CONTRACTORS
ENGINEERS
DEVELOPERS

MORRISON-KNUDSEN COMPANY, INC.

CONSTRUCTION DIVISION
MORRISON-KNUDSEN PLAZA
P.O. BOX 7808/BOISE, IDAHO U.S.A. 83729
PHONE: (208) 386-5000/TELEX: 368439

September 28, 1988 Serial #10CFR21-88-9

Mr. Thomas Murley
Director-Office of Nuclear Reactor Regulation
Nuclear Regulatory Commission
11555 Rockwell Pike
Rockwell, Maryland 20852

Subject: Report of Defects and Noncompliance - 10CFR21
Diesel Generator Standby Power Supply for
Nuclear Power Stations

Dear Sir:

Pursuant to previously supplied information regarding the Type 999 Unit Emergency Power Generator (Serial #10CFR-88-1), enclosed is the subject report prepared by our Power Systems Division in Rocky Mount, North Carolina. The Power Systems Division will notify all stations which were supplied with EMD 999 units. Additional information will be provided as it becomes available.

Very truly yours,

R. D. Kulchak
Director Quality Assurance

RDK/gs
Encl.

IE19
1/1

RDK88:n

REPORT NO.: 10CFR21-0037-1
DATE: 9/27/88 REV.: 0

MORRISON-KNUDSEN COMPANY, INC.
POWER SYSTEMS DIVISION

POST OFFICE BOX 1928
ROCKY MOUNT, NORTH CAROLINA 27802-1928
PHONE (919) 977-2720 / TWX (510) 929-0725
TELEX 802507 PSD-RYMO

REPORTING OF DEFECTS AND NONCOMPLIANCE

10CFR-21

MORRISON-KNUDSEN COMPANY, INC.
SERIAL NO. 10CFR21-88-1

COMPONENT: Diesel-Generator Standby Power Supply for Nuclear Power Stations
EMD Model 999 Systems Only

LOCATION: TVA - Browns Ferry Nuclear Plant

EVENT: During a 24-hour test run, the generator field circuit breaker tripped open causing loss of generator voltage, resulting in a failure of the diesel-generator to perform its safety function.

Harry W. Falter 9-27-88

Harry W. Falter, P.E. Date
Principal Engineer

N.C. License No. 7033

INDEX

REPORT NO.: 10CFR21-0037-1
DATE: 9/27/88 REV.: 0

REFERENCE: M-K Notice to NRC on February 5, 1988
Morrison-Knudsen Serial No. 10CFR21-88-1
Power Systems Division Serial No. ME-0-0045
MK/PSD File No. 10CFR21-0037

SUBJECT: Potential 10CFR21 Finding Conclusion
EMD 20-645E4 Type 999
Unit Emergency Power Generator
Generator Control Panel

INTRODUCTION:

The Electro-Motive Division furnished diesel-generators as emergency standby power supplies for nuclear power plant. The diesel-generator with its auxiliaries and controls is identified as Model 999 system generating plant. The specifications for the model 999 system are shown in Section 2. This type of diesel-generator system was furnished during the late 1960 and early 1970 period.

EVENT: Power Systems Division of Morrison-Knudsen received a phone call from Mr. Ed Freeman of the TVA-Browns Ferry Nuclear Plant on 1/25/88 in which he reported that the generator field breaker tripped open during a 24 hr. load test while the diesel-generator was carrying 2950 KW @ 0.8 P.F. The field current at the field circuit breaker was measured to be 96 amps. The field current to the generator was measured to be 112 amps. The EMD characteristic curves show that the generator field requires 100 amp at a load of 2600 KW and 80% P.F. The readings taken at Browns Ferry appear to be correct. The formula that relates the AC power input:

Field Amps x 1.732 = AC Amp

112 Amps x .866 = 96.99 ≈ 97 Amps

This agrees reasonably with the field readings at 2,950 KW and 0.8 P.F. of 96 Amps at the breaker and 112 Amps at the generator field.

REPORT NO.: 10CFR21-0037-1
DATE: 9/27/88 REV.: 0

The field circuit breaker is a General Electric size 100 amp, type TED 136100 which has a 5 to 10% margin. It is located in the generator control panel as shown in Fig. 1 and in the circuit shown schematically in Fig. 2 (located in Section 5).

EMD normally used a Square D 100A circuit breaker which had a 15% tolerance. At the time, since no instances were reported to date, it was thought that this higher tolerance would have prevented the circuit breaker trip. Since only the Browns Ferry diesel-generators had the GE circuit breakers, it was thought the problem may be limited to the Browns Ferry plant.

RECOMMENDATION:

1. On a February 9, 1988, Morrison-Knudsen advised Mr. Ed Freeman by phone of the following tentative recommendations:

   (a) Replace the 100 amp circuit breaker with a 125 amp circuit breaker. Original breaker was a G.E. TED 136100.

   (b) Replace the #4 AWG field wire with a minimum size #2 AWG but no larger than a size "00".

2. An alternative possible solution is as follows:

   (a) Remove the trip devices from the circuit breaker and convert it to a contactor. This would provide for control of the circuit breaker by means of the shunt trip coil in case of a differential relay trip signal. This would eliminate the tripping of the circuit breaker at any cost or risk to equipment. If there is a failure in the field, you have lost the safety function anyway and the high voltage fuses may blow.

   (b) Determine the life of the #4 AWG field wire considering that the total operating hours for 40 years may not exceed 8,000. During that time, most of the load would be less than 100% of rated and that the 200 hr. rating may only be used for a total of 200 hours. If the study shows the #4 AWG wire insulation can survive the service life, then it need not be replaced.

REPORT NO.: 10CFR21-0037-1
DATE: 9/27/88 REV.: 0

3. MK/PSD advised TVA of the recommendation by the engine manufacturer in our letter dated 7/1/88 (Serial No. 6981C-0-0010) located in Section 4.

ACTION TAKEN:

During a phone conversation between Mr. Ed Freeman of Browns Ferry and Harry Falter of MK/PSD on 9/21/88, the corrective action completed by Browns ferry was to replace the circuit breaker with a contactor with no overload coil but with a trip coil that would be actuated by the 86 relay. Also, the field wire was replaced by a larger size wire. This then eliminated the problem of field current tripping the field circuit breaker.

CONCLUSION:

Recently, Browns Ferry conducted a test to record temperatures inside the generator cabinet. The temperatures recorded are shown on Figure 3, 4 and 5 (located in Section 5).

The results indicate that the air temperatures around the field circuit could exceed 50°C at loads of 2850 KW and 0.8 P.F. which may cause the field breaker to trip at a lower amperage during an extended run period.

Since all Model 999 generator control panels are basically the same design and construction, the potential for the field circuit breaker to trip due to combined air temperatures and field current exists at all nuclear plants which have the Model 999 System.

Therefore, the recommendations given to Browns Ferry could be applicable to other nuclear power plants with the EMD 999 diesel-generator system.

NORTH CAROLINA PROFESSIONAL SEAL 7033 ENGINEER HARRY WILLIAM FALTER 9-27-88

Harry W. Falter 9-27-88

Harry W. Falter, P.E. Date
Principal Engineer

N. C. License No. 7033

Specifications for

GENERAL MOTORS

MODEL 999 SYSTEM

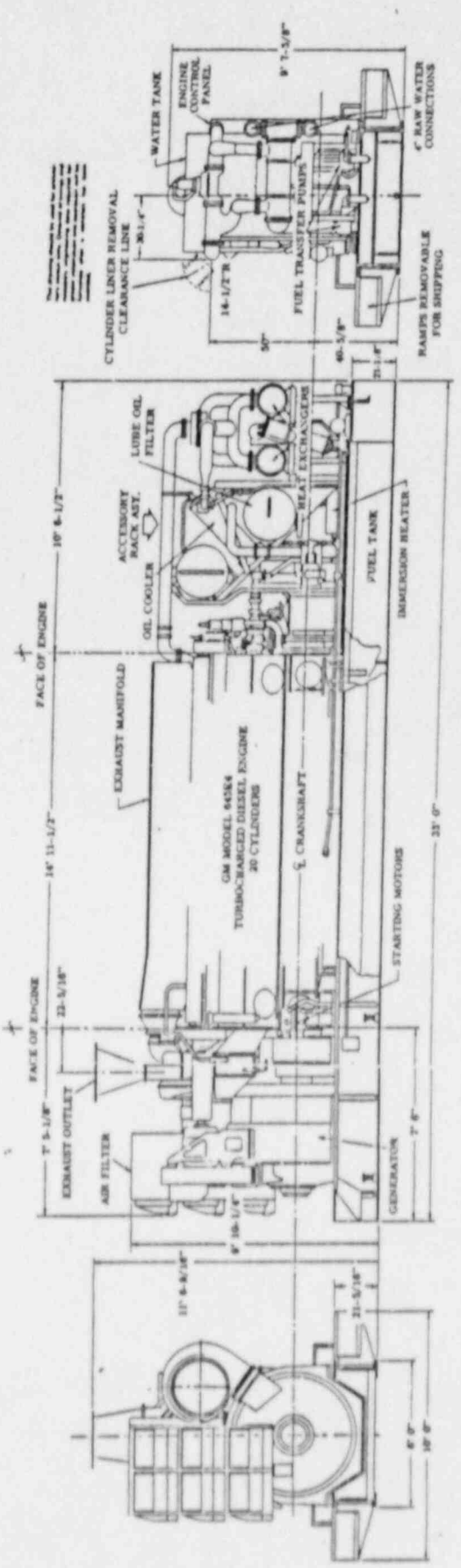
GENERATING PLANT

Specification No. 7500 Rev. B

January, 1970

Electro-Motive Division
General Motors Corporation
La Grange, Illinois 60525 U.S.A.

Pho In U.S.A.



MODEL 999-20 SYSTEM – WATER COOLED
INSTALLATION OUTLINE

ESTIMATED WEIGHT: 77,670 LBS.

