DOCUMENTS & DRAWINGS
FOR WORKING

PROJECT	SEMI-SUBMERSIBLE DRILLING RIG JBF14000 #1		MA/P245
OWNER			
SHIPYARD			
DESIGNER	HUISMAN,		
PREPARED BY	LX	MAIN GENERATOR SET 8xCAT 3616 4400eKW@900rpm	
CHECKED BY			
APPROVED BY			
DATE	SEP04, 2009		
VERSION	01		
HULL NO.	YRO 2007-242		

CONTENTS

1.0 TECHNICAL DATA

1.1 Diesel Engine

Model	CAT 3616
Type	V-16, 4 cycle
Aspiration	Turbocharger, Aftercooled
Rated power max	4600 bKW
Rated speed	900 rpm
Emission	IMO compliance
Overload 110% for 1 hr	5060 bkW

Rating and emission based on following ambient condition

Air inlet of the turbocharger	45 °C
Barometric pressure	100 kPa
Relative humidity	60 %
Sea water temperature	32 °C
BSFC (w/ pump +5 %/-0%) @100% load	195.5 g/kW-hr
TBO approx.	40,000 hours
Bore / Stroke	280 / 300mm
Displacement	296 L
Compression ratio	13:1
Firing pressure, max.	17300 kPa
BMEP@ 100% load	2283 kPa
Mean piston speed	9.0 m/s
Engine dry weight (approx)	28,500 kg

1.2 Alternator

Type Synchronous brushless revolving field w/ a direct connected rotating brushless exciter

Code	Kato 8P12-4700
Power rating	5500KVA, 4400eKW, 0.8ph+110% overload for 1 hr
Duty	Continuous
Rated speed	900rpm, 8poles
Electrical rating	11.2KV, 60Hz, 3ph
Connection	6 wire, wye
Temperature rise	90°C/50°C amb.
Insulation	Class F
Enclosure	IP44
Cooling	Totally Enclosed Water to Air
Bearing design	Two Sleeve w/ext. lube
Net weight (approx.)	25,946Kg

1.3 Air Inlet System

Flow of air at 100% load	501.6 m3/min
Air temp. @ air cleaner, max.	45 °C
Air temp. after after-cooler, alarm	60 °C
Intake manifold press. at 100% load	277 kPa
Air inlet restriction, new/max.	1.25/3.8 kPa
AC press. diff at 100%load, clean state	3.4 kPa

1.4 HT Cooling Water System – JW

Pump capacity @ 900 rpm	2630	Lpm
Pump rise @ 900 rpm	240	kPa
Pump inlet pressure, min.	30	kPa
Inlet temperature, nom.	90	°C
Inlet temperature, max.	95	°C
Inlet temperature, min.	83	°C
Outlet temperature, alarm	100	°C
Outlet temperature, stop	104	°C

1.5 LT Cooling Water System - AC/OC

AC/OC water flow rate required	1560	Lpm
Inlet temperature, nom.	32	°C
Inlet temperature, max.	38	°C

1.6 Exhaust Gas System

Gas flow at 100% load	1045	m3/min
Stack temp. at 100% load	356	°C
Stack temp. alarm at 100% load	550	°C
Temp. to turbo at 100% load	523	°C
Temp. to turbo alarm at 100% load	650	°C
Back pressure, max	2.54	kPa

1.7 Fuel Oil System

Flow rate, supply @ 900rpm	72.0	Lpm
Flow rate, return @ 900rpm	52	Lpm
Pump suction restriction, max.	-20	kPa
Manifold pressure at 100% load	430-676	kPa
Return line back pressure, max.	350	kPa
BSFC (w/ pump +5 %/-0%) @100% load	195.5	g/kW-hr

Fuel oil recommendation
ISO8217 DMA, DMB, DMX (20 cSt max, 1.4 cSt min. @ 38 °C)

* Fuel consumption are based on 35API, 16℃ fuel having a lower heating value of 42,780 kJ/kg used at 29℃ with density of 838.9 g/L

1.8 Lubricating Oil System

Lube oil flow	1117	Lpm
Manifold pressure, nom.	380	kPa
Manifold press, alarm (650-900rpm)	320	kPa
Manifold pressure, alarm (0-655rpm)	120	kPa
Manifold press. stop (650-900rpm)	260	kPa
Manifold pressure, stop (0-655rpm)	105	kPa
Manifold temperature, alarm	92	°C
Manifold temperature, stop	98	°C
Manifold temperature, nom.	85	°C
Prelube pump cap. continuous	23	Lpm
Prelube pump cap. intermittent	76	Lpm
Lube oil filter diff. press. max.	104	kPa
BSOC at 100% load	0.7	g/ kw-hr

Lube oil viscosity grade:	SAE40 or SAE15W40
Lube oil API classification:	CF
Caterpillar lube oil name:	DEO (API CG-4)

1.9 Starting Air System

Air pressure, nominal	1225	kPa
Air pressure, min.	620	kPa
Air pressure, max.	1575	kPa
Low air pressure, alarm	850	kPa

2.0 SCOPE OF SUPPLY

2.1 General

The scope of supply listed below are based on single engine unless otherwise specified

Engine rotation viewed fr. rear of flywheel	CCW
Engine service side viewed fr. rear of flywheel	Right Hand
Power supply on board	480V/60Hz/3ph
	230V/1ph
	24V DC

