Q. In a meeting with Hydro management on May 29, 2015, Hydro stated that a technical analysis was completed that concluded that the Newfoundland Power mobile turbine accompanied by a Newfoundland Power mobile diesel generator was a viable option for black start at the Holyrood Plant. Please provide the analysis completed by Hydro at that time as well as any other information that led Hydro to this conclusion.

A. Please see PR-PUB-NLH-172 Attachment 1 for the analysis completed by Hydro. As noted in more detail in Hydro's response to PR-PUB-NLH-173, the primary purpose of having the Newfoundland Power mobile generation at Holyrood (as opposed to another location on the Avalon) was to provide additional station service power and to enable pre-warming of ancillary equipment. As well, the analysis indicated that the Newfoundland Power mobile units could potentially be utilized as a blackstart backup.

Approved for Release	Date: MARCH 6, 2013

ANALYSIS OF HOLYROOD UNIT 2 BOILER FEED PUMP EAST START-UP USING NEWFOUNDLAND POWER'S GAS TURBINE / MOBILE DIESEL

Newfoundland and Labrador Hydro

March 2013

newfoundland labrador hydro
a nalcor energy company

Table of Contents

1. INTRODUCTION

This report provides motoring starting analysis of Unit 2 Boiler Feed Pump East during a Plant Black Start condition utilizing Newfoundland Power's Mobile Gas Turbine and Diesel units only. This analysis was requested as a result of the January 11th, 2013 outage and subsequent installation of Newfoundland Power (NP) back-up generation at Holyrood Plant to supply emergency generation to the Avalon as well as potential Black Start capability of the Holyrood Plant.

2. SCOPE AND OBJECTIVE

The objective of this analysis is to provide an assessment of the capability of both NP's portable generation sources being able to start the largest motor in the Holyrood Plant, which is the 3000Hp Boiler Feed Pump on Unit 1 or 2.

The scope of the study included the modeling and motor starting analysis of Unit 2 Boiler Feed Pump East utilizing NP's portable generation sources. Determination of operation of plant protective relays due to under voltage conditions is not in the scope of this work. The study involved the dynamic analysis of motoring starting using Version 33 of PSS®E software from Siemens PTI.

3. MODEL DETAILS

A simplified load flow model of Holyrood 4.16 kV system has been developed for analysis as depicted in Figure 1. This model includes NP's 7.5 MVA gas turbine generator connected directly to Holyrood plant Station Service Bus SB12 and NP's 3.06 MVA diesel genset connected through two transformers to Station Service Bus SB12. The 4.16 kV cables between the Unit Boards and Station Service Boards have been modelled as well. Finally, a modest plant load of 1 MW has been assumed with both NP generators operating prior to starting of Unit 2 Boiler Feed Pump East.

The following model details have been assumed:

3.1. NP Mobile Gas Turbine

A 7.5 MVA mobile gas turbine with generator voltage of 4.16 kV is modelled and Appendix A outlines NP's data sheets for this unit. PSS®E dynamics model for this unit are attached in Appendix C, these include the following:

- **GENROU** (Round Rotor Generator Model), data as per NP's data sheets in Appendix A.
- **IEEET2** (IEEE Type 2 Excitation System), this model was copied from the existing Greenhill Gas Turbine data with exception VRmax = 3.0 instead of 2.5.
- **GAST** (Gas Turbine-Governor Model), this model was copied from the existing Greenhill Gas Turbine data with exception Vmax = 1.0 instead of 0.8.

3.2. NP Mobile Diesel

A 3.06 MVA mobile diesel with generator voltage of 4.16 kV is modelled and Appendix B outlines NP's data sheets for this unit. PSS®E dynamics model for this unit are attached in Appendix C, these include the following:

- **GENROU** (Round Rotor Generator Model), data as per NP's data sheets in Appendix B.
- **IEEET2** (Same as Gas Turbine model).
- **GAST** (Same as Gas Turbine model).

3.3. Unit 2 Boiler Feed Pump East

This motor is a Westinghouse, 3000 Hp, induction motor with full load current rating of 350A. Appendix D outlines the technical data associated with this motor, including a locked rotor current of 581% of rated full load. PSS®E's Induction Motor Dynamics (IMD) program estimates the motor equivalent circuit data based on full load and locked rotor current, starting and pull up torque. Results of these parameters are then used in PSS®E 's Induction Motor Load Model CIM5BL to dynamically simulate a motor starting analysis. The results of the IMD program for motor equivalent and PSS®E model description are outlined in Appendix E.

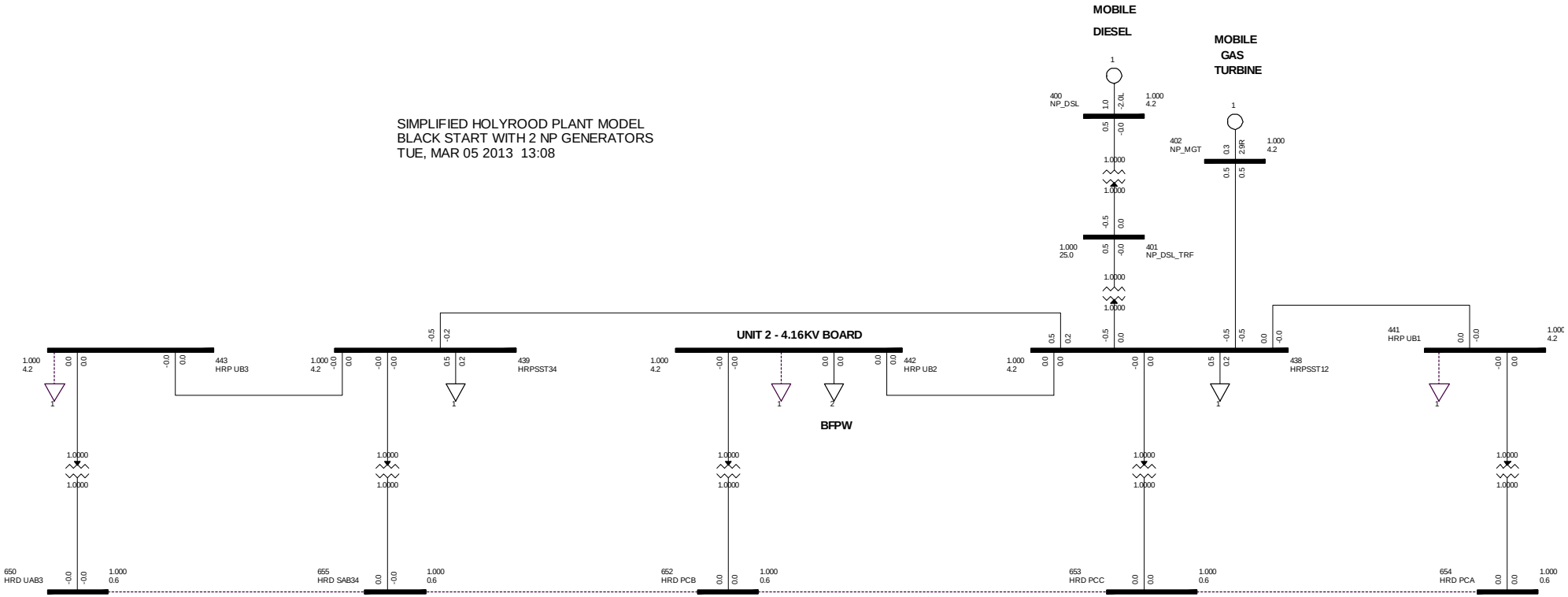


Figure 1

Simplified Model of Holyrood 4.16kV Network

4. MOTOR STARTING ANALYSIS

The simplified Holyrood system model of a black start condition forms the basis of the motor starting analysis. It is assumed an initial plant load of 1 MW is being fed by both NP's gas turbine and diesel genset in isolation from NLH system. Voltages prior to motor starting are unity.

Results of the dynamic motor starting simulation are outlined in Figures 2 through 6 below.

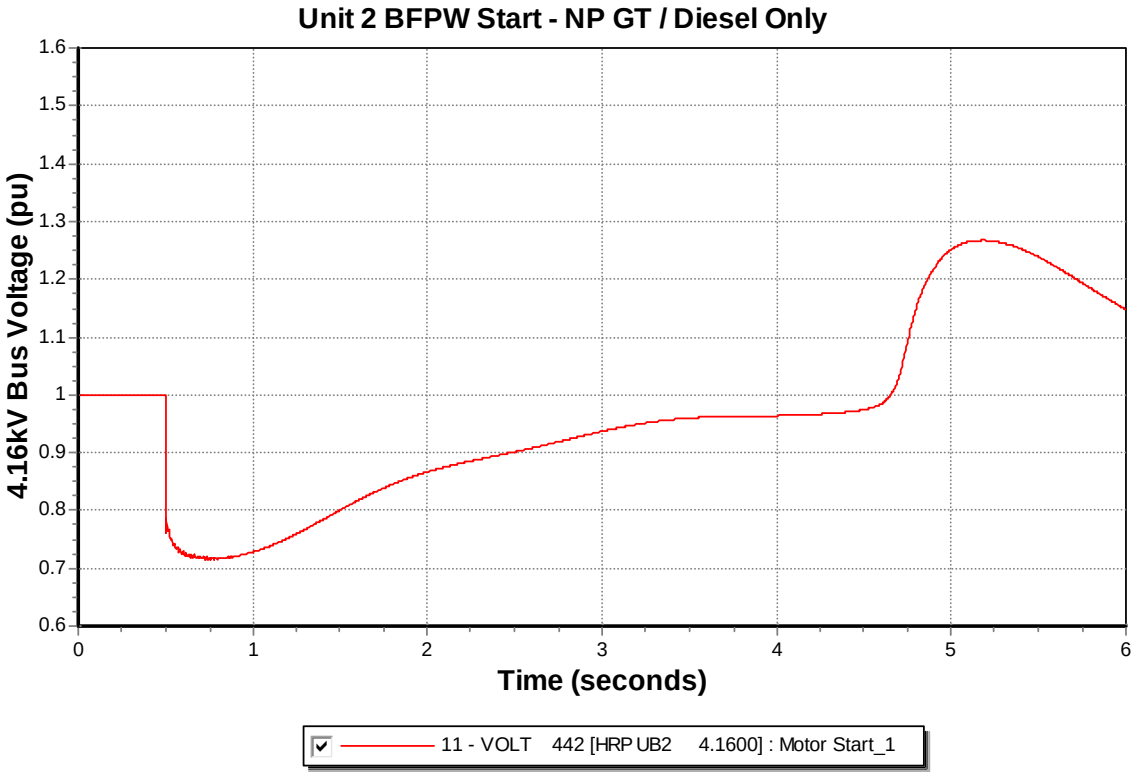


Figure 2
Motor Starting – 4.16kV Bus Voltage

As can be seen from Figure 2, motor starting will cause a very substantive drop in voltage on the 4.16kV bus to approximately 0.71 pu for roughly 0.5 seconds before it begins to recover. The voltage is below 0.9 pu for approximately 2 seconds.