SECTION I
GENERAL DESCRIPTION

This specification describes the EMD Model 999 System - a diesel-electric generating concept designed for nuclear power plant emergency standby protection by the Electro-Motive Division of General Motors Corporation.

The Model 999 System has been specifically developed to protect a nuclear reactor in case of major accident and to provide a completely independent source of start-up power for the nuclear station.

The Model 999 System can start automatically, be at synchronous speed and full voltage and be ready to accept load, all within ten seconds after the start signal. The Model 999 System can be at full load within 30 seconds after receipt of a start signal. When motor starting requirements exceed the capability of a single Model 999 System, the System can be modified to permit multiple unit installations on a common bus. In this case, the Systems will be in synchronism and ready to accept load within the time limits specified above.

This specification deals in detail with how the Model 999 System, engineered as an integrated arrangement, using proven components, and with but one source of responsibility, meets the design requirements.

Each System includes a complete unit embodying the engine, generator, and basic accessories mounted on a rigid common subbase. This unit is completely assembled, piped, wired and tested at the factory. In addition, the System includes an electrical cabinet and other accessories which are provided separately for mounting where convenient in the nuclear station.

The Model 999 System is available at two ratings:

2850 KW - Model 999-20 System - 2750 KW With EMD Radiator Cooling
2400 KW - Model 999-16 System - 2300 KW With EMD Radiator Cooling

The difference between the two models is the size of the Diesel engine. The Model 999-20 System is equipped with a 20-cylinder engine while the Model 999-16 System is supplied with a 16-cylinder engine. Unless otherwise indicated in this specification, each item discussed is common to either model.

RATING CONDITIONS

All ratings contained herein apply under the following conditions:

90° F. Air Intake Temperature
28.25" Hg. Barometer (Minimum)
19,350 BTU/LB. Fuel (HHV)
6" H_2O Air Intake Depression (Maximum)
5" H_2O Exhaust Back Pressure (Maximum)

TEMPERATURE AND ALTITUDE EFFECTS

The Model 999 System will maintain rated output at altitudes up to 6000 feet above sea level. For ratings at altitudes above 6000 feet, application should be made to Electro-Motive Division.

The Model 999 System ratings are based on combustion air inlet temperature of 90° F. For ratings at temperatures above 90° F., application should be made to Electro-Motive.

STARTING METHODS

The Model 999 System will accept two types of starting signals:

1) Emergency/Automatic. This signal which is normally furnished from customer-supplied relays (such as no-voltage or under-frequency), provides the Model 999 with the intelligence to operate as an isolated source of power. This signal will enable the engine-generator set to start and arrive at full speed and be ready to accept load within ten seconds. If multiple Model 999 Systems are to operate in parallel with each other, modifications permit synchronizing and real and reactive load sharing.

2) Exercise. In order to permit the Model 999 System to be loaded in parallel with the nuclear plant bus during routine maintenance exercises, an alternate starting signal is required. The 999 System is then under operator control.

MOTOR STARTING CAPABILITY

The Model 999 System has been specifically designed to protect the reactor in case of severe accident, and to provide start-up power for nuclear plants. These design parameters require the starting of large induction motors driving centrifugal pumps.

Maximum reliability with minimum voltage drop has been achieved with a static excitation system, low impedance generator and special field forcing equipment. Use of this combination allows computation of minimum voltage using the sub-transient reactance value rather than the more common transient reactance.

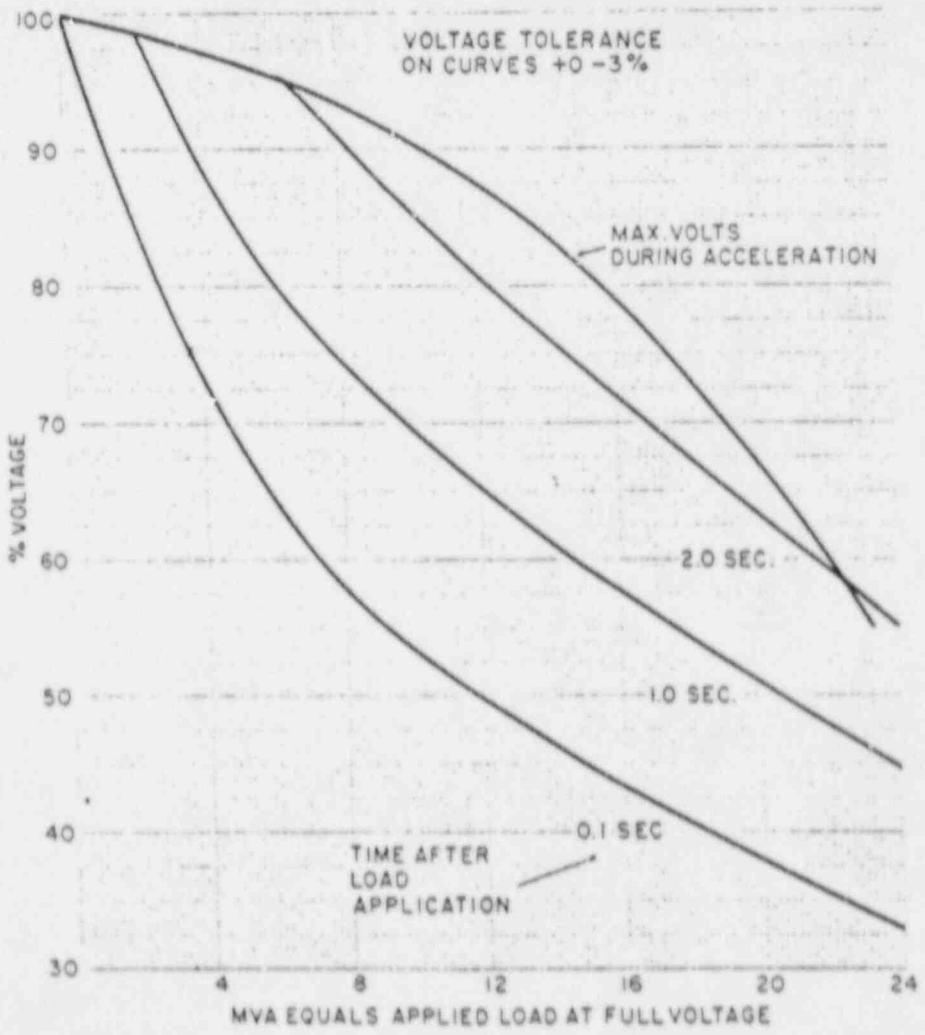
More important than the maximum voltage drop is rapid voltage recovery for acceleration of the motor and load. This is accomplished through the use of special "Power Current Transformers" which supplement the power available to the exciter from the Control Power Transformer.

The graph below shows the voltage that can be expected when loads of various starting inrushes are applied to the Model 999 System. The curve labeled 0.1 second indicates the voltage at 6 cycles, which is very close to the minimum voltage that will occur. The curve labeled 1.0 second shows the voltage that will be available for accelerating the load.

When multiple Model 999 Systems are installed on a common bus, sharing of real and reactive load during motor starting is required. This is accomplished through use of the Load Sharing Governor modification (See Section 8).

When the Model 999 System is so equipped, the curves can be used by dividing the motor starting KVA inrush by the number of Model 999 Systems installed on the bus.

MODEL 999 SYSTEM
DEAD LOAD PICKUP CAPABILITY



CONTRACTORS
ENGINEERS
DEVELOPERS

MORRISON-KNUDSEN COMPANY, INC.

CONSTRUCTION DIVISION
MORRISON-KNUDSEN PLAZA
P.O. BOX 7808/BOISE, IDAHO U.S.A. 83729
PHONE (208) 386-5000/TELEX 368439

February 5, 1988

Serial #10CFR21-88-1

Mr. James Taylor
USNRC
1717 H Street
Washington, D.C. 20555

Subject: Potential 10CFR21 Finding - Testing of EMD20-645E4
Type 999 Unit Emergency Power Generator

Dear Sir:

We have been advised by our Power Systems Division in Rocky Mount, North Carolina of a potential problem with the above subject Type 999 Unit which is in nuclear service (correspondence attached).

Please accept my apologies for the delay in transmitting this potential finding. We will forward additional information as it becomes available.

Very truly yours,

R. D. Kulchak
Director Quality Assurance

RDK/gs
Attach.

cc: H. Falter
V. Mitchell
File

MORRISON-KNUDSEN COMPANY, INC.

INTER OFFICE CORRESPONDENCE

DATE January 26, 1988

TO Ron Kulchak (Quality-Boise)
Vann Mitchell, Ken Lewis and
LOCATION Don Galeazzi (Rocky Mount)

FROM Harry W. Falter

LOCATION Rocky Mount, NC

SUBJECT Browns Ferry - Possible 10CFR21
Call 1/25/88 - Mr. Ed Freeman - 205-729-3363

1. Browns Ferry were conducting a test on the EMD20-645E4 - Type 999 unit. They were carrying a 2950 KW @ 80 PF when the field breaker tripped.

2. Freeman reported that they had measured 96 Amp at the circuit breaker and 112 Amp in the field.

3. Attached is a copy of the schematic which shows a 100A circuit breaker. Freeman identified the circuit breaker as a G.E. Type TED136100. The schematic is from an EMD drawing and the 100A is EMD's notation.

4. The EMD Characteristic Curves show that the generator field requires 100 Amps at 2600 KW and 80% PF.

5. It would appear that 100 Amp is too low a rating and should be 125 Amp, but this would require a larger frame size circuit breaker for which there would not be enough room in the cabinet.

6. I have asked EMD to check into this matter. I do not know why the Amps at the breaker should be less than the Amps at the field. As I see it, all the field Amps come from the EPT and PCT transformers.

Harry W. Falter

HWF:jb

Attachments (5)

Publications and Dimensions

Time-current Curves, Outline Drawings

PUBLICATIONS

Descriptive Bulletins

Order publications from local General Electric Sales Office or Circuit Protective Devices Department, Plainville, Conn. 06062.

