

# ELECTRICAL DATA SHEET

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## 1. RATING DETAILS

1.1	Frame size	BDAX 62-170R
1.2	Terminal voltage	13.80 kV
1.3	Frequency	60 Hz
1.4	Speed	3600 RPM
1.5	Altitude	up to 1000 m
1.6	Applicable national standard	ANSI C50.14
1.7	Rated air inlet temperature	15.0 °C
1.8	Rated output	27.400 MW, 32.235 MVA
1.9	Power factor	0.850
1.10	Rated stator line current	1348 Amps
1.11	Generator air flow	10.0 m <sup>3</sup> /sec

## 2. PERFORMANCE CURVES

2.1	Output vs air inlet temperature	H.E.P. 16058
2.2	Reactive capability diagram	H.E.P. 16059
2.3	Efficiency vs output	H.E.P. 16060
2.4	Open and Short circuit curves	H.E.P. 16061
2.5	Permitted duration of negative sequence current	H.E.P. 1216
2.6	Exciter Saturation	H.E.P. 8180

## 3. NEGATIVE SEQUENCE CAPABILITY

3.1	Max short time negative sequence $I_2^2 t$	30
3.2	Max continuous $I_2$ unbalance	15

The electrical details provided are calculated values. Unless otherwise stated, all values are subject to tolerances as given in the relevant national standards.  
The rotor inertia value may vary slightly with generator/turbine interface. In the event of conflict, the figure quoted on the rotor geometry drawing takes precedence

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**ELECTRICAL DATA SHEET - CONTINUATION**

BDAX 62-170R , 27.400 MW, 0.850 pf, 13.80 kV, 60 Hz

**4. REACTANCE AND SEQUENCE RESISTANCES****A) Direct Axis Reactances:**

4.1	Unsaturated Synchronous reactance, $X_{d(i)}$	257 %
4.2	Saturated transient reactance, $X'_{d(v)}$	24.8 %
4.3	Unsaturated transient reactance, $X'_{d(i)}$	28.7 %
4.4	Saturated subtransient reactance, $X''_{d(v)}$	17.2 %
4.5	Unsaturated subtransient reactance, $X''_{d(i)}$	21.0 %
4.7	Saturated negative sequence reactance, $X_{2(v)}$	16.8 %
4.7	Unsaturated negative sequence reactance, $X_{2(i)}$	20.5 %
4.8	Zero sequence reactance, $X_0$	10.5 %
4.9	Potier reactance, $X_p$	24.4 %
4.10	Saturated stator leakage, $X_{sl(v)}$	11.0 %
4.11	Unsaturated stator leakage, $X_{sl(i)}$	16.1 %

**B) Quadrature Axis Reactances:**

4.12	Saturated Synchronous reactance, $X_{q(v)}$	180 %
4.13	Unsaturated Synchronous reactance, $X_{q(i)}$	235 %
4.14	Saturated transient reactance, $X'_{q(v)}$	29.7 %
4.15	Unsaturated transient reactance, $X'_{q(i)}$	41.0 %
4.16	Saturated subtransient reactance, $X''_{q(v)}$	20.8 %
4.17	Unsaturated subtransient reactance, $X''_{q(i)}$	25.0 %

**C) Sequence resistances:**

4.18	Positive sequence resistance, $R_1$	0.0082 p.u at 75 °C
4.19	Negative sequence resistance, $R_2$	0.0371 p.u at 75 °C
4.20	Zero sequence resistance, $R_0$	0.0123 p.u at 75 °C

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**ELECTRICAL DATA SHEET - CONTINUATION**

BDAX 62-170R , 27.400 MW, 0.850pf, 13.80 kV, 60 Hz

**5. TIME CONSTANTS AT 20°C****A) Direct Axis:**

5.1	Transient O.C time constant, $T'_{do}$	7.64 seconds
5.2	Transient S.C time constant, 3 ph, $T'_{d3}$	0.59 seconds
5.3	Transient S.C time constant, L-L, $T'_{d2}$	1.16 seconds
5.4	Transient S.C time constant, L-N, $T'_{d1}$	1.40 seconds
5.5	Subtransient O.C time constant, $T''_{do}$	0.05 seconds
5.6	Subtransient S.C time constant, 3 ph, $T''_{d3}$	0.04 seconds
5.7	Subtransient S.C time constant, L-L, $T''_{d2}$	0.04 seconds
5.8	Subtransient S.C time constant, L-N, $T''_{d1}$	0.04 seconds

**B) Quadrature Axis:**

5.9	Transient O.C time constant, $T'_{qo}$	2.33 seconds
5.10	Transient S.C time constant, 3 ph, $T'_{q3}$	0.29 seconds
5.11	Transient S.C time constant, L-L, $T'_{q2}$	0.43 seconds
5.12	Transient S.C time constant, L-N, $T'_{q1}$	0.51 seconds
5.13	Subtransient O.C time constant, $T''_{qo}$	0.05 seconds
5.14	Subtransient S.C time constant, 3 ph, $T''_{q3}$	0.04 seconds
5.15	Subtransient S.C time constant, L-L, $T''_{q2}$	0.04 seconds
5.16	Subtransient S.C time constant, L-N, $T''_{q1}$	0.04 seconds

**C) Miscellaneous:**

5.17	D.C Armature time constant, 3 ph, $T_{a3}$	0.18 seconds
5.18	D.C Armature time constant, L-L, $T_{a2}$	0.18 seconds
5.19	D.C Armature time constant, L-N, $T_{a1}$	0.16 seconds