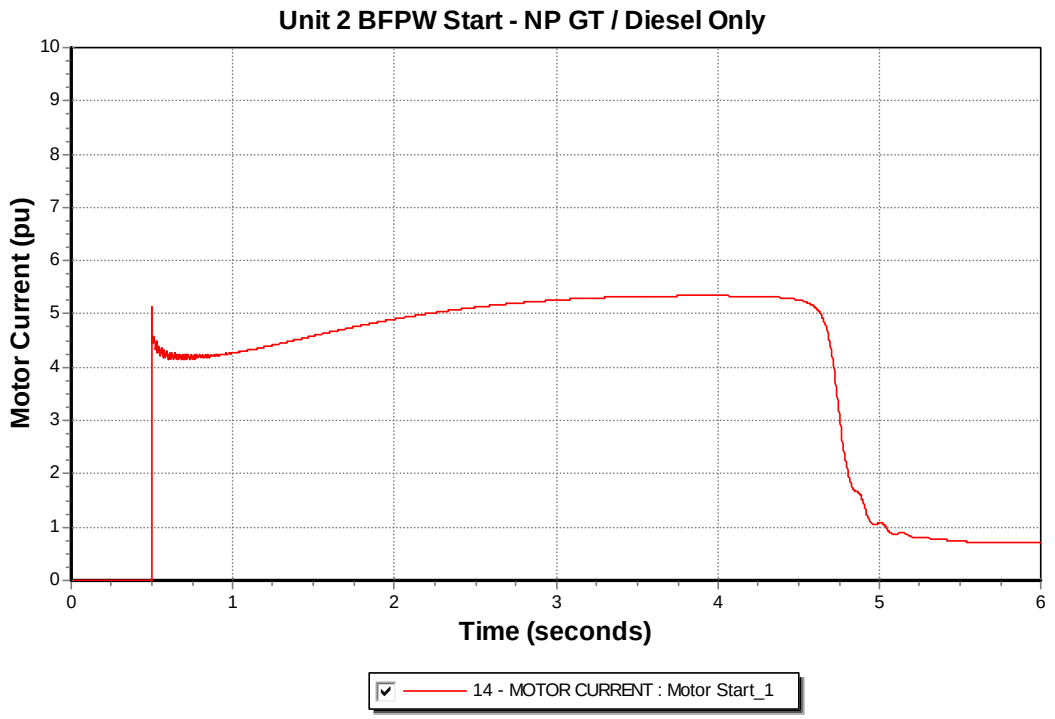


Figure 3 - Motor Starting Current

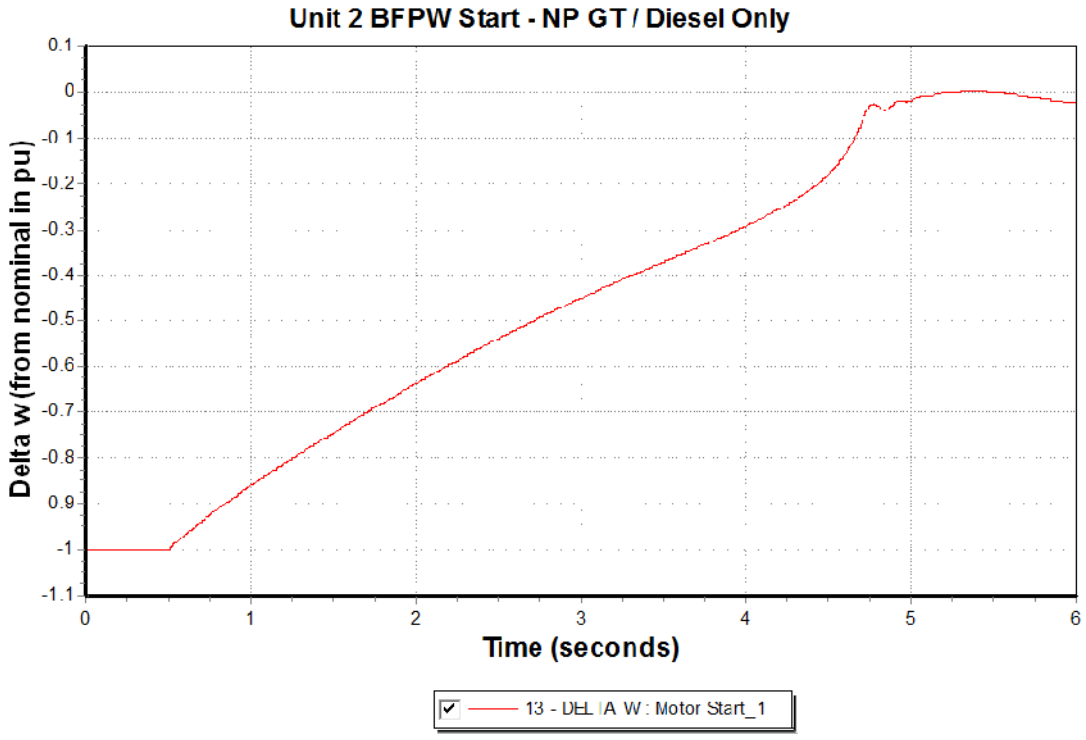


Figure 4 - Motor Starting Speed vs. Time

Figure 3 outlines the expected motor starting current in pu of the full load current of 350A. It is expected the starting current of the motor to exceed 5 pu, which significantly depresses the 4.16 kV bus voltage. Figure 4 outlines the pu speed of the motor from stand still to rated speed of 3580 RPM, it will take approximately 4 seconds to bring the motor from stand-still to rated speed. Documentation from the manufacturer states that normal starting at 100% voltage should only take 2.0 seconds, while at 90% voltage, motor starting should be about 2.9 seconds. With the NP generators, the expected voltage will be close to 70% which will reduce the starting torque, thus increase the time to rated speed.

Figure 5 outlines the expected MW power output from both NP generators. Both units in parallel are capable of producing the required output for motor start. Figure 6 outlines the expected MVAR output of both generators during motor start-up. It appears that the gas turbine exceeds its rated output for roughly 3 seconds. The capability of the unit to operate for this duration is questionable and needs verification from the manufacturer.

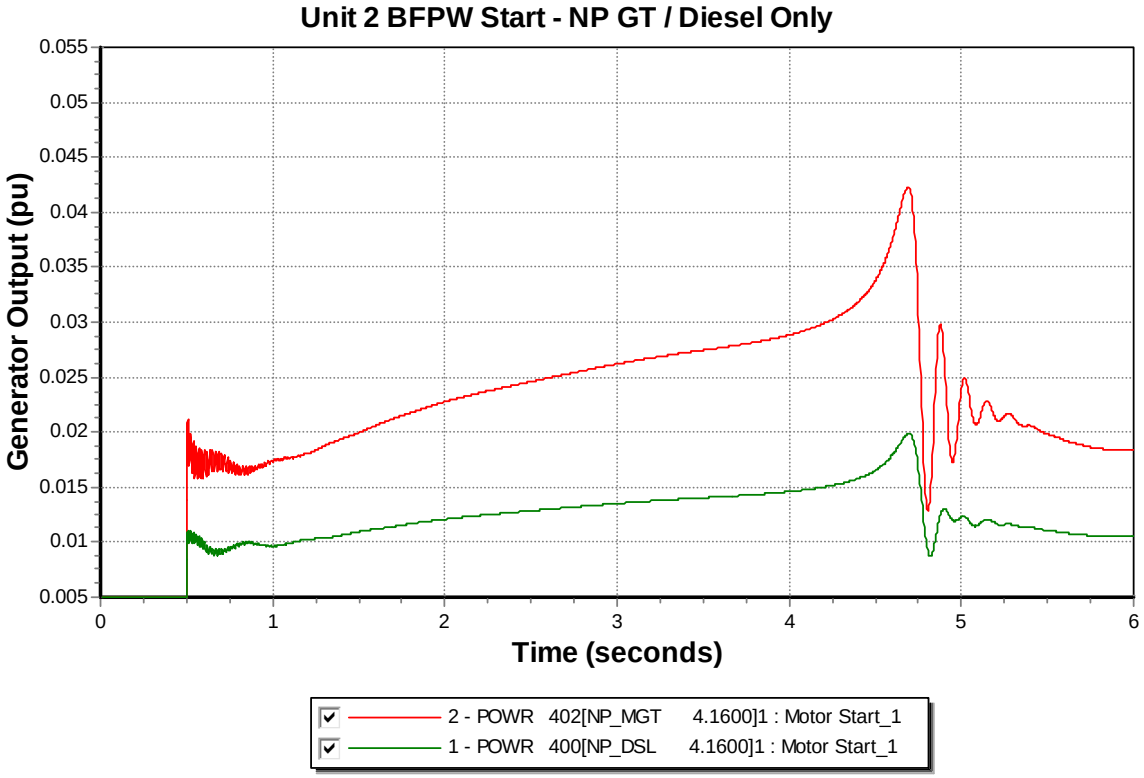


Figure 5 - NP Generator Power

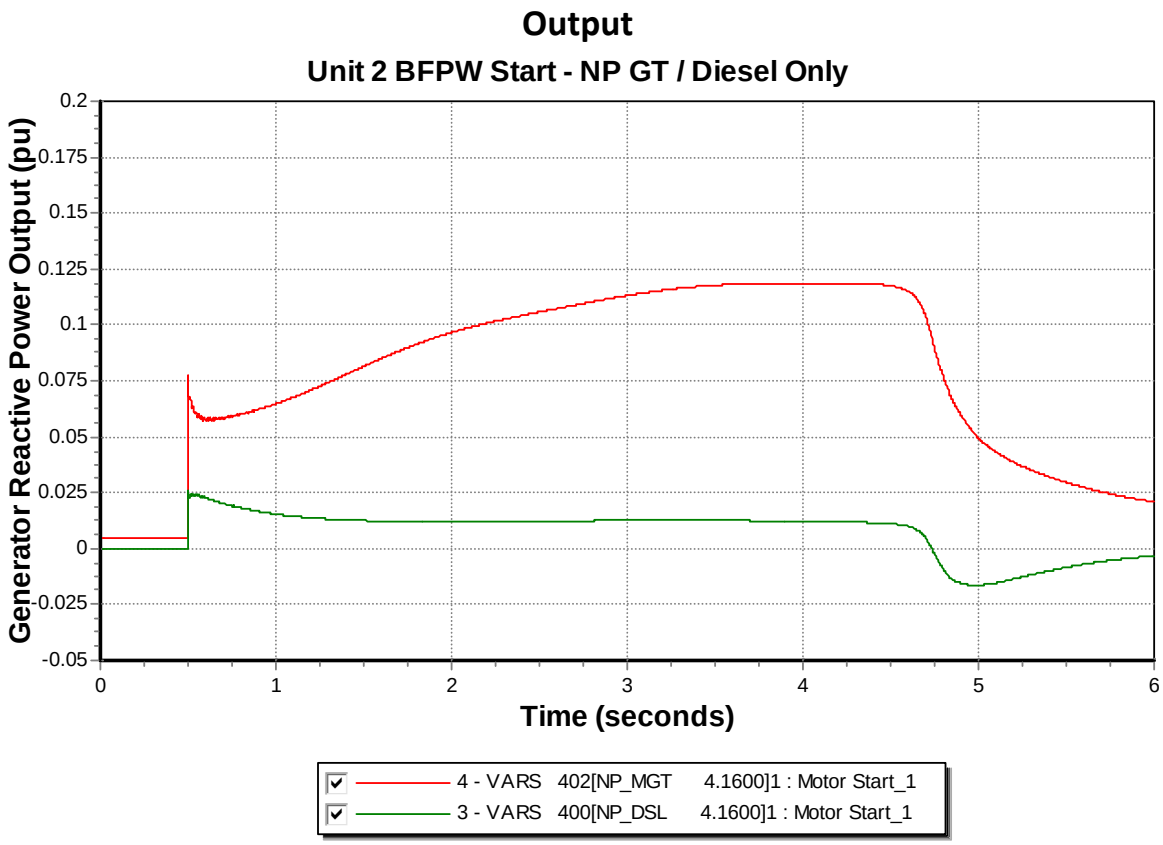


Figure 6

NP Generator Reactive Power Output

5. CONCLUSION

Based on this preliminary analysis it appears with both NP generators operational that starting of a 3000 Hp Boiler Feed Pump is theoretically possible, but increased starting time and depressed voltages can be expected on the 4.16 kV buses within the plant to a value close to 70% of nominal. Several areas of concern have been identified and need to be addressed if Black Start capability will be required from these units. They are as follows:

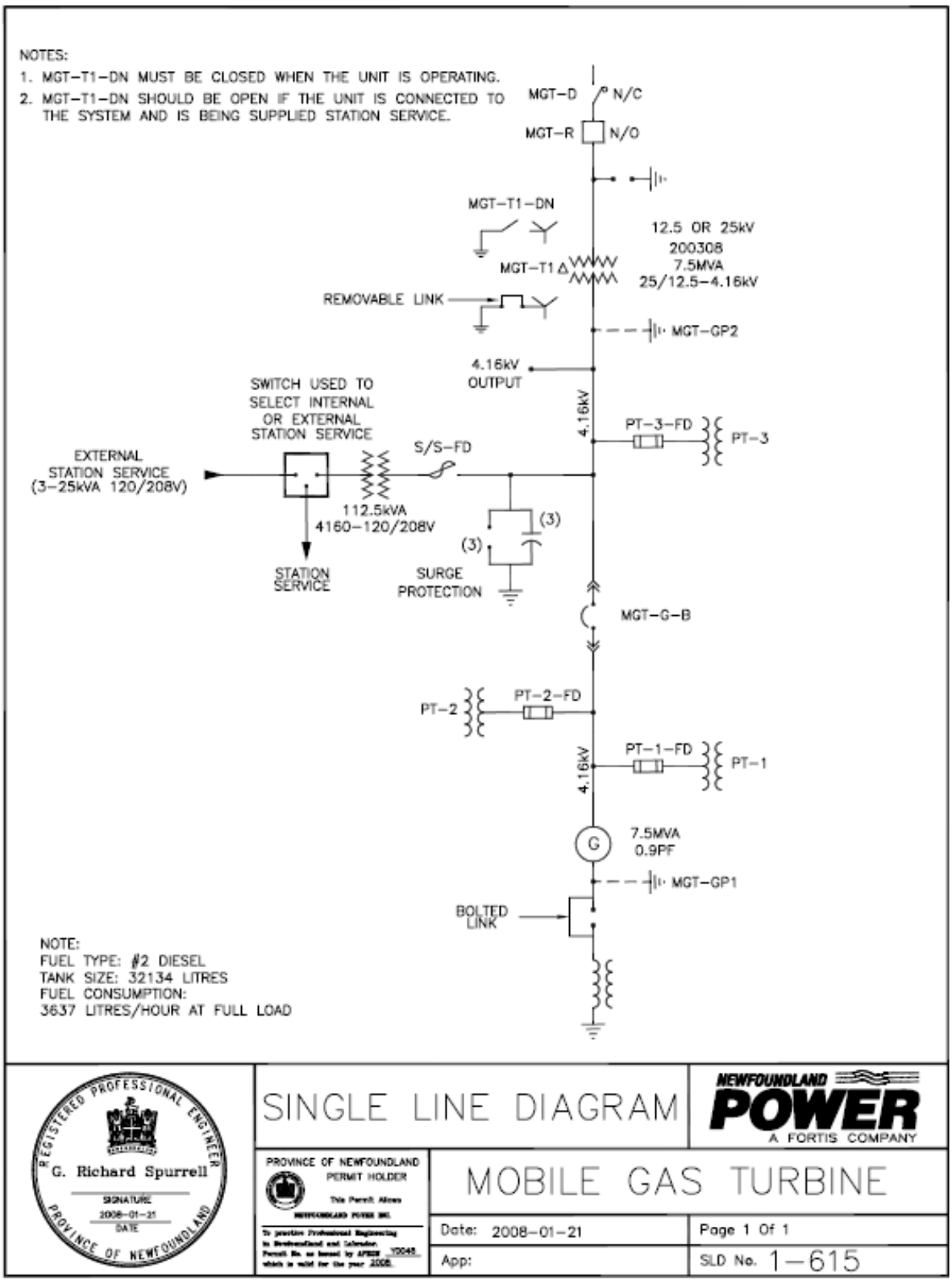
1. Are there any under voltage relay protection settings on the 4.16 kV or 600 V system within the plant that could cause equipment tripping as a result of the depressed voltages during motor starting.