Q Line Breakers and Accessories	GEA-8181
E 100 Line Molded-case Circuit Breakers	GEA-7403
F 225 Line Molded-case Circuit Breakers	GEA-7404
J 600 Line Molded-case Circuit Breakers	GEA-7405
K 1200 Line Molded-case Circuit Breakers	GEA-7406
S 2500 Molded-case Circuit Breakers	GEA-7479
CLB* Current-limiting Circuit Breakers	GEA-7386
TRI-BREAK* Fused Circuit Breaker	GEA-7477
TDF Safety Handles For Circuit Breakers, QMW and QMR Disconnect Switches	GEA-7439
Molded-case Circuit Breakers, Accessories and Enclosures, 15-1200 Amperes	GET-2779

Outline Drawings

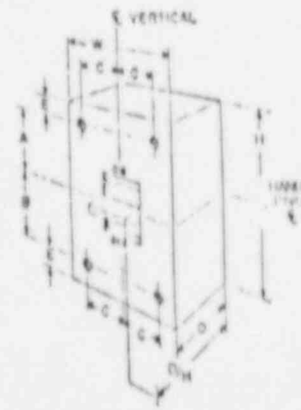
Circuit Breaker	Outline Drawing	Circuit Breaker	Outline Drawing
Type TQL	455C872	J 600 Line	455C564
Type TQC	455C874	K 1200 Line	455C840
Type TQB	455C873	S 2500	456C150
Type TQD	455C765	CLB	456C310
E 100 Line	455C299(TFU)	TRI-BREAK, 181	456C144
F 225 Line	455C561	184	456C145
		186, 188	456C146

Time-current Curves

GES curves may also be ordered from General Electric Company, A&SP Distribution Services, Bldg. No. 705, Corporations Park, Scotia, N. Y. 12302.

Breaker	10½" x 15" Translucent Paper for System Coordination Studies	8½" x 11" Size
TQL (1 pole, 10-20 Amp)		K215-80C
TQL (1-pole, 30-50 Amp)		K215-81C
TQL AC, TQB, TQC (15-50 Amp)		K215-63C
TQAL AC, TQB, TQC (60-100 Amp)		K215-64C
TQD	GES-6108A	K215-48C
E 100 (TE)	GES-6107B	K215-47C
E 100 (TEF, THEF)	GES-6102B	K215-38C
E 100 (TEF, THEF, Amb Comp)	GES-6102A	K215-49C
E 100 (TED, THED)		
(15-45 amp)	GES-6113	K215-87C
(50, 60, 70, 80 amp)	GES-6114	K215-88C
(90-100 amp)	GES-6115	K215-89C
F 225 (TFJ, TFK, THFK)	GES-6103A	K215-44C
J 600 (TJB, 400 Amp Max)	GES-6112	K215-[illegible]
J 600 (TJJ, TJK, THJK)	GES-6101B	K215-4[illegible]
K 1200 (300 to 1200 amp)	GES-6111B	K215-77D
S 2500 (600-2500 amp)	GES-6117	K215-78C
S 2500 (Dual selective trip)	GES-6118	K215-[illegible]
CLB		(See page 24)
181 (15-30 amp)		K215-71C
(40-100 amp)		K215-72C
184		K215-73C
186		K215-74C
188		K215-75C

DIMENSIONS (For Estimating Only)



Breaker Type	Poles	W	H	D	D H Max	A	B	C	E
Q 100	1	[illegible]	2 [illegible]						
TQL, THQL / TQAL, THQAL / TQB, THQB	2	2	3 [illegible]	2 [illegible]	2 [illegible]				
	3	3	3 [illegible]						
TQC, THQC	1	1							
	2	2	3 [illegible]	2 [illegible]	2 [illegible]				
	3	3							
Q 225	2	2 [illegible]	6 [illegible]	2 [illegible]	3 [illegible]	2 [illegible]	2 [illegible]	[illegible]	[illegible]
TQD	3	4 [illegible]							
E 100	1	1 [illegible]							
TE, TEF, THEF (1) / TED, THED (1)	2	2 [illegible]	6 [illegible]	3 [illegible]	4 [illegible]	2 [illegible]	2 [illegible]		[illegible]
	3	4 [illegible]						[illegible]	
F 225 TFJ, TFK, THFK	2, 3	4 [illegible]	10 [illegible]	3 [illegible]	5 [illegible]	3 [illegible]	3 [illegible]	[illegible]	1 [illegible]
J 600 TJJ, TJK4, TJK6, THJK, TJD	2, 3	8 [illegible]	10 [illegible]	3 [illegible]	5 [illegible]	3 [illegible]	3 [illegible]	1 [illegible]	1 [illegible]
K 1200 TKM8, THKM8, TKM12, THKM12	2, 3	8 [illegible]	15 [illegible]	5 [illegible]	7 [illegible]	8 [illegible]	5 [illegible]	1 [illegible]	[illegible]
S 2500	For dimension details, see page 24								
CLB*	2, 3,	4 [illegible]	17	4 [illegible]	5 [illegible]	11 [illegible]	4	[illegible]	1 [illegible]
TRI-BREAK* 181 / 184 / 186, 188	For dimension details, see page 19								

(1) 2-pole THEF and THED is in a 3-pole frame.

Data subject to change without notice.

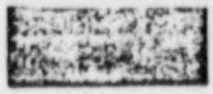
E 100 Line

Types TED and THED

Replaces Types TEF and THEF

15–100 Amperes

600 Volts, A-c
250 Volts, D-c



E100 circuit breakers comply with Federal Government Specifications W-C-375a Amendment 4 dated Feb. 18, 1965, as follows: Type TED and THED, Class 2, U/L listed.

New TED design (TED and THED) replaces existing TEF (TEF and THEF) type breakers. As stocks of TEF type breakers are depleted, orders will be filled by automatically substituting the new design.

(Photo 1209786)
TED 3-pole breaker

U/L LISTED INTERRUPTING RATINGS

(For IC Ratings Based on NEMA Test Procedures—see Page 3)

Breaker Type (2 and 3 pole)	240 Volt, A-c		480 Volt, A-c		600 Volt, A-c	
	Sym	Asym	Sym	Asym	Sym	Asym
TED						
480 V, 15-100 Amp	18,000	20,000	14,000	15,000		
600 V, 15-100 Amp	18,000	20,000	14,000	15,000	14,000	15,000
THED						
600 V, 15-100 Amp	65,000	75,000	25,000	30,000	18,000	20,000

LUG WIRE SIZES

Breaker Type	Amp Rating	Lug Wire Size
TED THED	15-100 Cu-Al	#14-2/0 Cat. No. TCA L12

For additional lugs, see page 8.

PRICES

TYPE TED 3-pole 480 and 600 Volts A-c (Includes load lugs only, add WL for line lugs)

CPD-P(175)

Amp Rating	TED 480 Volts A-c	List Price, Each, GO-135	TED 600 Volts A-c	VU-BREAK* 600 Volts A-c	List Price Each, GO-135
15	TED 134 015		TED 136 015	TED 136V 015	
20	TED 134 020		TED 136 020	TED 136V 020	
25	TED 134 025		TED 136 025	TED 136V 025	
30	TED 134 030		TED 136 030	TED 136V 030	
35	TED 134 035	$78.00	TED 136 035	TED 136V 035	$91.00
40	TED 134 040		TED 136 040	TED 136V 040	
45	TED 134 045		TED 136 045	TED 136V 045	
50	TED 134 050		TED 136 050	TED 136V 050	
60	TED 134 060		TED 136 060	TED 136V 060	
70	TED 134 070		TED 136 070	TED 136V 070	
80	TED 134 080	$93.00	TED 136 080	TED 136V 080	$111.00
90	TED 134 090		TED 136 090	TED 136V 090	
100	TED 134 100		TED 136 100	TED 136V 100	
100(1)	TED 134Y 100(1)	$71.00	TED 136Y 100(1)	TED 136VY 100 (1)	$91.00
	Packaged 8 to Carton, Ship. Wt 22 lb. Carton		Packaged 8 to Carton, Ship. Wt 22 lb. Carton	Packaged 4 to Carton, Ship. Wt 11 lb. Carton	

TYPE THED HI-BREAK* 2- and 3-pole 600 Volts A-c (Includes load lugs only, add WL for line lugs)

Amp Rating	THED 2 pole	List Price Each, GO-135	THED 3 pole	List Price Each, GO-135
15	THED 126 015		THED 136 015	
20	THED 126 020		THED 136 020	
25	THED 126 025		THED 136 025	
30	THED 126 030		THED 136 030	
35	THED 126 035	$117.00	THED 136 035	$137.00
40	THED 126 040		THED 136 040	
45	THED 126 045		THED 136 045	
50	THED 126 050		THED 136 050	
60	THED 126 060		THED 136 060	
70	THED 126 070		THED 136 070	
80	THED 126 080	$135.00	THED 136 080	$155.00
90	THED 126 090		THED 136 090	
100	THED 126 100		THED 136 100	

Packaged 8 to Carton, Ship. Wt 22 lb. Carton

ENCLOSURES ONLY (Includes Neutral)

CPD-P(175)

Description	Cat. No.	List Price, GO 134	Ship. Wt
NEMA 1, Hamilla-thru Cover, Surface or Flush	TE100F or S	$16.00	9½ lb
NEMA 1, with KO's (D) NEMA 12, without KO's (J)	TE100D or J	28.00	9 lb
NEMA 3R, Raintight with Hub, 2" Hubs, Add 8H	TE100RH	45.00	10 lb
NEMA 3, 3S, Water and Dust-tight Cast Iron (C)	Available Only with Factory-Installed Breaker		48 lb
NEMA 4, 5, Water and Dust-tight Stainless Steel (CS)	TE100CS	267.00	18 lb