2.2 Air Intake System

Front mounted turbocharger, BASIC 297, engine oil lubricated
Aftercooler, fresh water, corrosion resistant coated (air side)
Air inlet adapter (90 deg.), mounted to turbocharger inlet
Air cleaner, vertical, standard duty, normal volume
Air vertical support bracket
Air inlet shutoff

2.3 Control System

Woodward 2301D electronic governor with load sharing interface, hydraulic actuator, 24VDC power, loose supplied
Load sharing control is not our scope of supply

2.4 Cooling Water System

Separate cooling circuit suitable for sea water 32°C max
Plate type heat exchanger for JW circuit, titanium 0.4 mm, accessory module mounted, based on 32°C SW and sized to supply JW
Plate type heat exchanger for AC/OC/fuel/alternator cooler, titanium 0.4 mm, accessory module mounted, based on 32°C SW and size to supply these components with 38°C freshwater
Plate-type oil cooler, stainless steel
Plate-type fuel cooler, stainless steel
Jacket water pump, gear driven
AC/OC pump,gear driven
Boost pump, gear driven, not self-priming
Expansion tank, accessory module mounted
JW thermostat, 90°C
AC/OC thermostat, 32°C
Heat recovery connection, including thermostat, loose supplied
JW/LO heater, 480V /3ph/60Hz, base mounted
Cooling connections will include a single seawater inlet and a single seawater outlet
ANSI connection incl. a single sea water inlet and a single seawater outlet
Flexible connection
Sea water pump not included

2.5 Exhaust System

Dry gas tight exhaust manifolds with soft shields
Exhaust adapters, rectangular to round, vertical orientation, loose supplied
Exhaust expander, 14”-18”, loose supplied
Exhaust flexible fitting, 18”, loose supplied

Exhaust weld flange, 18”, loose supplied
Exhaust silencer not included

2.6 Fuel Oil System

Fuel unit injectors at each cylinder
Fuel transfer pump, gear driven
Manual fuel priming pump
Duplex fuel filter, engine mounted
Duplex fuel strainer, shipped loose, customer remote mounted
Flexible conn, At least 500mm long hose, incl. fuel pump inlet and return oil out let, loose supplied, with type approved or certificated by class

2.7 Alternator & Accessories

<u>Alternator & Accessories</u>

- Basler DECS 200 digital voltage regulator (supplied loose). 0.25% regulation, field over volt & over current, Exc. Diode Monitor, Under/Overolt, Loss of Sensing, Under/Over-exc. Limiter, Auto Tracking & Switching to Manual Control, VAR/PF Control, with reactive load sharing interface
- Reactive load sharing control in not our scope of supply
- PMG (300% SC 10 Sec) for Regulator Power
- Kato shall supply & mount coupling hub suitable for Caterpillar 3600 series engine
- Primary bearing lube oil pump for both exc. and drive end sleeve bearings. Oil. Oil Cooler, Pre-lube pump, and all piping by others
- Sleeve Bearing oil line connection fittings for external lubrication (per bearing). 60 Deg C maximum oil to be supplied by customer
- Drive End Sleeve Bearing -non-insulated - self lubricating
- Exciter End Sleeve bearing - insulated - self lubricating
- Stand-Off Terminal Connectors, mounted in outlet box.
- (6) Kato supplied CT's for differential protection. Three mounted in outlet box, three furnished loose for customer mounting.
- Oversized Outlet Box
- Double Tube copper-nickel air to water heat exchanger w/water leak detector. External Maximum 38°C water is required and to be supplied by others.
- Special frame for water cooled totally enclosed alternators.
- Six - 100 ohm RTD's embedded in stator windings for temperature monitoring, 2 per phase.
- Two - 100 ohm RTD's installed in bearing housing for temperature monitoring (1 per brg)
- Thermostat for commercial space heaters
- Commercial Space Heater, Single Phase 250V or less.
- ABS Test & Certification. Includes Air-gap, Over-speed Test, Overload Test, and Steady state short circuit Test. Heat Test on first unit may be required.
- Heat test per IEEE 115 for first unit only.
- Witness of Tests by Customer or Customers Agent per day for one unit only.
- Calculated X"D =0.137 saturated per request
- IP 55 Terminal Box located LHSFEE with bottom cable entry
- 2/3's Stator Winding Pitch
- Inrush current reduction module for AVR, mounted in switchboard, shipped loose

<u>Spares</u>

- Spare Rectifier/Suppressors (2), one (1) set per shipset
- Spare Bearing Liners, one (1) set per shipset

2.8 Lube Oil System - Generator

Primary mechanical lube oil pump, generator driven
Lube oil module:

- Pre-lube/standby electrical lube oil pump, 480 V, 3 ph, 60 Hz
- Lube oil tank
- Heat exchanger, 38C fresh water
- Lube oil filter
- Lube flow divider
- Module incl. wiring of the unit, motor starter, 24VDC controls, NEMA 4 enclosure, mounting bracket for mounting the unit to the base, lines group for connecting to the generator bearings
- Redundant air pre-lube pump for black start

2.9 Lube Oil System - Engine

Breather, crankcase top-mounted
Custom dry sump base assembly with an integral sump in the base assembly for 15 deg. static and 22.5 deg dynamic tilt capability
Lube oil pump, gear driven
Duplex lube oil filter, paper element, accessory module mounted
Centrifugal oil filters with single shutoff, service side engine mounted
Oil filter and dipstick valve
Oil pressure regulating valve
Crankcase explosion relief
Prelube pump, continuous mode, electrical driven, incl. 24VDC motor starter, engine base mounted
Backup/black start prelube pump, intermittent mode, air driven, base mounted
Lube oil is not scope of supply

2.10 Monitoring System

2.10.1 Genset Monitoring System (GMS)

Providing protection, monitoring and control, housed in a NEMA 4 (IP66) enclosure, sensors are wired to GMS

Control panel on accessory module
10 inch color monitor, displays all engine parameters and alarm annunciation
Start / prelube control switch
Fuel control switch
Emergency stop button
Speed control switch
Contacts are available for customer use.