2. Does the NP Mobile Gas Turbine generator / excitation system have the capability to supply up to 150% of nameplate rating for several seconds without tripping off-line.

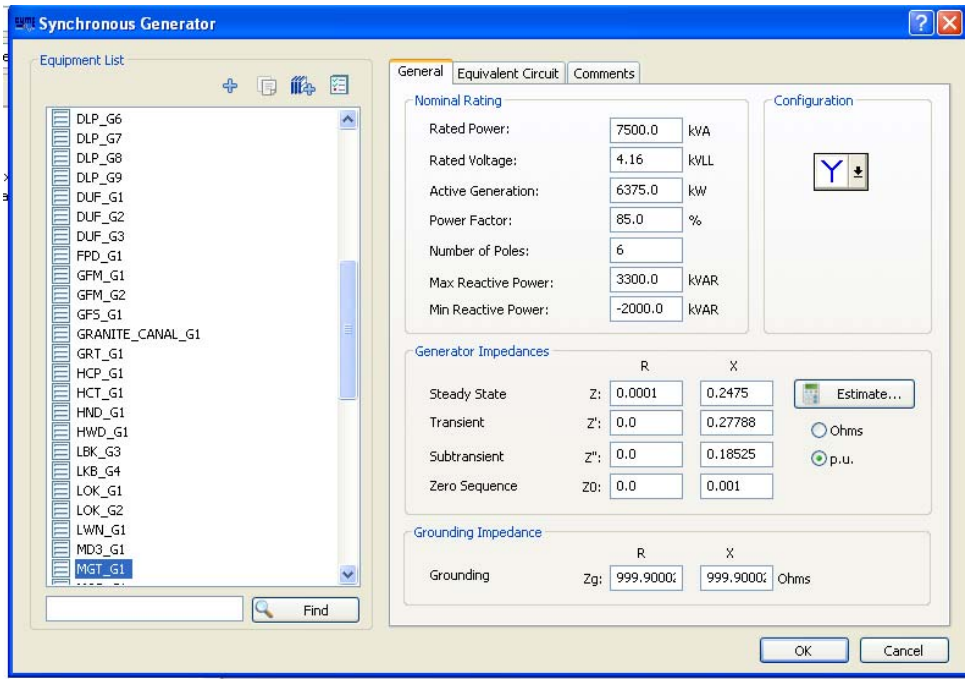
APPENDIX A

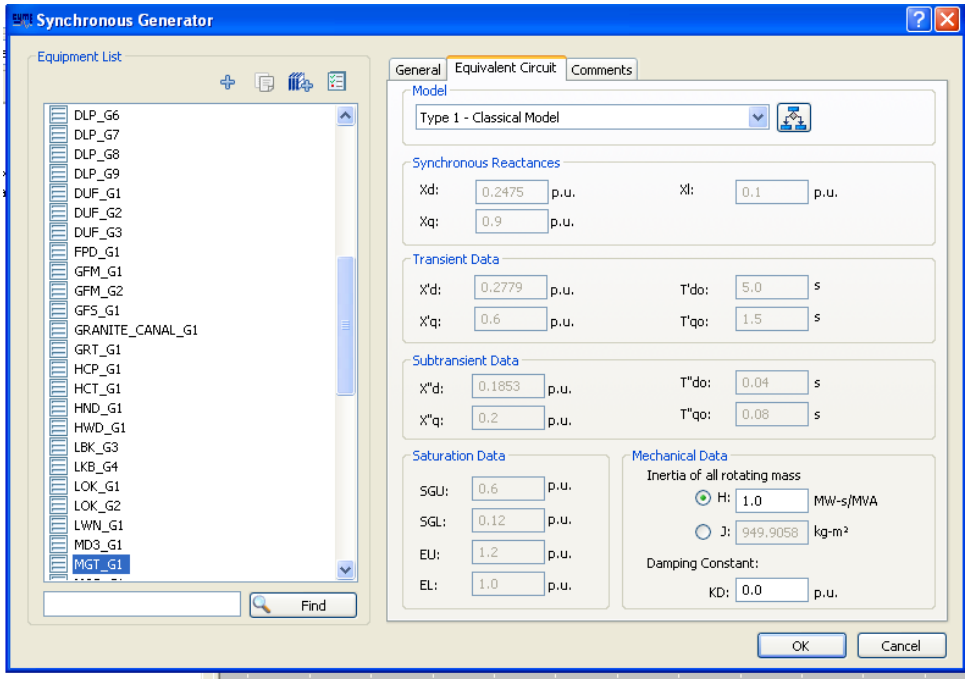
NP DATA SHEETS

FOR MOBILE GAS TURBINE


NOTES:
1. MGT–T1–DN MUST BE CLOSED WHEN THE UNIT IS OPERATING.
2. MGT–T1–DN SHOULD BE OPEN IF THE UNIT IS CONNECTED TO THE SYSTEM AND IS BEING SUPPLIED STATION SERVICE.
MGT–D
N/C
MGT–R
N/O
MGT–T1–DN
MGT–T1
12.5 OR 25kV
200308
7.5MVA
25/12.5–4.16kV
REMOVABLE LINK
MGT–GP2
4.16kV
OUTPUT
SWITCH USED TO SELECT INTERNAL OR EXTERNAL STATION SERVICE
EXTERNAL STATION SERVICE (3–25kVA 120/208V)
S/S–FD
112.5kVA
4160–120/208V
STATION SERVICE
(3)
(3)
SURGE PROTECTION
4.16kV
PT–3–FD
PT–3
MGT–G–B
PT–2
PT–2–FD
4.16kV
PT–1–FD
PT–1
G
7.5MVA
0.9PF
MGT–GP1
BOLTED LINK
NOTE:
FUEL TYPE: #2 DIESEL
TANK SIZE: 32134 LITRES
FUEL CONSUMPTION:
3637 LITRES/HOUR AT FULL LOAD
REGISTERED PROFESSIONAL ENGINEER
G. Richard Spurrell
SIGNATURE
2008–01–21
DATE
PROVINCE OF NEWFOUNDLAND
PERMIT HOLDER
SINGLE LINE DIAGRAM
NEWFOUNDLAND POWER
A FORTIS COMPANY
MOBILE GAS TURBINE
Date: 2008–01–21
Page 1 Of 1
App:
SLD No. 1–615

