Westinghouse

High Voltage Power Fuses

Expulsion Type

General Information

RBA and RDB are the expulsion type fuses which use Boric Acid (BA) as the arc extinguishing medium. The RBA is the designation given to all indoor fuses, while RDB denotes the outdoor dropout type fuse.

Since fuses are selected on the basis of interrupting ability, continuous current rating and melting characteristics, the RBA-RDB cover a wide range of system voltages from 2.4 Kv to 34.5 Kv. They offer a full range of continuous current ratings from 1/2 E ampere to 720 E ampere, along with high short circuit interrupting capabilities.

RBA-RDB-200 fuse refill continuous current ratings start at 10 E amperes and continue to 200 E ampere. This type of fuse is normally used on systems where a high interrupting capability is not required, and economics of installation is a determining factor.

The RBA-RDB-400 fuse has a much higher interrupting rating than the RBA-RDB-200. Continuous current ratings on this type of fuse begin at 1/2 E amperes and continue to 400 E amperes in sizes as prescribed by standards (see table A). To achieve higher E ampere sizes such as 540 and 720 E amperes, two 300 E ampere fuse refills are paralleled in separate fuseholders on a common mounting, they are then derated 10% to achieve the 540 E ampere continuous current rating. The same procedure is followed using two 400 E ampere refills to attain the 720 E ampere continuous current rating. RBA-RDB-800 fuse mountings and holders are provided for this purpose.

The average requirements of general-purpose high voltage fuse applications combined with the inherent features of conventional fuses have led to a realization that a ratio of approximately 2:1 between minimum melting current and continuous rated current will satisfy the majority of service conditions. Thus, this realization has led to a long established standard (USASI-C37.40 to C37.47, 1962, and NEMA SG2, 1969). The letter "E" following the ampere size on the refills is a NEMA-USASI designation and is based on their standards which read:

a. The current-responsive element of a power fuse rated 100 E ampere or below shall melt in 300 seconds at an RMS current within the range of 200 to 240 percent of the continuous current rating.

b. The current-responsive element of a power fuse rated above 100 E amperes shall melt in 600 seconds at an RMS current within the range of 220 to 264 percent of the continuous current rating.

To fully understand the application of the RBA-RDB fuses one must consider the integral parts that comprise a complete fuse. They are the (a) mounting, (b) fuseholder (c) refill (d) discharge filter or condenser. These parts are shown in DB-36-654 along with the illustration of a fuse operation under short circuit conditions.

The fuseholder is a refillable device which houses the spring and shunt assembly and the refill. When used on indoor applications it can be provided with a discharge filter or condenser to absorb the discharge gases.

The discharge filter is a device that is attached to the bottom of the fuseholder. When the fuse operates under fault conditions, the discharge filter will absorb and contain most of the gases, but will also permit a small and relatively inert amount of gas to escape. The addition of this device does not reduce the interrupting capability of the fuseholder.

The condenser in comparison does absorb and contain all the gases, in doing so, it reduces the interrupting capability of the fuseholder (See Table B).

Table A: E-Ampere Ratings RBA-RDB-200-400 Fuse Refills

Kv	RBA-RDB-200 Standard	Time-Lag	RBA-RDB-400 Standard	Time-Lag
2.4	10 E to 200 E	20 E to 200 E	½ E to 400 E, 540①, 720②	20 E to 200 E
4.8	10 E to 200 E	20 E to 200 E	½ E to 400 E, 540①, 720②	20 E to 200 E
7.2	10 E to 200 E	20 E to 200 E	½ E to 400 E, 540①, 720②	20 E to 200 E
13.8	10 E to 200 E	20 E to 200 E	½ E to 400 E, 540①, 720②	20 E to 200 E
14.4	10 E to 200 E	20 E to 200 E	½ E to 400 E, 540①, 720②	20 E to 200 E
23.0	10 E to 200 E	20 E to 200 E	½ E to 300 E, 540①	20 E to 200 E
34.5	10 E to 200 E	20 E to 200 E	½ E to 300 E, 540①	20 E to 200 E

Note:
E – Ampere rating sizes per standards, ½E, 3E, 5E, 7E, 10E, 15E, 20E, 25E, 30E, 40E, 50E, 65E, 80E, 100E, 125E, 150E, 200E, 250E, 300E and 400E.

① Two (2) 300 E ampere fuse refills used in parallel with 10% derating factor.
② Two (2) 400 E ampere fuse refills used in parallel with 10% derating factor.