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**ELECTRICAL DATA SHEET - CONTINUATION**BDAX 62-170R . 27.400 MW, 0.850 pf, 13.80 kV, 60 Hz**6. SHORT CIRCUIT RATIO**

6.1	Short circuit ratio	0.44
6.2	Saturation factor	1.84

**7. INERTIA**

7.1	Moment of inertia, $WR^2$	340 kg.m <sup>2</sup>
7.2	Inertia constant, H	0.75 kWsecs/KVA

**8. EXCITATION****A) No load (cold):**

8.1	Excitation current at no load, rated voltage	283 amps
8.2	Excitation voltage at no load, rated voltage	28 volts
8.3	Exciter field current at no load	2.0 amps
8.4	Exciter field voltage at no load	8 volts

**B) Rated load (hot):**

8.5	Excitation current at rated load and P.F	889 amps
8.6	Excitation voltage at rated load and P.F	126 volts
8.7	Exciter field current at rated load and P.F	6.0 amps
8.8	Exciter field voltage at rated load and P.F	34 volts

**C) Short circuit clearance of 2.5 p.u rated line amps (hot):**

8.9	Excitation current on clearance	1601 amps
8.10	Excitation voltage on clearance	228 volts
8.11	Exciter field current on clearance	13.5 amps
8.12	Exciter field voltage on clearance	78 volts

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**ELECTRICAL DATA SHEET - CONTINUATION**BDAX 62-170R . 27.400 MW, 0.850 pf, 13.80 kV, 60 Hz**9. INHERENT VOLTAGE REGULATION**

9.1	F.L to N.L rated pf, constant excitation	44 %
9.2	F.L to N.L unity pf, constant excitation	31 %
9.3	F.L to N.L steady state under full AVR control	± 0.5 %

**10. EFFICIENCY AND LOSSES**

These losses below are calculated values. The total loss and the resulting efficiencies are subject to a tolerance in accordance with IEC 34-1.

MW output	27.400	27.400
Power factor	0.850	Unity
Friction & windage loss(kW)	119	119
Stator core iron loss(kW)	67	67
Stator copper loss at 95°C(kW)	102	74
Stray load loss at 95°C(kW)	188	135
Rotor copper loss at 95°C(kW)	103	50
Exciter loss(kW)	7	3
Total loss(kW)	588	450

**Efficiencies:**

% load	100	75	50	25
0.850 power factor	97.90 %	97.99 %	97.85 %	96.79 %
Unity power factor	98.38 %	98.37 %	98.13 %	96.98 %

**11. CAPACITANCE AND SURGE IMPEDANCE**

11.1	Capacitance per phase of stator winding to earth	0.10 Microfarad
11.2	Surge impedance per phase	324 Ohms

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## BRUSH ELECTRICAL MACHINES LTD

# ELECTRICAL DATA SHEET - CONTINUATION

BDAX 62-170R . 27.400 MW, 0.850 pf, 13.80 kV, 60 Hz

### 12. RESISTANCES AT 20°C

12.1	Stator resistance per phase	0.0144 ohms
12.2	Rotor resistance	0.101 ohms
12.3	Exciter armature resistance per phase	0.00114 ohms
12.4	Exciter field resistance	4.17 ohms
12.5	Pilot exciter resistance	0.088 ohms

### 13. EXCITER

13.1	Exciter frame size	BX 10.13
13.2	Voltage rating	139 Volts D.C
13.3	Current rating	978 Amps D.C
13.4	Output	136 kW
13.5	Frequency	180 Hz
13.6	AC voltage at full load	130 Volts RMS
13.7	AC current at full load	672 Amps RMS
13.8	Power factor	0.74
13.9	Number of phases	3
13.10	Response ratio	2.9 Secs <sup>-1</sup>

### 14. ROTATING RECTIFIER

14.1	Number of diodes	12
14.2	Arrangement	3 ph full wave bridge; 6 arms; 2 fused diodes in parallel per arm.
14.3	Diode Repetitive peak reverse voltage	2000 Volts
14.4	Diode rated mean forward current	330 Amps
14.5	Diode mean forward current at rated load	148 Amps
14.6	Diode reverse voltage at rated load	126 Volts
14.7	Fuse rating	450 Amps

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## BRUSH ELECTRICAL MACHINES LTD

# ELECTRICAL DATA SHEET - CONTINUATION

BDAX 62-170R , 27.400 MW, 0.850 pf, 13.80 kV, 60 Hz

### 15. PERMANENT MAGNET PILOT EXCITER

15.1	Pilot exciter frame size	MXI 44.07
15.2	Open circuit volts	270 Volts
15.3	Full load voltage	264 Volts
15.4	Full load current	3.0 Amps
15.5	Power factor	0.26
15.6	Rated frequency	480 Hz
15.7	Number of phases	1

### 16. INSTANTANEOUS INITIAL FAULT CURRENTS

16.1	3 ph symmetrical fault from no load	7850 Amps RMS
16.2	L-L symmetrical fault from no load	6900 Amps RMS
16.3	L-N symmetrical fault from no load	9150 Amps RMS

### 17. MISCELLANEOUS GENERATOR DATA

17.1	X/R ratio	58
17.2	Synchronising coefficient	38 MW/radian
17.3	No load synchronising power	13 MW/radian
17.4	Full load synchronising power	30 MW/radian
17.5	Damping torque coefficient	15
17.6	Magnetic centering force for an axial displacement of 20mm	826 kg
17.7	Motoring power	197 kW
17.8	Anti-condensation space heaters approximate power rating	4 kW
17.9	Generator air outlet temperature	64 °C