ACCESSORIES AND MODIFICATIONS

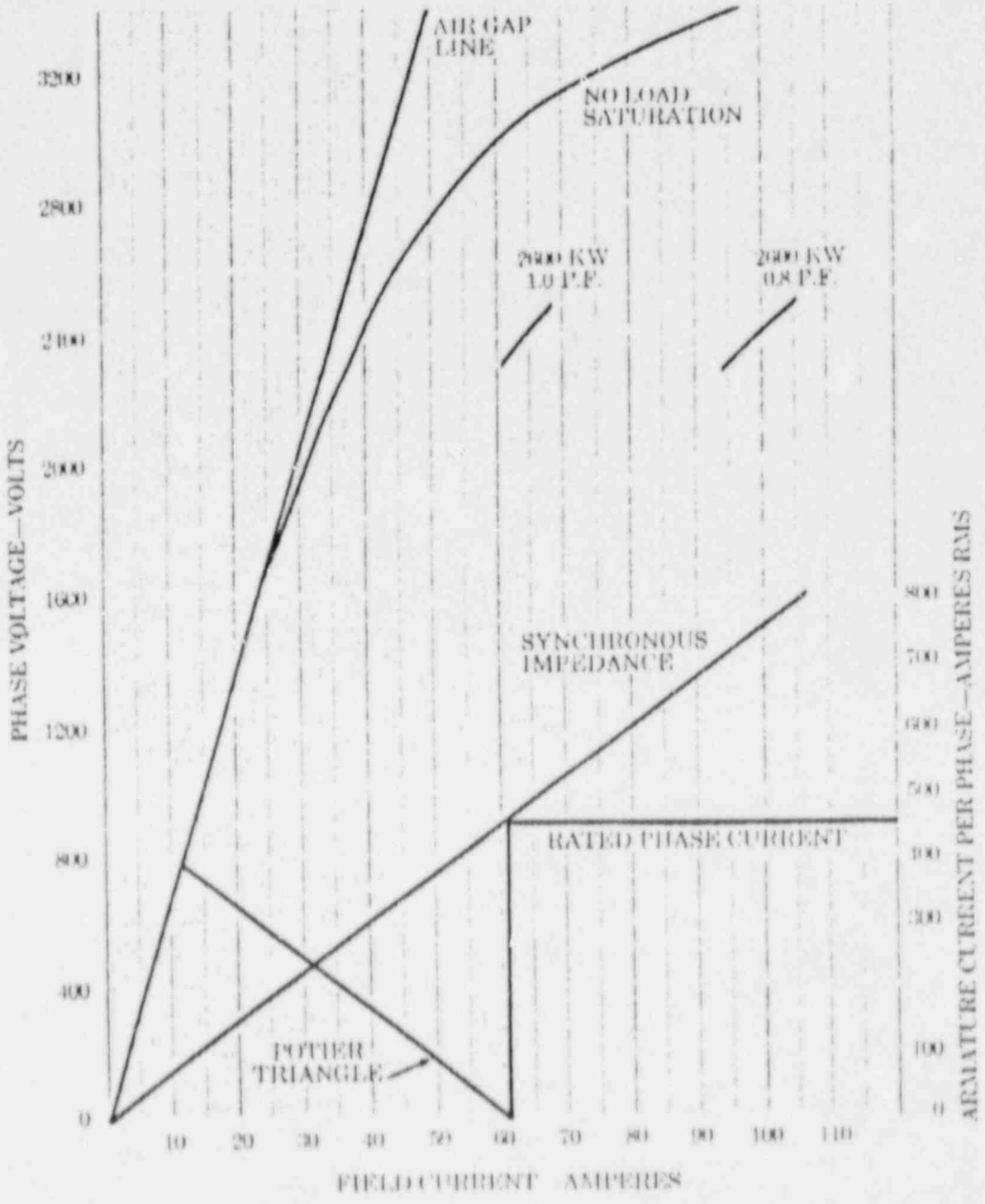
See pages 26-35

(1) Nonautomatic circuit interrupter, includes line and load lugs.
(2) U/L, NEMA Standards do not apply. Refer to Company for interrupting ratings.

*Registered trade mark of General Electric Co.