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Fuse Selection

Voltage Rating

The first rule regarding fuse selection is that the maximum line to line voltage of the system must not exceed the maximum design voltage of the fuse regardless of the system grounding conditions. The fuse voltage rating, on the other hand, is permitted to exceed the system voltage by any desired amount.

Continuous Current Rating

Power fuses are designed so that they can carry their rated current continuously without exceeding the temperature rises permitted by applicable NEMA and USASI Standards. In the majority of applications, however, the rated load current of the equipment which they are to protect should not be allowed to equal the current rating of the fuse. This is because fuses, having a rather low thermal capacity, cannot carry overloads of the same magnitude and duration as transformers of equal continuous current rating. E ampere ratings for RBA-RDB 200-400 are listed in Table A.

Note:
E – Ratings are defined by NEMA and USASI standards. See page 1.

Frequency Ratings

All RBA-RDB fuses may be applied at full interrupting rating on 50 or 60 cycle systems. Interrupting ratings are reduced when fuses are used on 25 cycle systems. Refer to Power Switching Equipment, East Pittsburgh for derating factor.

Interrupting Ratings

The rated interrupting capacity of power fuses is the RMS symmetrical value (Ac component) of the highest current which the fuse is able to interrupt under any condition of asymmetry. In other words, the interrupting rating denotes the maximum symmetrical fault current permitted at the fuse location.

The accepted asymmetry factor for power fuses is 1.6. The RMS asymmetrical amperes may be converted to the symmetrical value by dividing by 1.6. RBA-RDB 200 fuses have a lower interrupting rating than the RBA-RDB-400. Interrupting ratings for these fuses are listed in Table B.

Three phase kva ratings corresponding to the fuse interrupting ratings are calculated by the formula I x Kv x 1.73 where I is the interrupting current in symmetrical RMS amperes and kv is the system line-to-line voltage. Three phase kva interrupting ratings are also listed in Table B.

Table B: RBA-RDB Interrupting Ratings

Voltage		RBA Indoor Fuse Holder with Discharge Filter			RBA Indoor Fuse Holder with Condenser			RDB Outdoor Fuse Holder Vented			Recovery Frequency in Khz	
Nominal Kv	Max. Design Kv	Amps Sym	Amps Asym	3-Phase Sym Kva	Amps Sym	Amps Asym	3-Phase Sym Kva	Amps Sym	Amps Asym	3-Phase Sym Kva	Primary Fault①	Secondary Fault①
RBA-RDB-200												
2.4	2.75	19000	30000	80000	10000	16000	42000	19000	30000	80000	9.0	26.0
4.16	4.8	19000	30000	137000	10000	16000	72000	19000	30000	137000	9.0	26.0
4.8	5.5	19000	30000	158000	10000	16000	83000	19000	30000	158000	9.0	26.0
7.2	8.25	16600	26500	205000	10000	16000	125000	16600	26500	205000	9.0	26.0
13.8	14.4	14400	23000	345000	8000	12800	191000	14400	23000	345000	5.5	17.4
14.4	15.5	14400	23000	360000	8000	12800	200000	14400	23000	360000	5.5	17.4
23.0	25.5	10500	16800	420000	6300	10100	250000	10500	16800	420000	4.2	13.0
34.5	38.0	6900	11100	410000	5000	8000	300000	6900	11100	410000	4.3	8.3
RBA-RDB-400②												
2.4	2.75	37500	60000	150000	20000	32000	84000	37500	60000	150000	9.0	26.0
4.16	4.8	37500	60000	270000	20000	32000	144000	37500	60000	270000	9.0	26.0
4.8	5.5	37500	60000	310000	20000	32000	166000	37500	60000	310000	9.0	26.0
7.2	8.25	29400	47000	365000	16000	25600	200000	29400	47000	365000	9.0	26.0
13.8	14.4	29400	47000	700000	12500	20000	300000	29400	47000	700000	5.5	17.4
14.4	15.5	29400	47000	730000	12500	20000	312000	29400	47000	730000	5.5	17.4
23.0	25.5	21000	33500	840000	10000	16000	400000	21000	33500	840000	4.2	13.0
34.5	38.0	16800	26800	1000000	10000	16000	600000	16800	26800	1000000	4.3	8.3

① Amplitude factor equals 1.6.
② Use these ratings for RBA-RDB 800.

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Asymmetry Factor
The asymmetry factor is the ratio between the rms values of the asymmetrical current, which includes a dc component, and that of the symmetrical current. The theoretical maximum of the asymmetry factor is 1.73. With the X/R ratios encountered in power circuits, it is hardly ever more than 1.6.

