53.30000	0.005000000
70.00000	0.006000000
90.00000	0.014000000
132.30000	0.020000000
169.20000	0.034000000
197.10000	0.044000000
254.40000	0.064000000
305.70000	0.082000000
365.20000	0.082000000
429.50000	0.090000000
430.00000	0.090000000

- T = 0.02
- Tc = T/1+N25WB

HP ROTOR SPEED DECELERATION LIMIT- NCD REGULATOR

- NCDGN = 0.7595
- NCDWB = 0.1
- T = 0.01
- Tc = T/1+NCDWB

HP ROTOR SPEED ACCELERATION LIMIT - NCA REGULATOR

- NCAGN = 1.519
- NCDWB = 0.05
- T = 0.01
- Tc = T/1+NCAWB

HP TURBINE INLET TEMPERATURE LIMIT - T48 REGULATOR

T48GN = 6.0
T48WB = 0.025

WOODWARD
Industrial Controls

Customer: GE S&S Energy Products
Subject: LM6000 PC Core Fuel Control Dynamic Settings

Date: May 28, 1999
Revision:

T = 0.04
Tc = T/1+T48WB

HP COMPRESSOR DISCHARGE TEMPERATURE LIMIT - T3H REGULATOR

T3HGN = 1.3023
T3HWB = 0.8
T = 0.04
Tc = T/1+T3HWB

HP COMPRESSOR DISCHARGE PRESSURE LIMIT - PS3 REGULATOR

- PS3GN = 28.94
- PS3WB = 0.04
- T = 0.02
- Tc = T/1+PS3WB

BRUSH ELECTRICAL MACHINES LTD

BRUSH
BRUSH ELECTRICAL MACHINES LTD

ELECTRICAL DATA SHEET

P O Box 18, Falcon Works, Loughborough, Leics. LE11 1HJ, England
Telephone: +44 (0) 1509 611511 Telefax: +44 (0) 1509 612345 E-mail: Sales@bem.fki-eng.com

1. RATING DETAILS

1.1	Frame size	BDAX 7-290RT
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	60.500 MW, 71.176 MVA
1.9	Power factor	0.850
1.10	Rated stator line current	2977 Amps
1.11	Generator air flow	21.0 m^3/sec

2. PERFORMANCE CURVES

2.1	Output vs air inlet temperature	H.E.P. 14765
2.2	Reactive capability diagram	H.E.P. 14766
2.3	Efficiency vs output	H.E.P. 14839
2.4	Open and Short circuit curves	H.E.P. 14838
2.5	Permitted duration of negative sequence current	H.E.P. 1216
2.6	Exciter Saturation	H.E.P. 13726

3. NEGATIVE SEQUENCE CAPABILITY

3.1	Max short time negative sequence I^2_2t	30
3.2	Max continuous I_2 unbalance	15

419401

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

Doc: 141937/16/612S/120R
Ref: Standard
Date: 2-Feb-2000

ELECTRICAL DATA SHEET - CONTINUATION

BDAX 7-290RT , 60.500 MW, 0.850 pf, 13.80 kV, 60 Hz

4. REACTANCE AND SEQUENCE RESISTANCES

A) Direct Axis Reactances:

4.1	Unsaturated Synchronous reactance, $X_{d(I)}$	235 %
4.2	Saturated transient reactance, $X'_{d(v)}$	20.0 %
4.3	Unsaturated transient reactance, $X'_{d(I)}$	24.5 %
4.4	Saturated subtransient reactance, $X''_{d(v)}$	14.4 %
4.5	Unsaturated subtransient reactance, $X''_{d(I)}$	18.1 %
4.7	Saturated negative sequence reactance, $X_{2(v)}$	14.1 %
4.7	Unsaturated negative sequence reactance, $X_{2(I)}$	17.6 %
4.8	Zero sequence reactance, X_0	9.5 %
4.9	Potier reactance, X_P	20.8 %
4.10	Saturated stator leakage, $X_{sl(v)}$	8.2 %
4.11	Unsaturated stator leakage, $X_{sl(I)}$	13.0 %

B) Quadrature Axis Reactances:

4.12	Saturated Synchronous reactance, $X_{q(v)}$	168 %
4.13	Unsaturated Synchronous reactance, $X_{q(I)}$	215 %
4.14	Saturated transient reactance, $X'_{q(v)}$	24.0 %
4.15	Unsaturated transient reactance, $X'_{q(I)}$	35.0 %
4.16	Saturated subtransient reactance, $X''_{q(v)}$	17.4 %
4.17	Unsaturated subtransient reactance, $X''_{q(I)}$	21.5 %

C) Sequence resistances:

4.18	Positive sequence resistance, R_1	0.0053 p.u at 75 °C
4.19	Negative sequence resistance, R_2	0.0273 p.u at 75 °C
4.20	Zero sequence resistance, R_0	0.0079 p.u at 75 °C

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.

ELECTRICAL DATA SHEET - CONTINUATION

BDAX 7-290RT , 60.500 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}	9.67 seconds
5.2	Transient S.C time constant, 3 ph, T'_{d3}	0.66 seconds
5.3	Transient S.C time constant, L-L, T'_{d2}	1.32 seconds
5.4	Transient S.C time constant, L-N, T'_{d1}	1.63 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}	2.95 seconds
5.10	Transient S.C time constant, 3 ph, T'_{q3}	0.33 seconds
5.11	Transient S.C time constant, L-L, T'_{q2}	0.49 seconds
5.12	Transient S.C time constant, L-N, T'_{q1}	0.59 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}	0.30 seconds
5.18	D.C Armature time constant, L-L, T_{a2}	0.47 seconds
5.19	D.C Armature time constant, L-N, T_{a1}	0.27 seconds

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 7-290RT , 60.500 MW, 0.850 pf, 13.80 kV, 60 Hz

6. SHORT CIRCUIT RATIO

6.1	Short circuit ratio	0.47
6.2	Saturation factor	1.71

7. INERTIA

7.1	Moment of inertia, WR^2	970 $kg.m^2$
7.2	Inertia constant, H	0.97 kWsecs/KVA

8. EXCITATION

A) No load (cold):

8.1	Excitation current at no load, rated voltage	325 amps
8.2	Excitation voltage at no load, rated voltage	45 volts
8.3	Exciter field current at no load	2.5 amps
8.4	Exciter field voltage at no load	13 volts

B) Rated load (hot):

8.5	Excitation current at rated load and P.F	951 amps
8.6	Excitation voltage at rated load and P.F	185 volts
8.7	Exciter field current at rated load and P.F	6.5 amps
8.8	Exciter field voltage at rated load and P.F	48 volts

C) Short circuit clearance of 3.0 p.u rated line amps (hot):

8.9	Excitation current on clearance	2059 amps
8.10	Excitation voltage on clearance	402 volts
8.11	Exciter field current on clearance	25.0 amps
8.12	Exciter field voltage on clearance	187 volts

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 7-290RT , 60.500 MW, 0.850 pf, 13.80 kV, 60 Hz

9. INHERENT VOLTAGE REGULATION

9.1	F.L to N.L rated pf, constant excitation	35 %
9.2	F.L to N.L unity pf, constant excitation	27 %
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	60.500	60.500
Power factor	0.850	Unity
Friction & windage loss(kW)	305	305
Stator core iron loss(kW)	155	155
Stator copper loss at 95°C(kW)	127	91
Stray load loss at 95°C(kW)	233	168
Rotor copper loss at 95°C(kW)	162	162
Exciter loss(kW)	12	6
Total loss(kW)	995	808

Efficiencies:

% load	100	75	50	25
0.850 power factor	98.38 %	98.31 %	97.99 %	96.67 %
Unity power factor	98.68 %	98.56 %	98.17 %	96.79 %

11. CAPACITANCE AND SURGE IMPEDANCE

11.1	Capacitance per phase of stator winding to earth	0.18 Microfarad
11.2	Surge impedance per phase	94 Ohms

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.

- 419401

ELECTRICAL DATA SHEET - CONTINUATION

BDAX 7-290RT , 60.500 MW, 0.850 pf, 13.80 kV, 60 Hz

12. RESISTANCES AT 20°C

12.1	Stator resistance per phase	0.0033 ohms
12.2	Rotor resistance	0.138 ohms
12.3	Exciter armature resistance per phase	0.00130 ohms
12.4	Exciter field resistance	5.39 ohms
12.5	Pilot exciter resistance	0.088 ohms

13. EXCITER

13.1	Exciter frame size	BX 10.20
13.2	Voltage rating	204 Volts D.C
13.3	Current rating	1047 Amps D.C
13.4	Output	214 kW
13.5	Frequency	180 Hz
13.6	AC voltage at full load	199 Volts RMS
13.7	AC current at full load	717 Amps RMS
13.8	Power factor	0.71
13.9	Number of phases	3
13.10	Response ratio	3.3 $Secs^{-1}$

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	158 Amps
14.6	Diode reverse voltage at rated load	185 Volts
14.7	Fuse rating	450 Amps

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.

ELECTRICAL DATA SHEET - CONTINUATION

BDAX 7-290RT , 60.500 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	263 Volts
15.4	Full load current	3.6 Amps
15.5	Power factor	0.34
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	20700 Amps RMS
16.2	L-L symmetrical fault from no load	18150 Amps RMS
16.3	L-N symmetrical fault from no load	23550 Amps RMS

17. MISCELLANEOUS GENERATOR DATA

17.1	X/R ratio	95
17.2	Synchronising coefficient	86 MW/radian
17.3	No load synchronising power	33 MW/radian
17.4	Full load synchronising power	70 MW/radian
17.5	Damping torque coefficient	16
17.6	Magnetic centering force for an axial displacement of 20mm	797 kg
17.7	Motoring power	480 kW
17.8	Anti-condensation space heaters approximate power rating	4 kW
17.9	Generator air outlet temperature	55 °C

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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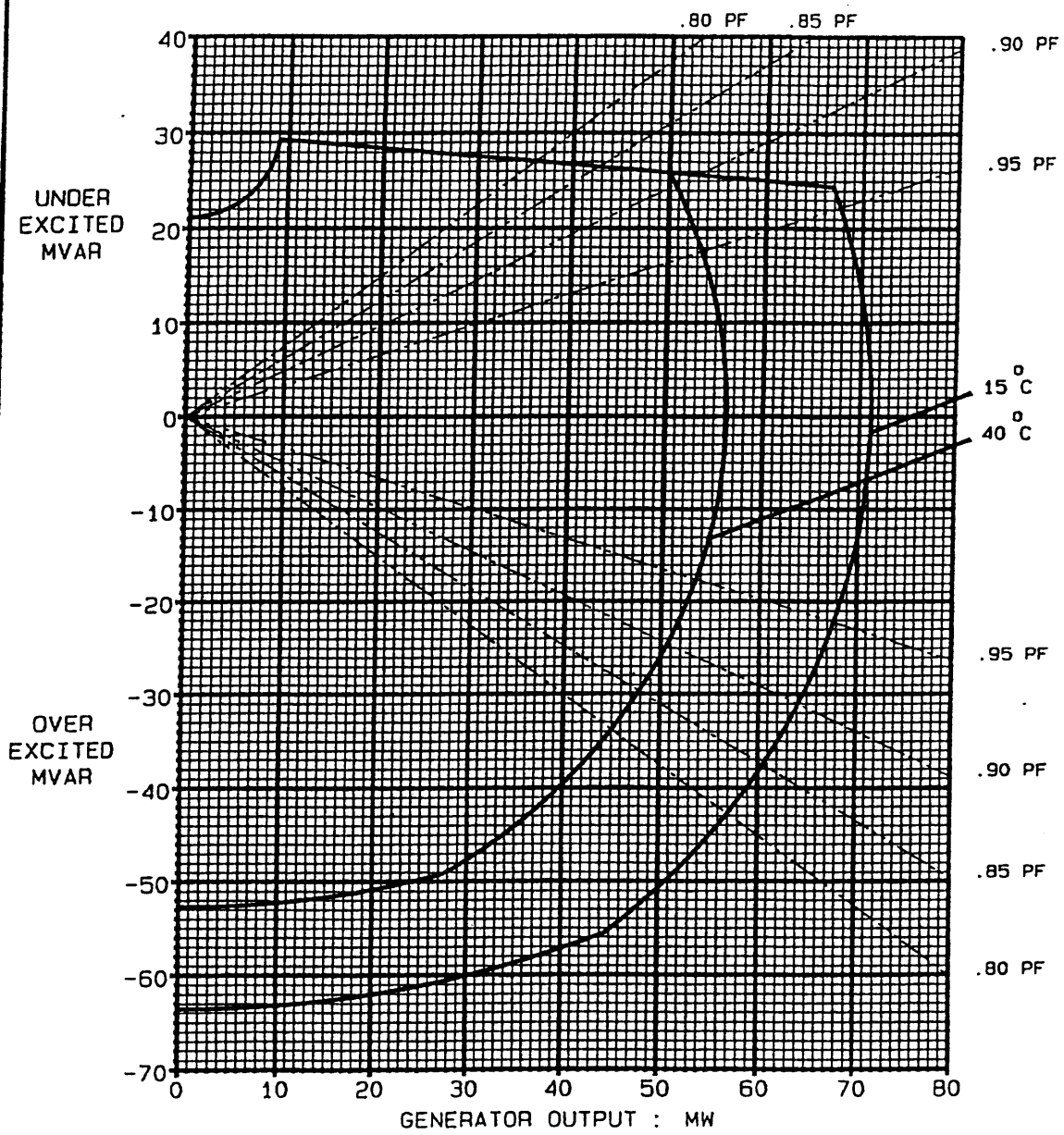
BRUSH ELECTRICAL MACHINES LTD.
(A Hawker Siddeley Company)

H.E.P 14766

GENERATOR CAPABILITY DIAGRAM



BDAX 7.290RT
13.80KV, 3Ph, 60.Hz.