MGT Screen Shots

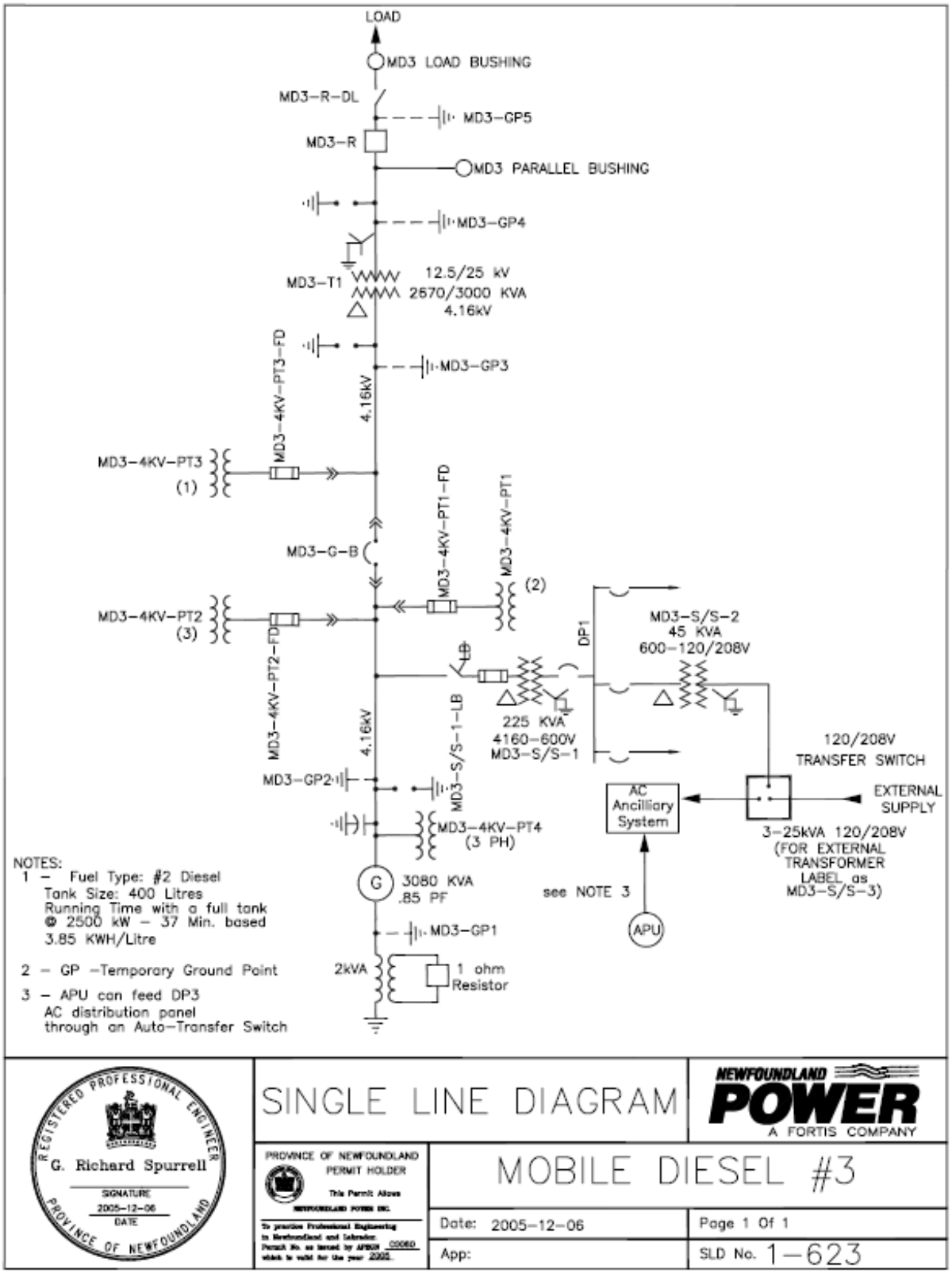




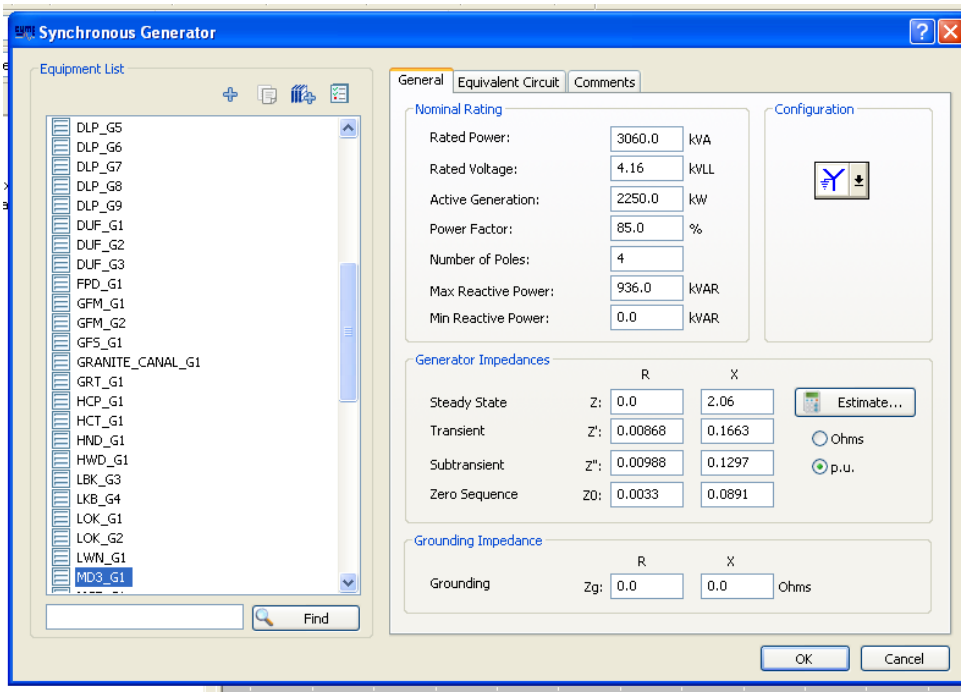
APPENDIX B

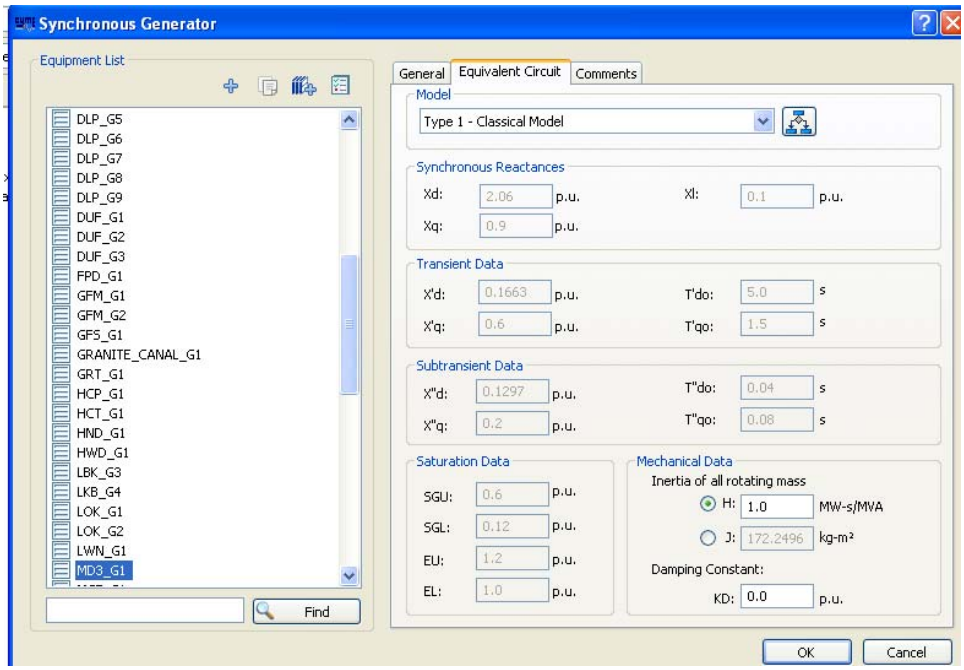
NP DATA SHEETS

FOR MOBILE DIESEL GENERATOR


LOAD
MD3 LOAD BUSHING
MD3–R–DL
MD3–GP5
MD3–R
MD3 PARALLEL BUSHING
MD3–GP4
MD3–T1
12.5/25 kV
2670/3000 KVA
4.16kV
MD3–GP3
MD3–4KV–PT3–FD
4.16kV
MD3–4KV–PT3
(1)
MD3–G–B
MD3–4KV–PT1–FD
MD3–4KV–PT1
(2)
MD3–4KV–PT2
(3)
MD3–4KV–PT2–FD
DP1
MD3–S/S–2
45 KVA
600–120/208V
LB
225 KVA
4160–600V
MD3–S/S–1
MD3–S/S–1–LB
4.16kV
MD3–GP2
MD3–4KV–PT4
(3 PH)
120/208V
TRANSFER SWITCH
AC
Ancilliary
System
EXTERNAL
SUPPLY
3–25kVA 120/208V
(FOR EXTERNAL
TRANSFORMER
LABEL as
MD3–S/S–3)
see NOTE 3
APU
G
3080 KVA
.85 PF
MD3–GP1
2kVA
1 ohm
Resistor
NOTES:
1 – Fuel Type: #2 Diesel
Tank Size: 400 Litres
Running Time with a full tank
@ 2500 kW – 37 Min. based
3.85 KWH/Litre
2 – GP –Temporary Ground Point
3 – APU can feed DP3
AC distribution panel
through an Auto–Transfer Switch
REGISTERED PROFESSIONAL ENGINEER
G. Richard Spurrell
SIGNATURE
2005–12–06
DATE
PROVINCE OF NEWFOUNDLAND
SINGLE LINE DIAGRAM
NEWFOUNDLAND POWER
A FORTIS COMPANY
PROVINCE OF NEWFOUNDLAND
PERMIT HOLDER
MOBILE DIESEL #3
Date: 2005–12–06
Page 1 Of 1
App:
SLD No. 1–623

MD3 Screen Shots





Caterpillar Generator Data

Page 1 of 9

GENERATOR DATA

MARCH 28, 2012

For Help Desk Phone Numbers Click here

Selected Model

Engine: 3516 **Generator Frame:** 825 **Genset Rating (kW):** 1825.0 **Line Voltage:** 600
Fuel: Diesel **Generator Arrangement:** 3062928 **Genset Rating (kVA):** 2281.0 **Phase Voltage:** 346
Frequency: 60 **Excitation Type:** Permanent Magnet **Pwr. Factor:** 0.8 **Rated Current:** 2194.9
Duty: PRIME **Connection:** SERIES STAR **Application:** EPG **Status:** Pending

Version: 40400 /39715 /40365 /31

Spec Information

Generator Specification			Generator Efficiency		
Frame: 825 **Type:** SR4B	**No. of Bearings:** 1		**Per Unit Load**	**kW**	**Efficiency %**
Winding Type: FORM WOUND	**Flywheel:** 21.0		0.25	456.3	93.5
Connection: SERIES STAR	**Housing:** 00		0.5	912.5	96.1
Phases: 3	**No. of Leads:** 6		0.75	1368.8	96.9
Poles: 4	**Wires per Lead:** 8		1.0	1825.0	97.2
Sync Speed: 1800	**Generator Pitch:** 0.6667		1.1	2007.5	97.2

Reactances	Per Unit	Ohms
SUBTRANSIENT - DIRECT AXIS X''_d	0.1584	0.0250
SUBTRANSIENT - QUADRATURE AXIS X''_q	0.1470	0.0232
TRANSIENT - SATURATED X'_d	0.2357	0.0372
SYNCHRONOUS - DIRECT AXIS X_d	2.9815	0.4705
SYNCHRONOUS - QUADRATURE AXIS X_q	1.4220	0.2244
NEGATIVE SEQUENCE X_2	0.1527	0.0241
ZERO SEQUENCE X_0	0.0095	0.0015

Time Constants	Seconds
OPEN CIRCUIT TRANSIENT - DIRECT AXIS T'_{d0}	6.2860
SHORT CIRCUIT TRANSIENT - DIRECT AXIS T'_d	0.4964
OPEN CIRCUIT SUBSTRANSIENT - DIRECT AXIS T''_{d0}	0.0087
SHORT CIRCUIT SUBSTRANSIENT - DIRECT AXIS T''_d	0.0077
OPEN CIRCUIT SUBSTRANSIENT - QUADRATURE AXIS T''_{q0}	0.0068
SHORT CIRCUIT SUBSTRANSIENT - QUADRATURE AXIS T''_q	0.0061
EXCITER TIME CONSTANT T_e	0.2225
ARMATURE SHORT CIRCUIT T_a	0.0637

Short Circuit Ratio: 0.44	Stator Resistance = 0.0021 Ohms	Field Resistance = 1.003 Ohms

Voltage Regulation	
Voltage level adustment: +/-	5.0%
Voltage regulation, steady state: +/-	0.5%
Voltage regulation with 3% speed change: +/-	0.5%
Waveform deviation line - line, no load: less than	3.0%
Telephone influence factor: less than	50

Generator Excitation			
	No Load	**Full Load, (rated) pf**	
		Series	**Parallel**
Excitation voltage:	8.28 Volts	35.89 Volts	Volts
Excitation current	2.18 Amps	7.77 Amps	Amps

Caterpillar Generator Data

Selected Model

Engine: 3516	**Generator Frame:** 825	**Genset Rating (kW):** 1825.0	**Line Voltage:** 600
Fuel: Diesel	**Generator Arrangement:** 3062928	**Genset Rating (kVA):** 2281.0	**Phase Voltage:** 346
Frequency: 60	**Excitation Type:** Permanent Magnet	**Pwr. Factor:** 0.8	**Rated Current:** 2194.9
Duty: PRIME	**Connection:** SERIES STAR	**Application:** EPG	**Status:** Pending

Version: 40400 /39715 /40365 /31

Generator Mechanical Information

Center of Gravity

Dimension X	0.0 mm	0.0 IN.
Dimension Y	0.0 mm	0.0 IN.
Dimension Z	0.0 mm	0.0 IN.

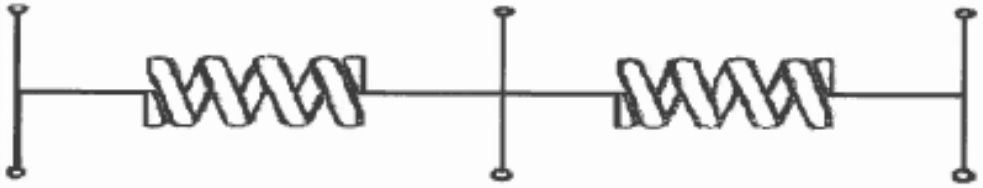
- "X" is measured from driven end of generator and parallel to rotor. Towards engine fan is positive. See General Information for details
- "Y" is measured vertically from rotor center line. Up is positive.
- "Z" is measured to left and right of rotor center line. To the right is positive.

Generator WT = 0 kg	* Rotor WT = 0 kg	* Stator WT = 0 kg
0.0 LB	0.0 LB	0.0 LB

Rotor Balance = 0.0508 mm deflection PTP

Overspeed Capacity = 100% of synchronous speed

Generator Torsional Data



J1 = Coupling and Fan | **J2 = Rotor** | **J3 = Exciter End**

TOTAL J = J1 + J2 + J3

K1 = Shaft Stiffness between J1 + J2 (Diameter 1)

K2 = Shaft Stiffness between J2 + J3 (Diameter 2)

J1	K1	Min Shaft Dia 1	J2	K2	Min Shaft Dia 2	J3
0.0 LB IN. s^2	0.0 MLB IN./rad	0.0 IN.	0.0 LB IN. s^2	0.0 MLB IN./rad	0.0 IN.	0.0 LB IN. s^2
0.0 N m s^2	0.0 MN m/rad	0.0 mm	0.0 N m s^2	0.0 MN m/rad	0.0 mm	0.0 N m s^2

Total J

0.0 LB IN. s^2

0.0 N m s^2

Caterpillar Generator Data

Selected Model

Engine: 3516	**Generator Frame:** 825	**Genset Rating (kW):** 1825.0	**Line Voltage:** 600
Fuel: Diesel	**Generator Arrangement:** 3062928	**Genset Rating (kVA):** 2281.0	**Phase Voltage:** 346
Frequency: 60	**Excitation Type:** Permanent Magnet	**Pwr. Factor:** 0.8	**Rated Current:** 2194.9
Duty: PRIME	**Connection:** SERIES STAR	**Application:** EPG	**Status:** Pending

Version: 40400 /39715 /40365 /31

Generator Cooling Requirements - Temperature - Insulation Data

Cooling Requirements:		**Temperature Data: (Ambient 40 ^{0}C)**	
Heat Dissipated: 52.6 kW		**Stator Rise:**	105.0 ^{0}C
Air Flow:	0.0 m^3/min	**Rotor Rise:**	105.0 ^{0}C

Insulation Class: H

Insulation Reg. as shipped: 100.0 MΩ minimum at 40 ^{0}C

Thermal Limits of Generator

Frequency:	60 Hz
Line to Line Voltage:	600 Volts
B BR 80/40	1893.0 kVA
F BR -105/40	2281.0 kVA
H BR - 125/40	2500.0 kVA
F PR - 130/40	2500.0 kVA