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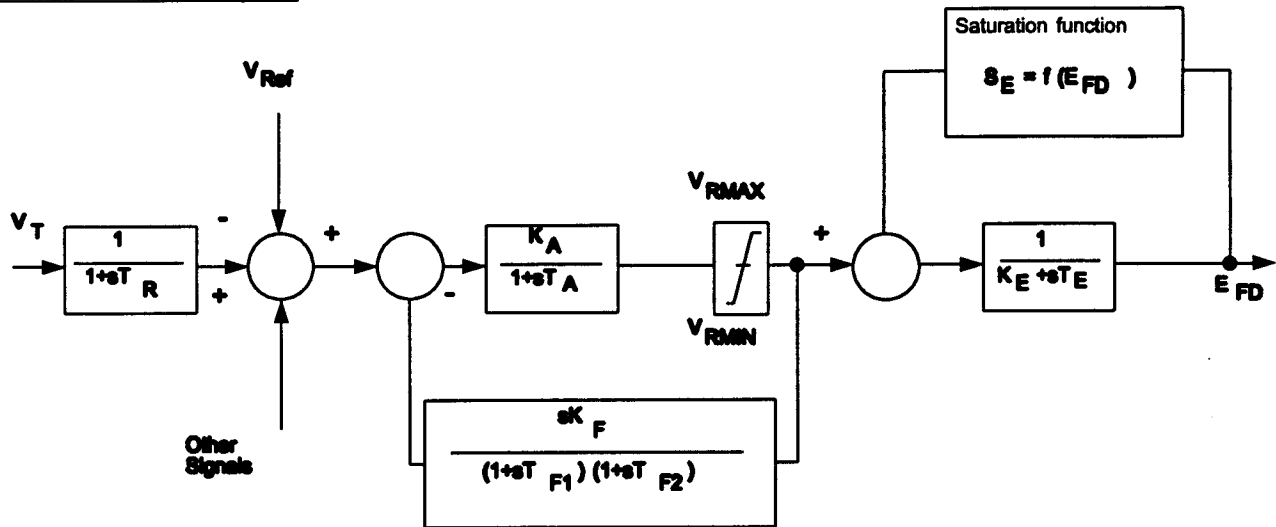
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## TYPE 2 BRUSHLESS EXCITATION SYSTEM INCORPORATING AN AUTOMATIC VOLTAGE REGULATOR

Reference no	03680	Rating	27.4 MW, 0.85 pf	Supply	13.80 kV, 60Hz
Frame sizes	Generator	BDAX 62-170R	Exciter	BX 10.13	Pilot Exciter
					MXI 44.07

The brushless excitation system is a type 2 system as defined in "Computer Representation of Excitation Systems", IEEE PAS 87, June 1968 (paper number 31-TP-67-424).

### Transfer Function Diagram



### Generator / Exciter Parameters

$V_R$	1 per unit exciter field voltage (hot)	3.1	volts
$R_F$	Exciter field resistance	5.5	ohms
$V_{PMG}$	Open circuit pilot exciter output voltage at rated speed	270	volts
$T_E$	Exciter time constant	1.0	sec
$K_E$	Exciter constant	1.0	
$S_{E75}$	Exciter saturation function	2.08	
$S_{E100}$	Exciter saturation function	6.58	

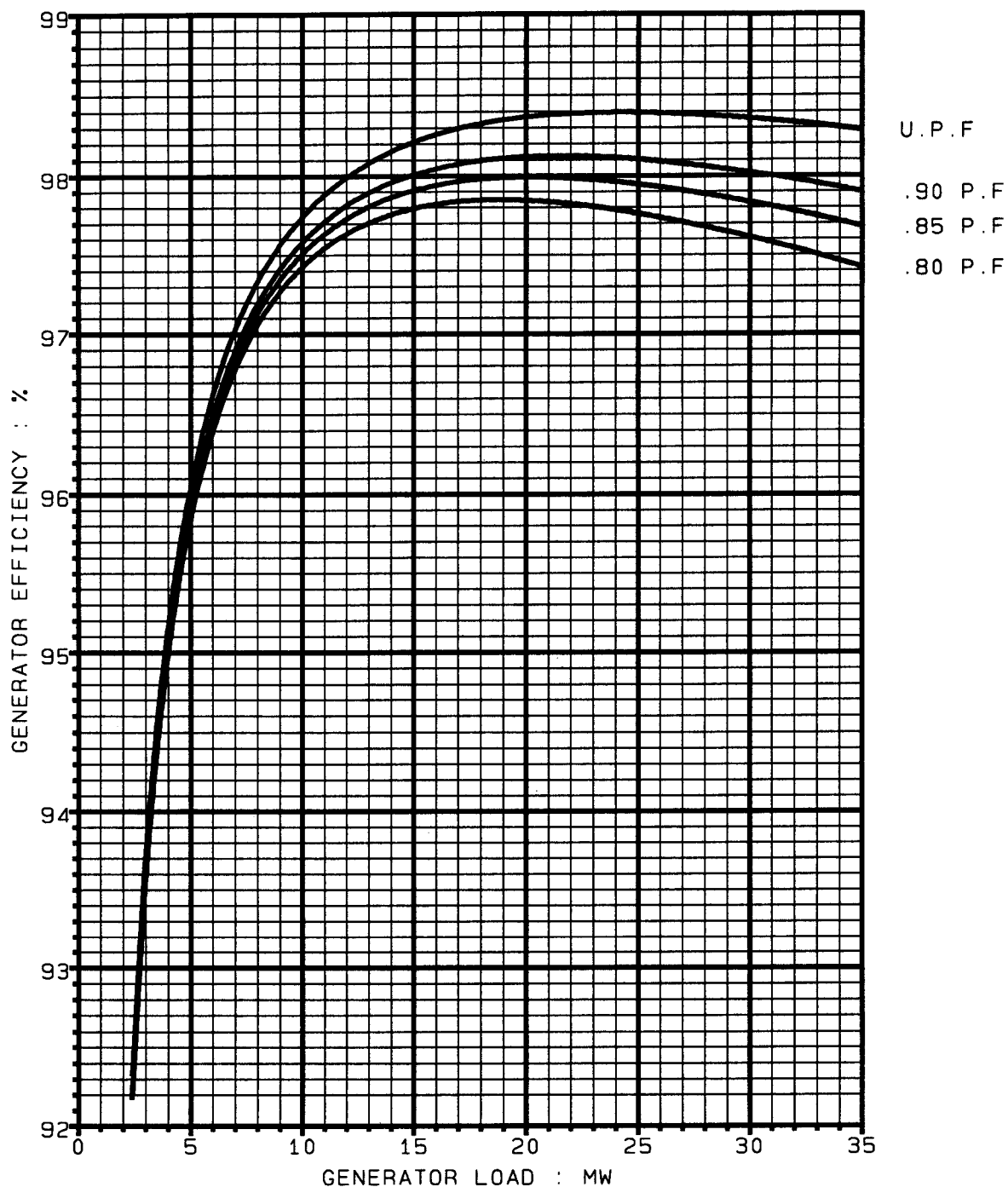
### Automatic Voltage Regulator Parameters