- Selection of local/remote control of engine
- Selection of idle/rated control of engine
- Equipped for remote communication
- Four 4-20 mA outputs (programmable)
- Relay contact signals to the remote monitoring system

Gauge

- Engine hour meter
- Digital tachometer
- Starting air pressure gauge

Light

- Pre-lube status light
- Summary alarm light

- Summary shutdown light
- PLC failure light

<u>Engine sensors</u>
Contactors:
- Lube oil pressure (hi/low speed)
- Jacket water pressure
- AC/OC pressure
- Start air pressure
- Crankcase pressure

4-20 mA transducers:
- Lube oil pressure (to filter/to engine)
- Fuel pressure (to filter/to engine)
- Inlet air manifold pressure

RTD (PT100):
- Lubricating oil to engine temperature
- Inlet air manifold temperature
- Fuel to engine temperature
- AC/OC inlet temperature
- Jacket water outlet temperature (alarm)
- Jacket water outlet temperature (shutdown)
- Generator rear bearing temperature
- Generator front bearing temperature
- Generator stator A temperature
- Generator stator B temperature
- Generator stator C temperature

Switches:
- Jacket water detector
- Metal particle detector
- Starting oil pressure or detector

Thermocouples:
* Exhaust thermocouple temperatures (one per cylinder plus inlet to turbine and stack)

<u>MODBUS communication</u>
All monitored parameters and status available except engine start/stop control witch is connected by hardwire

<u>Alarms</u>
Pressures:
- Low oil pressure
- High oil filter differential
- Low fuel pressure
- High fuel filter differential
- High inlet air manifold pressure
- Low starting air pressure
- Low jacket water pressure
- Low AC/OC water pressure
- Low raw/sea water pressure (customer supplied contact)

Temperatures:
- High lube oil temperature
- High inlet air manifold temperature
- High fuel temperature
- High AC/OC inlet temperature
- High jacket water outlet temperature

- High generator rear bearing temperature
- High generator front bearing temperature
- High generator stator A temperature
- High generator stator B temperature
- High generator stator C temperature
- High individual exhaust port temperature
- High turbine inlet temperature
- High exhaust stack temperature
- High exhaust port deviation temperature

Other:
- Low battery voltage
- Low oil level
- Sensor failure
- Jacket water detection
- Low coolant level (switch is supplied with expansion tank)
- Metal particle detection

<u>Shutdowns</u>
Pressure:
- Low oil pressure
- High crankcase pressure
- Temperature:
- High jacket water temperature
- High lube oil temperature
- High generator bearing temperature
- Other:
- Metal particle detector
- Engine overspeed
- Customer shutdown (normally open contact customer supplied)

<u>Programmable Inputs</u>
2 of customer supplied RTD's
2 of customer supplied 4-20mA (0-10 VDC) sensors
3 of discrete alarms, and 3 of discrete shutdowns

<u>Beacon and horn</u>

<u>Oil mist detector incl. drain GP</u>

<u>Engine mounted gauges</u>
Fuel pressure
Lube oil pressure
Inlet air restriction

<u>Other engine protection</u>
Cylinder pressure relief valve
Mechanical cylinder press GA valve

2.10.2 Remote Monitoring

The items of remote monitoring, alarm and protection are complied with ABS class notation of ACCU.

All monitored parameters, alarms, protection and engine status are available on communication port (RS232, RS422 or RS485 are available).

2.11 Mounting and Base

Skids mounted, three point mounting, 36" I-beam base
Vibration isolators, shipped loose

2.12 Starting Air System

Air start motors, vane type, incl. silencer, lubricator, air strainer, shutoff valve and flexible hose, max. air pressure 1575 kPa
Air pressure reducing valve containing relief valve, 3100-850 kPa, loose supplied, shipyard installed
Flexible hoses
Starting air vessel not included

2.13 General Items

High inertia flywheel
Electric barring device, 480V/3ph/60Hz motor, equipped with a pendant switch on a 40 ft. cord. Incl. 50:1 manual barring device and a 24 VDC motor starter
Standard damper guard
Flywheel and coupling guard
Torsional coupling for two bearing generator, ABS certificafied
Engine lifting eyes
Custom accessory module
Paint, CAT yellow
Shrink wrap and tarpaulin protection for transportation and storage
Approved custom genset TVA, one per shipset
Noise and vibration technical data
Test/commissioning procedure
Factory Acceptance Test for one gen-set per shipset

2.14 Spare Parts & Tools

Spare parts kit
As per ABS recommened for unrestricted voyage zone and CAT standard, one (1) set per shipset

Service tool group
3600 specialized tooling, one (1) set per shipset
Manuel service pump, one (1) per shipset
Protection system calibration kit, one (1) set per shipset
Oil mist detector tool kit, one (1) set per shipset