Caterpillar Generator Data

Selected Model

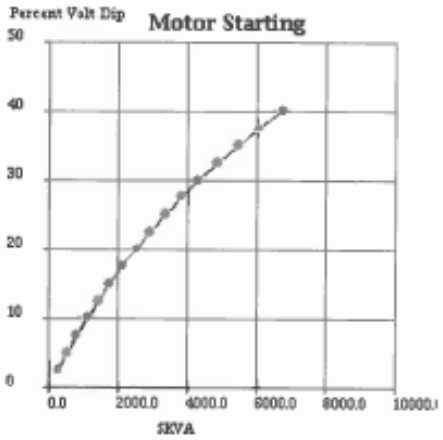
Engine: 3516 **Generator Frame:** 825 **Genset Rating (kW):** 1825.0 **Line Voltage:** 600
Fuel: Diesel **Generator Arrangement:** 3062928 **Genset Rating (kVA):** 2281.0 **Phase Voltage:** 346
Frequency: 60 **Excitation Type:** Permanent Magnet **Pwr. Factor:** 0.8 **Rated Current:** 2194.9
Duty: PRIME **Connection:** SERIES STAR **Application:** EPG **Status:** Pending

Version: 40400 /39715 /40365 /31

Starting Capability & Current Decrement

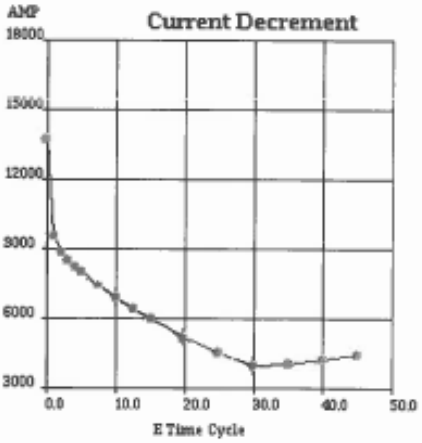
Motor Starting Capability (0.4 pf)

SKVA	Percent Volt Dip
259	2.5
531	5.0
818	7.5
1,122	10.0
1,442	12.5
1,781	15.0
2,141	17.5
2,524	20.0
2,931	22.5
3,365	25.0
3,829	27.5
4,326	30.0
4,860	32.5
5,435	35.0
6,056	37.5
6,729	40.0



Current Decrement Data

E Time Cycle	AMP
0.0	13,755
1.0	9,566
2.0	8,836
3.0	8,523
4.0	8,265
5.0	8,020
7.5	7,446
10.0	6,917
12.5	6,431
15.0	5,985
20.0	5,197
25.0	4,530
30.0	3,976
35.0	3,995
40.0	4,207
45.0	4,464



Instantaneous 3 Phase Fault Current: 13755 Amps **Instantaneous Line - Line Fault Current:** 12136 Amps
Instantaneous Line - Neutral Fault Current: 20404 Amps

Caterpillar Generator Data

Selected Model

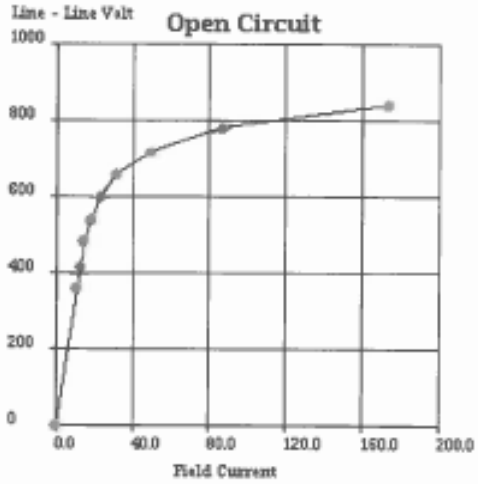
Engine: 3516	**Generator Frame:** 825	**Genset Rating (kW):** 1825.0	**Line Voltage:** 600
Fuel: Diesel	**Generator Arrangement:** 3062928	**Genset Rating (kVA):** 2281.0	**Phase Voltage:** 346
Frequency: 60	**Excitation Type:** Permanent Magnet	**Pwr. Factor:** 0.8	**Rated Current:** 2194.9
Duty: PRIME	**Connection:** SERIES STAR	**Application:** EPG	**Status:** Pending

Version: 40400 /39715 /40365 /31

Generator Output Characteristic Curves

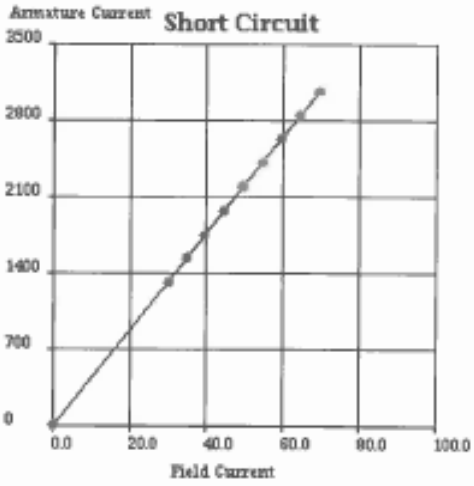
Open Circuit Curve

Field Current	Line - Line Volt
0.0	0
10.6	360
12.6	420
14.9	480
17.9	540
22.6	600
31.2	660
48.8	720
87.1	780
173.3	840



Short Circuit Curve

Field Current	Armature Current
0.0	0
29.8	1,317
34.8	1,537
39.7	1,756
44.7	1,976
49.7	2,195
54.6	2,415
59.6	2,634
64.6	2,854
69.5	3,073



Selected Model

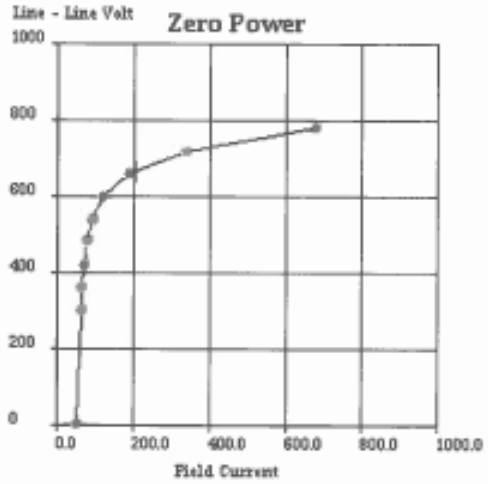
Engine: 3516	**Generator Frame:** 825	**Genset Rating (kW):** 1825.0	**Line Voltage:** 600
Fuel: Diesel	**Generator Arrangement:** 3062928	**Genset Rating (kVA):** 2281.0	**Phase Voltage:** 346
Frequency: 60	**Excitation Type:** Permanent Magnet	**Pwr. Factor:** 0.8	**Rated Current:** 2194.9
Duty: PRIME	**Connection:** SERIES STAR	**Application:** EPG	**Status:** Pending

Version: 40400 /39715 /40365 /3

Generator Output Characteristic Curves

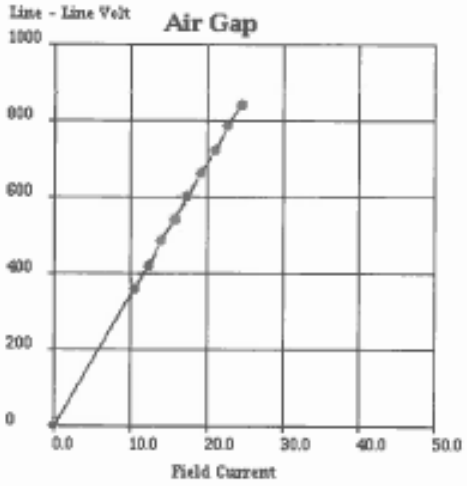
Zero Power Factor Curve

Field Current	Line - Line Volt
49.7	0
63.2	300
65.9	360
70.0	420
76.9	480
90.7	540
120.2	600
186.3	660
336.9	720
683.0	780



Air Gap Curve

Field Current	Line - Line Volt
0.0	0
10.4	360
12.2	420
13.9	480
15.7	540
17.4	600
19.2	660
20.9	720
22.6	780
24.4	840



Caterpillar Generator Data

Selected Model

Engine: 3516	**Generator Frame:** 825	**Genset Rating (kW):** 1825.0	**Line Voltage:** 600
Fuel: Diesel	**Generator Arrangement:** 3062928	**Genset Rating (kVA):** 2281.0	**Phase Voltage:** 346
Frequency: 60	**Excitation Type:** Permanent Magnet	**Pwr. Factor:** 0.8	**Rated Current:** 2194.9
Duty: PRIME	**Connection:** SERIES STAR	**Application:** EPG	**Status:** Pending

Version: 40400 /39715 /40365 /31

Reactive Capability Curve

Click to view Chart

Caterpillar Generator Data

Selected Model

Engine: 3516	**Generator Frame:** 825	**Genset Rating (kW):** 1825.0	**Line Voltage:** 600
Fuel: Diesel	**Generator Arrangement:** 3062928	**Genset Rating (kVA):** 2281.0	**Phase Voltage:** 346
Frequency: 60	**Excitation Type:** Permanent Magnet	**Pwr. Factor:** 0.8	**Rated Current:** 2194.9
Duty: PRIME	**Connection:** SERIES STAR	**Application:** EPG	**Status:** Pending

Version: 40400 /39715 /40365 /31

General Information

DM7828 Caterpillar Custom Generators (50 Hz, 60 Hz)
Data for Custom SR4, SR4B, SR4B-HV, SR5 and SR5-HV
Caterpillar generators built by Leroy Somer – USA and
Leroy Somer – France.

Refer to DM7821 for explanation of all generator data in Technical Marketing Information (TMI) except generator efficiency for which the explanation is given below.

GENERATOR EFFICIENCY
Generator efficiency is the percentage of engine flywheel (or other prime mover) power that is converted into electrical output. The generator efficiency shown is calculated by the summation of all losses method, and is determined in accordance with the IEC Standard 60034. The efficiency considers only the generator. There is no consideration of engine or parasitic losses here.

Caterpillar Generator Data

Selected Model

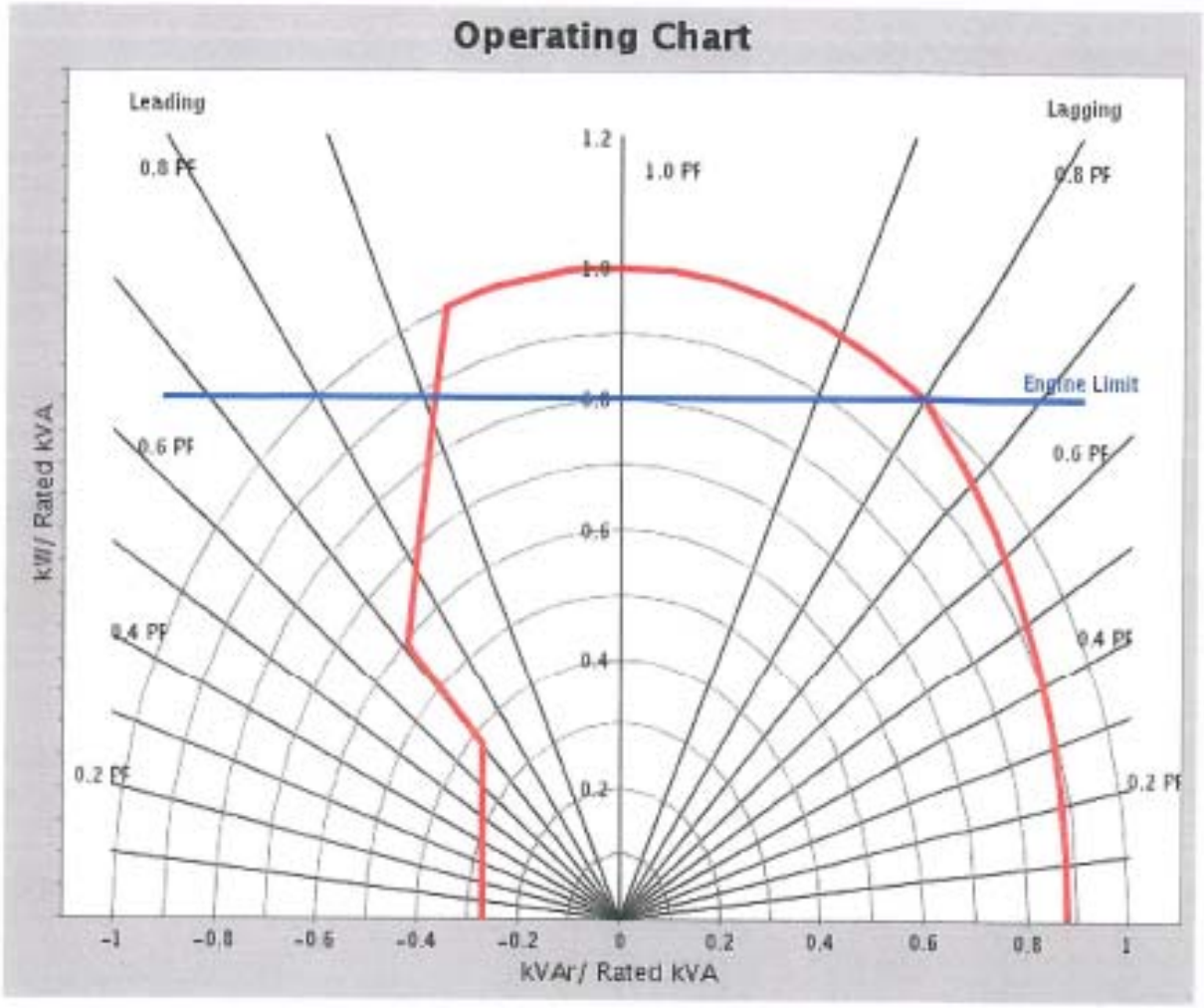
Engine: 3516	**Generator Frame:** 825	**Genset Rating (kW):** 1825.0	**Line Voltage:** 600
Fuel: Diesel	**Generator Arrangement:** 3062928	**Genset Rating (kVA):** 2281.0	**Phase Voltage:** 346
Frequency: 60	**Excitation Type:** Permanent Magnet	**Pwr. Factor:** 0.8	**Rated Current:** 2194.9
Duty: PRIME	**Connection:** SERIES STAR	**Application:** EPG	**Status:** Pending