REFERENCE- E 100:
Publications and Dimensions Page 4

TYPICAL CHARACTERISTIC CURVES



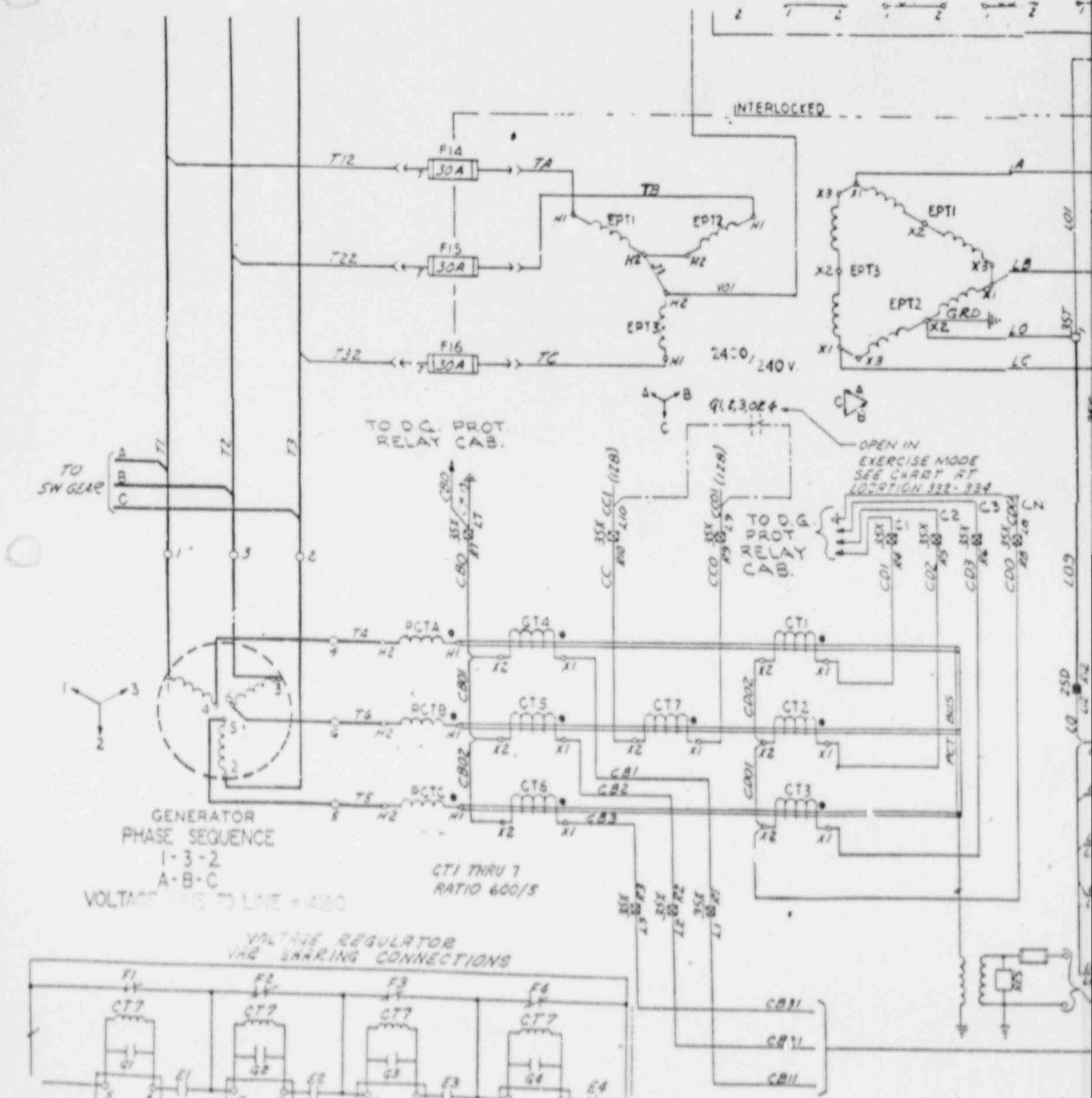
A20 SYNCHRONOUS GENERATOR
2600 KW - 60 CYCLE - 900 RPM
2400 VOLTS PER PHASE

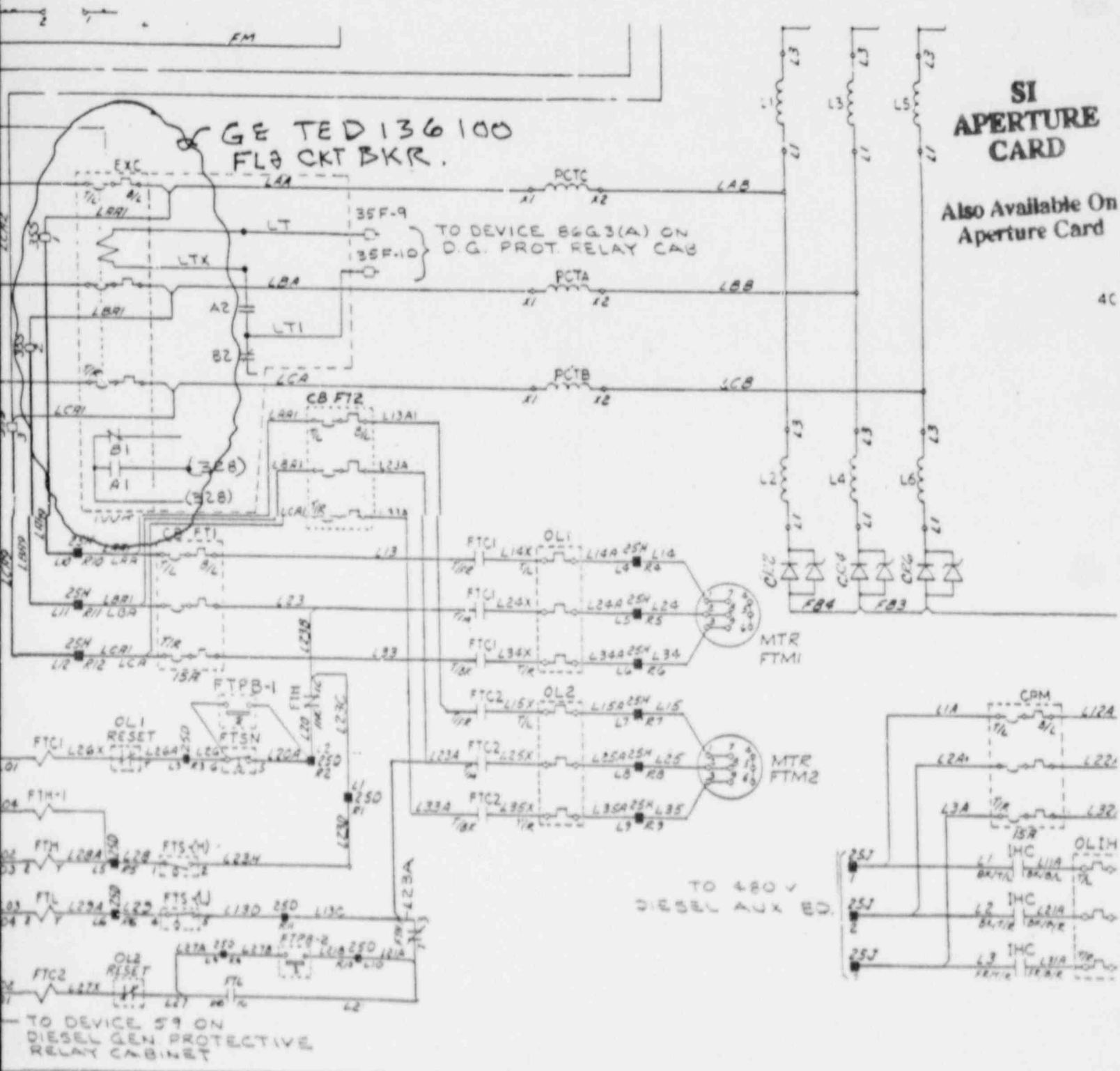
SYNCHRONOUS GENERATOR DATA

BASE LOAD RATINGS

Electro-Motive Generator Model	A20	A20	A20-6	A20-6
Generator Frequency - Hz (cycles per second)	60	50	60	60
Speed - rpm	900	750	900	900
Rating - KW	2600	2200	1680	2100
KVA	3250	2750	2000	2625
Power Factor	0.8	0.8	0.8	0.8
Terminal Voltage - 3-phase				
Wye	4160	4160	----	----
Delta	2400	2400	480	600
Efficiency - Rated KVA and Power Factor	97.2	96.5	96.2	96.4
Armature Current - Amperes				
Wye	451	382	----	----
Delta	782	662	2400	2525
Nominal Stator Temperature Rise - °C	80	65	100	110
°F	176	149	212	230
Reactances - Per unit				
Direct Axis Synchronous, x_d	1.66	1.21	1.25	1.04
Quadrature Axis Synchronous, x_q	1.00	0.73	0.75	0.63
Direct Axis Transient, x_d'	0.44	0.27	0.316	0.266
Direct Axis Subtransient, x_d''	0.28	0.17	0.217	0.182
Negative Sequence, x_2	0.22	0.22	0.180	0.158
Zero Sequence, x_0	0.11	0.10	----	----
Time Constants - Seconds @ 75° C (193° F)				
Direct Axis Transient Open Circuit, T_{do}'	4.34	4.34	4.34	4.34
Direct Axis Subtransient Short Circuit, T_d''	0.017	0.018	0.023	0.023
Direct Axis Transient Short Circuit, T_d'	0.654	0.620	1.02	1.02
Armature Time Constant T_a	0.09	0.09	0.044	0.044
Short Circuit Ratio	0.685*	1.11	0.83	1.12
T.I.F. Balanced	14	14	30	30
Residual	----	----	29	29
Regulation at Rated Load - Per Cent	42.8	23.3	43.8	20
Synchronizing Coefficient - KW/Radian				
Full Load	5770	5940	4350	6213
No Load	3250	3780	2670	4130
Field Data				
Resistance at 75° C (193° F)	1.258	1.258	1.258	1.258
Excitation at No Load Rated Volts	39.2	55.0	34.0	43.0
Excitation at Full Load Rated V	100	171.5	69.0	79.0
Nominal Field Temperature Rise, °C	65	85	80.0	90
°F	150	185	150	195
Total Weight - Pounds	18,100	18,100	18,100	18,100
Stator	9,000	9,000	9,000	9,000
Rotor	8,100	8,100	8,100	8,100
End Housing & Bearing	1,000	1,000	1,000	1,000

* In making applications at this rating, be aware that this low short circuit ratio has limitations.


INTERLOCKED
F14
30A
F15
30A
F16
30A
T12
T22
T32
TA
TB
TC
EPT1
EPT2
EPT3
2400/240 V.
GRD
TO D.G. PROT RELAY CAB.
Q1,2,3,OR 4
OPEN IN EXERCISE MODE SEE CHART AT LOCATION 332-334
TO D.G. PROT RELAY CAB.
TO SW GEAR
PCTA
PCTB
PCTC
CT4
CT5
CT6
CT7
CT1
CT2
CT3
PCT BUS
CB1
CB2
CB3
CB31
CB21
CB11
GENERATOR
PHASE SEQUENCE
1-3-2
A-B-C
CT1 THRU 7
RATIO 600/5
VOLTAGE REGULATOR
VAR SHARING CONNECTIONS



ELECTRO-MOTIVE

Electro-Motive Division General Motors Corporation LaGrange, Illinois 60525 (312) 387-6000

May 25, 1988

ONLY APPLICABLE to Browns Ferry

Mr. Harry Falter
Power Systems Division/M-K
P. O. Box 1928
Rocky Mount, NC 27801

SUBJECT: Model 999 Excitation System
Circuit Breaker and Wiring
T.V.A. Brown's Ferry

Dear Harry:

This is in response to the T.V.A.'s inquiry into the sizing of the exciter cable and excitation power circuit breaker for the subject units. Electro-Motive has investigated the excitation power circuit breaker and wiring loads and offer the following recommendations.

1. The circuit breaker should be changed to a 125 ampere 600 volt breaker. The General Electric E150 line is calibrated to carry full load at 50° C and would be a good replacement. Additional interlocks or shunt trips required for the installation will specify the part number for the breaker.

2. If the symbol III cables are tightly bound together, they should be separated to provide some air space between them. EMD recommends that the cables be inspected for cable insulation condition approximately every 6 years or closest convent nuclear plant refueling outage. There should be no thermal ageing for the duty cycle of these units.

The duty cycle is such that there is no significant thermal aging for the life of these units

Very truly yours,

E. W. Ralls

E. W. Ralls, Manager
Power Products Service

EWR:vad

cc: M. J. Fleckenstein
J. J. Hayden
K. E. Jones
G. B. Morman
P. B. Russell
K. R. Thompson

April 28, 1988
FAX: 919-446-3830

Power Systems Division/M-K
Rocky Mount, NC
ATTN: Harry Falter

SUBJECT: Brown's Ferry Nuclear
999 Model Generating Units
Operating Ambient Temperatures

In response to TVA's request for maximum ambient temperatures under which skid-mounted components and controls cabinets can function, we offer the following:

The limiting factors used in establishing maximum ambient room air temperatures is the ratings of components within the electrical cabinets. EMD estimates the maximum allowable ambient for the electrical cabinet to be 60° C (140° F).

I trust that the above provides the information needed.

Very truly yours,

E. W. Ralls vad

E. W. Ralls, Manager
Power Products Service

EWR:vad

cc: M. J. Fleckenstein
G. B. Morman
K. E. Jones
P. B. Russell
K. R. Thompson

MORRISON-KNUDSEN COMPANY, INC.
POWER SYSTEMS DIVISION

POST OFFICE BOX 1928
ROCKY MOUNT, NORTH CAROLINA 27802-1928
PHONE: (919) 977-2720 / TWX: (510) 929-0725
FAX: (919) 446-3830

AUTHORIZED DISTRIBUTOR

July 1, 1988 S/N 6981C-0-0010

Tennessee Valley Authority
Browns Ferry Nuclear Plant
Decatur, Alabama 35601

Attention: P.J. Speidel

Reference: Tennessee Valley Authority
Browns Ferry Nuclear Plant
Model 999 Excitation System
Circuit Breaker and Wiring

Gentlemen:

In response to your inquiry into the sizing of the exciter cable and excitation power circuit breaker for subject units, MK/PSD contacted Electro Motive who in turn investigated the excitation power circuit breaker and wiring loads. The have offered the following recommendations.

1. The circuit breaker should be changed to a 125 ampere 600 volt breaker. The General Electric E150 line is calibrated to carry full load at 50°C and would be a good replacement. Additional interlocks or shunt trips required for installation will specify the part number for the breaker.

2. If the symbol III cables are tightly bound together, they should be separated to provide some air space between them. EMD recommends that the cables be inspected for cable insulation condition approximately every six (6) years or closest convent nuclear plant refueling outage. The duty cycle is such that there is no significant thermal aging for the life of these units.