2.15 Drawing & Document

Drawing & Document for approval	7 paper+1CD per shipset
Drawing & Document for working	7 paper+1CD per shipset
Parts Book	7 paper+7CD per shipset
Service Manual	7 paper per shipset
Technical. Manual	7 paper per shipset
ABS Engine Certificates	1 per engine
ABS Generator Certificates	1 per generator
IMO EIAPP Certification	1 per engine

LAFAYETTE POWER SYSTEMS
Generator Specifications

Printed: 10/16/2008

Price List Code: Spec. No: 8P12-4700 Page 1/2

************ Specifications ************

Poles	8
Excitation:	PMG
Pitch:	0.667
Connection:	Wye
Max Overspeed (60 sec)	125%
Number of Bearings	Two
Number of Leads	Six
Number of Terminals	Four

************ Ratings ************

Power	4400 EkW
K.V.A.	5500
P.f.	0.8
Voltage-L.L.	11,200 V
Voltage-L.N.	6467 V
Current-L.L.	284 A
Frequency	60 Hz
Speed	900 RPM

************ Efficiency and Heat Dissipation ************

(As per NEMA and IEC at 95°C)

Load PU	Kilowatts	Efficiency	Heat Rejection	
0.25	1100.0	92.0%	326461	BTU/hr
0.50	2200.0	95.3%	370309	BTU/hr
0.75	3300.0	96.2%	444896	BTU/hr
1.00	4400.0	96.5%	544665	BTU/hr

********* Temperature & Insulation Data *********

Ambient Temperature	50 °C
Temperature Rise	90 °C
Insulation Class	F (155 °C)
Insulation Resistance (as shipped)	100 Megaohms (at 40 °C)

************ Fault Currents ************

Instantaneous 3-Ø symmetrical fault current	2070 Amps
Instantaneous L-N symmetrical fault current	2709 Amps
Instantaneous L-L symmetrical fault current	1682 Amps

************ Exciter Armature Data ************

(at full load, 0.8 p.f.)

Voltage	274	V
Current	102	A

************ Time Constants ************

OC Transient - Direct Axis	**T'DO**	4.436 Sec
SC Transient - Direct Axis	**T'D**	1.113 Sec
OC Subtransient - Direct Axis	**T"DO**	0.044 Sec
SC Subtransient - Direct Axis	**T"D**	0.031 Sec
OC Subtransient - Quadrature Axis	**T"QO**	0.022 Sec
SC Subtransient - Quadrature Axis	**T"Q**	0.006 Sec
Armature SC	**TA**	0.077 Sec

************ Resistances ************

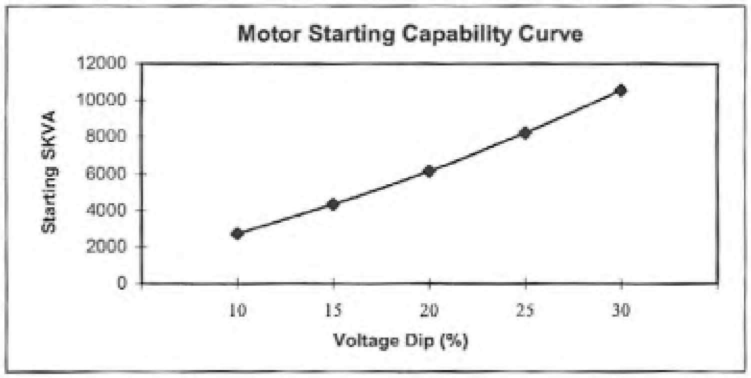
Base Impedence	22.807 ohms
Stator (at 25 °C)	0.086 ohms
Field (at 25 °C)	1.86 ohms
Zero Sequence R0	0.26 ohms
Positive Sequence R1	0.11 ohms
Short Circuit Ratio	1.21

************ Reactances ************

		Saturated		Unsaturated	
		Per Unit	Ohms	Per Unit	Ohms
Subtransient - Direct Axis	**X"D**	0.137	3.1	0.161	3.7
Subtransient - Quadrature Axis	**X"Q**	0.173	3.9	0.203	4.6
Transient - Direct Axis	**X'D**	0.197	4.5	0.223	5.1
Transient Quadrature Axis	**X'Q**	0.159	3.6	0.604	13.8
Synchronous - Direct Axis	**XD**	0.830	18.9	1.052	24.0
Synchronous - Quadrature Axis	**XQ**	0.459	10.5	0.604	13.8
Negetive Sequence	**X2**	0.155	3.5	0.182	4.2
Zero Sequence	**X0**	0.022	0.5	0.025	0.6

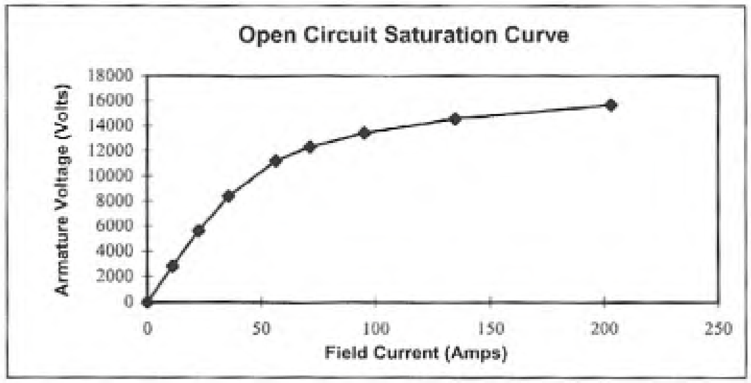
****** Motor Starting Capability Data ******

