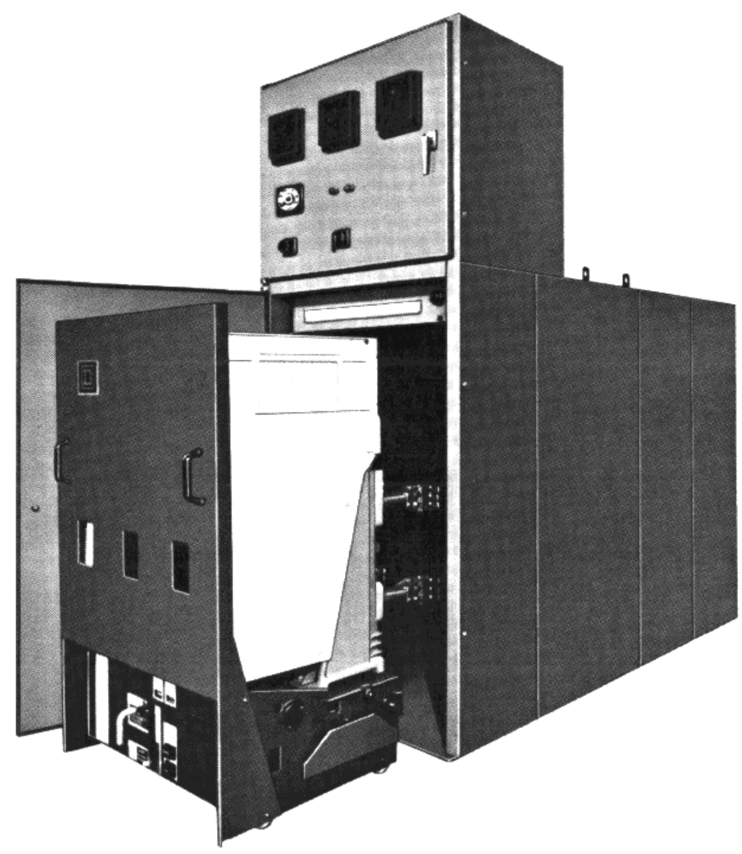
Now Available

DSE-23E 500 MVA 4.16 kV Nominal Voltage Class Metal-Clad Circuit Breaker



Square D Company is pleased to announce the availability of a 500 MVA, 4.16 kV nominal voltage class Metal-Clad circuit breaker. This rating is not currently listed in ANSI C37.06 but has been developed by Square D Company to fulfill the need of those users with higher source capabilities. The 500 MVA rating given herein has been documented in KEMA test report #2213-77 dated 12/28/77. Table 1 below gives a comparison between the present ANSI C37.06, 350 MVA class and the new Square D DSE-23E 500 MVA breaker rating. Development of the primary rating factors will be presented following Table 1.

TABLE 1
350 MVA - 500 MVA RATING COMPARISON

	Present C37.06 350 MVA Class	New Square D 500 MVA Class
Nominal Voltage Class, kV, RMS	4.16	4.16
Nominal 3 Phase MVA Class	350	500
Rated Max. Voltage, kV, RMS	4.76	4.76
Rated Voltage Range Factor, K	1.19	1.19
Low Frequency Insulation Level, kV, RMS	19	19
Impulse Insulation Level, kV, Crest	60	60
Rated Continuous Current at 60 Hertz, Amperes, RMS	1200/3000	2000/3000
Rated Short Circuit Current (At Rated Mx. kV), kA, RMS	41	59
Rated Interrupting Time, Cycles	5	5
Rated Permissible Tripping Delay, Y, Seconds	2	2
Rated Minimum Voltage, kV, RMS	4.0	4.0
Max. Symmetrical Interrupting Capability, kA, RMS	49	70
3 Second Short Time Current Carrying Capability, kA, RMS	49	70
Closing and Latching Capability, kA, RMS asymmetrical	78	103

Continued

RATED SHORT CIRCUIT CURRENT AT RATED MAXIMUM VOLTAGE

In establishing the new 500 MVA rating, primary consideration is given to developing the rated short circuit current at rated maximum voltage. The equation for short circuit current is as follows:

megavolt-amperes (MVA) = $\sqrt{3}$ x V line to line (V_{LL}) x I short circuit (I_{SC}) where V_{LL} and I_{SC} are in kilovolts and kiloamperes

Therefore

$$I_{SC} = \frac{500\text{ MVA}}{\sqrt{3} \times 4.76}$$

$$= 60.65 \text{ kiloamperes RMS symmetrical}$$

Short circuit current values at maximum kV as given in C37.06 are decreased from calculated values as shown in Table 2 below.

TABLE 2

MVA	Max. kV	Calculated Short Circuit Current At Max. Voltage (KA)	Rated Short Circuit Current At Max. Voltage From C37.06 (KA)	ISC Calculated/ISC Rated
75 MVA	4.76	9.10	8.8	1.03
150 MVA	4.76	18.19	18	1.01
250 MVA	4.76	30.32	29	1.05
350 MVA	4.76	42.45	41	1.04

In the 4.76 maximum kV class I_{SC} Calculated/I_{SC} Rated varies from 1.01 to 1.04 with 1.04 being applicable to the 350 MVA rating. 1.03 is selected for the new 500 MVA rating since it would be more stringent than that used for the 350 MVA rating.

$$I_{SC} \text{ therefore becomes } = \frac{60.65 \text{ kiloamperes RMS symmetrical}}{1.03}$$

$$= 58.88 \text{ kiloamperes RMS symmetrical}$$

Thus 59 kiloamperes RMS becomes the new RATED SHORT CIRCUIT CURRENT at maximum kV as shown in Table 1.