Version: 40400 /39715 /40365 /31

Internal Information

Max Block Load : 0.0	**Max Motor Load :** 0.0	**Max Single Step :** 0.0
Block Kg : 0.076	**Motor Kg :** 0.099	**KVA Derate :** 2281.0
Derate Code : BR	**Temperature Rise:** 105.0	**Target ekW:** 1825.0

The user information for this generator is unavailable for reference.
Generator Data Uploaded On: October 06, 2011


Operating Chart
Leading
Lagging
0.8 PF
1.0 PF
0.8 PF
1.2
1.0
0.8
0.6
0.4
0.2
Engine Limit
0.6 PF
0.6 PF
0.4 PF
0.4 PF
0.2 PF
0.2 PF
kW/ Rated kVA
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
kVAr/ Rated kVA

APPENDIX C

PSS®E DATA SHEETS

FOR GAS TURBINE AND MOBILE DIESEL GENERATOR

SIEMENS

Generator Model Data Sheets
GENROU

PSS®E 33.3
PSS®E Model Library

MOBILE GAS TURBINE (data provided by NP - Brad Tucker Jan.17/13)

1.19 GENROU MGT

Round Rotor Generator Model (Quadratic Saturation)

This model is located at system bus #_____ IBUS,

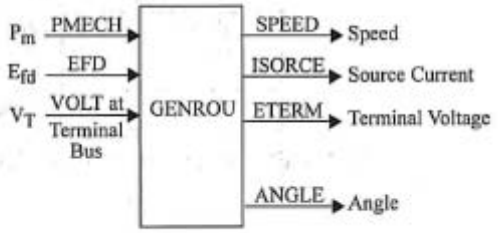
Machine identifier #_____ ID,

This model uses CONs starting with #_____ J,

and STATEs starting with #_____ K.

The machine MVA is _____ for each of _____ units = _____ MBASE.

ZSORCE for this machine is _____ + j _____ on the above MBASE



CONs	#	Value	Description
J		5.0	T'_{do} (>0) (sec)
J+1		0.04	T''_{do} (>0) (sec)
J+2		1.5	T'_{qo} (>0) (sec)
J+3		0.08	T''_{qo} (>0) (sec)
J+4		1.00	H, Inertia
J+5		0	D, Speed damping
J+6		0.2475	X_d
J+7		0.9	X_q
J+8		0.2779	X'_d
J+9		0.6	X'_q
J+10		0.1853	$X''_d = X''_q$
J+11		0.1	X_l
J+12		0.12	S(1.0)
J+13		0.60	S(1.2)

Note: X_d, X_q, X'_d, X'_q, X''_d, X''_q, X_l, H, and D are in pu, machine MVA base.

X''_q must be equal to X''_d.

MVA base = 7.5

SIEMENS

Generator Model Data Sheets
GENROU

PSS®E 33.3
PSS®E Model Library

MOBILE DIESEL MD3 (data provided by NP - Brad Tucker, Jan. 17/13)

1.19 GENROU

Round Rotor Generator Model (Quadratic Saturation)

This model is located at system bus #____ IBUS,

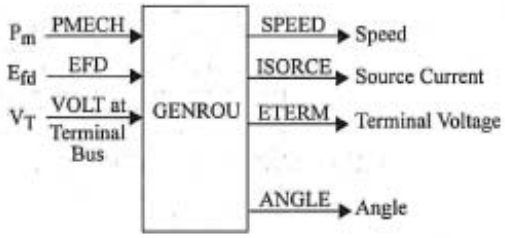
Machine identifier #____ ID,

This model uses CONs starting with #____ J,

and STATEs starting with #____ K.

The machine MVA is _____ for each of _____ units = _____ MBASE.

ZSORCE for this machine is _____ + j _____ on the above MBASE



CONs	#	Value	Description
J		5.0	T'_{do} (>0) (sec)
J+1		0.04	T''_{do} (>0) (sec)
J+2		1.50	T'_{qo} (>0) (sec)
J+3		0.08	T''_{qo} (>0) (sec)
J+4		1.0	H, Inertia
J+5		0	D, Speed damping
J+6		2.06	X_d
J+7		0.90	X_q
J+8		0.1663	X'_d
J+9		0.6	X'_q
J+10		0.1297	$X''_d = X''_q$
J+11		0.1	X_l
J+12		0.12	S(1.0)
J+13		0.60	S(1.2)

Note: X_d, X_q, X'_d, X'_q, X''_d, X''_q, X_l, H, and D are in pu, machine MVA base.

X''_q must be equal to X''_d.

MVA base = 3.06

SIEMENS

Excitation System Model Data Sheets
IEEET2

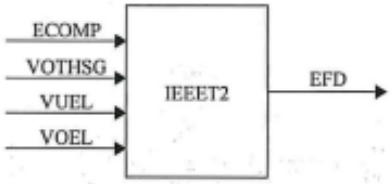
PSS®E 33.3
PSS®E Model Library

6.40 IEEET2

ASSUMED SETTINGS SAME AS GREEN HILL GAS TURBINE (except V_{RMAX} = 3 instead of 0)

IEEE Type 2 Excitation System

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VAR #_____ L.



CONs	#	Value	Description
J		0.035	T_R (sec)
J+1		400	K_A
J+2		0.22	T_A (sec)
J+3		3.0	V_{RMAX} or zero
J+4		0	V_{RMIN}
J+5		0	K_E
J+6		1.0	T_E (>0) (sec)
J+7		0.088	K_F
J+8		0.38	T_{F1} (>0) (sec)
J+9		1.00	T_{F2} (>0) (sec)
J+10		1.82	E_1
J+11		0.5	$S_E(E_1)$
J+12		2.43	E_2
J+13		0.86	$S_E(E_2)$

STATEs	#	Description
K		Sensed V_T
K+1		Regulator output, V_R
K+2		Exciter output, EFD
K+3		First feedback integrator
K+4		Second feedback integrator

VAR	#	Description
L		K_E

SIEMENS

PSS®E 33.3
PSS®E Model Library

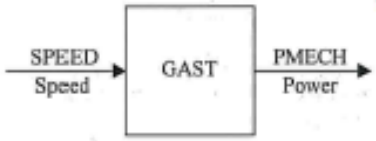
Turbine-Governor Model Data Sheets
GAST

7.5 GAST

ASSUMED MODEL FOR MOBILE DIESEL AND GAS TURBINE, SAME AS GREENHILL GAS TURBINE (except Vmax increased from 0.8058 to 1.0)

Gas Turbine-Governor

This model is located at system bus #_____ IBUS,
Machine identifier #_____ ID,
This model uses CONs starting with #_____ J,
and STATEs starting with #_____ K,
and VAR #_____ L.



CONs	#	Value	Description
J		0.07	R (speed droop)
J+1		0.40	T_1 (>0) (sec)
J+2		0.10	T_2 (>0) (sec)
J+3		3.00	T_3 (>0) (sec)
J+4		1.0	Ambient temperature load limit, AT
J+5		2.0	K_T
J+6		1.0	V_{MAX}
J+7		0	V_{MIN}
J+8		0	D_{turb}

STATEs	#	Description
K		Fuel valve
K+1		Fuel flow
K+2		Exhaust temperature

VAR	#	Description
L		Load reference

Vmax, Vmin, D_{turb} and R are in pu on generator MVA base.

IBUS, 'GAST', ID, CON(J) to CON(J+8) /

APPENDIX D

3000 HP INDUCTION MOTOR DATA

TECO-WESTINGHOUSE MOTOR COMPANY
ROUND ROCK, TEXAS U.S.A.

CUSTOMER NEW FOUNDLAND & LABRADOR HYDR DATE - FEB 19, 2013
CUSTOMER ORDER NO. 1022269
APPLICATION ELECTRIC UTILITY PUMP
S.O. 8052AA

DATA FOR WORLD SERIES, HORIZONTAL, BRACKET TYPE INDUCTION MOTOR

1. RATING

HP	3000	HERTZ	60.0	INSUL CLASS	F
RPM FL	3580	SERVICE FACTOR	1.15	KVA CODE	E
VOLTS	4160	RISE C (1.00 SF)	80	DUTY	CONTINUOUS
AMPS FL	350	METHOD	RES	NUMBER OF POLES	2
PHASES	3	AMBIENT C	40		

2. MECHANICAL

FRAME	5011	BRG TYPE	SLEEVE	END PLAY INCH	0.50
ENCL TYPE	WP2	LUBE TYPE	FLOOD	MOTOR WK2	423
		ROTATION(FROM NDE)	CCW	LOAD WK2	70

3. STARTING PERFORMANCE - NOMINAL, VALUES WITH (*) ARE GUARANTEED

		100% VOLTS	90% VOLTS
AMPS (LR)		2032	1789
AMPS (LR)	%	581	511
POWER FACTOR	%	15.2	14.8
START TORQUE	%	78	60
ACCELERATION SEC		2.0	2.9
SAFE LOCK SEC	FROM HOT	9.2	11.8
SAFE LOCK SEC	FROM COLD	10.7	13.7

PULLOUT TORQUE AT 100% VOLTS = 248 %

4. EFFICIENCY - NOMINAL

LOAD	%	115	100	75	50
EFFICIENCY	%	96.67	96.86	97.03	96.82

5. POWER FACTOR - NOMINAL

LOAD	%	115	100	75	50
POWER FACTOR	%	91.2	91.6	91.3	88.6

6. POWER FACTOR CORRECTION

MAX KVAR = 327 MAX FL P.F. = 95.8 %

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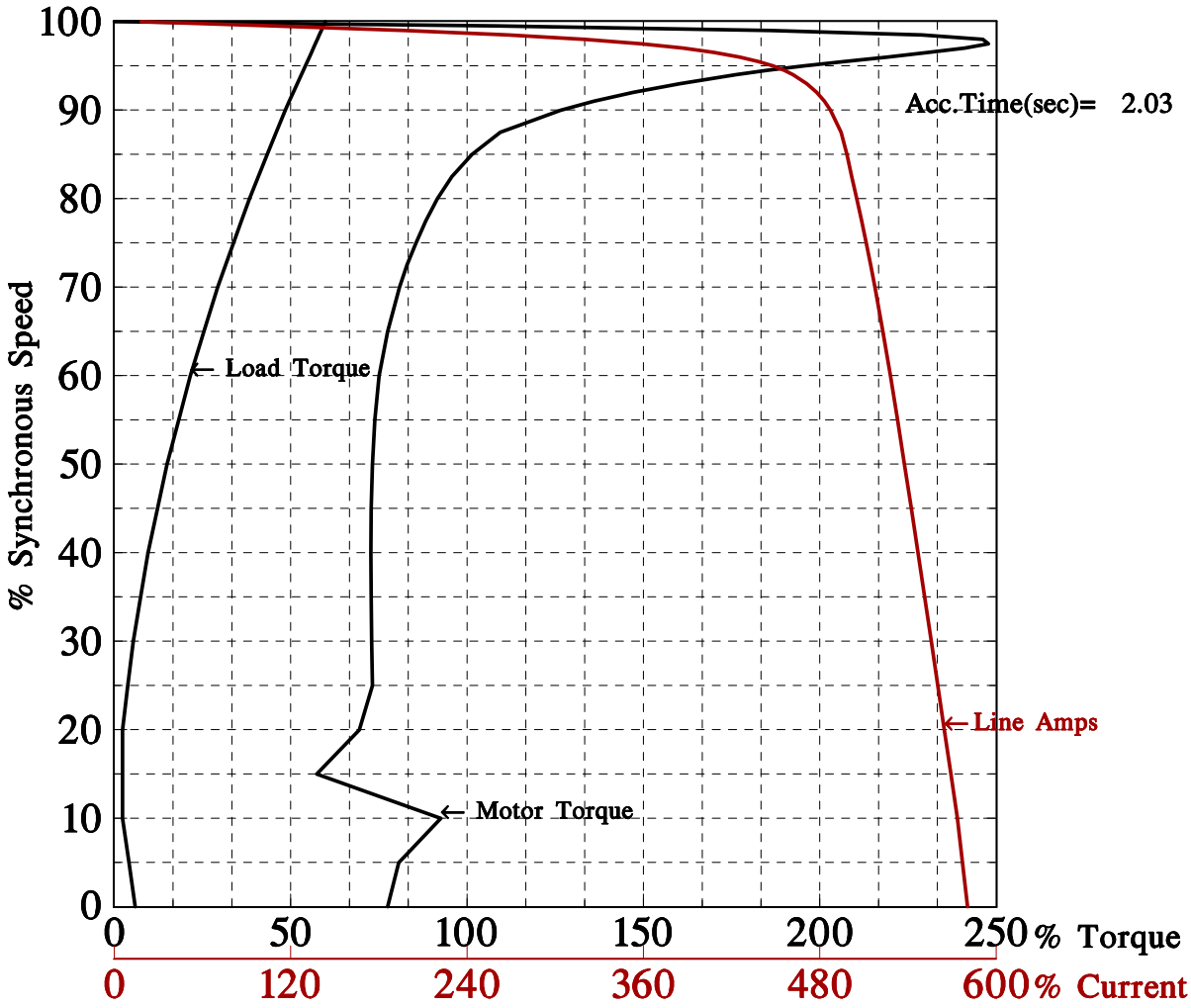
Induction Motor Starting Characteristics
Calculated at 100% Line Voltage