Up to 1000. meters ASL

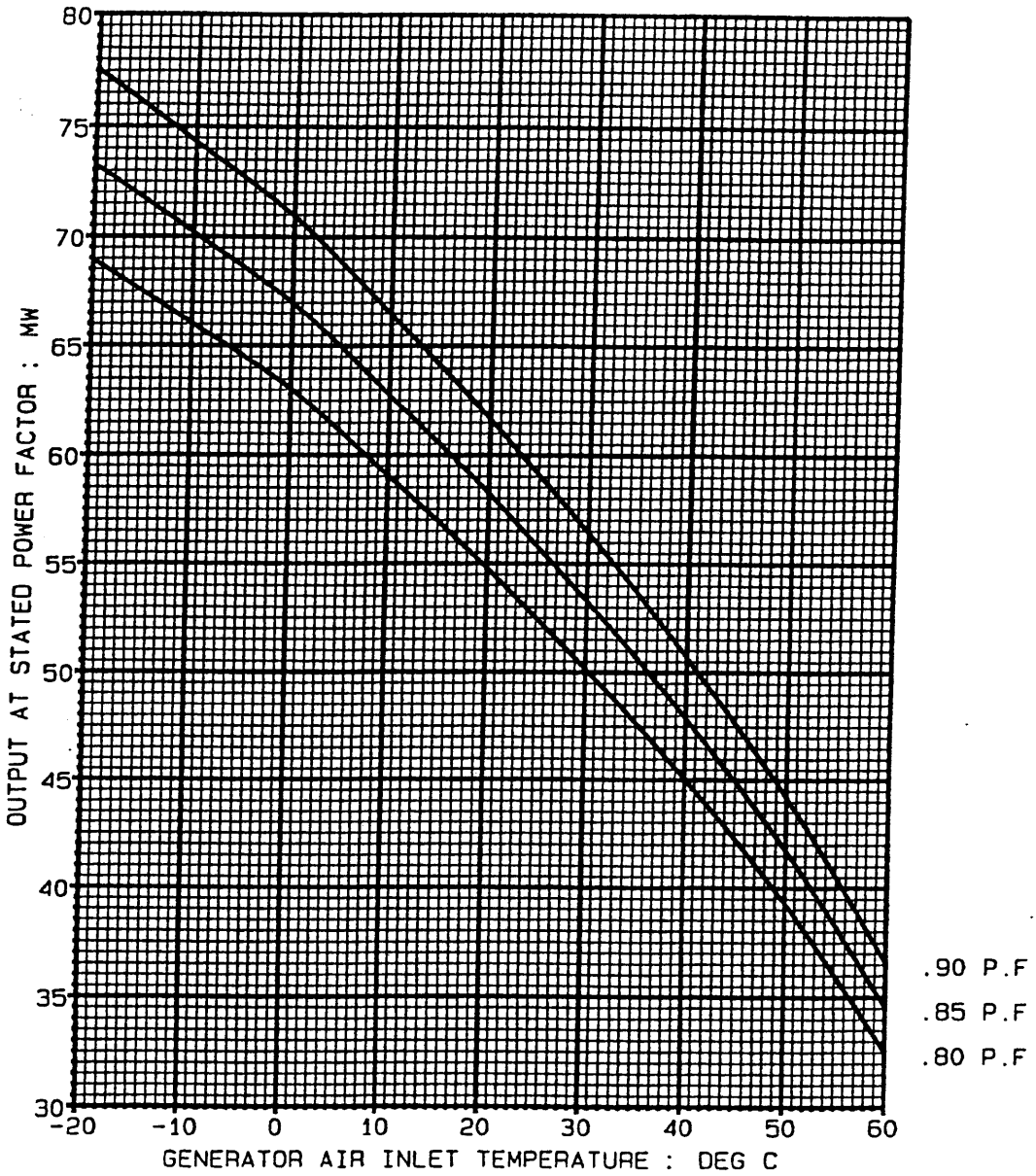
IN ACCORDANCE WITH
ANSI C50.14.
Class B temperatures.
Curves show base outputs.
Peak outputs are 8% higher.

419401

BRUSH ELECTRICAL MACHINES LTD.
(A Hawker Siddeley Company)

H.E.P 14765

VARIATION OF GENERATOR OUTPUT WITH AIR INLET TEMP



BDAX 7.290RT
13.80KV, 3Ph, 60.Hz.

Up to 1000. meters ASL

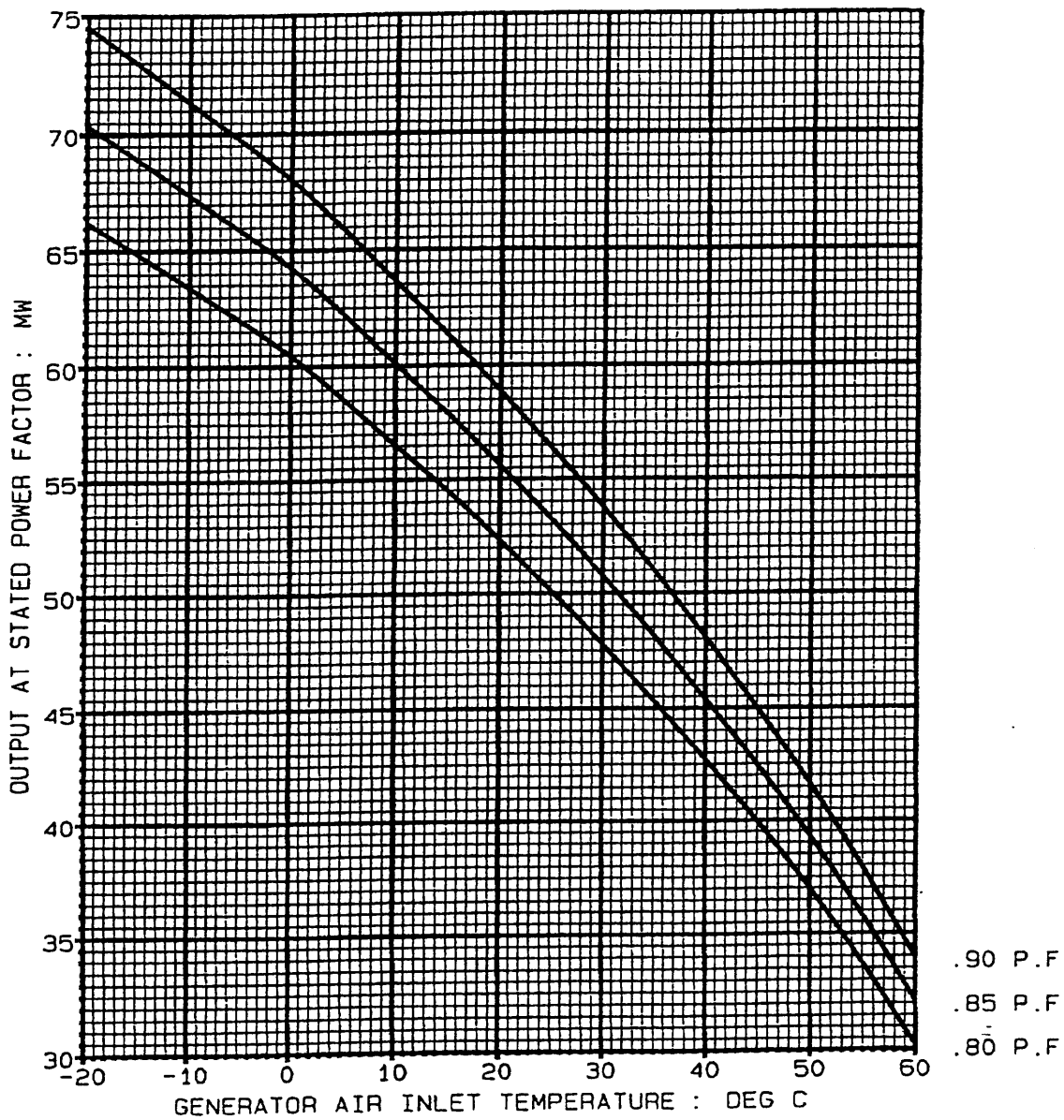
IN ACCORDANCE WITH
ANSI C50.14.
Class B temperatures.
Curves show base outputs.
Peak outputs are 8% higher.

419401

BRUSH ELECTRICAL MACHINES LTD.
(A Hawker Siddeley Company)

H.E.P 16885

VARIATION OF GENERATOR OUTPUT WITH AIR INLET TEMP



BDAX 7.290RT
13.80KV, 3Ph, 60.Hz.

Up to 1523. meters ASL

IN ACCORDANCE WITH
ANSI C50.14.
Class B temperatures.
Curves show base outputs.
Peak outputs are 8% higher.

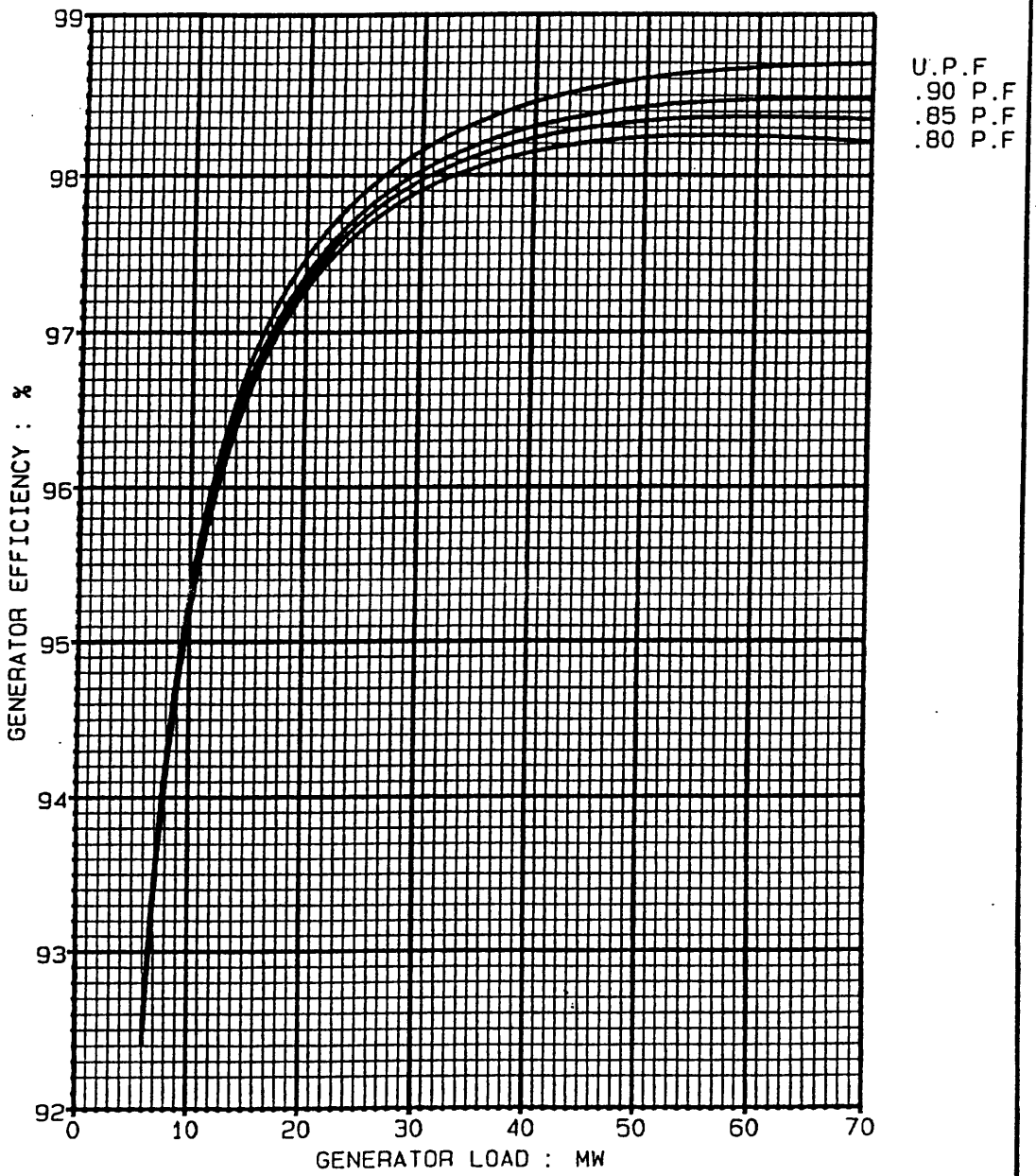
Issue No. 1: 17-May-1999

419401

BRUSH ELECTRICAL MACHINES LTD.
(A Hawker Siddeley Company)