MAXIMUM SYMMETRICAL INTERRUPTING CAPABILITY AND 3 SECOND SHORT TIME RATING

Maximum symmetrical interrupting capability and three second short time ratings are developed by multiplying I_{SC} at maximum kV by the rated voltage range factor (1.19).

I_{SC} max. = 59 kiloamperes x 1.19 = 70.21 kiloamperes RMS symmetrical

This is rounded to 70 kiloamperes RMS and becomes the MAXIMUM SYMMETRICAL INTERRUPTING CAPABILITY shown in Table 1.

CLOSING AND LATCHING RATING

The closing and latching rating requirement is determined by the power factor of the circuit and the maximum symmetrical short circuit current available. When a circuit breaker closes on a circuit containing resistance and inductance, the transient current flow is expressed by the equation:

$$*i\ inst = \frac{Em}{Z} \sin(2\pi ft + \alpha - \emptyset) - \frac{Em}{Z} \sin(\alpha - \emptyset)\, e^{-\frac{tR}{L}}$$

Where EM = Peak voltage in volts

Z = Circuit impedance in ohms

f = Frequency in hertz

t = Time in seconds

α = Phase displacement between the instantaneous voltage and a reference wave which passes through zero at time = 0

$\emptyset$ = Phase displacement between circuit current and voltage

***Standard handbook for Electrical Engineers,** Fink & Carroll, Tenth Edition, McGraw-Hill, Section 2-131, pages 2-34

Simplifying the above equation gives:

$$i\ inst = \sqrt{2}\, I\ RMS\ SYM\ [\sin(2\pi ft + \alpha - \emptyset) - \sin(\alpha - \emptyset) e^{-\frac{tR}{L}}]$$

Since the phase voltage and phase currents in a 3 phase system are 120 electrical degrees displaced from each other, each will respond differently when the breaker contacts close. It can be shown that the maximum symmetrical offset occurs when the phase displacement between the reference wave (which passes through zero at t = 0) subtracted by the phase displacement between current and voltage equals —90° or $-\frac{\pi}{2}$

$$(\alpha - \emptyset) = -\frac{\pi}{2}$$

$$i\ inst\ becomes\ \sqrt{2}\, I\ RMS\ SYM\ [\sin(2\pi ft - \frac{\pi}{2}) - \sin(-\frac{\pi}{2}) e^{-\frac{tR}{L}}]$$

$$= \sqrt{2}\, I\ RMS\ SYM\ [\sin(2\pi ft - \frac{\pi}{2}) + e^{-\frac{tR}{L}}]$$

on the first current cycle when t = ½ cycle

$$t = \frac{1}{2f}$$

$$i\ peak = \sqrt{2}\, I\ RMS\ SYM\ [\sin(2\pi f \frac{1}{2f} - \frac{\pi}{2}) + e^{-\frac{R}{L}\frac{1}{2f}}]$$

$$i\ peak = \sqrt{2}\, I\ RMS\ SYM\ [1 + e^{-\frac{R}{L}\frac{1}{2f}}$$

Converting this equation to include power factor

$$Pf = \cos \phi$$

$$\tan \phi = \frac{X_L}{R} = \frac{2 \pi fL}{R}$$

$$\phi = \tan^{-1}\left(\frac{2 \pi fL}{R}\right)$$

$$Pf = \cos\left[\tan^{-1}\left(\frac{2 \pi fL}{R}\right)\right]$$

$$\cos^{-1} pf = \tan^{-1}\left(\frac{2 \pi fL}{R}\right)$$

$$\tan \cos^{-1} pf = \frac{2 \pi fL}{R}$$

$$\frac{R}{L} = \frac{2 \pi f}{\tan \cos^{-1} pf}$$

Substituting into i peak

$$i\ peak = \sqrt{2}\, I\ RMS\ SYM\left[1 + e^{-\frac{\pi}{\tan \cos^{-1} pf}}\right]$$

From the KEMA test report the maximum peak interrupting capability of the 500 MVA breaker is 175 kiloamperes peak. Using this value with a circuit having a 70 kiloamperes RMS symmetrical current available allows for calculation of the minimum acceptable circuit power factor.

$$175\ KA\ peak = \sqrt{2}\, 70\ KA\ RMS\ SYM\left[1 + e^{-\frac{\pi}{\tan \cos^{-1} pf}}\right]$$

Solving for pf gives a value of 8.5%.

Therefore the new 500 MVA breaker operating at its maximum rating can be used on circuits with power factors as low as 8.5%. 175 KA peak is related to RMS by a factor of 1.7. Therefore, the CLOSE AND LATCH RATING in Table 1 is 103 KA RMS on a circuit having a power factor of 8.5% or greater. If the maximum current available is lower than 70 KA RMS symmetrical, the above equation can be used to calculate a correspondingly lower permissible circuit power factor.

The 500 MVA 4.16 kV voltage class breaker is available now from Square D Company and is part of its complete line of ANSI rated Solenarc breakers. Copies of KEMA test reports are available on request. Contact your nearest field office for additional details.

J. Weber

SQUARE D COMPANY

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