$K_A$	Regulator gain ( $11.6 \times 10^3 / V_R$ )	3751	
$T_A$	Regulator time constant	0.1	sec
$T_R$	Regulator time constant	0.022	sec
$T_{F1}$	Feedback time constant (adjustable in the range 0.05 to 1.0 sec)	0.6	sec
$T_{F2}$	Feedback time constant (equal to $T_E$ )	1.0	sec
$V_{RMIN}$	Minimum regulator output voltage	0.0	per unit
$V_{RMAX}$	Maximum regulator output voltage ( $0.7V_{PMG} / V_R$ )	61	per unit
$K_F$	Feedback gain (adjustable in the range 0 to $0.06 V_R / R_F$ , typically $0.03 V_R / R_F$ )	0.017	*

\* Typical settings



VARIATION OF GENERATOR EFFICIENCY WITH LOAD



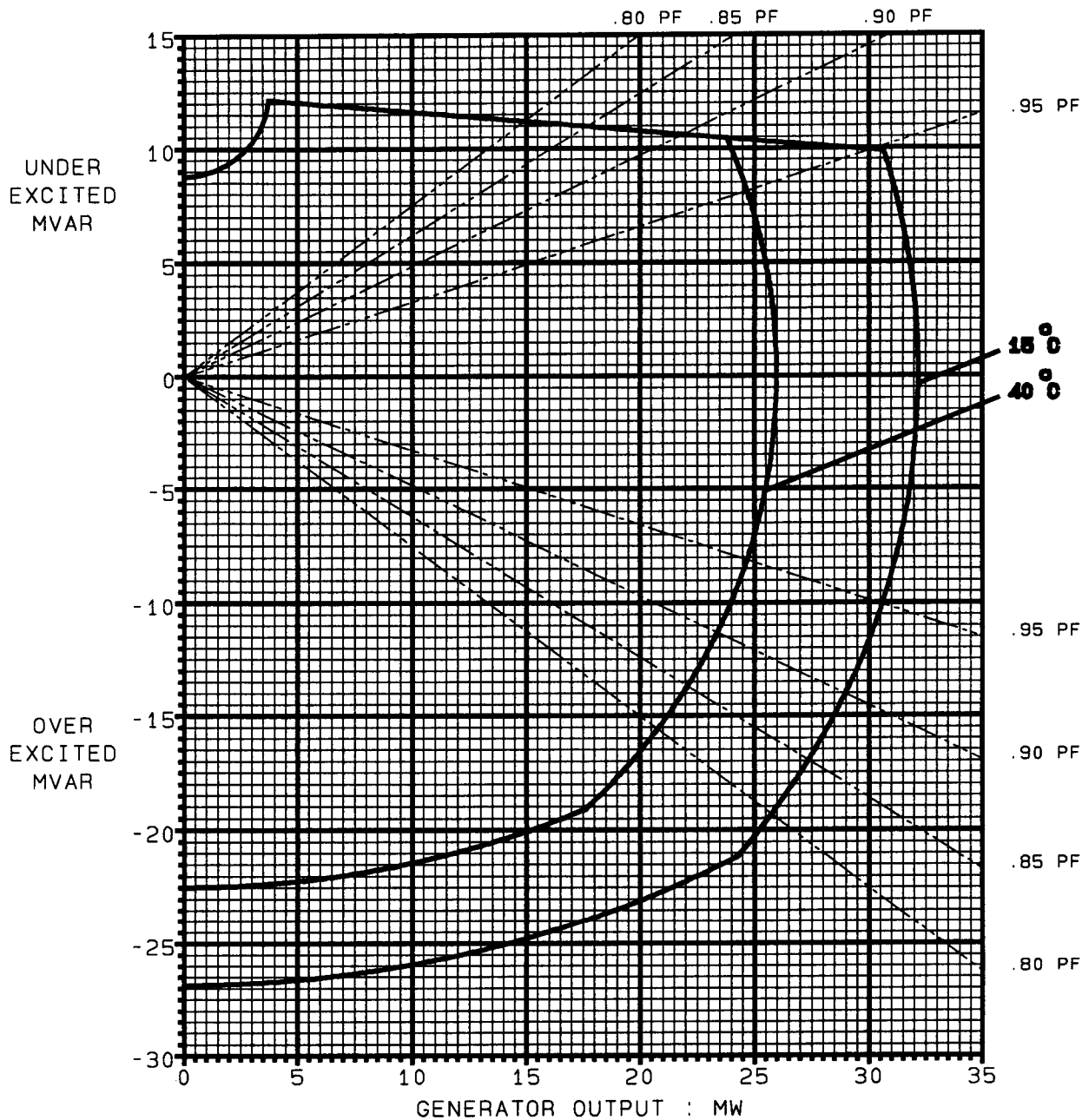
BDAX 62-170R  
13.80KV, 3Ph, 60.Hz.

