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Heat generation estimation for historic switchgear type D (to 4.76 kV) and type F (to 15 kV) with air magnetic circuit breakers

We are often asked for estimated heat generation data for our equipment. These requests are most common for our modern products, but we also have requests for data on the historic types D and F switchgear designs that used air magnetic circuit breakers. This issue of TechTopics provides information on these historic designs to allow calculation of approximate heat generated by the switchgear under assumed loading conditions.

The heat generation data in Tables 2 and 3 are based on full-rated continuous current. Actual heat generation estimates must consider the true loading of the equipment. The amount of heat generated is related to the square of the current, so a circuit breaker operating at one-half rated current will have heat generation only one-quarter of that at full rated continuous current. Because the effect of the square relationship is very significant, it is overly conservative to estimate heat generation based on the assumption that all sections and all circuit breakers each carry their rated continuous current at all times. Air conditioning systems sized based upon such estimates will be significantly larger than the real operating conditions require.

To estimate the heat generated under actual loading conditions, determine the component heat generation for each of the components indicated in Table 2 (type D) or Table 3 (type F). Estimated heat generation for circuit breakers should be adjusted for actual loading based on the ratio of the squares of the actual current and the rated current. To be precise, this adjustment should also be made for the actual current loading for the main bus in each individual vertical section, but this is frequently ignored in the interests of simplification. Instead, the main circuit breaker loading is usually assumed to be equal to the main bus loading in all vertical sections.

Example: Assume a lineup of type F switchgear with five vertical sections, one 2,000 A main breaker (loaded to 1,400 A), three 1,200 A feeder circuit breakers (loading 250 A, 600 A and 550 A), with 2,000 A main bus, and including space heaters. The lineup includes one voltage transformer (VT) rollout, one 10 kVA control power transformer (CPT) and non-complex electromechanical relaying (for example, three induction disk relays), and instrumentation (for instance, an ammeter with selector switch)

The calculations would be as follows:

If true loading were not considered (for example, all calculations performed on the basis of full-rated current), the calculations would yield a heat generation of 8,420 watts, or about 170 percent of the “real” heat generation.

Table 1: Example

Category		Heat generation	
A	2,000 A circuit breaker at 1,400 A = 1,290 x (1,400/2,000)^2 =	632 W	
	1,200 A circuit breaker at 250 A = 910 x (250/1,200)^2 =	39 W	
	1,200 A circuit breaker at 600 A = 910 x (600/1,200)^2 =	228 W	
	1,200 A circuit breaker at 550 A = 910 x (550/1,200)^2 =	191 W	
	Total heat generation for circuit breaker cells		1,090 W
B	Vertical sections with 2000 A bus at 1,400 A = 5 x 210 x (1,400/2,000)^2 =		515 W
C	Space heaters for five vertical sections = 5 x 500 =		2,500 W
D	VT rollout = 1 x 50 =		50 W
E	CPT = 1 x 4% x 10 kVA =		400 W
F	Relaying and instrumentation = 4 x 100 =		400 W
Total estimated heat generation under assumed loading conditions			4,955 W

Table 2: Type D switchgear (to 4.76 kV) with type MA or type FA air magnetic circuit breakers - approximate full-load heat generation (in watts)

		Continuous current - circuit breaker (rows 1-3) or main bus (row 4)			
Category	Rated current	1,200 A	2,000 A	3,000 A	3,750 A
	Actual current	1,200 A	2,000 A	3,000 A	3,750 A
Circuit breaker cell with circuit breaker		750 W	1,050 W	2,390 W	3,520 W
Vertical section with main bus		100 W	150 W	310 W	480 W
Space heaters per vertical section		500 W	500 W	500 W	500 W
VT trunnion		50 W	50 W	50 W	50 W
CPT (drawout or stationary)		4% of CPT kVA rating	4% of CPT kVA rating	4% of CPT kVA rating	4% of CPT kVA rating
Relaying and instrumentation per circuit breaker cell	Microprocessor type	50 W	50 W	50 W	50 W
	Electromechanical non-complex	100 W	100 W	100 W	100 W
	Electromechanical complex	200 W to 300 W	200 W to 300 W	200 W to 300 W	200 W to 300 W

		Continuous current - circuit breaker(rows 1-3) or main bus (row 4)			
Category	Rated current	1,200 A	2,000 A	3,000 A	3,750 A
	Actual current	1,200 A	2,000 A	3,000 A	3,750 A
Circuit breaker cell with circuit breaker		910 W	1,290 W	2,390 W	3,520 W
Vertical section with main bus		140 W	210 W	310 W	480 W
Space heaters per vertical section		500 W	500 W	500 W	500 W
VT trunnion		50 W	50 W	50 W	50 W
CPT (drawout or stationary)		4% of CPT kVA rating	4% of CPT kVA rating	4% of CPT kVA rating	4% of CPT kVA rating
Relaying and instrumentation per circuit breaker cell	Microprocessor type	50 W	50 W	50 W	50 W
	Electromechanical non-complex	100 W	100 W	100 W	100 W
	Electromechanical complex	200 W to 300 W	200 W to 300 W	200 W to 300 W	200 W to 300 W

Table 3: Type F switchgear (to 15.0 kV) with type FB or type FC air magnetic circuit breakers - approximate full-load heat generation (in watts)

Footnotes for Tables 2 and 3:

[1] Space heaters, when provided, are not normally controlled by a thermostat. Hence, their load is represented as a continuous load. The purpose of space heaters is to prevent condensation, and this is not limited by the absolute temperature. Even when a thermostat is used to control the heaters, it is set to shut the heaters off at a temperature of approximately 110 °F. Therefore, in an air-conditioned room, the heaters would be energized continuously.

[2] Heat generated by current transformers (CTs) is ignored as it is usually insignificant and varies according to the CT ratio as well as the loading.

[3] The CPT heat generation estimate is very conservative and assumes that the CPT is operated at full-rated capacity. If normal loading is at less than full rating, heat generation may be adjusted by the square of the percent loading.

[4] Relaying and instrumentation heat generation estimates are very approximate and are normally estimated based on the number of circuit breaker cells. Extensive relaying and instrumentation may warrant additional conservatism in the estimation of associated heat generation.

[5] Conversion factor: watts x 3.415179 = BTU/hour.

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