Voltage Dip (%)	Starting SKVA
10	2737
15	4346
20	6157
25	8210
30	10555



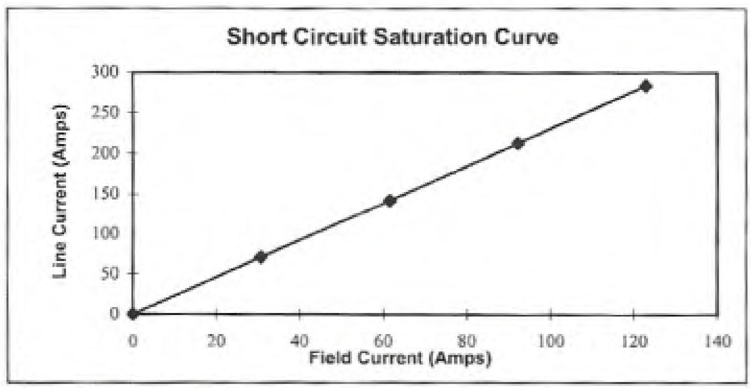
******* Open Circuit Saturation Data *******

Field Current (Amps)	Armature Voltage (Volts)
0.0	0
11.1	2800
22.6	5600
35.7	8400
56.5	11200
71.5	12320
95.2	13440
134.8	14560
203.1	15680



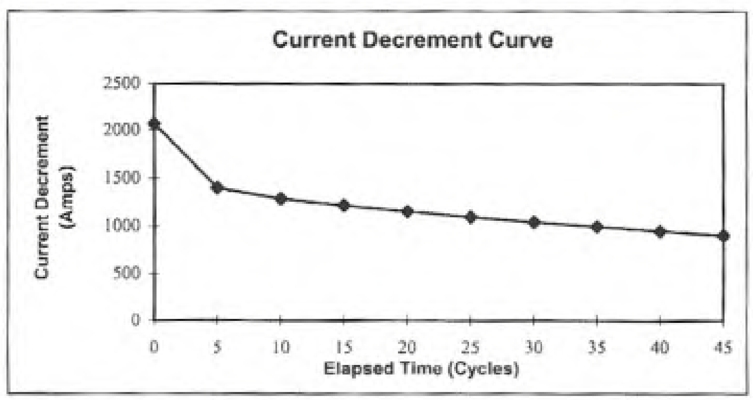
******* Short Circuit Saturation Data *******

Field Current (Amps)	Line Current (Amps)
0.0	0.0
30.8	70.9
61.5	141.8
92.3	212.6
123.0	283.5



********* Current Decrement Data **********

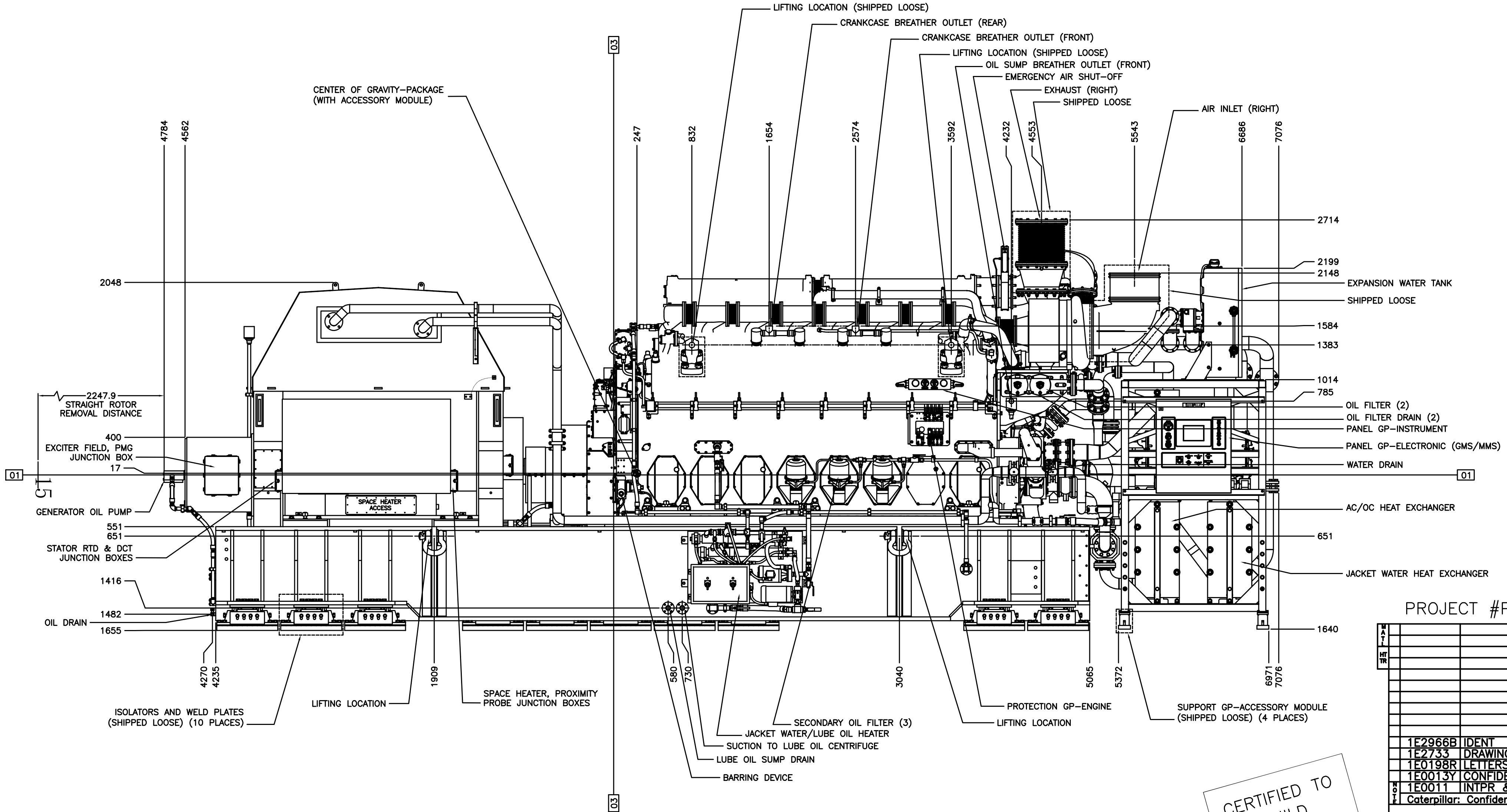
Elapsed Time (Cycles)	Current Decrement (Amps)
0	2070
5	1404
10	1289
15	1219
20	1155
25	1096
30	1042
35	992
40	945
45	901