H.E.P 14839

VARIATION OF GENERATOR EFFICIENCY WITH LOAD



BDAX 7.290RT
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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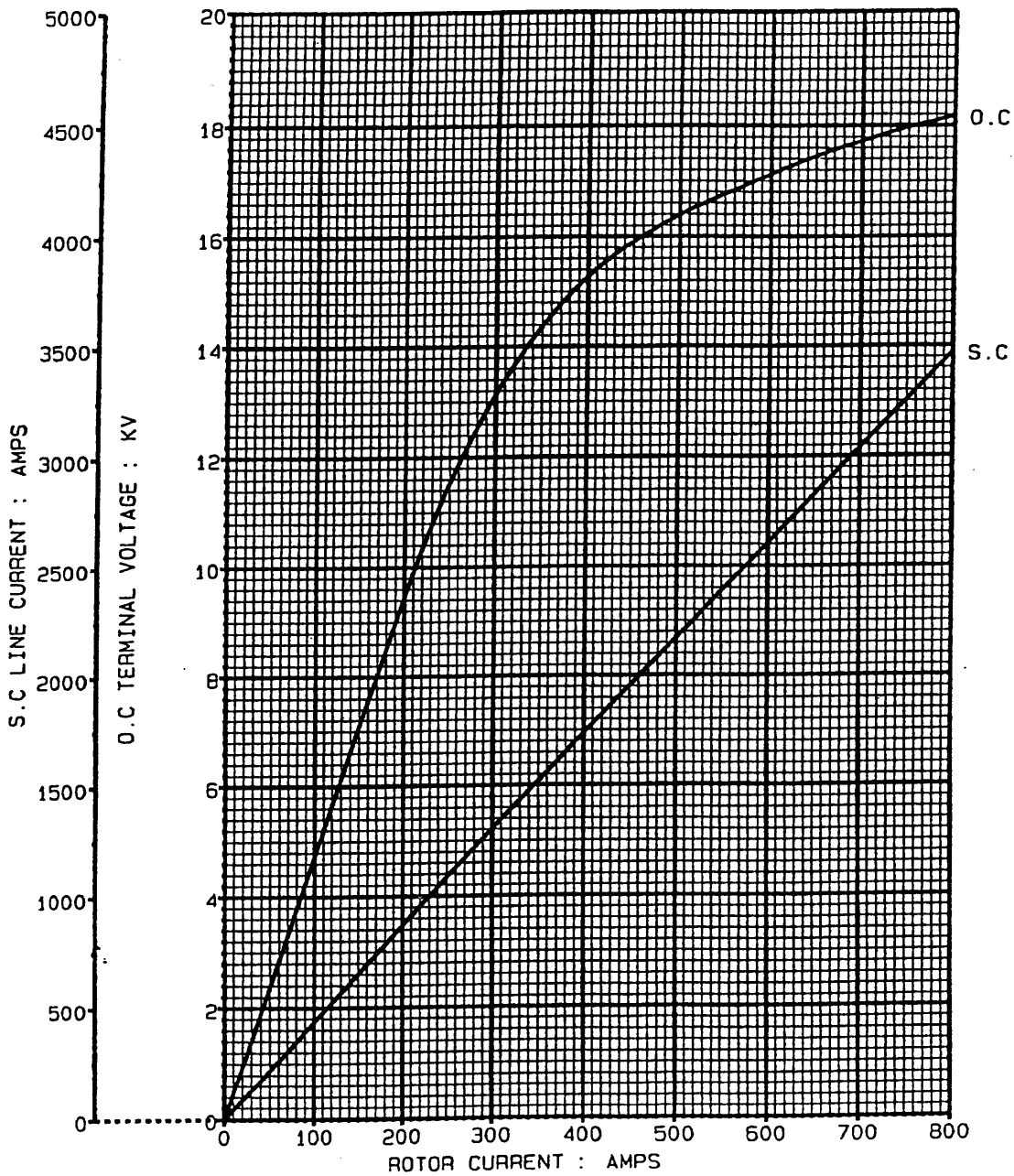
BRUSH ELECTRICAL MACHINES LTD.
(A Hawker Siddeley Company)

H.E.P 14838

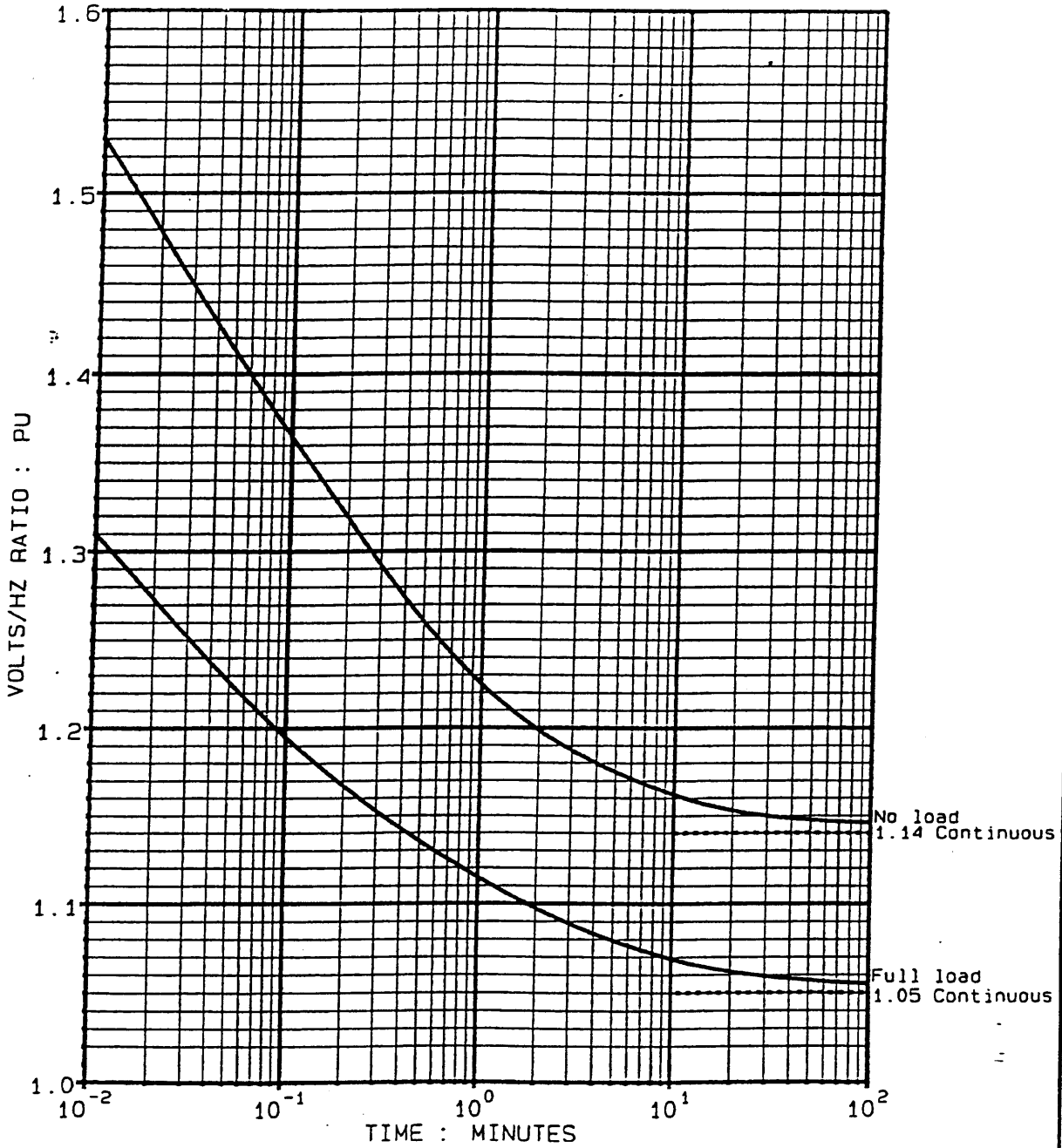
OPEN CIRCUIT AND SHORT CIRCUIT CHARACTERISTIC



BDAX 7-290RT
3Ph, 60.Hz, 3600. RPM.

419401

GENERATOR VOLTS/HZ CAPABILITY

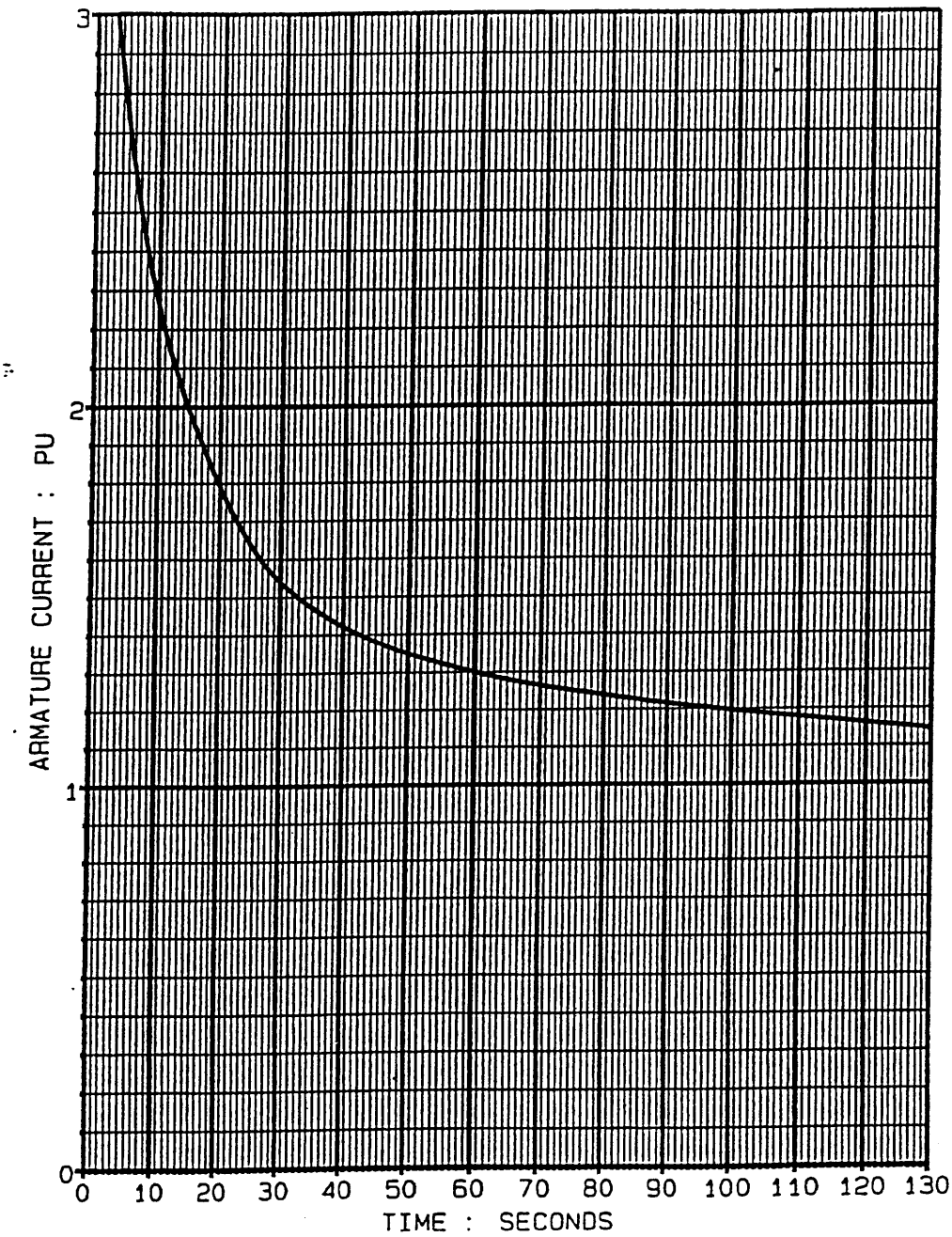


All DAX Generators

No load limitation is with respect to stator iron. Full load limitation is with respect to rotor heating at rated MVA and power factor.