Design.ID 8052AA		Customer	NEW FOUNDLAND & LABRADOR
Engineer T.NGUYEN		Application	ELECTRIC UTILITY PUMP
Poles 2	Volts 4160	Rpm(fl) 3580	Load Curve ASSUMED
Hp 3000	Fl Amps 350	Rpm(syn) 3600	Lock Amps(%) 581
Pf 0.92	Frame 5011	Load Wk^2 70	Fl Torque(lb-ft) 4400
Phase 3	Hertz 60.0	Motor Wk^2 423	Lock Torque(%) 78



TECO-Westinghouse Motor Company Round Rock, Texas

Signature _____ Curve No.

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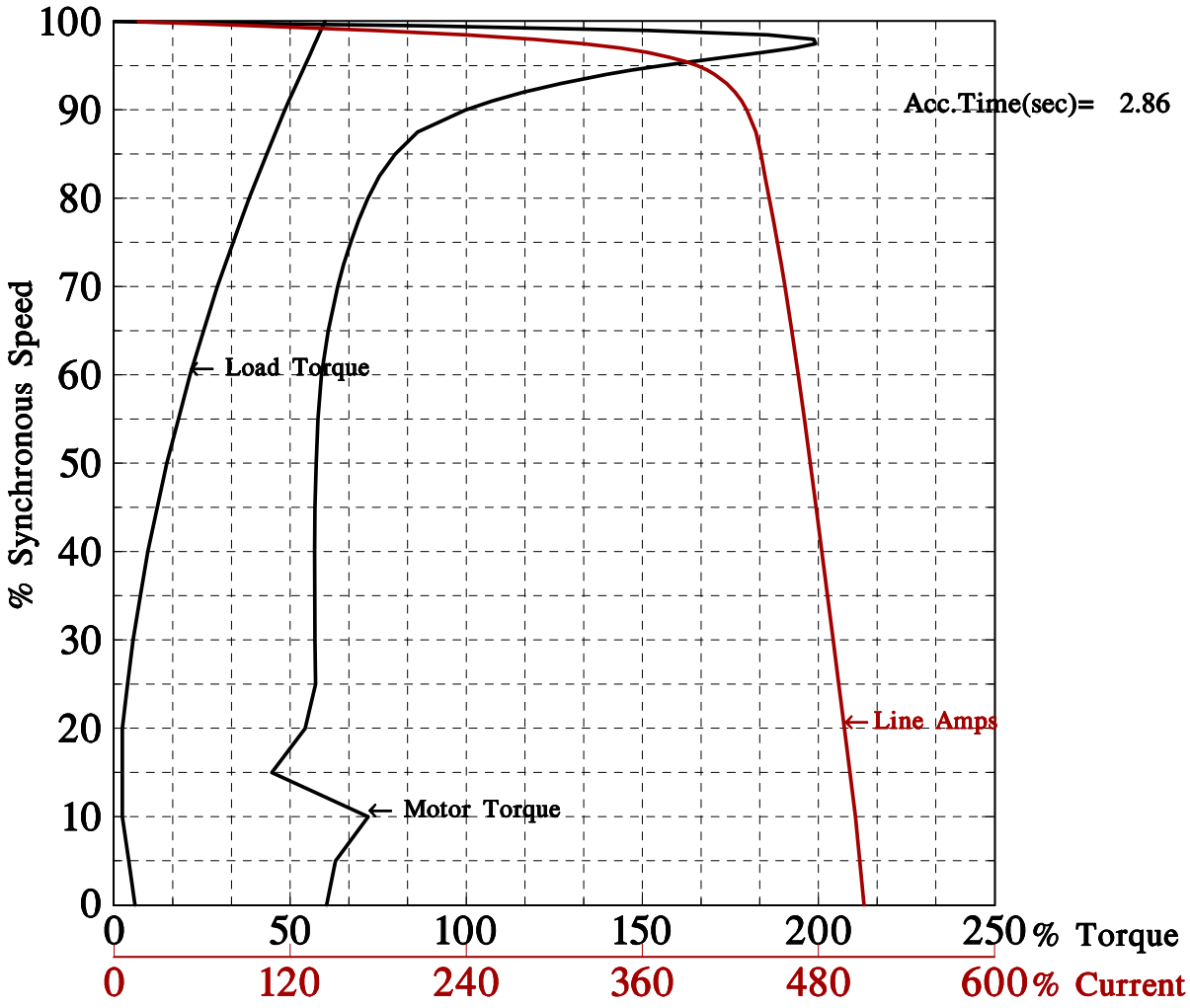
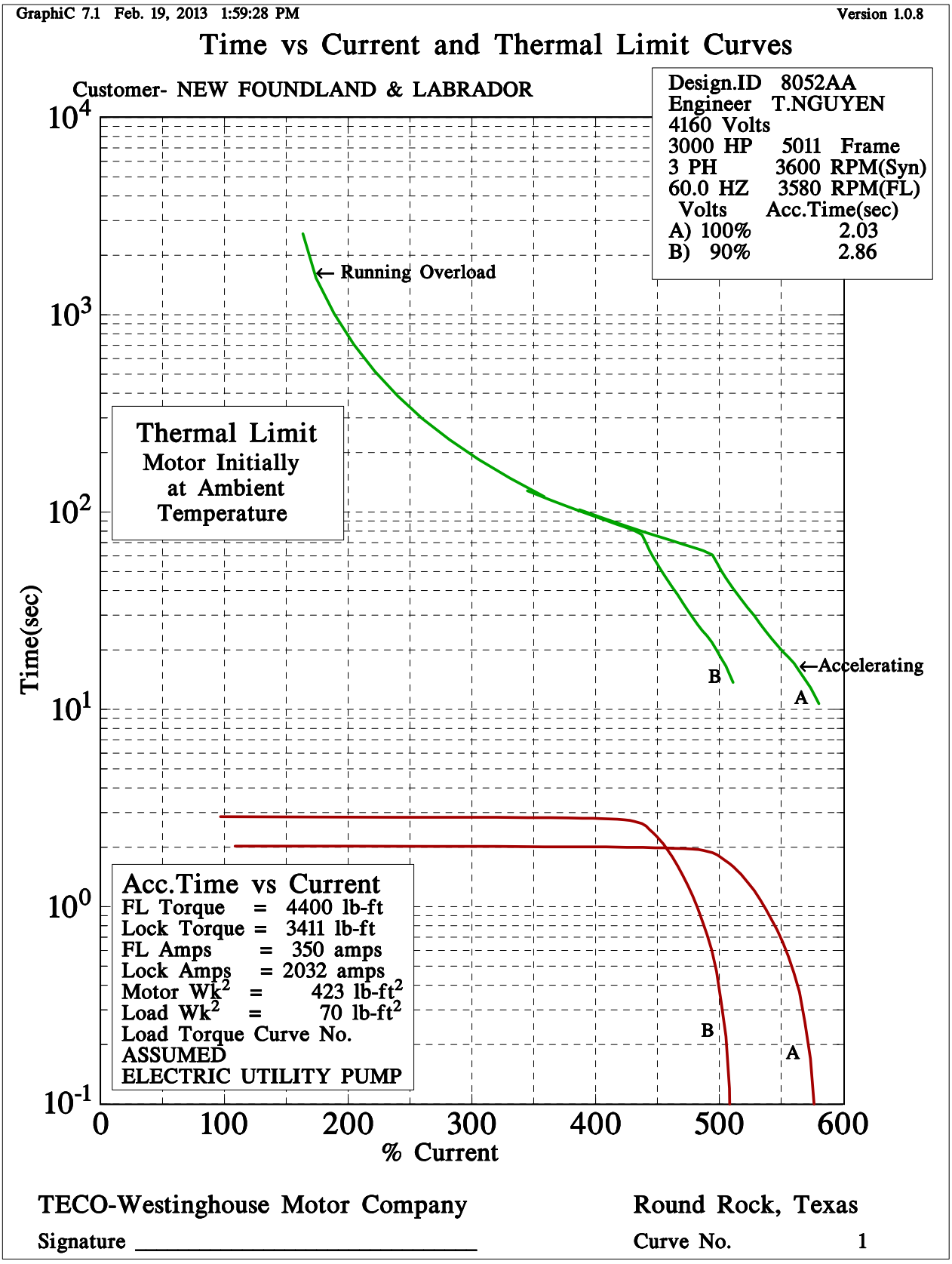
Induction Motor Starting Characteristics
Calculated at 90% Line Voltage

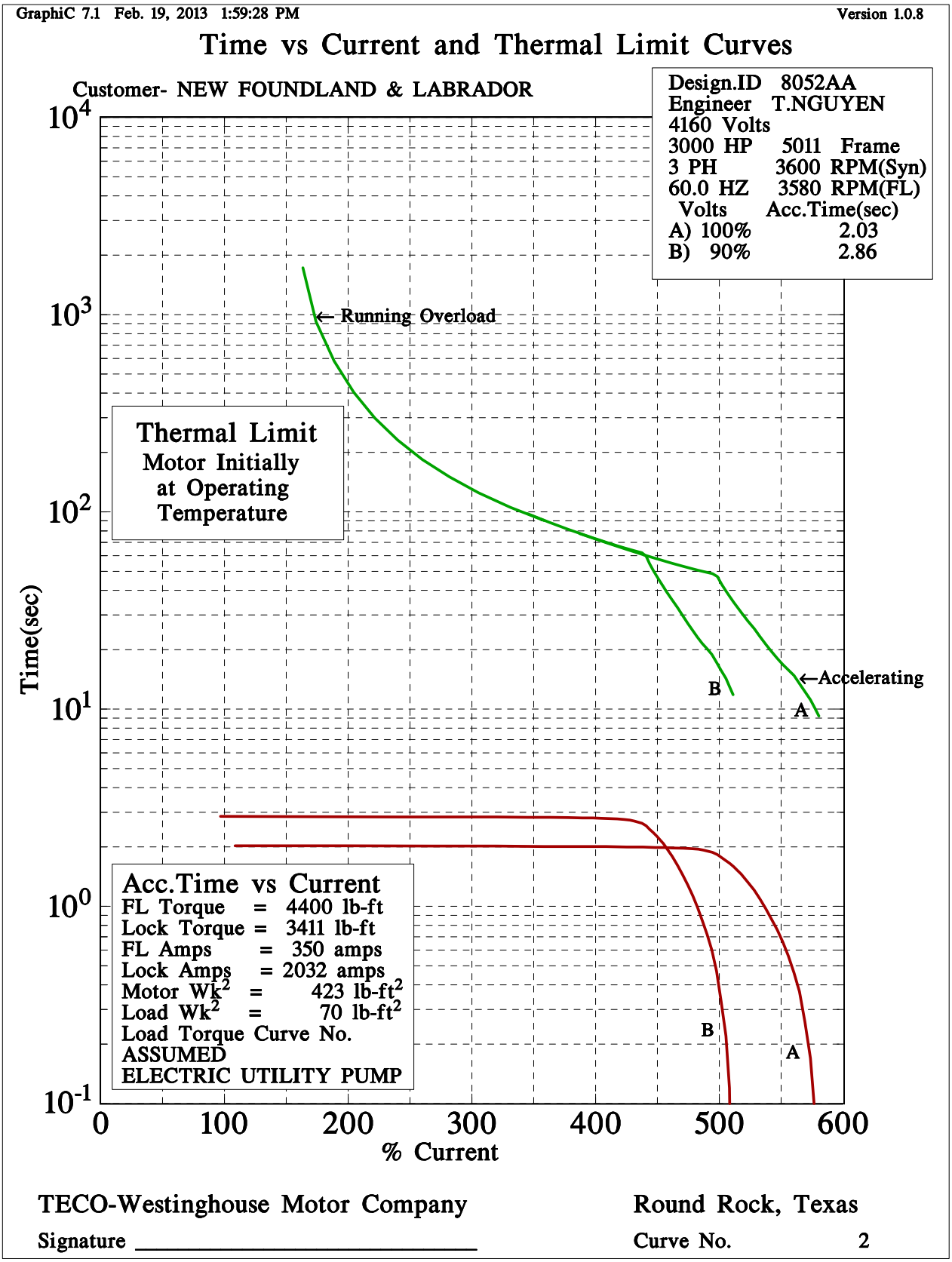
Design.ID 8052AA		Customer	NEW FOUNDLAND & LABRADOR
Engineer T.NGUYEN		Application	ELECTRIC UTILITY PUMP
Poles 2	Volts 4160	Rpm(fl) 3580	Load Curve ASSUMED
Hp 3000	Fl Amps 350	Rpm(syn) 3600	Lock Amps(%) 511
Pf 0.92	Frame 5011	Load Wk^2 70	Fl Torque(lb-ft) 4400
Phase 3	Hertz 60.0	Motor Wk^2 423	Lock Torque(%) 60



TECO-Westinghouse Motor Company Round Rock, Texas

Signature _____ Curve No.