Very truly yours,

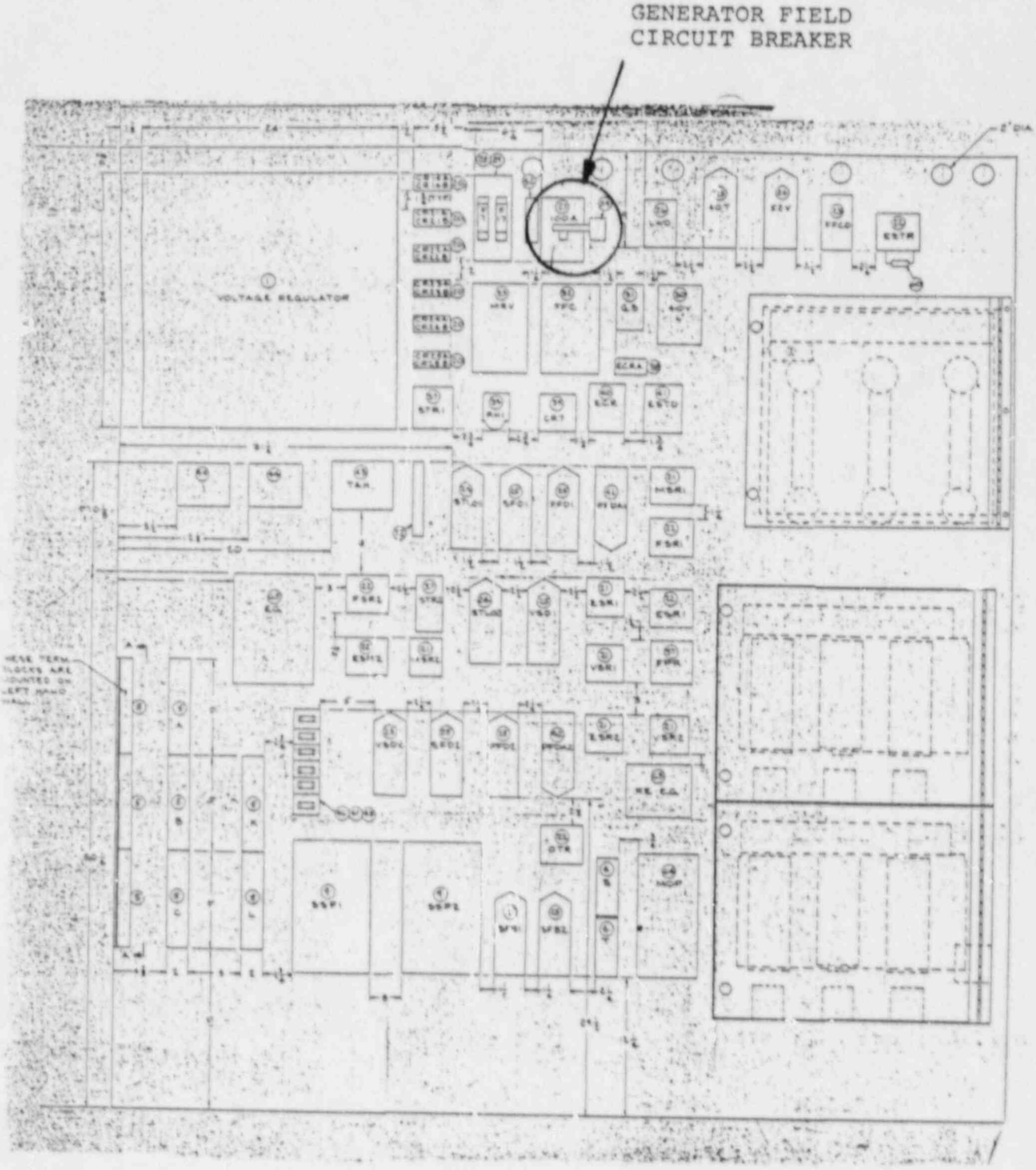
MORRISON KNUDSEN COMPANY
POWER SYSTEMS DIVISION