Melting Time
The minimum melting time of a particular fuse unit is the minimum amount of time in seconds required to melt the fuse elements at a particular value of symmetrical current under specified conditions.

Arcing Time
The fuse arcing time is the amount of time in cycles elapsing from the melting of the fuse element to the final interruption of the circuit.

Clearing Time
The total clearing time is the maximum amount of time in seconds, measured from the beginning of a particular overcurrent condition, to complete interruption of the circuit. The total clearing time is the sum of the arcing time and melting time.

Transient Recovery Voltages
Westinghouse power fuses are designed to protect against both primary and secondary faults. Short circuits on the secondary side of a power transformer will produce lower values of fault current because of the limiting effect of the transformer impedance. This same transformer impedance, however, determines the resonant, or natural frequency at which the recovery voltage oscillates as the circuit is interrupted. The frequency of this oscillation, and the amplitude factor, determine the transient recovery voltage (TRV) conditions for the fuse.

Primary faults, that is, short circuits at the bus or on the primary side of the transformer, will produce severe maximum short circuit currents. This type of fault has a lower TRV, but a much greater energy input to the fuse. Primary faults establish the maximum interrupting rating which can be put on the devices.

The different parameters for primary and secondary faults are recognized by Westinghouse in the testing of power fuses. The International Electro-technical Commission (IEC) Recommended Standards for High Voltage Expulsion Fuse and similar fuses has proposed values of natural frequency and amplitude factor. All ratings of Westinghouse RBA-RDB fuses have been tested at values more severe than those given in the IEC Standards. Table "B" lists the various TRV natural frequencies and amplitude factor.

Amplitude Factor
Amplitude factor is defined as the highest peak value of the transient recovery voltage to the peak value of the power frequency (60 cycle) recovery voltage. Due to the transformer impedance characteristics, the TRV conditions for secondary faults are more severe than for primary faults.

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Transformer Protection

Fuses in the primary of a power transformer should not blow on transformer magnetizing or inrush current, nor should they blow or deteriorate under long duration overloads to which the transformer is subjected in normal service and in cases of emergency.

On the other hand, they must protect the transformer against short circuits. These considerations usually determine the upper and lower limit of the fuse rating. The coordination with other protective devices on the system often further limits the range. In general, the "fuse rating to load current" ratio determines the fuse rating which should be selected.

In the routine process of applying fuses on the basis of the kva rating of a transformer, one assumes that adequate secondary protection is provided. The ordinary procedure then is to employ a fuse rating that does not blow nor is its structure damaged by overheating due to any inrush or overload current which the transformer permits and can carry safely. Based on transformer characteristics as known from standards, one arrives at the following minimum fuse ratings to transformer full load current ratings.

Ratio of fuse rating to transformer full load rating for RBA-RDB is: 1.4:1. (see appendix # 1 of AD 36-660, page 12)

These ratios are based on the emergency overloads to which transformers may be subjected in accordance with data presented in ASA appendix C57.92.

If provisions are made, by thermal relays or otherwise, to limit transformer overloads to a lower range, the fuse-to-load ratio can be reduced below the values indicated below. It must be remembered that:

a. Under no condition must the fuse current rating be allowed to be less than the continuous load current.

b. No E-rated fuse can provide any protection between the range of one and two times the continuous load current.

c. With forced-cooled transformers, coordination must be based on the higher continuous current rating. Ratios of fuse rating to transformer full load rating forced cooled are: 1.2:1.

Table "C" lists the E-Ampere rating of fuses that can be applied based on KVA and Full Load Current using the 1.4:1 ratio. The table below indicates a fuse size which is satisfactory from the standpoint of inrush current and normal transformer over-loading practices. The E-Ampere rating suggested does not relieve the user of the problem of properly coordinating the fuses with other switchgear and protective devices.

The RBA-RDB 200 and 400 fuse refills overlap in some E-Ampere ratings, so required interrupting rating should be the determining factor in selecting the proper fuse. Interrupting ratings are listed in Table B.