Efficiencies shown are calculated  
and subject to tolerance as  
I.E.C 34.1

Minimum efficiencies are  
0.1 (100-calculated efficiency)%  
lower.

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GENERATOR CAPABILITY DIAGRAM



BDAX 62-170R  
13.80KV, 3Ph, 60.Hz.

Up to 1000. meters ASL

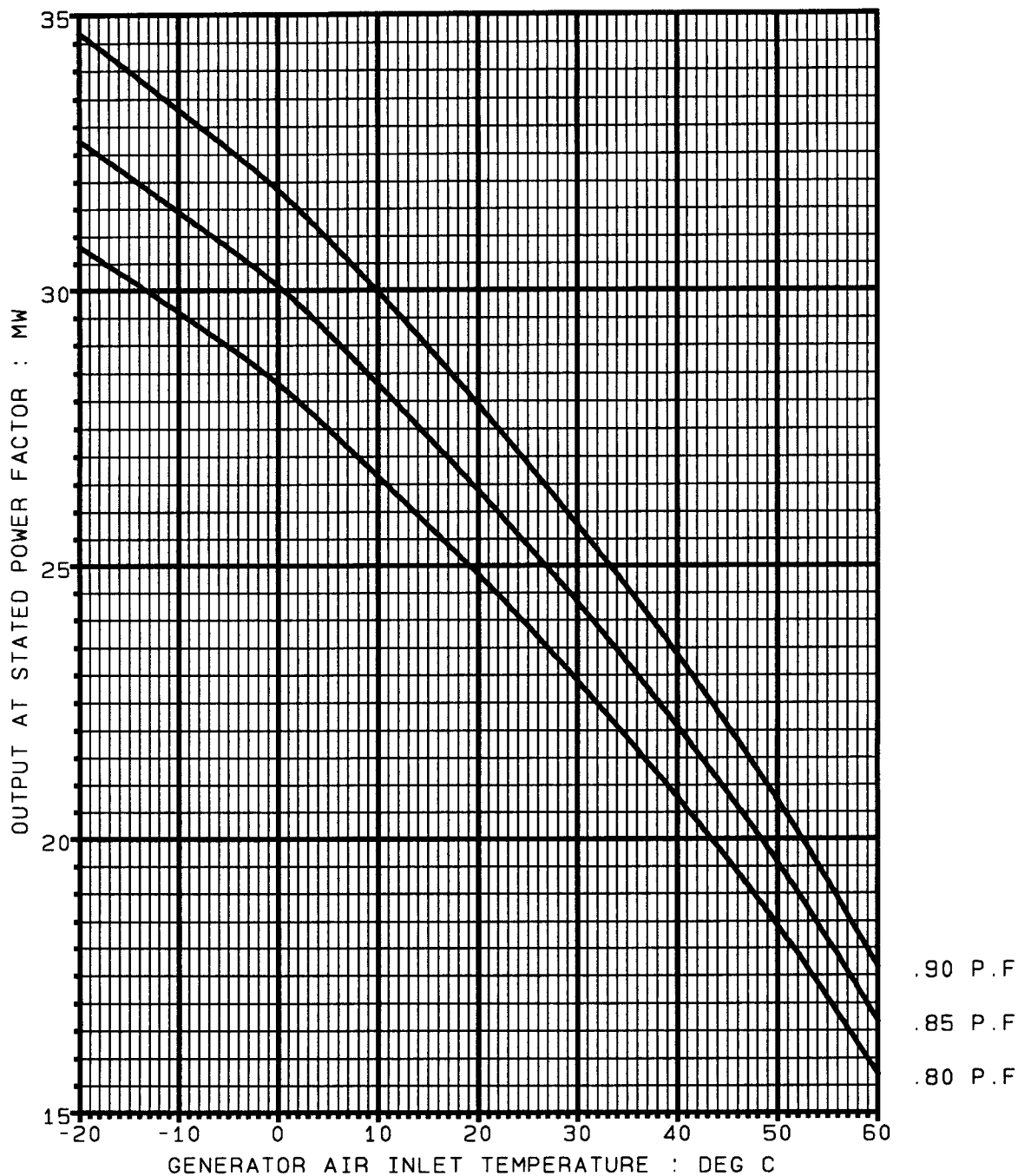
IN ACCORDANCE WITH  
ANSI C50.14.

Class B temperatures.

Total temperatures Stator 110 Deg C  
Rotor 125 Deg C

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VARIATION OF GENERATOR OUTPUT WITH AIR INLET TEMP



BDAX 62-170R  
13.80KV, 3Ph, 60.Hz.