419401

PERMITTED DURATION OF GENERATOR ARMATURE CURRENT



All DAX Generators

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

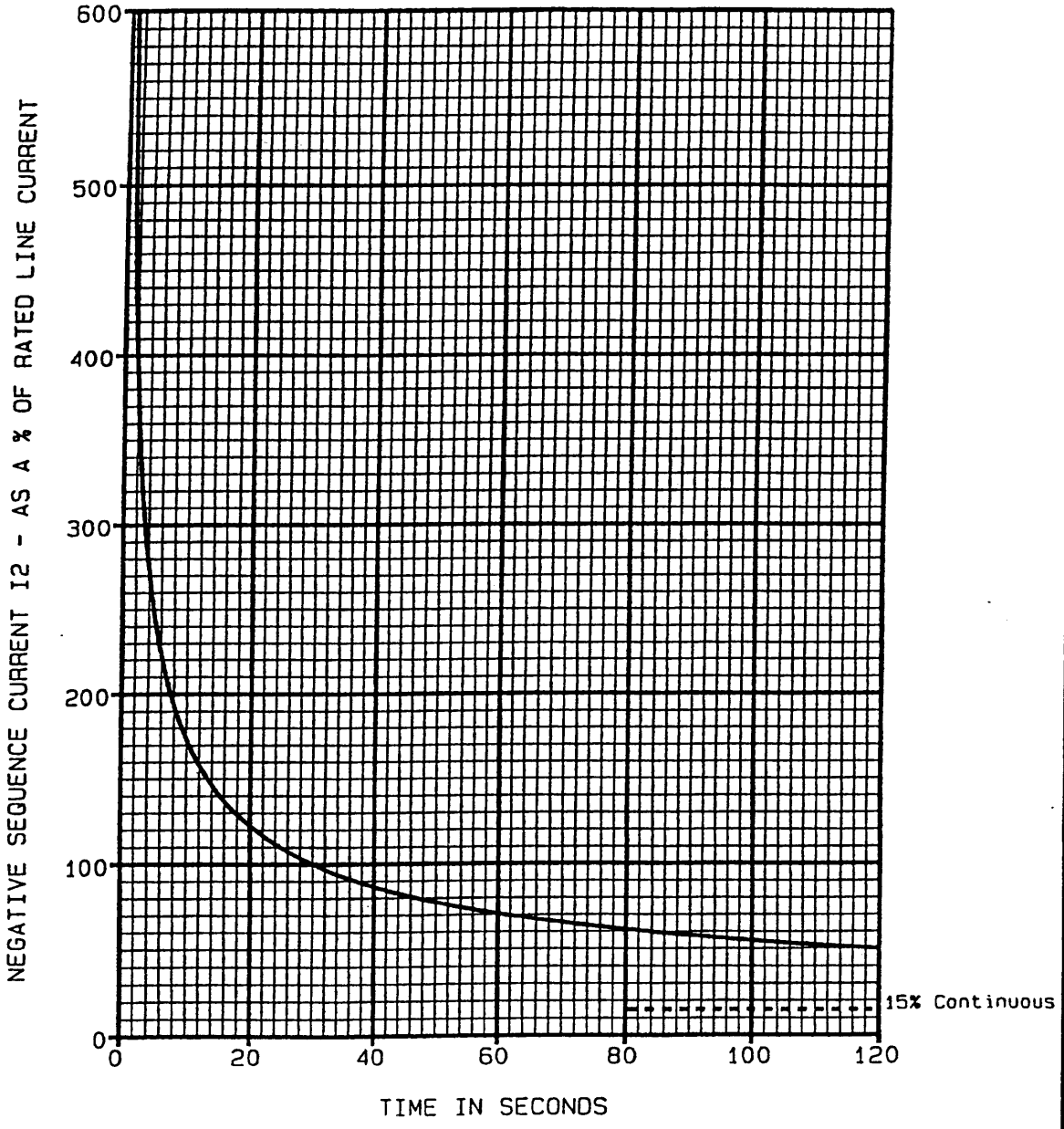
419401

BRUSH ELECTRICAL MACHINES LTD.
(A Hawker Siddeley Company)

H.E.P 1216

PERMISSIBLE DURATION OF NEGATIVE SEQUENCE CURRENT

$$I_2^2 t = 30$$



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

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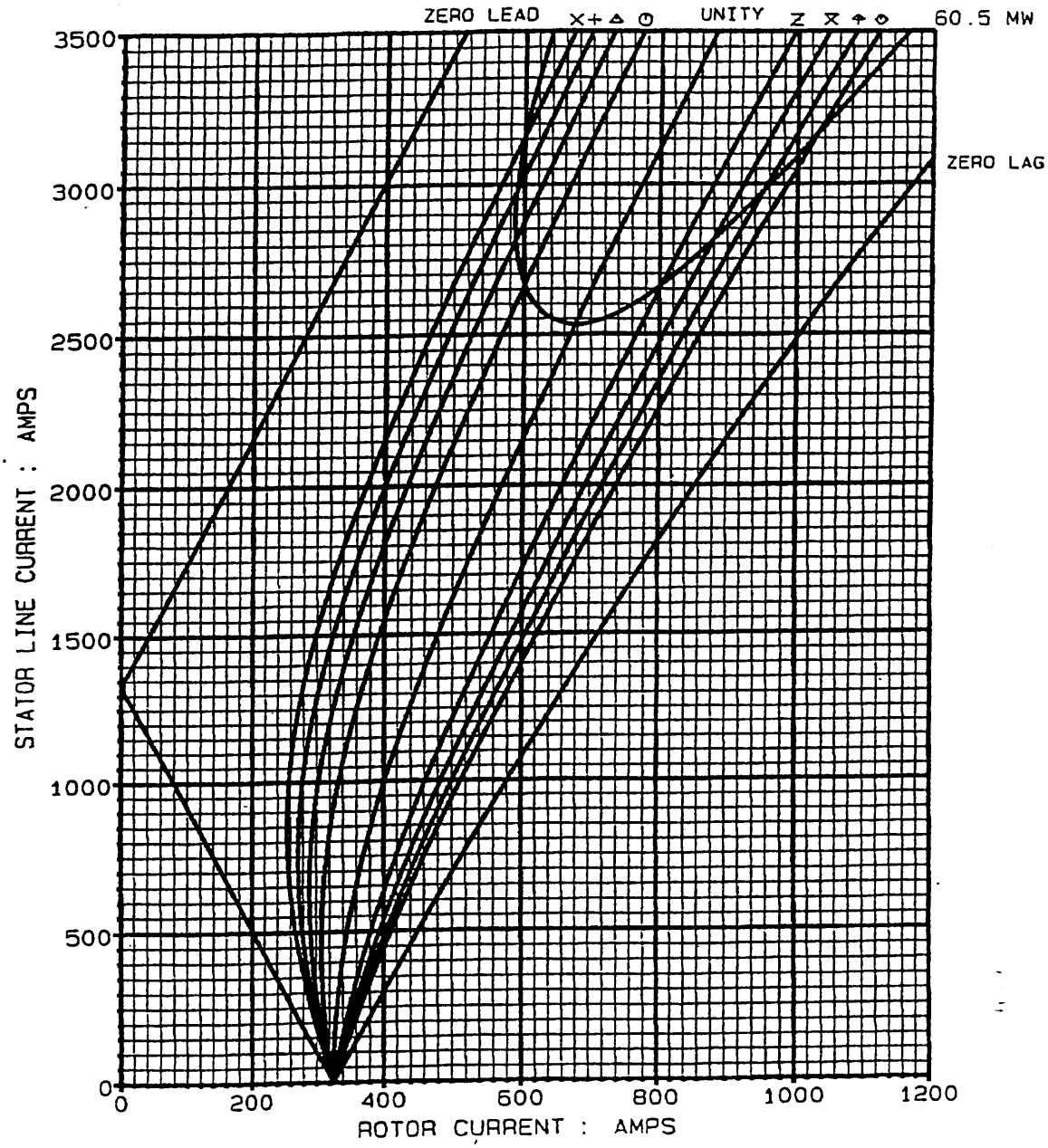
BRUSH ELECTRICAL MACHINES LTD.
(A Hawker Siddeley Company)

H.E.P 15800

CALCULATED GENERATOR V-CURVES



BDAX 7-290RT
13.80KV. 3Ph. 60.Hz.

KEY TO POWER FACTORS SHOWN

⊙	- .95 PF LEAD	⊖	- .80 PF LAG
△	- .90 PF LEAD	↑	- .85 PF LAG
+	- .85 PF LEAD	⧖	- .90 PF LAG
×	- .80 PF LEAD	Z	- .95 PF LAG

Issue No. 1: 8-Jan-1998

419401

EXCITATION SYSTEM MODEL

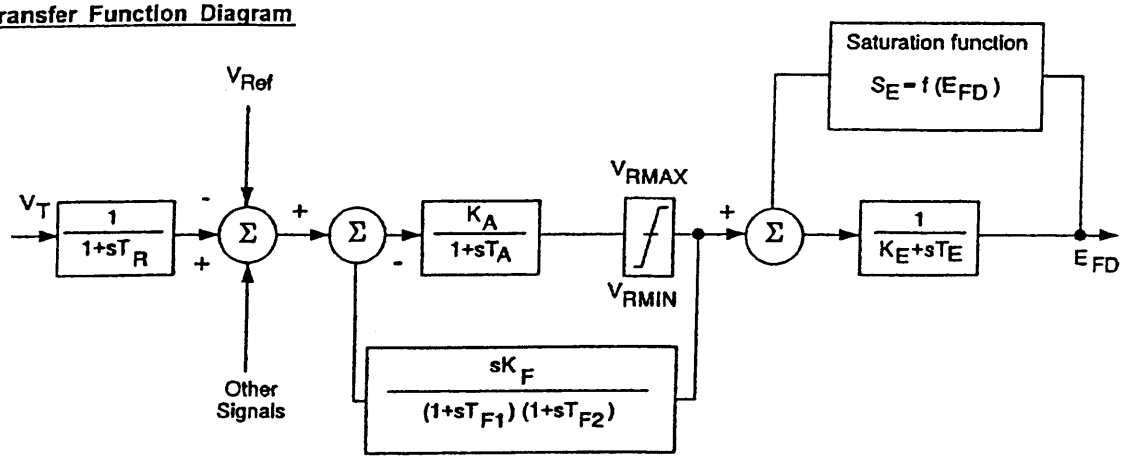
BRUSH ELECTRICAL MACHINES LTD

TYPE 2 BRUSHLESS EXCITATION SYSTEM INCORPORATING
A TYPE MAVR AUTOMATIC VOLTAGE REGULATOR

Reference no	S & S	Rating	60.5 MW, 0.85 pf	Supply	13.80 kV, 60Hz
Frame sizes	Generator	BDAX 7-290ERT	Exciter	BX 10.20	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)	4.0	volts
R_F	Exciter field resistance	7.1	ohms
V_{PMG}	Open circuit pilot exciter output voltage at rated speed	270	volts
T_E	Exciter time constant	1.2	sec
K_E	Exciter constant	1.0	
S_{E75}	Exciter saturation function	2.44	
S_{E100}	Exciter saturation function	5.24	

Automatic Voltage Regulator Parameters

K_A	Regulator gain ($11.6 \times 10^3 / V_R$)	2894	
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)	1.2	sec
V_{RMIN}	Minimum regulator output voltage	0.0	per unit
V_{RMAX}	Maximum regulator output voltage ($0.7V_{PMG} / V_R$)	47	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

2340/93

419401

"H" Constant – LM6000 60 Hz Generator Set Using Brush BDAX- 290 ERJT Generator

Moment of Inertia	**kg-m^2**	**lb-ft^2**
LM6000 LP Shaft	194.06	4,616
Coupling	11.89	282.87
BDAX-290 ERJT Generator	970.00	23,077
Total WR^2	**kg-m^2**	**lb-ft^2**
	1,176 kg-m^2	**27,976 lb-ft^2**

