse that will coordinate with the selected Bay-O-Net fuse.

A. Calculate the maximum thru fault for the particular transformer as follows:

$$\text{Maximum Thru Fault} = \frac{\text{Full Load Current of the Transformer} \times 100}{\text{Z\% Impedance of the Transformer}}$$

(A general rule of thumb for impedances single- and three-phase, when values are not known, they can be found on the last page.)

B. Place the family of minimum melting curves for the backup underoil (ELSP) current limiting fuse directly on top of (one on one) the total clearing of the chosen Bay-O-Net fuse curve.

C. Select an ELSP fuse whose minimum melt curve crosses the maximum clear curve of the bay-o-net fuse at a time-current relationship (crossover) that is greater than the calculated maximum thru fault (step one).

This ensures that the current limiting fuse is only subjected (melt) to a current that would represent a failed transformer (current greater than maximum secondary fault). The first current limiting fuse that meets this criterion is then the smallest ampere rated current limiting fuse that can be selected. Any ampere rated fuse larger will also coordinate properly.

D. Lookup the minimum interrupting current for the current limiting fuse chosen in Step 3 (minimum interrupting currents are listed on the individual spec sheets found in your protective equipment catalog).

E. Re-examine the crossover point of the current limiting fuse to the expulsion fuse (do step 2 over again).

Crossover point of the two fuses should also be at a current magnitude that is equal to or greater than the minimum interrupting current of the current limiting fuse.

This ensures that the current limiting fuse is only subjected (melt) to a current that it can clear by itself.

F. Re-examine the crossover point of the current limiting fuse to the expulsion fuse (as done in step E).

Crossover point of the two fuses should also be at a current magnitude that is less than the maximum interrupting rating of the Bay-O-Net fuse assembly.

This ensures that the Bay-O-Net fuse will interrupt all secondary fault currents below the maximum thru fault and up to where the two fuses cross (Bay-O-Net Clear and ELSP Minimum Melt TCC curves).

G. To complete the coordination between backup current limiting fuses and Bay-O-Net fuses, the chosen Bay-O-Net fuse's maximum clear current must be equal to or less than 90% of the current limiting fuse's minimum melt current at 300 seconds.

ELS in Bay-O-Net – (oil immersed full-range clearing current-limiting fuse)

Step 1. **Inrush** – Selected "full range clearing" current limiting fuse (ELS) minimum melt should withstand 12 x transformer full load current for .1 seconds and 25 x transformer full load current at .01 seconds.

Step 2. **Cold Load** – Selected fuse's minimum melt should withstand 3 x transformer full load current for 10 seconds (optional requirements for transformers.)

Step 3. **Loading Recommendations:** Percent of overload protection is based on the fuse's long-time minimum melt current (4 to 8 hour minimum melt) considering maximum top oil temperature divided by transformer rated current. Determination of percent of overload protection is done as follows:

A. Determine long-time melting current of selected fuse (4 to 8 hours) in 25 °C oil – given on right hand corner of minimum melt TCC curves.

B. Determine top oil temperature of the transformer (given by customer, utility, etc…).

C. De-rate the selected fuse (Step 3) for maximum top oil temperature (Step 2B) using the long-time melting current (Step 1B) as follows: .24% per every degree C above 25 °C.

(Example: For fuse operation in 100 °C oil – 100 °C - 25 °C = 75 °C x .24% - 18%; 4 to 8 hour melt current of the selected fuse, 4 to 8 hours, in 100 °C oil.)

D. Using the de-rated value of melting current for the selected fuse (Step 3B), divide by the nameplate rating of the transformer (full load current). The resulting number x 100 yields the percent of load required to melt the selected fuse at maximum oil temperature (top oil temperature determined by user–de-rated), 4 to 8 hours.

E. Chosen values for "percent of load" required to melt the fuse at maximum oil temperature will vary from utility to utility, depending on the particular transformer loading philosophies and determined top oil temperatures. Commonly used levels of overload protection (melting are 140-200% and 200 to 300% at maximum except oil temperatures).

F. To ensure that the fuse will not be damaged by long-time heating effects. Selected fuse should not be allowed to see a continuous current more than 80% (.8) of that calculated current that will cause it to melt including de-ration.

Step 4. Select a fuse to meet Steps 1, 2, and 3.

Current-limiting fuse in dry well canister (air)

Step 1. **Inrush** – Selected full range clearing (or general purpose) current limiting fuse's minimum melt should withstand 12 x transformer full load current for .1 seconds and 25 x transformer full load current at .01 seconds.

Step 2. **Cold Load** – Selected fuse's minimum melt should withstand 3 x transformer full load current for 10 seconds (optional requirements for transformers).

Step 3. **Loading Recommendations:** Percent of overload protection is based on the fuse's long-time minimum melt current (4 to 8 hour melt) considering maximum operating temperature, divided by transformer rated current.

A. Lookup the 4 hours melting current on (TCC curves) of the fuse chosen to meet the electrical considerations (initial Step 3).

B. De-rate the melting current at 4 hours by 12% for dry well canister application. (4 hour minimum melt less 12%)

C. Determine top oil temperature of the transformer, (given by customer – utility etc…).

D. Using the de-rated melting current for the chosen fuse (Step 2, B), de-rate this value further .2% per every °C rise of the transformer's top oil temperature above 25 °C (TCC curves are based at 25 °C).

Example: 4 hour minimum melt of 15.5 kV, 25c NX fuse – 35 amps

1. Dry well application 35 amp less 12% – 31 amps new minimum melt.

2. For a top oil temperature of 110 °C
110 ° - 25 ° = 85 °C x .2 = 17%

3. 4 hour minimum melt (de-rated for application) 31 amps less 17% for top oil.

4. 4 hour minimum melt – 26 amps (full de-ration for application and top oil).

E. Using the fully de-rated value of melting current for the selected fuse (Step 4B) divide by the nameplate rating of the transformer (full load current). The resulting number x 100 yields the percent of load required to melt the selected fuse at maximum expected ambient conditions, 4 to 8 hours.

F. Chosen values for "percent of load" required to melt the fuse at maximum temperature conditions will vary from utility to utility, manufacturer to manufacturer. Common values listed in tabular form are 140 to 200% and 200 to 300%. Again, fuse size is temperature dependent based on percent of de-ration.

G. To ensure that the fuse will no be damaged by long-time heating effects. Selected fuse should not be allowed to see a continuous current more than 80%. (.8) of that calculated current that will cause it to melt including duration (Step 5B).

Step 4. Select a fuse that meets Steps 1 and 2.

Standard transformer impedances used to calculate maximum thru fault

Single-Phase Impedances Transformer Sizes (kVA)	Single-Phase Impedances (%)
10	1.90
15	1.90
25	1.90
37.5	1.90
50	1.90
75	1.90
100	2.00
267	2.60
250	4.00
333	5.00
500	6.00

Three-Phase Impedances Transformer Sizes (kVA)	Single-Phase Impedances (%)
75	1.60
112.5	1.80
150	2.00
225	3.00
300	3.50
500	4.00
750 and up	5.75

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