Kathy L. Cary

Kathy L. Cary
Contracts Administrator

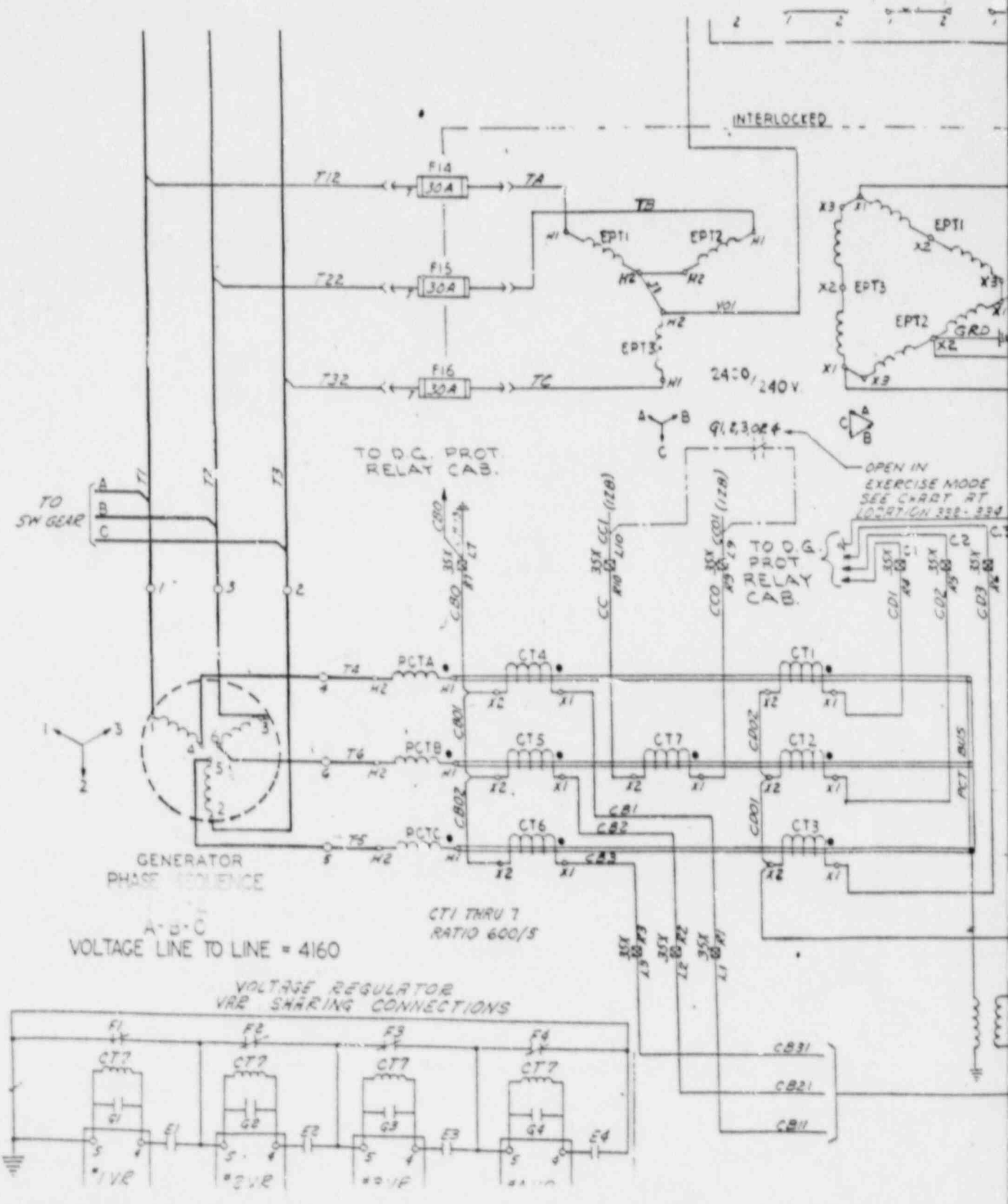
KLC/jm

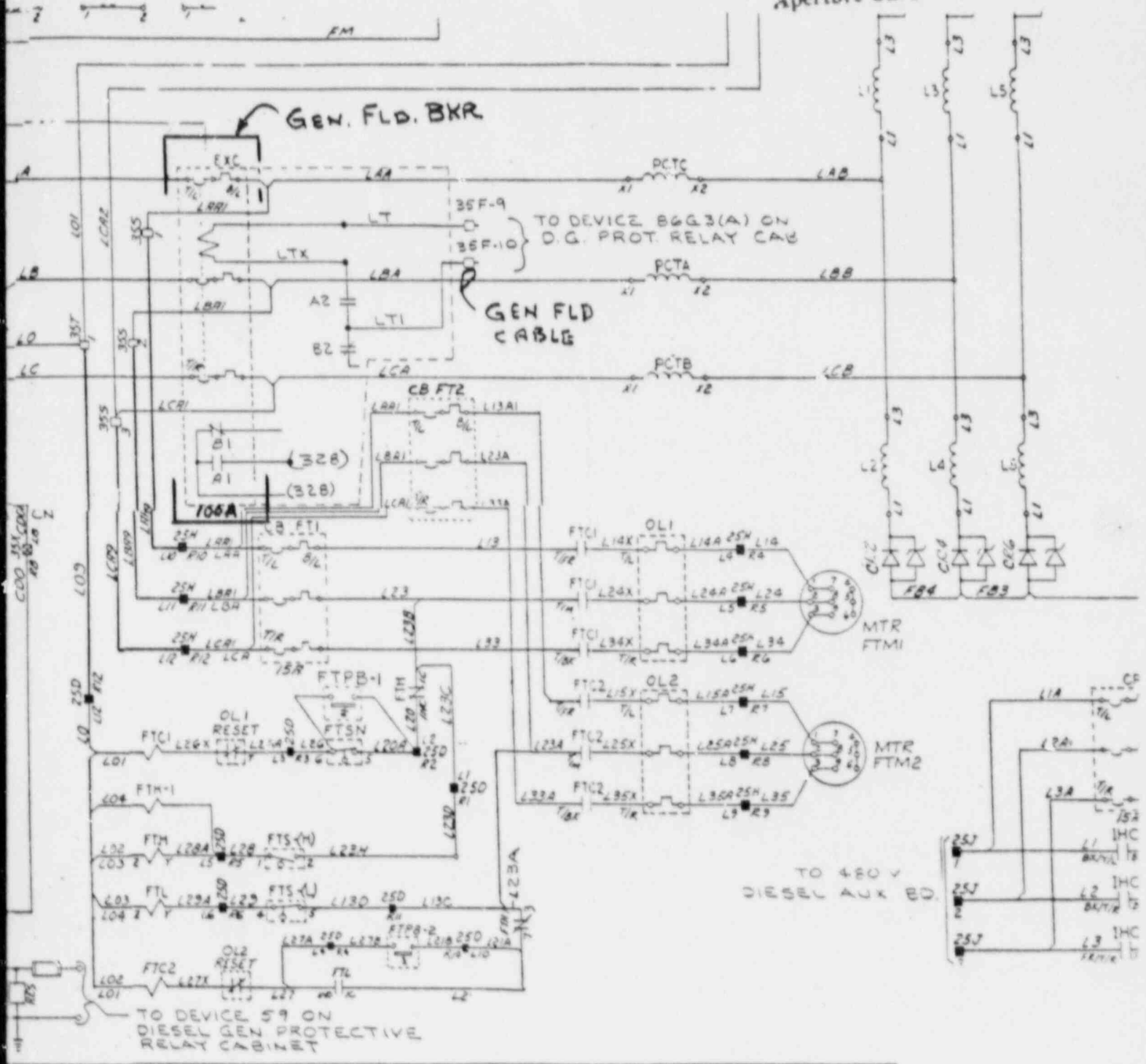
bc: H. Falter
K. Lewis



GENERATOR CONTROL PANEL
FRONT

FIG. 1


INTERLOCKED
F14
30A
F15
30A
F16
30A
T12
T22
T32
TA
TB
TC
EPT1
EPT2
EPT3
240/120V
TO D.G. PROT. RELAT CAB.
TO SW GEAR
T1
T2
T3
OPEN IN EXERCISE MODE SEE CHART AT LOCATION 328-334
TO D.G. PROT. RELAY CAB.
PCTA
PCTB
PCTC
CT4
CT5
CT6
CT7
CT1
CT2
CT3
GENERATOR PHASE SEQUENCE
A-B-C
VOLTAGE LINE TO LINE = 4160
CT1 THRU 7
RATIO 600/5
VOLTAGE REGULATOR
VRR SHARING CONNECTIONS
CB31
CB21
CB11



PARTIAL SCHEMATIC
EXCITER FIELD
POWER SUPPLY

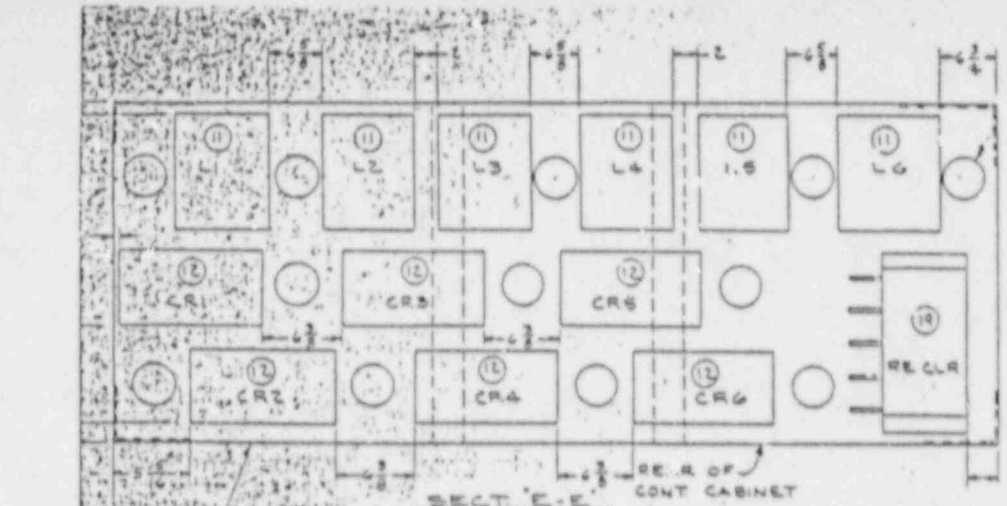
FIG. 2

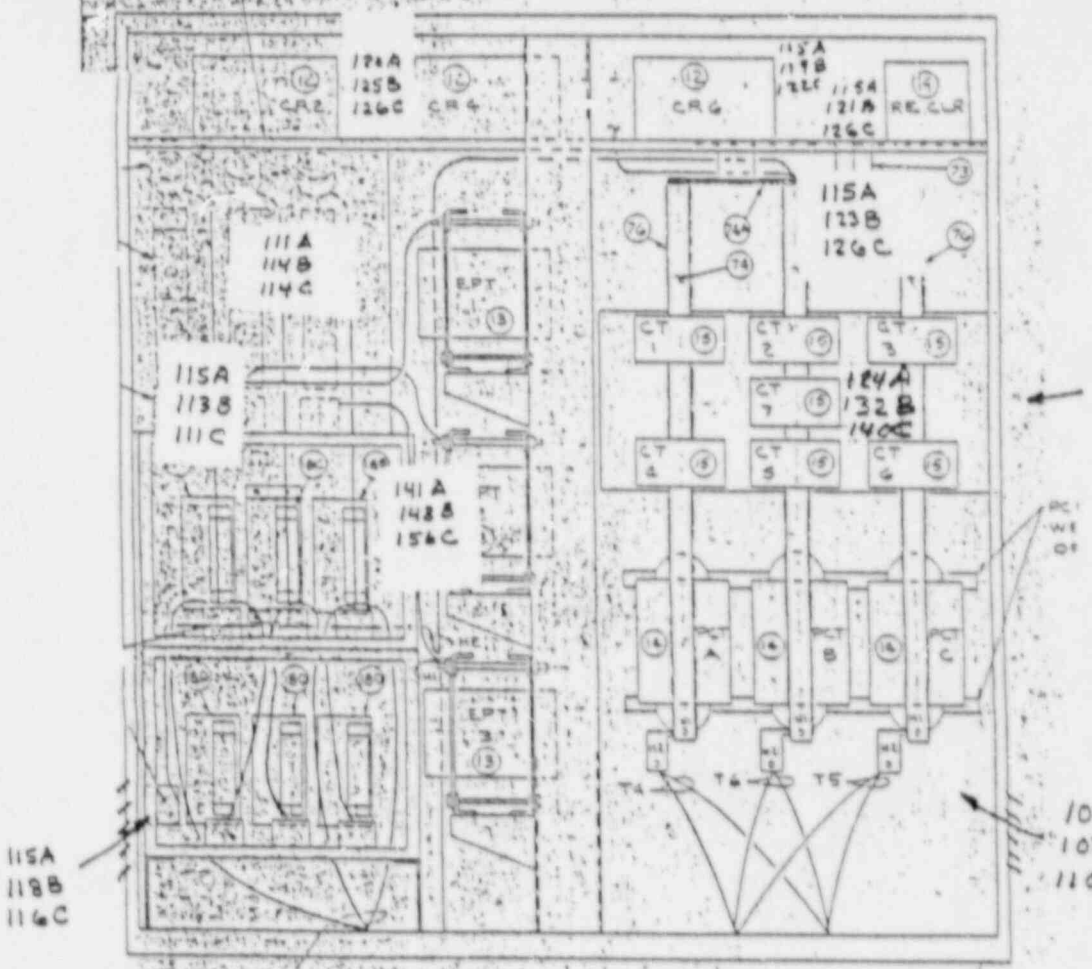
8810040405-02

GENERATOR
CONTROL PANEL
REAR

Operating Temperature
Browns Ferry Test

FIG. 3





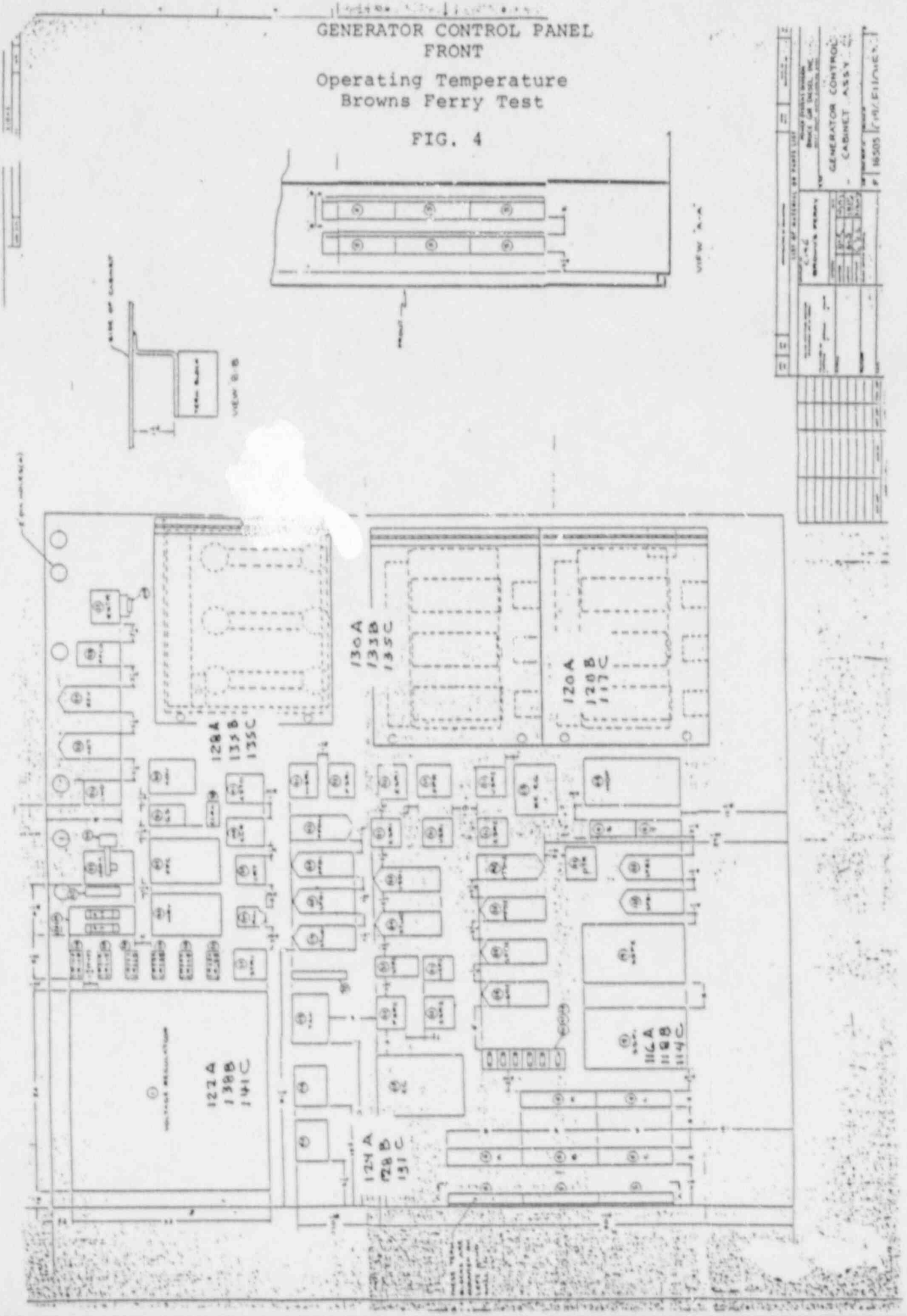
Example - 115A: 115°F @ 2000KW & .8PF
115B: 115°F @ 2600KW & .8PF
115C: 115°F @ 2850KW & .8PF