GraphiC 7.1 Feb. 19, 2013 1:59:28 PM
Version 1.0.8
Time vs Current and Thermal Limit Curves
Customer- NEW FOUNDLAND & LABRADOR
Design.ID 8052AA
Engineer T.NGUYEN
4160 Volts
3000 HP 5011 Frame
3 PH 3600 RPM(Syn)
60.0 HZ 3580 RPM(FL)
Volts Acc.Time(sec)
A) 100% 2.03
B) 90% 2.86
← Running Overload
Thermal Limit
Motor Initially
at Ambient
Temperature
←Accelerating
B
A
Acc.Time vs Current
FL Torque = 4400 lb-ft
Lock Torque = 3411 lb-ft
FL Amps = 350 amps
Lock Amps = 2032 amps
Motor Wk² = 423 lb-ft²
Load Wk² = 70 lb-ft²
Load Torque Curve No.
ASSUMED
ELECTRIC UTILITY PUMP
B
A
Time(sec)
10⁴
10³
10²
10¹
10⁰
10⁻¹
0
100
200
300
400
500
600
% Current
TECO-Westinghouse Motor Company
Round Rock, Texas
Signature _____
Curve No. 1


GraphiC 7.1 Feb. 19, 2013 1:59:28 PM
Version 1.0.8
Time vs Current and Thermal Limit Curves
Customer- NEW FOUNDLAND & LABRADOR
Design.ID 8052AA
Engineer T.NGUYEN
4160 Volts
3000 HP 5011 Frame
3 PH 3600 RPM(Syn)
60.0 HZ 3580 RPM(FL)
Volts Acc.Time(sec)
A) 100% 2.03
B) 90% 2.86
← Running Overload
Thermal Limit
Motor Initially
at Operating
Temperature
←Accelerating
B
A
Acc.Time vs Current
FL Torque = 4400 lb-ft
Lock Torque = 3411 lb-ft
FL Amps = 350 amps
Lock Amps = 2032 amps
Motor Wk² = 423 lb-ft²
Load Wk² = 70 lb-ft²
Load Torque Curve No.
ASSUMED
ELECTRIC UTILITY PUMP
B
A
Time(sec)
10⁴
10³
10²
10¹
10⁰
10⁻¹
0
100
200
300
400
500
600
% Current
TECO-Westinghouse Motor Company
Round Rock, Texas
Signature _____
Curve No. 2

APPENDIX E

PSS®E DATA FOR 3000 HP INDUCTION MOTOR DATA

9.2 CIM5BL, CIM5OW, CIM5ZN, CIM5AR, CIM5AL

Induction Motor Load Model

This model uses CONs starting with	#_____	J,
and STATEs starting with	#_____	K,
and VARs starting with	#_____	L,
and ICON	#_____	M,
and Reserved ICONs starting with	#_____	N.

CONs	Value	Description
J	0.022	R_A
J+1	0.113	X_A
J+2	3.92	$X_m > 0$
J+3	0.047	$R_1 > 0$
J+4	0.034	$X_1 > 0$
J+5	0.00585	R_2 (0 for single cage)[1]
J+6	0.0430	X_2 (0 for single cage)
J+7	1.0	$E_1 \geq 0$
J+8	0.17	$S(E_1)$
J+9	1.2	E_2
J+10	0.52	$S(E_2)$
J+11	2.515	MBASE[2]
J+12	1	PMULT
J+13	0.58	H (inertia, per unit motor base)
J+14	0	V_I (pu)[3]
J+15	0.1667	T_I (cycles)[4]
J+16	0.0833	T_B (cycles)
J+17	1.0	D (load damping factor)
J+18	0.756	T_{nom}, Load torque at 1 pu speed (used for motor starting only) (≥ 0)

1 To model single cage motor: set $R_2 = X_2 = 0$.

2 When MBASE = 0, motor MVA base = PMULT x MW load. When MBASE > 0, motor MVA base = MBASE.

3 V_I is the per unit voltage level below which the relay to trip the motor will begin timing. To disable relay, set $V_I = 0$.

4 T_I is the time in cycles for which the voltage must remain below the threshold for the relay to trip. T_B is the breaker delay time cycles.

SIEMENS

Load Characteristic Model Data Sheets
CIM5BL, CIM5OW, CIM5ZN, CIM5AR, CIM5AL

PSS®E 33.3
PSS®E Model Library

STATEs	Value	Description
K		E'_q
K+1		E'_d
K+2		E''_q
K+3		E''_d
K+4		Δ speed (pu)
K+5		Angle deviation

VARs	Value	Description
L		Admittance of initial condition Mvar difference
L+1		Motor Q
L+2		T_{elec} (pu motor base)
L+3		$\Delta\omega$
L+4		T (pu on motor base)[1, 2]
L+5		I_Q
L+6		I_D
L+7		Motor current (pu motor base)
L+8		Relay trip time
L+9		Breaker trip time
L+10		MVA rating

1 Load torque, $T_L = T(1 + D\omega)^D$

2 For motor starting, $T=T_{nom}$ is specified by the user in CON (J+18). For motor online studies, T=To is calculated in the code during initialization and stored in VAR (L+4).

ICON	Value	Description
M	2	IT, motor type (1 or 2)

Reserved ICONs	Value	Description
N		Relay action code
N+1		Relay trip flag
N+2		Breaker action code
N+3		Breaker trip flag

I, 'CIM5xx', LID, ICON(M), CON(J) to CON(J+18) /

SIEMENS

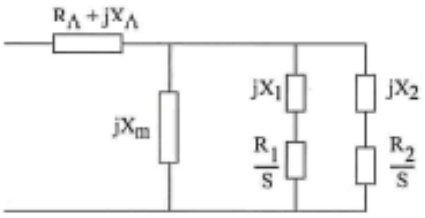
PSS®E 33.3
PSS®E Model Library

Load Characteristic Model Data Sheets
CIM5BL, CIM5OW, CIM5ZN, CIM5AR, CIM5AL

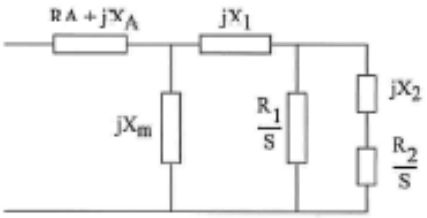
LID is an explicit load identifier or may be * for application to loads of any ID associated with the subsystem type.

Model suffix xx	I Description
BL	Bus number
OW	Owner number
ZN	Zone number
AR	Area number
AL	0

Type 1



Type 2



Impedances on Motor MVA Base

RATING : 3000 HP @ assumed pf = 0.89

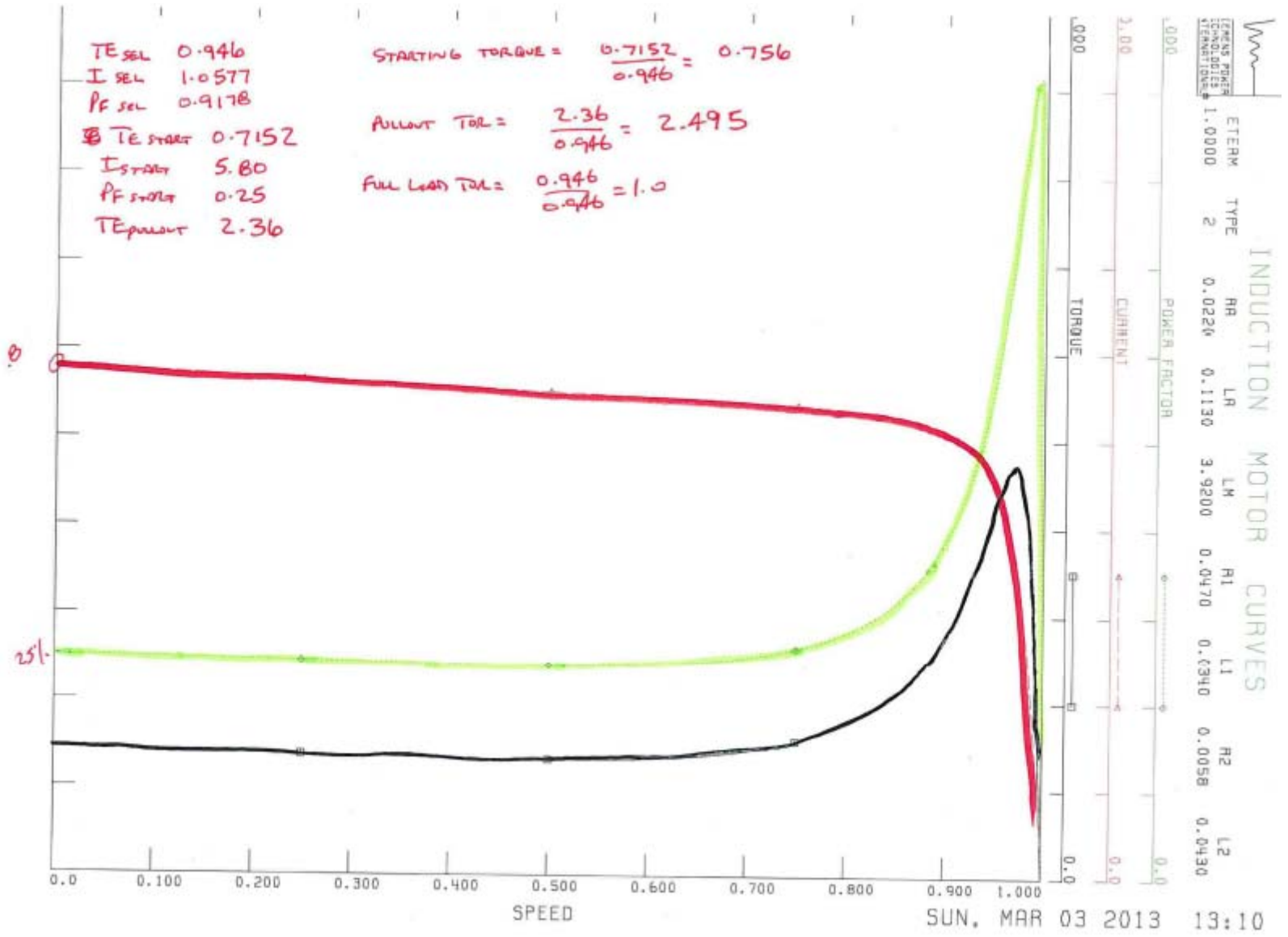
$$\frac{3000 \times 746}{0.89} = 2.515 \text{ MVA}$$

H: MOTOR $WK^2 = 423$
LOAD $WK^2 = 70$ (assumed)
493

$$H = \frac{0.231 \times 10^{-6} (RPM)^2 \times WK^2}{KVA \text{ mach}}$$

$$H = \frac{0.231 \times 10^{-6} (3580)^2 \times 493}{2515}$$

$$H = 0.58$$


TE SEL 0.946
I SEL 1.0577
PF SEL 0.9178
TE START 0.7152
I START 5.80
PF START 0.25
TE PULLOUT 2.36
STARTING TORQUE = 0.7152/0.946 = 0.756
PULLOUT TOR = 2.36/0.946 = 2.495
FULL LOAD TOR = 0.946/0.946 = 1.0
0
25
0.0
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
SPEED
TORQUE
CURRENT
POWER FACTOR
INDUCTION MOTOR CURVES
ETERM 1.0000
TYPE 2
RA 0.0220
LA 0.1130
LM 3.9200
R1 0.0470
L1 0.0340
R2 0.0058
L2 0.0430
SUN. MAR 03 2013 13:10