"H" Constant:

$$H = \frac{(2.31 * 10^{-10}) * WR^2 * RPM^2}{\text{MVA Rating}} = \frac{(2.31 * 10^{-10}) * 27{,}976 * 3600^2}{71.176} = \mathbf{1.176\ kW\text{-}sec/kVA}$$

419401

PROLEC

ISO 9001 CERTIFIED

TECHNICAL PROPOSAL INFORMATION

Customer: *EQUI Sales*

Proposal No: -

Spec No: -

Date: 11/18/98

Item No: G837981/C

RATING

Type	Transformer	Class	H Winding		X Winding		Y Winding	
Phase	3		115 Wye	kV	13.8 Delta	kV	-	kV
Hertz	60	OA	36,000	KVA	36,000	KVA	-	KVA
Temp Rise	65 °C	FA	48,000	KVA	48,000	KVA	-	KVA
Insul Liquid	NON PCB OIL TYPE II	FA	60,000	KVA	60,000	KVA	-	KVA
	-	-	-	KVA	-	KVA	-	KVA

ADDITIONAL TAP VOLTAGES

H Winding (Kv) ±2 of 2.5% NLTC

X Winding (Kv) -

CONNECTIONS FOR OPERATION

Transformers in Bank	To Transformer From	Phase	Connected	To Transformer To	Phase	Connected
-	-	-	-	-	-	-

PERFORMANCE BASED ON A LOADING OF

H Winding	115.0	kV	36.0	MVA
X Winding	13.8	kV	36.0	MVA
Y Winding	-	kV	-	MVA
-	-	-	-	-
-	-	-	-	-

DIELECTRIC TESTS

Applied Voltage (To other winding and ground)	H Winding	50	kV
	X Winding	50	kV
	Y Winding	-	kV
Induced Voltage	One Hour	105	kV
	Enhancement	120	kV

INSULATION LEVELS

ITEMS	Basic Lightning Impulse Insulation Level	Low Frequency Voltage Insulation Level
H Line	450	185
H neutral	150	50
X line	150	50
X neutral	-	-
Y line	-	-

PERFORMANCE DATA, Based on 85 °C Reference Temperature, 36 MVA Altitude: 1000 Mts.

Losses and Exciting Current				Regulation	
Excitation	% Ex	No Load Kw (20°C)	Total Loss Kw	Power Factor	% Regulation
100%	0.514	32	167	0.80	6.617
110%	2.158	41.9	176.9	1.0	0.877
-	-	-	-	-	-

AUXILIARY LOSSES

Transformer KVA	Class	KWatts Aux Loss
36,000 -	OA	0
48,000 -	FA	3.7
60,000 -	FA	5.5
- -	-	-
- -	-	-

Average Sound Level 76/78/79 dB OA/FA/FA

PERCENT IMPEDANCE VOLTS

% IZ	Between Windings	At kVA	% IZ Zero	Between Windings	At kVA
10	H-X	36,000	8.5	H-X	36,000
-	-	-	-	-	-
-	-	-	-	-	-

EFFICIENCIES (p.f = 1) AT 36 MVA

Load	Full Load	3/4 Load	1/2 Load	1/4 Load
%	99.545	99.611	99.649	99.578

MECHANICAL DATA

Not for Construction Purposes

Outline Dwg No: B2

Dimensions (Approximate)		Ft. (Mts.)
Height	(A)	18.0 (5.50)
Width	(B)	19.4 (5.90)
Depth	(C)	15.9 (4.85)
Height over Cover	(D)	13.5 (4.10)
Untanking (Plus slings)	(E)	23.6 (7.20)
Shipping Dimensions: Ft	WxDxH	13.7 x 10.2 x 13.5

Masses (Approximate)		pounds (Kg)
Core and Coils		58,970 (26,750)
Tank and Fittings		39,020 (17,700)
Liquid	5,650 Gl	42,510 (19,280)
Total Mass		140,500 (63,730)
Shipping without OIL		78,050 (35,400)
Shipping with OIL		111,890 (50,750)

PROLEC

GE-PROLEC Standard Specifications For GSU Transformers

for U.S. Application

SPECIFICATIONS AND INDUSTRY STANDARDS

This specification describes a three-phase oil-filled generator step-up transformer to be built in accordance with the latest applicable standards of ANSI, IEEE, and NEMA as specified, except that this specification shall take precedence wherever any conflict with these Standards may appear.

1.0 Equipment Data:

Type:	Outdoor, Oil-filled, Generator Step-up
Number of Phases:	Three (3)
Frequency:	60 HZ
Altitude:	1000 MASL, 3300 FT above Sea Level
Temperature Rise:	55/65°C
Winding Material:	Copper
Cooling Class:	ONAN/ONAF/ONAF
Vector Group:	The angular displacement between the high voltage and low voltage phase voltages of three-phase transformers with Wye-Delta connections shall be 30°, with the low voltage lagging the high voltage.
High Voltage Winding Taps (Off Load):	+5%, +2.5%, Rated, -2.5%, -5%
Average Winding Rise by Resistance above average daily ambient temperature of	55/65°C 30°C
not to exceed a maximum ambient of	40°C
Hottest Spot Winding Rise by Resistance not to exceed a maximum ambient of	80°C 40°C
Auxiliary Power:	To be supplied by Buyer at 240 /120 V, 1 Phase, 3 Wire

2.0 Ratings:

MVA: 60/80/100/112 Frequency: 60

High Voltage (Wye)	HV Winding BIL	HV Neutral BIL	Low Voltage (Delta)	LV Winding BIL	Standard % IZ	HV CT's 2 per Phase C-400 Multi-Ratio	LV CT's 1 per Phase C-400 Multi-Ratio	HO Neutral CT C-400 Multi-Ratio
69 kV	350	110	13.8 kV	110	8.0	1200/5	6000/5	600/5
115 kV	450	110	13.8 kV	110	8.5	600/5	6000/5	600/5
138 kV	550	110	13.8 kV	110	9.0	600/5	6000/5	600/5
161 kV	650	110	13.8 kV	110	9.5	600/5	6000/5	600/5
230 kV	750	110	13.8 kV	110	10.0	600/5	6000/5	600/5

Note: If user requires BIL's or %impedances different from ANSI standards listed above, please advise manufacturer at time of quotation.

3.0 Construction Requirements:

3.1 General Construction Requirements:

- Transformer windings will be suitably clamped with mechanical means at the top and bottom to prevent shifting under Short Circuit conditions.
- Core Steel will be grain-oriented steel.
- Transformer winding material will be copper.
- Transformer winding leads will be connected to porcelain apparatus bushings using flexible connections or bare copper bars.
- Transformer core and windings will be suitably mounted in the tank to prevent movement during faults, shipping or installation.
- Transformer bushing arrangement and terminal markings will be per ANSI C57.12.10-1988 and ANSI C57.12.70-1978. High-voltage line bushings will be located on the transformer cover in ANSI Segment 3. (The high-voltage neutral bushing will be located on the transformer cover in ANSI Segment 2). Low-voltage line bushings will be located on the transformer cover in ANSI Segment 1.
- Jacking, lifting and rolling provisions will be provided to allow for installers choice of installation methods.
- Provision for tank grounding will be provided at diagonally opposite corners of the tank.

3.2 Tap Changer:

A tap changer will be provided for de-energized operation on the High Voltage winding. Taps will be externally selected by a handle permanently attached to the tap changer mechanism. The tap changer will be provided with provisions for padlocking.

3.3 Oil Preservation System:

The standard oil preservation system will be composed of: A conservator tank, a flexible separator, a silica gel breather and a Buchholz relay.

3.4 Instrumentation:

All instruments, gauges and indicators will be marked in English units to comply with ANSI standards. They will be located so that they can be seen by a person standing on the ground (eye level).

3.5 Motor Starter Controls:

The manufacturer will provide motor control and protection for auxiliary motors such as fan motors. Motor starter controls will be internally derived by GE-PROLEC from the Buyer's auxiliary power feeder. Motor protection will be provided.

3.6 Nameplate:

- All major equipment, devices, panels, cubicles and motors will be provided with permanently fastened non-corrosive nameplates. (They will be provided by GE-Prolec or the OEM of the accessories)
- A transformer rating and winding connections nameplate will be provided. The nameplate will be located and permanently mounted on the transformer. The nameplate will be of non-oxidizing metal with permanent markings of ratings and connections.

3.7 Cooling Class:

ONAN/ONAF/ONAF The transformer shall be designed for continuous self-cooled operation at rated KVA, 133% operation above rated KVA for fan cooled operation (stage 1), and 167% above rated KVA for fan cooled operation (stage 2). Average winding temperature rise over ambient as measured by resistance will not exceed 55°C for the ONAN rating. Additional 112% MVA will be available with an average temperature rise of 65°C, and hottest-spot rise will not exceed 80°C. The two additional stages of fan cooling shall operate as follows: When the temperature nears the limits of the self cooled rating the first stage activates a portion of the fans and the second stage activates the remainder of the fans as the temperature and load increase. Fan operation shall be controlled by a winding-temperature indicator-relay. Single-phase 230 volt fans shall be provided.

Fan blades shall be carefully balanced to keep sound levels to a minimum and to ensure long trouble free life. Fans shall be furnished with water tight connections. Fan motors shall be TENV (totally enclosed non-ventilated) with automatic reset thermal protectors.

Radiators Removable radiators mounted on the transformer will be supplied. (A shut-off valve will be furnished at each radiator connection for isolating individual radiators). A drain connection and filling connection will be supplied on each individual radiator.

3.8 Control Cabinet and Wiring:

A control cabinet will be integrally mounted to the transformer tank and will contain all control circuits, auxiliary relays and terminal boards etc... as required to provide a single interface location for the Buyer's field installed wiring to the transformer. The control cabinet will be NEMA 3R and suitable for outdoor use.

- Door hinge pins will be plated steel.
- All CT secondary leads will be routed to shorting type terminal boards located in the control cabinet.
- All alarm, control and trip device contacts for Buyer's use will be routed to terminal boards located in the control cabinet.
- All factory installed wiring will be rated 600 V minimum service. Cable insulation will be GE-PROLEC standard (600 V / 105C fire retardant). Conductor material will be copper with minimum sizes as follows:
  - ⇒ Control and Alarm Circuits: No. 14 AWG
  - ⇒ CT Circuits: No. 10 AWG
  - ⇒ Power Circuits No. 14 AWG

- All wires will be uniquely identified at their points of termination using heat shrink type wire markers.
- All wiring routed on the exterior of the tank will be routed in galvanized electrical steel conduit. Conduits will be securely fastened to the transformer tank using fittings approved for this purpose.
- The control cabinet will contain a thermostatically controlled heater of sufficient size to prevent condensation.
- The control cabinet will contain a duplex receptacle and interior light.
- The control cabinet will have a field drillable removable bottom plate for conduit entrance located with a minimum clearance of 16 inches to the base of the transformer to facilitate the conduit installation.
- Standard control wiring voltage will be 240/120 VAC, single phase, 3 wire.

4.0 Standard Accessories:

- (1) Removable dial-type Winding Temperature indicator for remote indication with resettable drag hand and adjustable alarm and trip contacts. Dial indication to be 0-180°C. Must be removable without breaking tank seal.
- (1) Removable dial-type Liquid Oil Thermometer indicator for remote indication with resettable drag hand and adjustable alarm and trip contacts. Dial indication to be 0-120°C. Must be removable without breaking tank seal.
- (1) Removable dial type Magnetic Liquid-Level Gauge with alarm contacts. Device must be removable without breaking tank seal.
- Cover-mounted mechanical Pressure Relief Device with automatic resealing-resetting operation, alarm contacts and mechanical signal for indication of device operation.
- Thermal Plate for remote Winding Temperature and Liquid Temperature gauges.
- Thermal Current Transformer located on the X2 bushing for Winding Temperature indicator.
- Cooling Fans, single phase, 1/3 HP or 1/6 HP, 230 VAC.
- Diagrammatic nameplate.
- Tank cover-mounted, oil-filled, capacitor type bushings for connection of the high voltage winding to the Buyer's system. Color shall be standard gray.
- Tank cover-mounted, low voltage bushings. Bushings to be suitable for connection to an isolated phase bus duct. Color shall be standard gray.
- Tank cover-mounted, neutral bushing. Color shall be standard gray.
- Transformer control cabinet mounted on the transformer for alarms, fans & current transformer terminals.
- CT terminal box.
- Base designed for rolling, provision for pulling in directions of center lines of segments.
- Lifting Lugs for lifting complete transformer.
- Jacking facilities at four corners of the base.
- Lifting Eyes for Cover only.
- Facilities for lifting core and coil assembly from tank.
- Two ground pads with tapped holes (NEMA two hole drilling) for tank grounding located on diagonally opposite corners.
- Two manholes in the cover.
- The transformer core will be grounded to the transformer tank. To facilitate testing of the core clamp insulation, the core ground will be accessible through a 1.2kV bushing located in a terminal box on the top of the tank cover.
- Upper Filter Press Valve, 2", globe-type.
- Pressure-Vacuum gauge for monitoring units shipped dry air.
- Main Tank Drain Valve, 2", globe-type, with 3/8" sampling device and plug.
- All gaskets shall be reusable nitrile rubber with means provided for controlled compression.
- ASTM Type I insulating transformer oil.
- Conservator Tank

- Conservator Fill Valve, globe-type.
- Manhole for inspection on conservator tank.
- Conservator pressure equalization valve, 1", globe-type.
- Conservator tank to Main tank valve, 3", ball-type.
- Conservator tank drain valve, globe -type with 3/8" sampling device and plug.
- Sealed - Oil Silica Gel Breather.
- Buchholz Relay.
- Provision for mounting one Station or Intermediate type surge arrester on each High voltage line bushing.