Table C: Fuse Current Ratings For Power Transformers, Type RBA-RDB-200-400 Fuse Refills

System Kv	2.4		4.16		4.8		7.2		12.0		13.2		13.8	
Fuse Kv	7.2		7.2		7.2		7.2		14.4		14.4		14.4	
Transformer Kva Rating Self-Cooled	Full Load Current Amps	Fuse E-Ampere Rating	Full Load Current Amps	Fuse E-Ampere Rating	Full Load Current Amps	Fuse E-Ampere Rating	Full Load Current Amps	Fuse E-Ampere Rating	Full Load Current Amps	Fuse E-Ampere Rating	Full Load Current Amps	Fuse E-Ampere Rating	Full Load Current Amps	Fuse E-Ampere Rating
Three Phase Transformers														
9	2.16	3E	1.25	3E	1.1	3E	0.72	3E	0.43	3E	0.40	3E	0.38	3E
15	3.6	5E	2.08	3E	1.8	3E	1.2	3E	0.72	3E	0.66	3E	0.62	3E
30	7.2	10E	4.2	7E	3.6	5E	2.4	5E	1.44	3E	1.32	3E	1.25	3E
45	10.8	15E	6.2	10E	5.4	10E	3.6	5E	2.16	3E	1.98	3E	1.88	3E
75	18	25E	10.4	15E	9.0	15E	6.0	10E	3.60	5E	3.30	5E	3.1	5E
112.5	27	40E	15.6	25E	13.6	20E	9	15E	5.4	10E	4.95	7E	4.7	7E
150	36	50E	20.8	30E	18.0	25E	12	20E	7.2	10E	6.56	10E	6.2	10E
225	54	80E	31.3	50E	27.2	40E	18	25E	10.8	15E	9.9	15E	9.4	15E
300	72	100E	41.6	65E	36.0	50E	24	40E	14.4	20E	13.1	20E	12.5	20E
500	120	200E	69.4	100E	60	100E	40	65E	24.1	40E	21.9	30E	21.0	30E
750	180	250E	104	150E	90	125E	60	100E	36.1	50E	32.8	50E	31	50E
1000	241	400E	140	200E	120	200E	80	125E	48.1	80E	43.7	65E	42	65E
1500	360	540E①	208	300E	180	250E	120	200E	72.0	100E	65.6	100E	62	100E
2000	481	720E②	278	400E	241	400E	160	250E	96.2	150E	87.5	125E	84	125E
2500	600	....	346	540E①	301	540E①	200	300E	120.0	200E	109	150E	104	150E
3750	....	....	....	....	....	....	....	....	180.0	250E	165	250E	156	250E
5000	....	....	....	....	....	....	....	....	241.0	400E	218	300E	210	300E
Single Phase Transformers														
5	2.08	3E	1.20	3E	1.04	3E	0.695	3E	0.416	3E	0.38	3E	0.362	3E
10	4.17	7E	2.40	5E	2.08	3E	1.39	3E	0.832	3E	0.76	3E	0.724	3E
15	6.25	10E	3.60	5E	3.13	5E	2.08	3E	1.25	3E	1.14	3E	1.085	3E
25	10.4	15E	6.0	10E	5.2	10E	3.47	5E	2.08	3E	1.90	3E	1.81	3E
37.5	15.6	25E	9.0	15E	7.8	10E	5.21	10E	3.12	5E	2.84	5E	2.71	5E
50	20.8	30E	12.0	20E	10.4	15E	6.95	10E	4.16	7E	3.80	5E	3.62	5E
75	31.3	50E	18.0	25E	15.6	25E	10.4	15E	6.25	10E	5.7	10E	5.43	10E
100	41.7	65E	24.0	40E	20.8	30E	13.9	20E	8.32	15E	7.6	15E	7.24	10E
167	70	100E	40.0	65E	35.0	50E	23.2	40E	13.9	20E	12.7	20E	12.1	20E
250	104	150E	60.0	100E	52.0	80E	34.8	50E	20.8	30E	19.0	30E	18.1	25E
333	139	200E	80	125E	69.5	100E	46.3	65E	27.7	40E	25.2	40E	24.1	40E
500	208	300E	120	200E	104	150E	69.6	100E	41.6	65E	38.0	65E	36.2	50E
667	278	400E	160	250E	139	200E	92.6	150E	55.4	80E	50.5	80E	48.2	80E
833	347	540E①	200	300E	173	250E	115.5	150E	69.4	100E	63.5	100E	60.4	100E
1250	521	720E②	300	540E①	260	400E	174	250E	104	150E	95.0	150E	90.6	125E

① Two (2) 300 E Ampere fuse refills used in parallel with 10% derating factor ② Two (2) 400 E Ampere fuse refills used in parallel with 10% derating factor

Note: See Application Data 36-664-A for melting and total clearing time current curves.

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