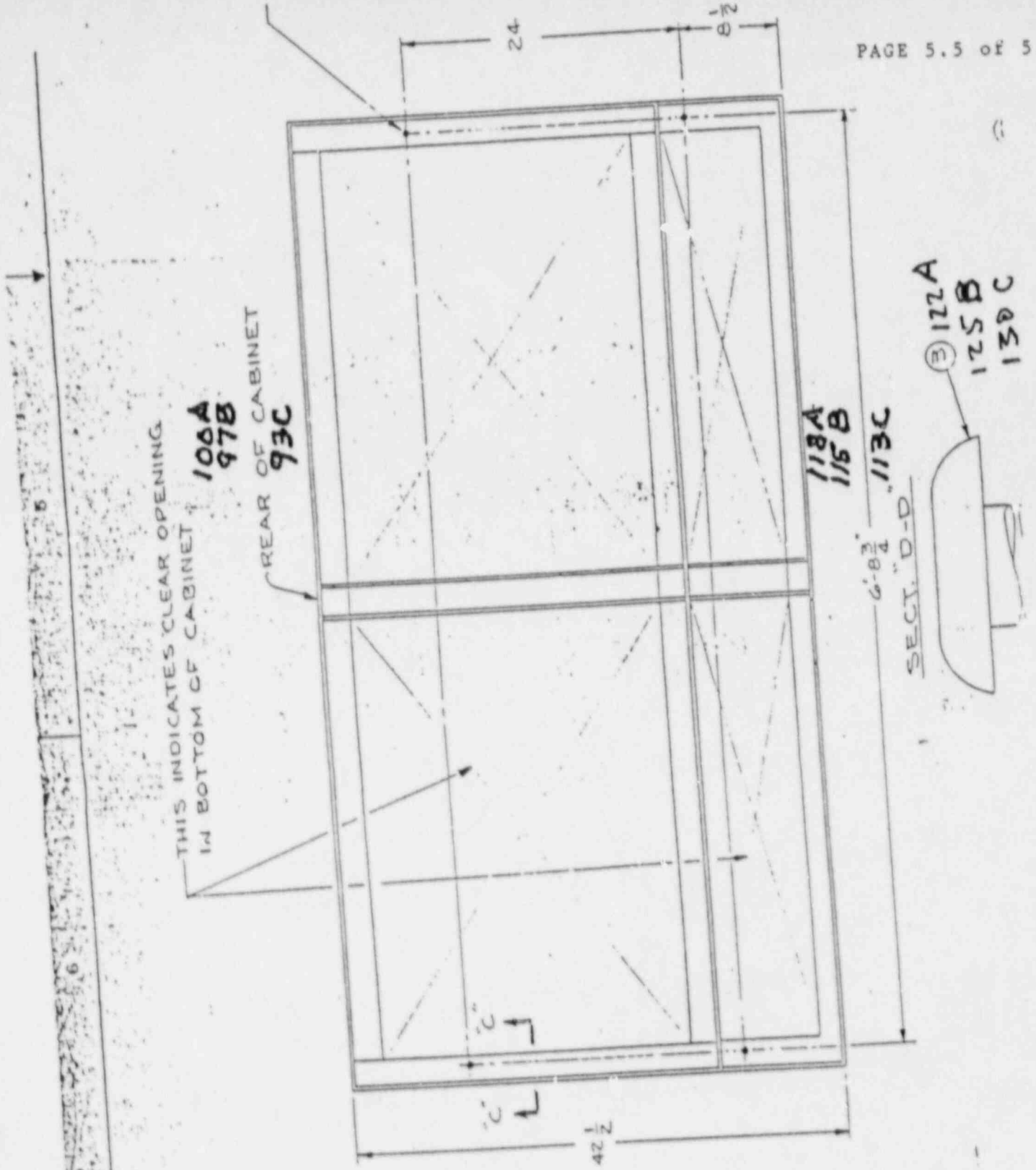
Room Air Inlet @ Louvre: 96A, 93B, 88C
Room Outlet Air @ Louvre = 110A, 110B, 104C
Design Ambient of Air Intake 100°F
Room Air 110F

GENERATOR CONTROL PANEL
FRONT

Operating Temperature
Browns Ferry Test

FIG. 4

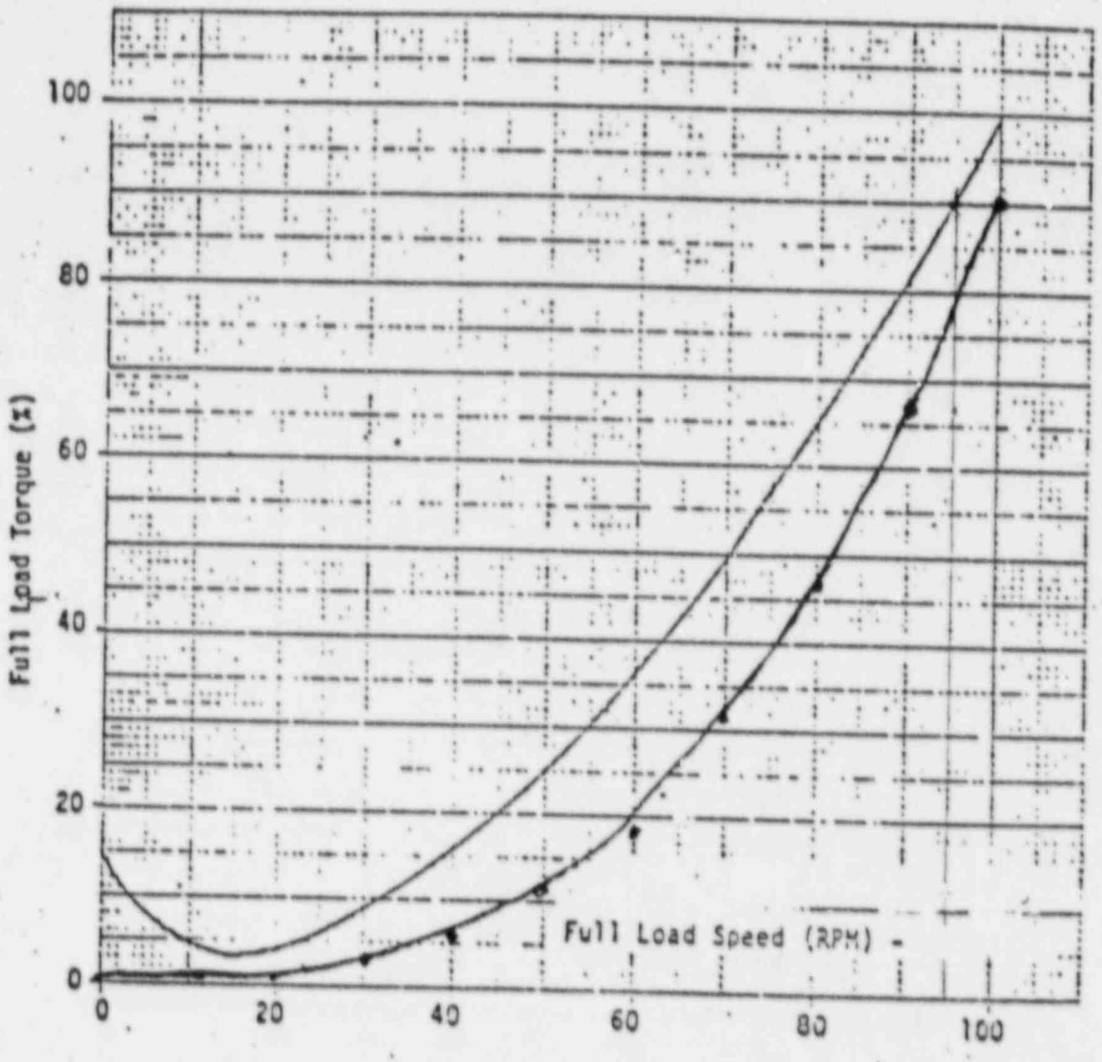




GENERATOR CONTROL PANEL
PLAN VIEW & AIR EXHAUST TOP

Operating Temperature
Browns Ferry Test

FIG. 5



Open Discharge Starting Condition

CENTRIFUGAL PUMP SPEED-TORQUE CHARACTERISTIC

TYPICAL