5.0 **Painting and Corrosion Protection of Equipment:**

Painting and corrosion protection of equipment will be in accordance with manufacturer's standards. Finish paint color will be ANSI 70 Gray.

6.0 **Testing:**

- Testing will be in accordance with ANSI C57.12.90-1993. Standard shop tests will also be performed in addition to the above. Seller will advise the Buyer of shop tests performed in addition to ANSI.
- All transformers will be tested at 60 Hz.
- The Buyer will have the option to witness all tests without causing any delays in factory schedules.
- The Seller will notify Buyer at least one week prior to commencing any of the tests.
- The transformer shall receive at the factory those test identified in ANSI Standard C57.12.00-1998, Section 8, as "Routine Tests" which are listed as follows:
    - DC Resistance tests of all windings
    - Polarity of windings and angular displacements tests
    - Ratio tests
    - No-load loss and exciting current tests
    - Load loss and impedance tests
    - Lightning impulse tests on all Class II transformers
    - Low-frequency dielectric tests
        - Applied voltage tests of all windings
        - Insulation power factor tests on Class II transformers
        - Induced tests
        - Partial discharge tests of all Class II transformers measured in microvolts
        - Partial discharge tests of all Class II transformers measured in picocoulombs
    - Fault gas analyses on transformers above 10 MVA and all Class II transformers
    - Accessory equipment and wiring tests

Class I power transformers have high-voltage windings 69 KV and below. Class II power transformers have high-voltage windings from 115 KV through 765 KV.

7.0 **Spare Parts:**

A recommended Spare Parts List will be issued by the manufacturer for the Buyer to select.

EQUISALES 7137334122 11/10 '00 12:57 NO.734 06/19

8.0 **Insulating Liquid:**

The insulating liquid will be mineral oil refined from a naphthenic base. The PCB content will be less than 2 ppm (considered PCB free). The transformers will be shipped dry air or dry nitrogen unless otherwise specified and approved by the manufacturer.

9.0 **Shipping, Handling and Storage:**

- Manufacturer will supply their standard shipment preparation that is suitable for below deck ocean transport.
- All equipment will be adequately prepared for shipment and for a maximum period of outdoor storage for three months.
- The equipment will be prepared for shipment after testing has been completed. Lifting points will be clearly marked and all openings will be tightly and effectively closed. Flanges will be protected by covers and screw openings closed with steel plugs.
- Equipment that is liquid leak tested in the shop by the manufacturer will be completely drained prior to shipment unless specified otherwise. When such drainage requires the removal of plugs, drain valves or other parts, Seller will reinsert or reassemble these parts prior to shipment.
- During shipment the transformers will be monitored by calibrated and certified impact recorder meters.
- All instructions for proper care and handling after delivery, including outdoor storage procedures, will be furnished by the manufacturer before the equipment is shipped to the jobsite.
- The transformers will be assembled and vacuum filled in the field by the customer unless otherwise specified and approved by the manufacturer.

10.0 **Design Data:**

Saturation curves of each design voltage level and frequency (69, 115, 138, 161 and 230 kV) shall be furnished once for record only.

PROLEC

TRANSFORMER

SERIAL No. G459-__, OA/FA/FA, THREE-PHASE, 60 HERTZ, 3300 FASL.

VOLTAGE RATING 115000GrdY/66395-13800

KVA RATING 36000 CONTINUOUS 65°C RISE SELF COOLED.

KVA RATING 48000 CONTINUOUS 65°C RISE FORCED AIR.

KVA RATING 60000 CONTINUOUS 65°C RISE FORCED AIR.

BASIC IMPULSE LEVEL (KV).

	H.V.	L.V.	HO
BUSHING	550	150	150
WINDING	650	150	150

WEIGHTS (POUNDS)

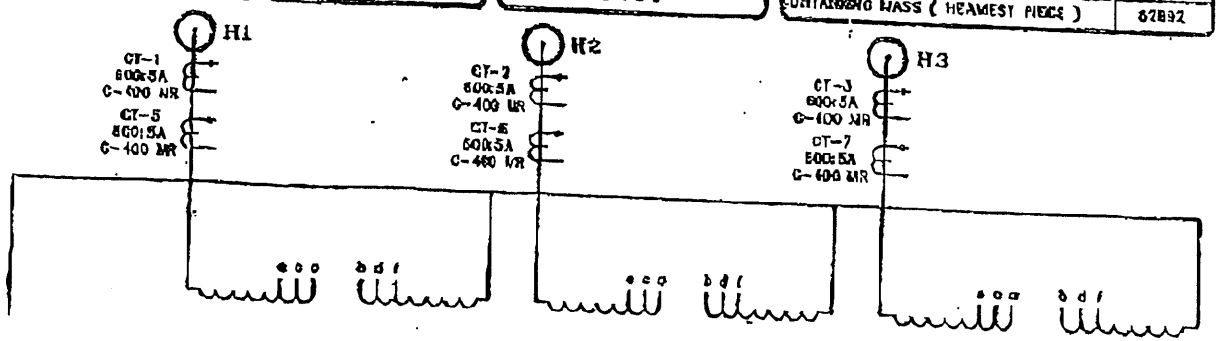
CORE AND COILS	62892
TANK AND FITTINGS	35740
LIQUID (4967 GALS)	37160
TOTAL MASS	135792
UNTANKING MASS (HEAVIEST PIECE)	62892

IMPEDANCE @ 85°C

X 2	KVA BASE	KV BASE
	36000	115 - 13.8

CUSTOMER P.O.
9897243

INSTRUCTION BOOK
G459



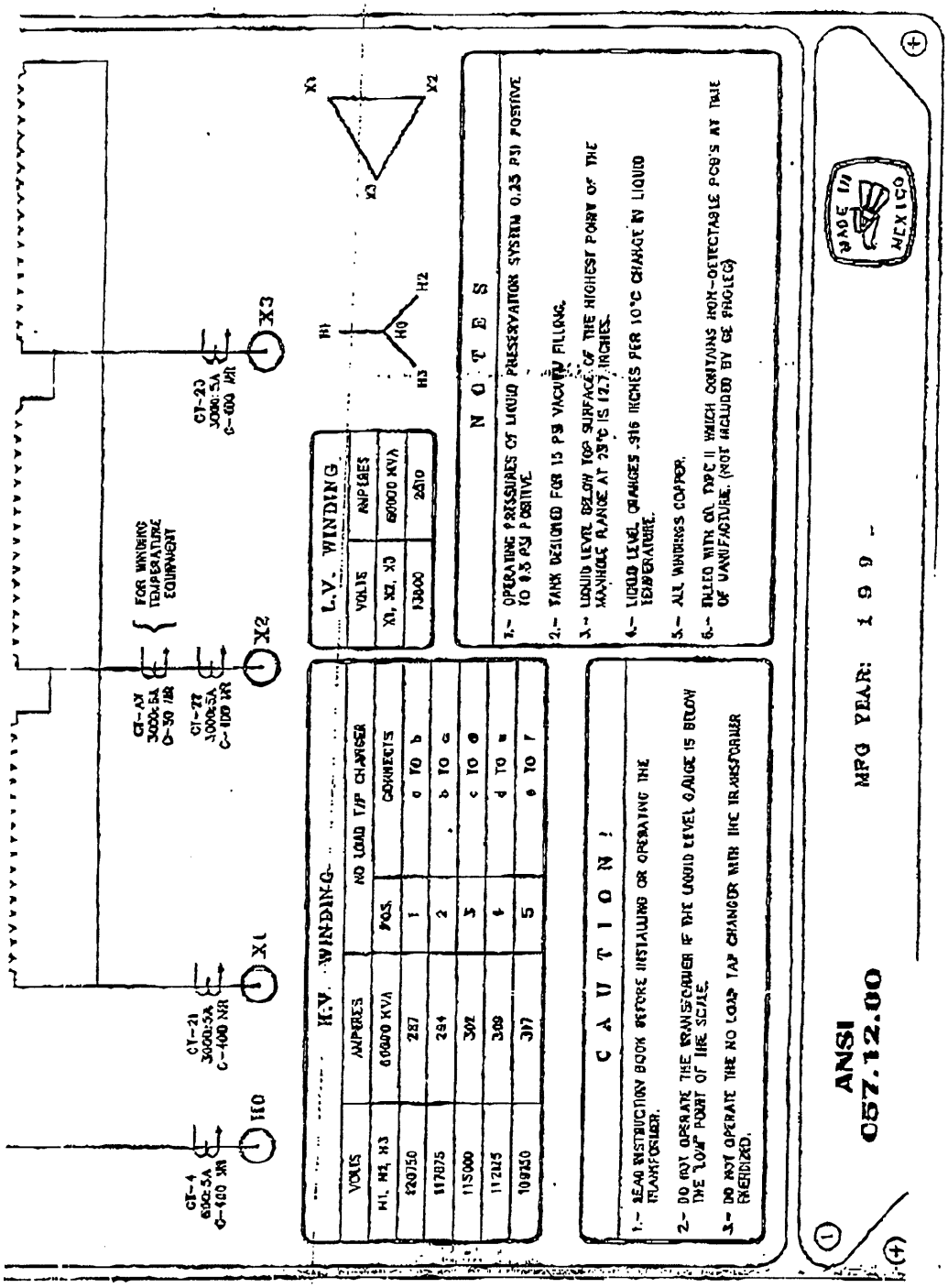
EQUIP SALES
CUSTOMER P.O. No 9897243
G.E. REQUISITION No. 420-82313
G.E. PROLEC SERIAL No. G459-01
G459-02
G459-03

STEP UP TRANSFORMER
36/48/60 MVA, OA/FA/FA, THREE PHASE
60 ~, 3300 FASL, 60 HERTZ
115/66395 KV-Y 13.8 KV Δ

REV.	REV.
3	4

* MATERIAL
* DIMENSIOI

A



H.V. WINDING

VOLTS	AMPERES	NO LOAD T/P CHANGER	
H1, H2, H3	60000 KVA	POS.	CONNECTS
120750	287	1	a TO b
117075	294	2	b TO c
115000	302	3	c TO d
112125	309	4	d TO e
109250	317	5	e TO f

L.V. WINDING

VOLTS	AMPERES
X1, X2, X3	60000 KVA
13800	2510

NOTES

1.- OPERATING PRESSURES OF LIQUID PRESERVATION SYSTEM 0.25 PSI POSITIVE TO 0.5 PSI POSITIVE.
2.- TANK DESIGNED FOR 15 PSI VACUUM FILLING.
3.- LIQUID LEVEL BELOW TOP SURFACE OF THE HIGHEST POINT OF THE MANHOLE RANGE AT 25°C IS 12.7 INCHES.
4.- LIQUID LEVEL CHANGES .916 INCHES PER 10°C CHANGE IN LIQUID TEMPERATURE.
5.- ALL WINDINGS COPPER.
6.- FILLED WITH OIL TYPE II WHICH CONTAINS NON-DETECTABLE PCB'S AT TIME OF MANUFACTURE. (NOT INCLUDED BY GE PROLEC)