Up to 1000. meters ASL

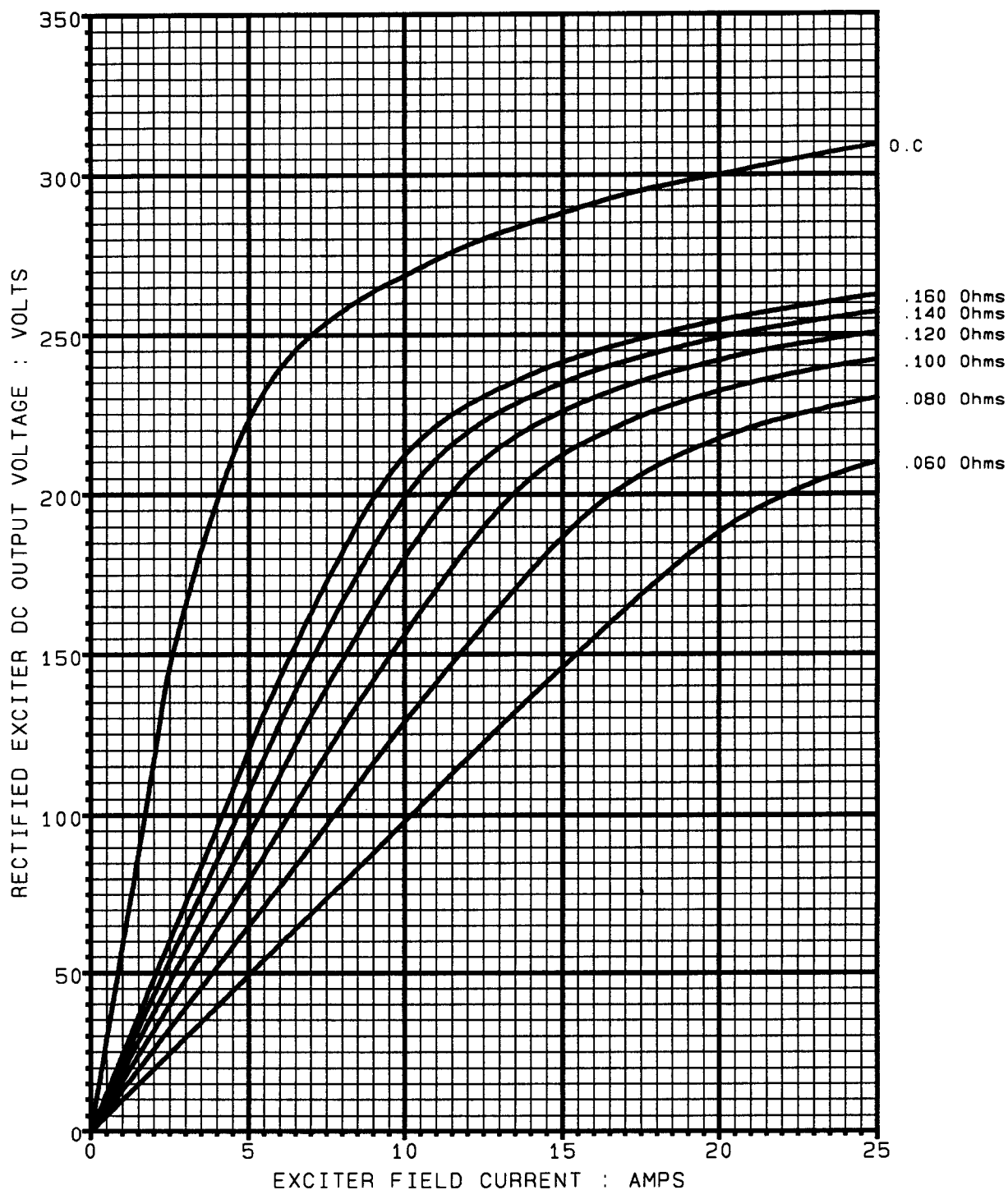
IN ACCORDANCE WITH  
ANSI C50.14.

Class B temperatures.

Total temperatures Stator 110 Deg C  
Rotor 125 Deg C

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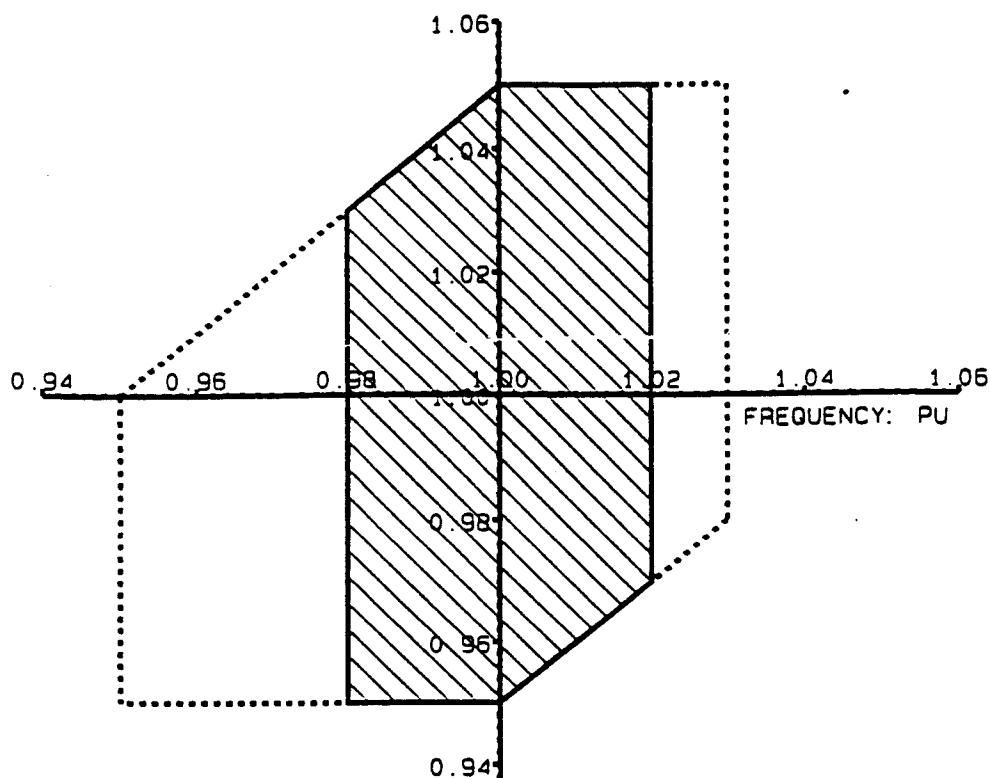
EXCITER OPEN CIRCUIT AND LOADED CHARACTERISTIC



