Typical Derating Calculation for a Tray

The general approach utilized in these calculations was as follows:

1. Obtain the ampacity value from the appropriate industry standard, accounting for environmental conditions, such as equipment temperature, ambient temperature, cable type, and raceway construction.

2. Adjust the ampacity value from the industry standard for differences in cable diameters per ICEA P-54-440 Section 2.3 "Correction Factor for Diameters of Cables."

3. Apply an additional derating factor to account for the presence of Thermo-Lag, utilizing data provided in References 1 and 2.

4. Calculate the ampacity margin.

The following is a sample calculation for tray number 106, which contains three energized circuits.

TRAY NO. 106		
DESCRIPTION		REMARKS
SIZE	18" x 3" LENGTH = 157'	
TYPE	4.16 KV / 480 V SINGLE LAY	DIVISION 1
MATERIAL	LADDER TYPE, HOT DIPPED, GALVANIZED STEEL	
THERMO-LAG	THICKNESS = 5/8" (MAX) LENGTH = 55'	1-HOUR FIRE RATING
FIRE ZONE	CC-1A	AMBIENT TEMPERATURE = 88°F
TRAY FILL (%)	33.67	CABLE O.D. VS. TRAY WIDTH
TOTAL NO. OF CABLES	3	

Tray 106 contains three circuits: 1P42F1A, 1P47F1A, and 1P47H1A, with the following cable characteristics.

CABLE CHARACTERISTIC	1P42F1A	1P47F1A	1P47H1A
CABLE NUMBER	1P42	1P47	1P47
VOLTAGE CLASS	480 V	480 V	4 KV
CABLE ID NUMBER	1A	1A	1A
CABLE TRAY DEPTH (INCHES)	1.0	1.0	1.0
CABLE CONFIGURATION	3 CONDUCTOR	3 CONDUCTOR	3 CONDUCTOR
CABLE SIZE	4/0	4/0	4/0
CABLE CONSTRUCTION	5 KV (ARMOR)	5 KV (ARMOR)	5 KV (ARMOR)
CABLE O.D. (INCHES)	2.02	2.02	2.02
BASELINE AMPACITY (AMPS)	288.41	288.41	288.41
EQUIPMENT DESCRIPTION	PUMP	PUMP	CHILLER
FULL LOAD CURRENT (AMPS)	115.0	115.0	94.0
ENERGIZED OR DE-ENERGIZED	ENERGIZED	ENERGIZED	ENERGIZED

The depth of cables routed in trays that contain well below 50% tray fill is calculated per ICEA Publication P-54-440 Section 2.2 "Calculated Depth of Cables in Trays" as follows:

$$\text{Calculated Depth (in)} = \frac{\Sigma d^2}{w}$$

where: d = diameter of cables (in)
w = width of tray (in)

However, this tray consists of a single layer arrangement of the cables. Single and three-conductor 600 V and 5 KV cables #4 AWG and larger are routed in power trays in a single layer with 3/8" minimum spacing between cables. A cable depth of 1" was used for cable trays consisting of a single layer arrangement of the cables. Cable ampacities, shown below, are obtained from ICEA P-54-440 Tables 3-15 for a cable depth of 1.0".

CIRCUIT NUMBER	CABLE AMPACITY
1P42F1A	257 amps
1P47F1A	257 amps
1P47H1A	257 amps

The diameters of PNPP 600 V and 5 KV cables are generally not the same as those used in the ICEA tables. Therefore, cable ampacities are adjusted for differences in cable diameters per ICEA P-54-440 Section 2.3 "Correction Factor for Diameters of Cables" as follows:

$$I_x = \frac{d_x}{d_o} \times I_o$$

where:
d_x = PNPP cable diameter
d_o = cable diameter from ICEA Table 3-15
I_o = ampacity of cable diameter d_o from ICEA Table 3-15
I_x = ampacity of cable diameter d_x

The result of the cable ampacity adjusted for differences in cable diameters is the baseline ampacity. The following table provides the results of the cable ampacities for the circuits in tray 106, corrected for differences in cable diameters.

	1P42F1A	1P47F1A	1P47H1A
ICEA Cable Diameter	1.80"	1.80"	1.80"
PNPP Cable Diameter	2.02"	2.02"	2.02"
ICEA Cable Ampacity	257 amps	257 amps	257 amps
PNPP Cable Ampacity	288.41 amps	288.41 amps	288.41 amps

ICEA P-54-440 also provides a correction factor for differences in temperatures. The ICEA tables are based on a conductor temperature of 90°C (194°F) and an ambient air temperature of 40°C (104°F). However, the highest actual ambient temperature surrounding the cables evaluated in PNPP Calculation MISC-0009 is 94°F. To be conservative, the calculation for tray 106 does not include correction factors for a lower ambient temperature.

The percent margin between cable ampacity and full load current rating is determined for the cable with and without a Thermo-Lag fire barrier in place. The actual conductor load is based on equipment FULL LOAD AMPERE (FLA) ratings. The load factor is 1.0 for resistive loads and 1.1 for other loads. The calculation of the percent margin between cable ampacity and full load current rating is detailed below for circuit 1P42F1A.

$$\text{\% Margin Without Thermo - Lag} = \frac{(\text{Cable Ampacity}) - (\text{Full Load Current} \times \text{Load Factor})}{\text{Cable Ampacity}}$$

$$\text{\% Margin Without Thermo - Lag} = \frac{288.41 - (115.0 \times 1.1)}{288.41} = 56\%$$

Applying the additional derating factor (0.315 for cables in trays), as stated in step 3, to account for the presence of Thermo-Lag, the ampacity with Thermo-Lag is:

$$\text{Ampacity With Thermo - Lag} = (\text{Cable Ampacity}) \times (1 - \text{Derating Factor})$$

$$\text{Ampacity With Thermo - Lag} = 288.41 \text{ amps} \times (1 - 0.315) = 197.56 \text{ amps}$$

$$\% \text{ Margin With Thermo - Lag} = \frac{(\text{Cable Ampacity}) - (\text{Full Load Current} \times \text{Load Factor})}{\text{Cable Ampacity}}$$

$$\% \text{ Margin With Thermo - Lag} = \frac{197.56 - (115.0 \times 1.1)}{197.56} = 36\%$$

The percent margin between cable ampacity and full load current rating was also calculated for circuits 1P47F1A and 1P47H1A. The results for the three cables in tray 106 are shown below.

CIRCUIT NO.	1P42F1A	1P47F1A	1P47H1A
FULL LOAD CURRENT (AMPS)	115.0	115.0	94.0
CABLE AMPACITY (AMPS)	288.41	288.41	288.41
AMPACITY WITH THERMO-LAG (AMPS)	197.56	197.56	197.56
AMPACITY MARGIN WITHOUT THERMO-LAG	56%	56%	64%
AMPACITY MARGIN WITH THERMO-LAG	36%	36%	48%

REFERENCES

1. Omega Point Laboratories Report No. 12340-94583, 95165-95168, 95246, "Ampacity Derating of Fire Protected Cables," dated 03/19/93.
2. NRC Letter to Texas Utilities Electric Company dated 06/14/95, "Safety Evaluation of Ampacity Issues Related to Thermo-Lag Fire Barriers at Comanche Peak Steam Electric Station, Unit 2 (TAC No. M85999)."
3. Insulated Cable Engineers Association (ICEA) (IPCEA) Standard P-54-440 (NEMA WC 51), 1986, Ampacities of Cables in Open-Top Cable Trays.