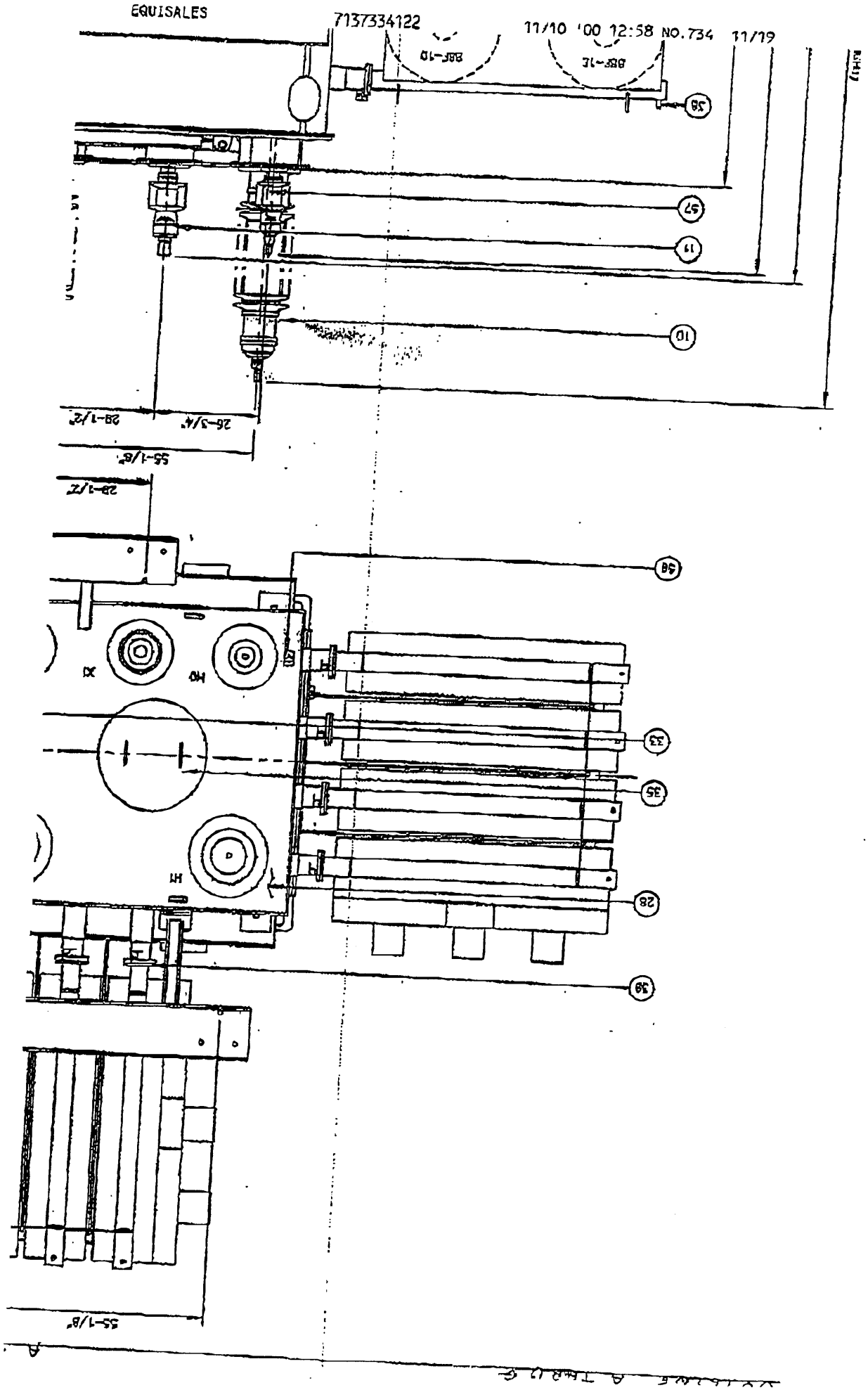
CAUTION!

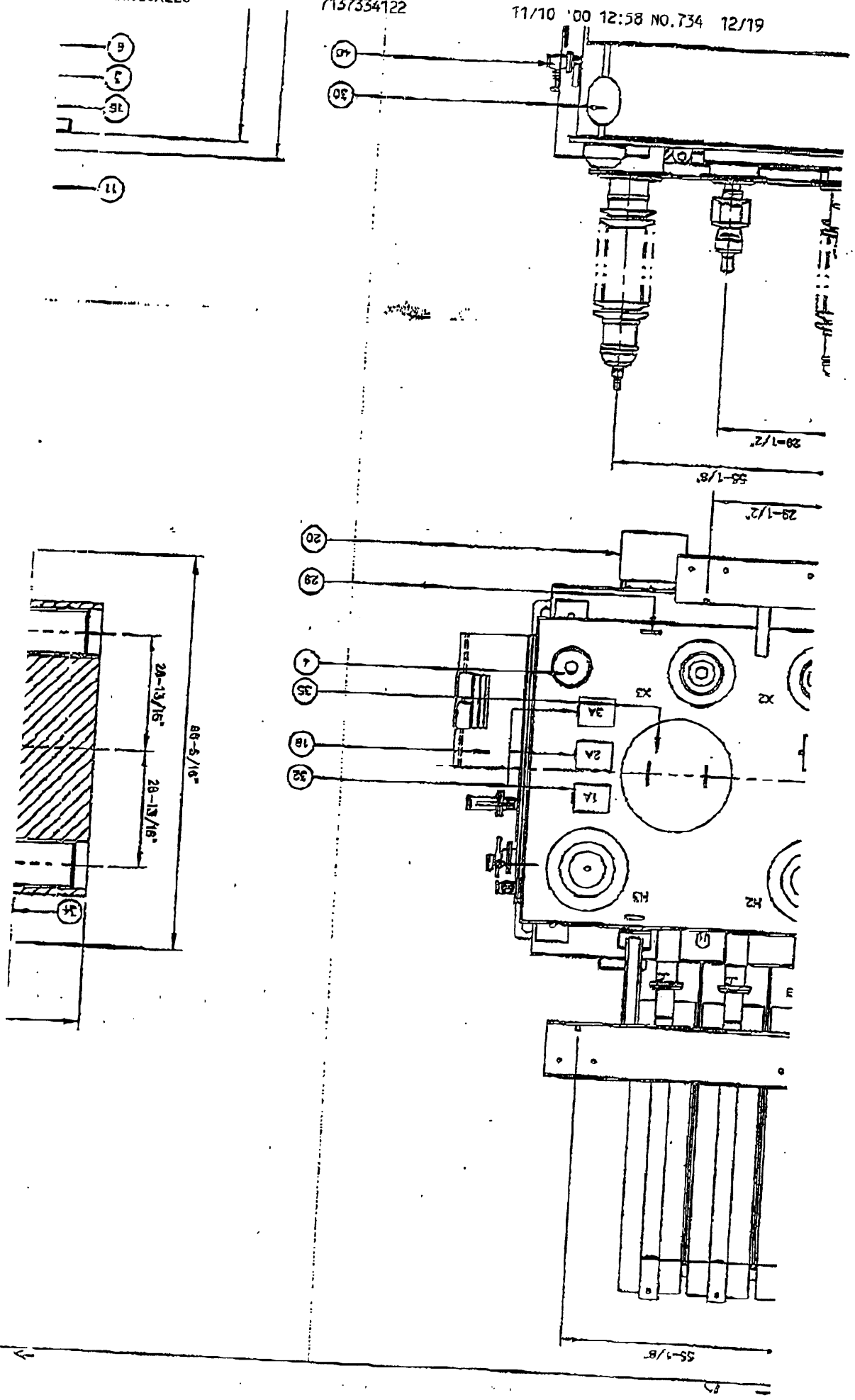
1.- READ INSTRUCTION BOOK BEFORE INSTALLING OR OPERATING THE TRANSFORMER.
2.- DO NOT OPERATE THE TRANSFORMER IF THE LIQUID LEVEL GAUGE IS BELOW THE "LOW" POINT OF THE SCALE.
3.- DO NOT OPERATE THE NO LOAD TAP CHANGER WITH THE TRANSFORMER ENERGIZED.

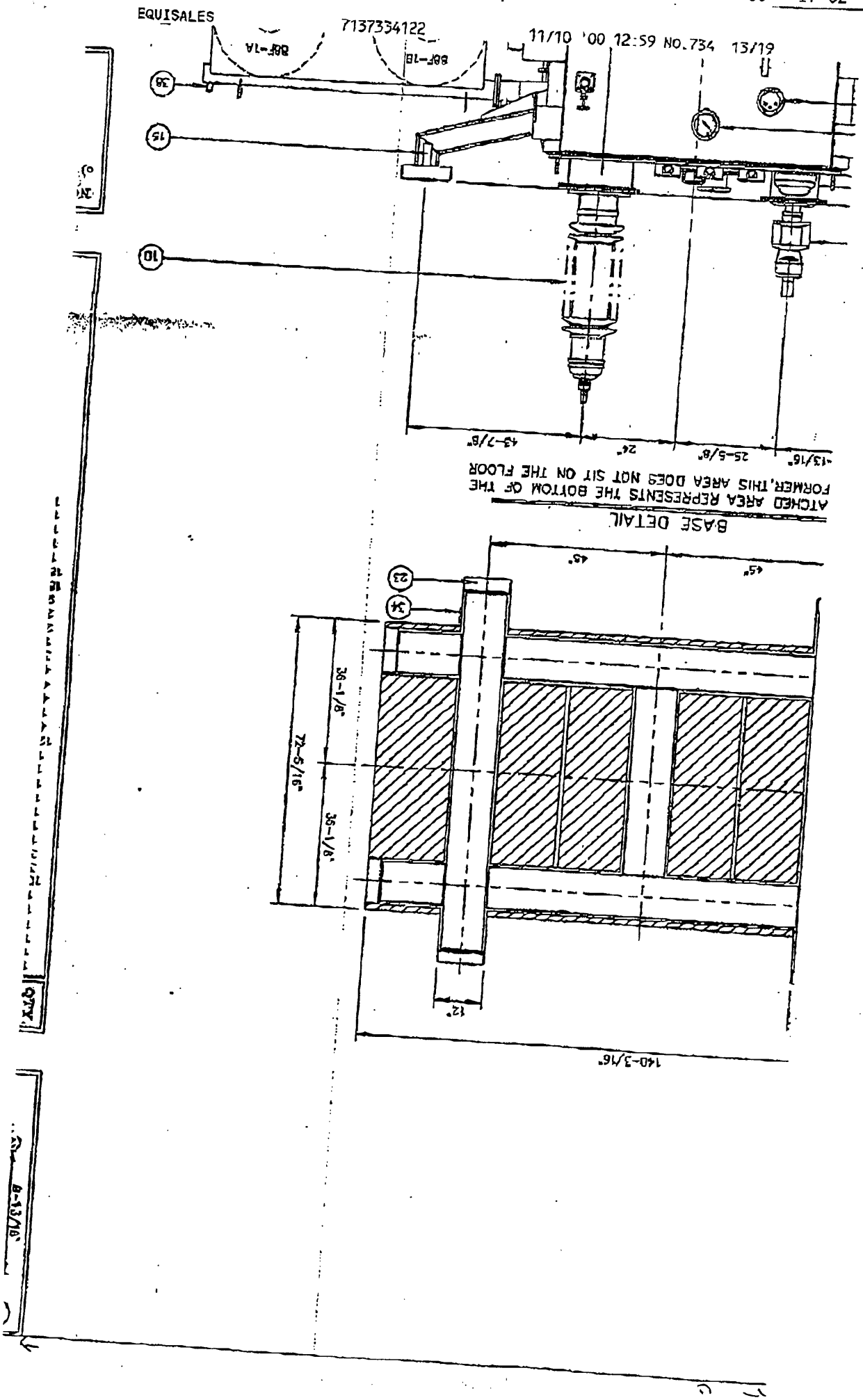
: STAINLESS STEEL

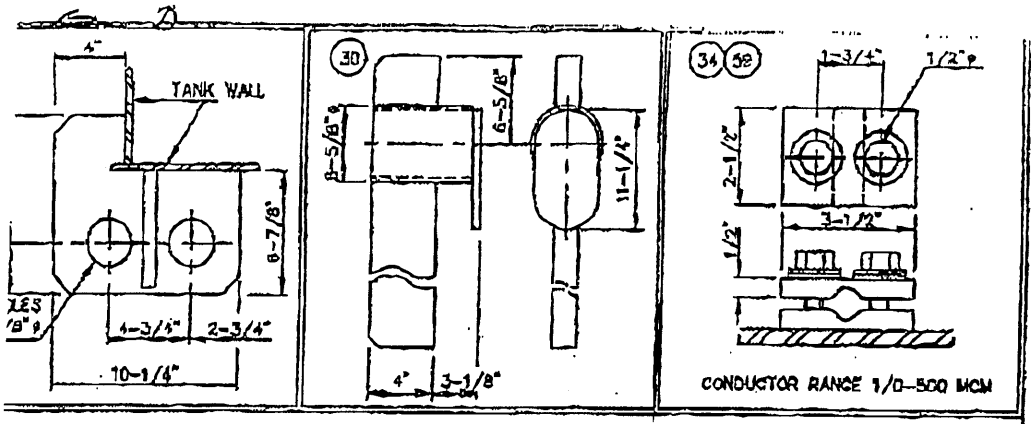
NS: 8" x 12"