BX 10.13  
3600 RPM, 6 Poles, 180 Hz

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# PERMITTED VOLTAGE AND FREQUENCY VARIATION



Specified temperatures will not be exceeded at rated voltage and frequency. At other operating points within the hatched area, the specified temperatures will be exceeded by up to 10 Degrees C.

Operation is permitted within the dotted areas (temperature rises further increased) but should be limited in extent, duration and frequency of occurrence. Corrective measures should be taken as soon as possible.

## OUTPUT FACTORS FOR CONTINUOUS OPERATION

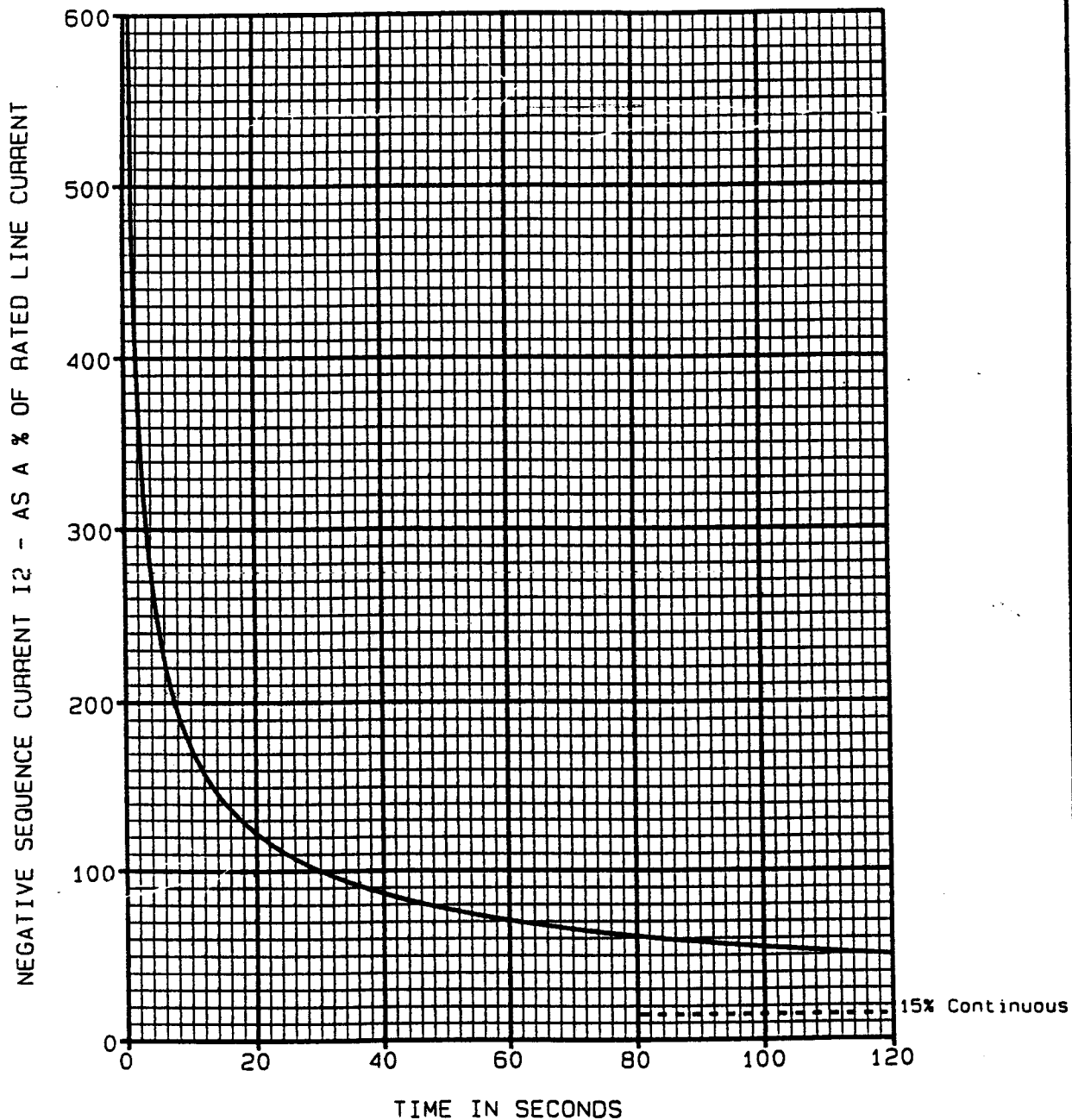
		Voltage: pu			
		0.90	0.95	1.00	1.05
Frequency: pu	1.03	0.95	1.00	1.00	1.00
	1.02	0.95	1.00	1.00	1.00
	1.00	0.95	1.00	1.00	1.00
	0.98	0.93	1.00	1.00	0.98
	0.95	0.90	0.95	0.97	-

This curve applies to all "DAX" Generators.