REV.			
1	H.V., L.V. & HO GT'S ADDED.	Drawn: Edwin Mtz.	Title: NAMEPLATE
REV. 2		Chkd:	PROLEC
		Appd:	
		Sheet: 1 of 1	
		Rev.: 1	


EQUISALES
7137334122
11/10 '00 12:58 NO.734 11/19
28-1/2"
26-3/4"
55-1/8"
28-1/2"
55-1/8"


6
3
16
11
40
30
29-1/2"
55-1/8"
29-1/2"
20
29
4
35
18
32
34
3A
2A
1A
X3
X2
H3
H2
28-13/16"
28-13/16"
86-5/16"
55-1/8"


EQUISALES
7137334122
11/10 '00 12:59 NO.734 13/19
38
15
10
43-7/8"
24"
25-5/8"
13/16"
BASE DETAIL
ATCHED AREA REPRESENTS THE BOTTOM OF THE FORMER,THIS AREA DOES NOT SIT ON THE FLOOR
23
34
45"
45"
36-1/8"
72-5/16"
36-1/8"
12"
140-3/16"



D E S C R I P T I O N

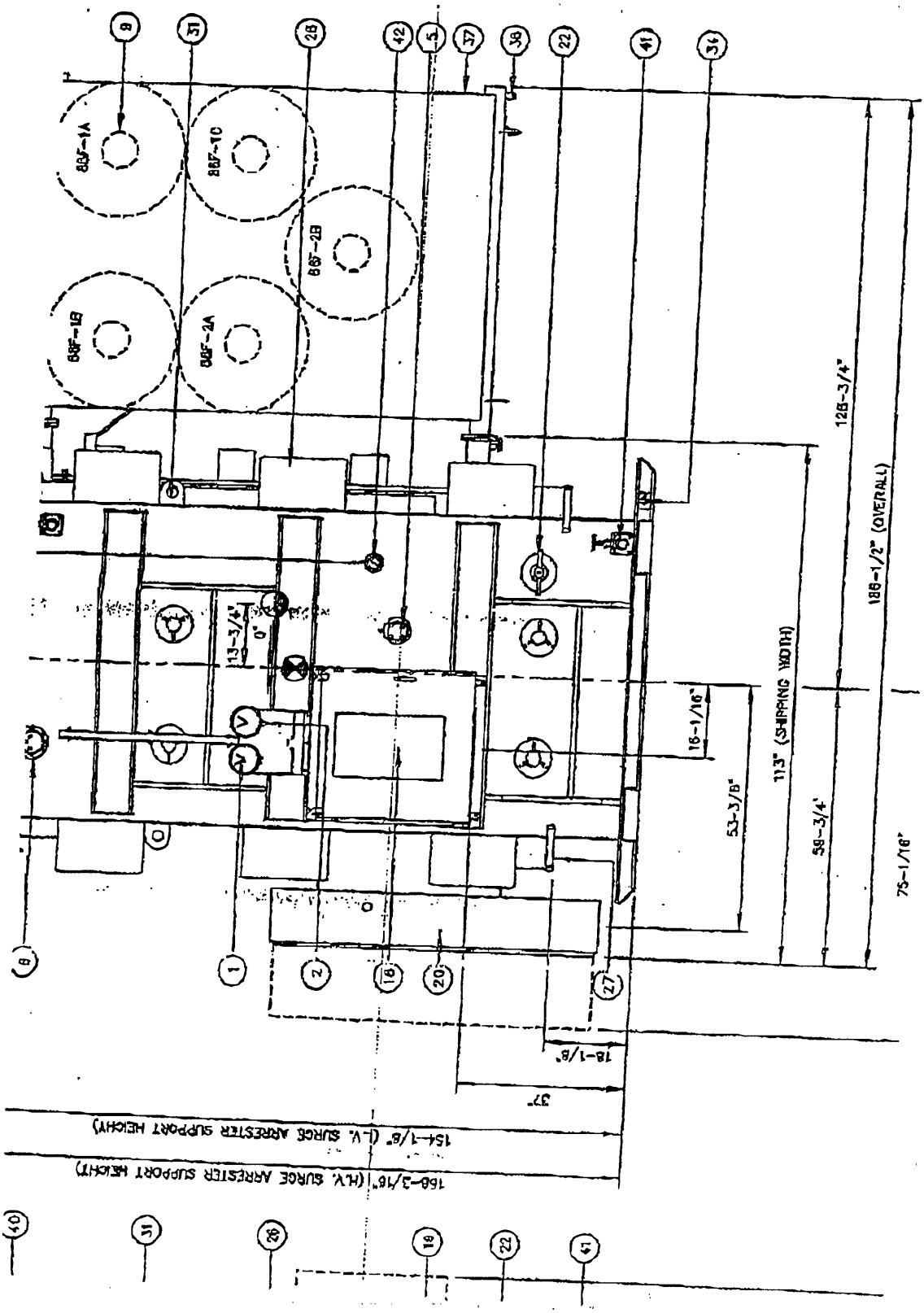
1	WINDING TEMPERATURE INDICATOR (49T-1)
2	LIQUID TEMPERATURE INDICATOR (26O-1)
3	MAGNETIC LIQUID LEVEL GAUGE (71O-1)
4	PRESSURE RELIEF DEVICE (63PR-1)
5	SUDDEN PRESSURE RELAY (63FP-1)
6	THERMAL PLATE
8	COOLING FANS (88F)
10	HIGH VOLTAGE BUSHING
11	LOW VOLTAGE BUSHING
15	HIGH VOLTAGE SURGE-ARRESTERS MOUNTING BRACKET
16	LOW VOLTAGE SURGE-ARRESTERS MOUNTING BRACKET
18	NAMEPLATE
19	CONTROL CABINET, INCLUDING TERMINAL BLOCK FOR INSTRUMENTS AND ACCESSORIES
20	AUTOMATIC CONTROLLED NITROGEN EQUIPMENT FOR OPERATION (63P-1)
22	NO-LOAD TAP-CHANGER
23	SKIDDING BASE WITH EXTERNAL BRACES
26	TANK BRACES
27	JACKING PADS AND PULLING EYES
28	MAIN COVER
29	LIFTING LUGS FOR LIFTING COVER ONLY
30	LIFTING LUGS FOR LIFTING COMPLETELY ASSEMBLED TRANSFORMER
31	SHIPPING LUGS
32	CT TERMINAL BOX
33	CORE GROUNDING BUSHING TERMINAL BOX PRINCIPAL
34	TRANSFORMER GROUND PAD
35	MANHOLE FOR INSPECTION ON MAIN COVER
37	COOLING RADIATORS, INCLUDING SUPPORT AND BRACES
38	RADIATORS VENT AND DRAIN PLUG (1" Ø)
39	RADIATORS VALVE BUTTERFLY-TYPE (4" Ø)
40	TOP FILTER PRESS VALVE (2" Ø) GLOBE-TYPE
41	MAIN TANK DRAIN VALVE (2" Ø) GLOBE-TYPE, WITH SAMPLING DEVICE (3/8 Ø) AND PLUG
42	PRESSURE-VACUUM BLEEDER AND GAUGE
57	NEUTRAL BUSHING HO
59	TRANSFORMER GROUND PAD FOR NEUTRAL

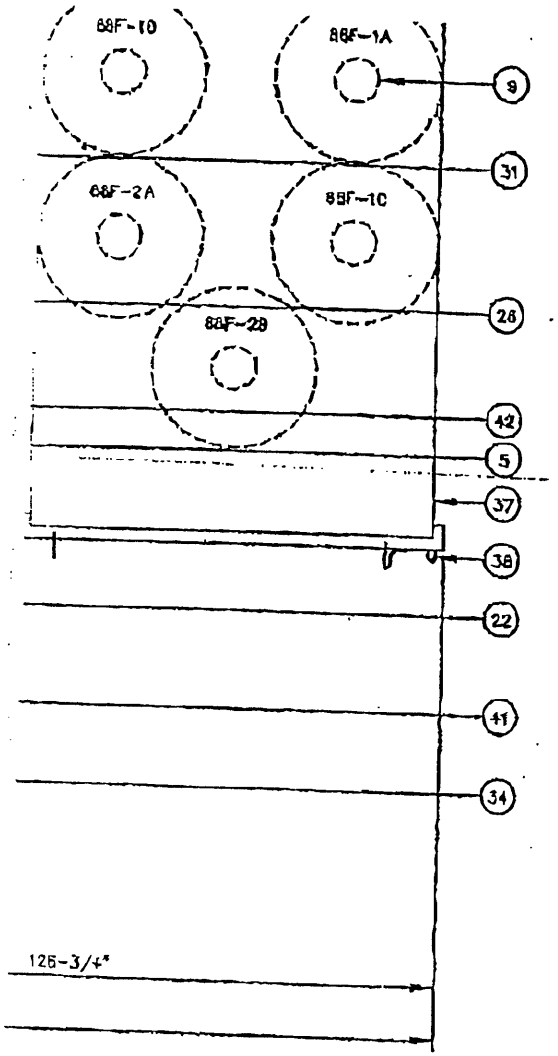
OTES

ITEMS REMOVED FOR SHIPMENT ARE :

1,2,4,5,9,10,11,15,16,37 & 57

APPROXIMATE WEIGHTS	POUNDS
CORE AND COILS :	82892
TANK AND FITTINGS:	35740
MAIN TANK LIQUID (4202 GALS) :	31584
RADIATORS LIQUID (745 GALS) :	5500
TOTAL MASS :	135792
UNTANKED MASS (HEAVIEST PIECE) :	82892
SHIPPING MASS :	81308


OPERATION CENTER
SHIPPING CENTER OF
EQUI SALES
CUSTOMER P.O. No: 9897
G.E. REQUISITION No: 420-
G.E. PROJECT SERIAL No: G458 G459 G456
STEP UP TRAN
36/48/60 MVA, ON/FA
65°C, 3300 FASE
115/66.395 KV.
REV. 1
REV. 2
GENERAL REVIEW
Sheet: 1 of 1
88F-1A
88F-1C
88F-2B
88F-1B
88F-2A
126-3/4"
188-1/2" (OVERALL)
113" (SHIPPING WIDTH)
58-3/4"
75-1/16"
53-3/8"
16-1/16"
13-3/4"
0"
18-1/8"
37"
154-1/8" (L.V. SURGE ARRESTER SUPPORT HEIGHT)
168-3/16" (H.V. SURGE ARRESTER SUPPORT HEIGHT)



OPERATION CENTER OF GRAVITY

SHIPPING CENTER OF GRAVITY

EQUI SALES
CUSTOMER P.O. No: 9897243
G.E. REQUISITION No: 420-82313
G.E. PROLEC SERIAL No: G459-01
G459-02
G459-03

STEP UP TRANSFORMER
36/48/60 MVA, OA/FA/FA, THREE PHASE
65°C, 3300 FASL, 60 HERTZ
115/86.395 KV. -(13.8 KV. Δ

APPROXIMATE SHIPPING DIMENSIONS

LENGTH :	170"
WIDTH :	113"
HEIGHT :	159"

T O L E R A N C E

Center line distance of not inclined bushings	±1/4"
Center line distance of inclined bushings	+1" -5/8"
Bushings height (distance to floor)	±1/2"
Outlet of control cabinet distance	±1/4"
Hv & Lv bushings center line	±1/4"
Bushings & surge arrester center line	±1/4"
Surge arrester height (distance to floor)	±1/2"
Center tank distance to short side	±1/2"
Center tank distance to large side	±1/2"
Conservator height	±1/2"
Anchoring center line	±1/8"
Bracing boss center line	±1/8"
Pattern distance	+1/16" -3/16"
Outline Dimensions Height 0"-118"	±1"
Height 118"-197"	±1.1/2"
Height 197" & Above	±2"

REV.		REV.
1		3
2	- GENERAL REVIEW	4

Drwn: Edwin Hts.
Chkd:
Appd:
Sheet: 1 of 1

Title: TRANSFORMER'S OUTLINE

PROLEC

Third Angle Projection:
Scale: 1/2" = 1'
Dimensions in: INCHES
Sec: 80
Drawing No. G45901D801