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PERMISSIBLE DURATION OF NEGATIVE SEQUENCE CURRENT

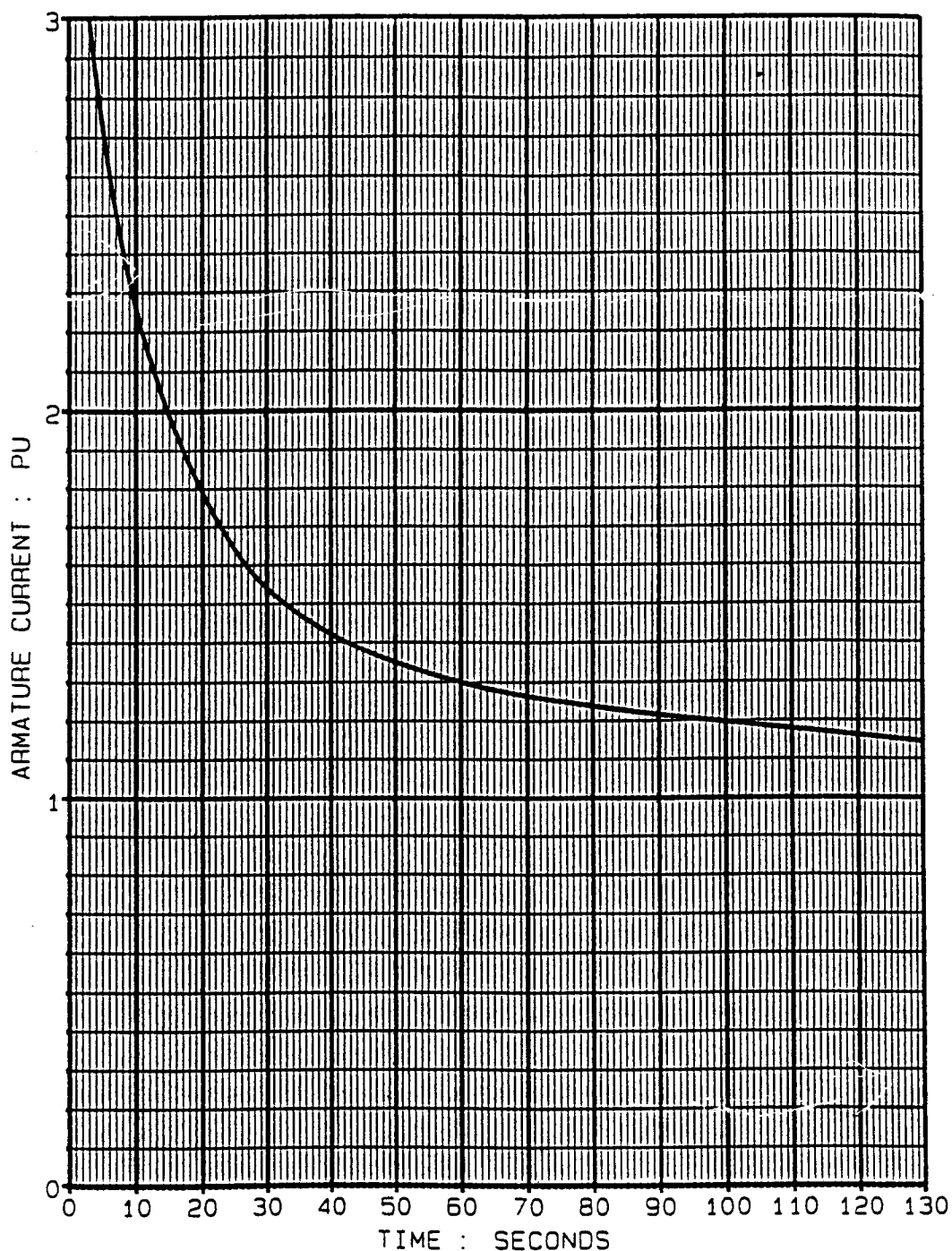
$$\frac{I_2^2}{I^2} t = 30$$



NOTE: For continuous operation  
rated current must not be  
exceeded in any one phase.

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# PERMITTED DURATION OF GENERATOR ARMATURE CURRENT



All DAX Generators

For continuous operation, rated current should not be exceeded in any one phase.

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**“H” Constant – TM2500 60 Hz Generator Set Using BDAX-170 ER**

<b><u>Moment of Inertia</u></b>	<b><u>kg-m<sup>2</sup></u></b>	<b><u>lb-ft<sup>2</sup></u></b>
LM2500 Power Turbine Shaft	71.12	1692
Coupling	11.89	282.87
Brush 170-ER Generator	340	8089
<b><u>Total WR<sup>2</sup></u></b>	<b><u>423 kg-m<sup>2</sup></u></b>	<b><u>10,064 lb-ft<sup>2</sup></u></b>

**“H” Constant:**

$$H = \frac{(2.31 * 10^{-10}) * WR^2 * RPM^2}{MVA \text{ Rating}} = \frac{(2.31 * 10^{-10}) * 10,064 * 3600^2}{32.235 \text{ Rating}} = \underline{\underline{0.935 \text{ kW-sec/kVA}}}$$

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