3.0 INSTALLATION DRAWING

No	Drawing No	REV.	Drawing Name	Total Pages
1	332-2698-01	01	Genset Right Side View	1
2	-02	01	Genset Rear & Front View	1
3	-03	01	Genset Left Side View	1
4	-04	01	Genset Top View	1
5	-05	01	Genset Plan View (TBA)	1
6	-06	01	Detail Sheet	1
7	-07	01	Detail Sheet	1
8	-08	01	Detail Sheet	1
9	-09	01	Detail Sheet	1
10	-10	01	Detail Sheet	1
11	-11	01	Connection Data Sheet	1
12	-12	01	3616 Cooling Schematic	1
13	7W4451	01	Erection and Handling Procedure	1

METRIC 332-2698



PROJECT #PG0708

CERTIFIED TO BUILD

RIGHT SIDE VIEW

RIGHT HAND SERVICE
RIGHT HAND COOLANT CONNECTIONS

SCALE 1=20

PACKAGE WEIGHT

ENTIRE PACKAGE (WITH ACCESSORY MODULE)	82,285 KG

THE ▭—▭ LINE IS USED AS A LINEAR DATUM FOR THE VIEW IN WHICH IT APPEARS. DIMENSIONS ARE PRINTED PARALLEL TO THE DATUM LINE TO WHICH THEY PERTAIN. DIMENSIONS WITH ARROW-HEADS DO NOT PERTAIN TO THE DATUM LINES EXCEPT IN AUXILIARY VIEWS.

DATUMS	
01	- CENTERLINE OF CRANKSHAFT
02	- CENTERLINE OF ENGINE
03	- REAR FACE OF CRANKSHAFT ADAPTER

REVISION	CHANGE DESCRIPTION
01	MOVED GMS PANEL TO ACC. MOD.-LEFT SIDE; ADDED GLM SUMP BREATHER OUTLET
01	ADDED 341-3623 LINES GP-WATER AT GENERATOR LUBE MODULE
01	UPDATED GENERATOR GRAPHICS AND LABELING; ADDED CG AND WEIGHT DATA

1E2966B	IDENT
1E2733	DRAWING-AUTOCAD
1E0198R	LETTERS
1E0013Y	CONFIDENTIALITY
1E0011	INTPR & TOL
Caterpillar: Confidential Yellow	

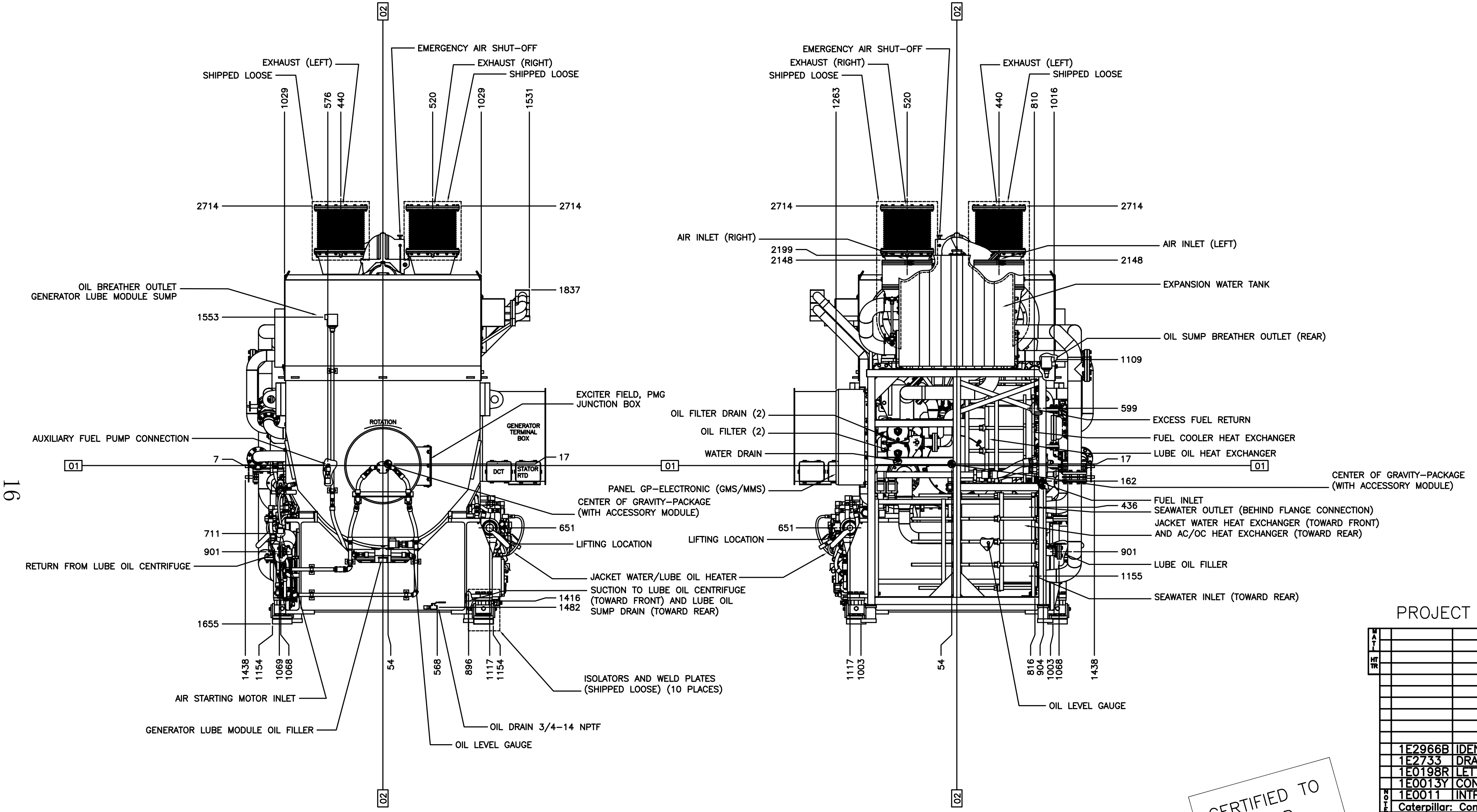
ENGINE MODEL 3616 FMT
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE
SHEET 1 OF 12 THIRD ANGLE PROJECTION

CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 VER – W853

METRIC 332-2698



PROJECT #PG0708

CERTIFIED TO BUILD

RIGHT HAND SERVICE
RIGHT HAND COOLANT CONNECTIONS

SCALE 1=20

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ENGINE MODEL 3616 FMT
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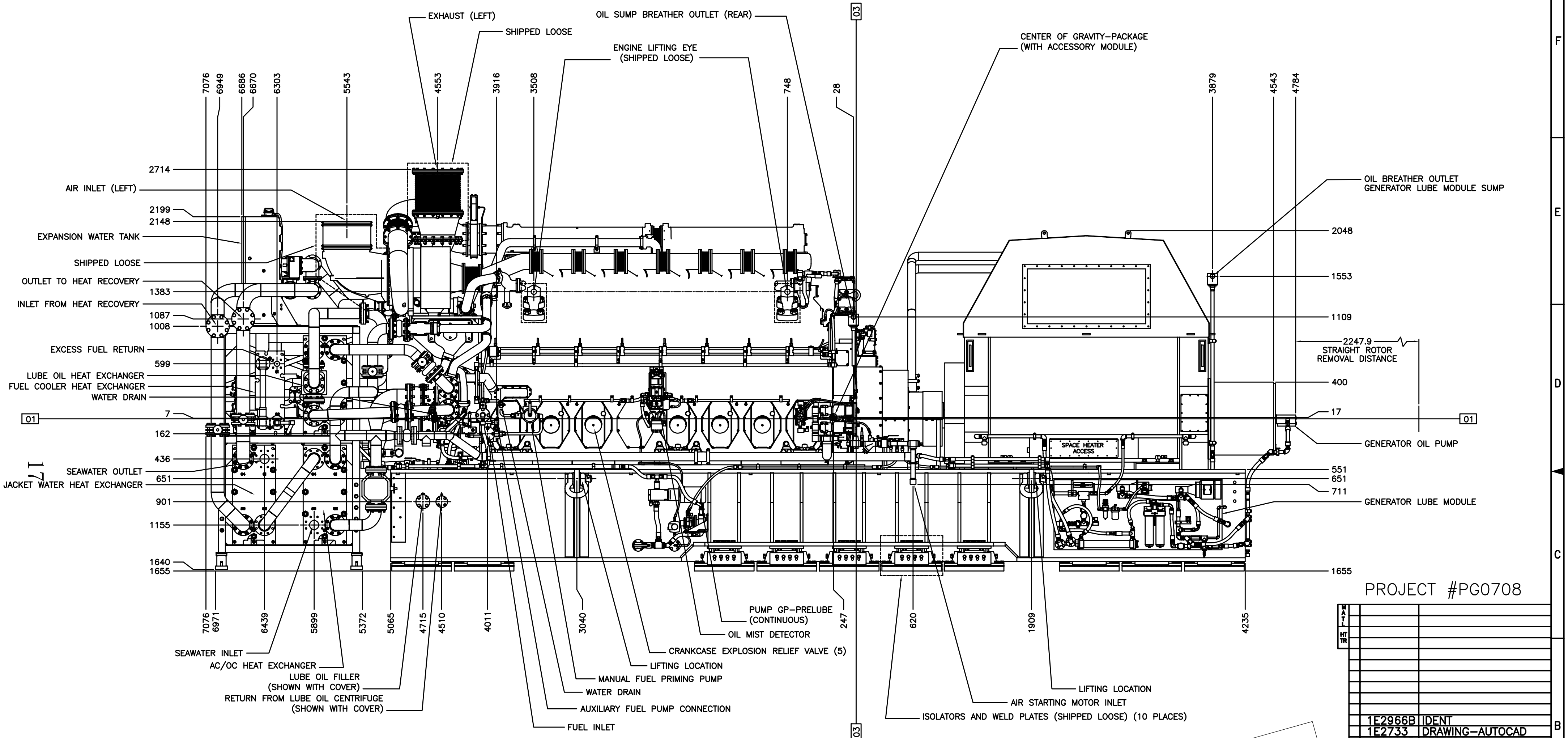
SHEET 2 OF 12 THIRD ANGLE PROJECTION

CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 VER - DES X SUB CONTROL W853 D

METRIC 332-2698



PROJECT #PG0708

LEFT SIDE VIEW

RIGHT HAND SERVICE
RIGHT HAND COOLANT CONNECTIONS

SCALE 1=20

CERTIFIED TO BUILD

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1E0013Y	CONFIDENTIALITY
1E0011	INTPR & TOL
Caterpillar: Confidential Yellow	

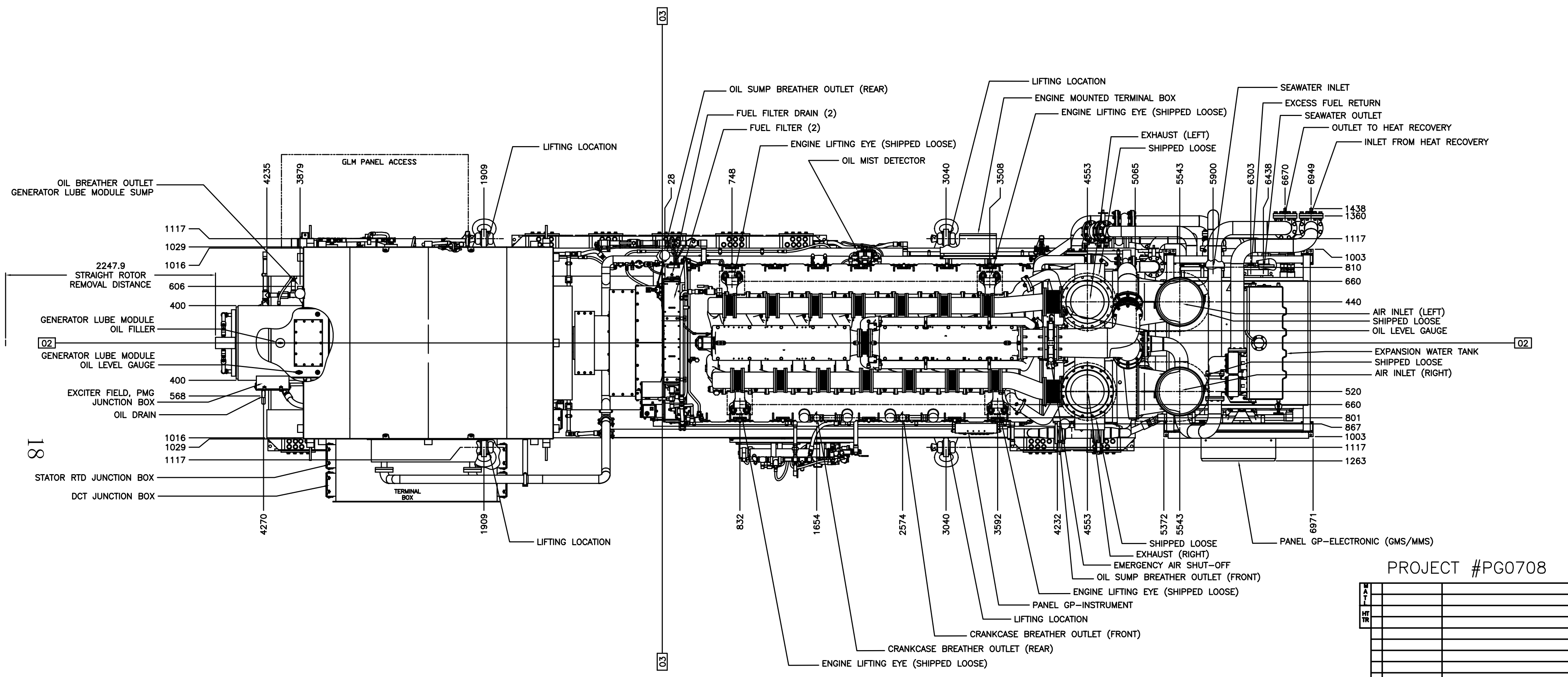
ENGINE MODEL 3616 FMT
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE
SHEET 3 OF 12
THIRD ANGLE PROJECTION

CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 VER – DES X W853 D

METRIC 332-2698



PROJECT #PG0708

TOP VIEW
RIGHT HAND SERVICE
RIGHT HAND COOLANT CONNECTIONS

SCALE 1=20

CERTIFIED TO BUILD

THE □—□ LINE IS USED AS A LINEAR DATUM FOR THE VIEW IN WHICH IT APPEARS. DIMENSIONS ARE PRINTED PARALLEL TO THE DATUM LINE TO WHICH THEY PERTAIN. DIMENSIONS WITH ARROWHEADS DO NOT PERTAIN TO THE DATUM LINES EXCEPT IN AUXILIARY VIEWS.

DATUMS	
01	- CENTERLINE OF CRANKSHAFT
02	- CENTERLINE OF ENGINE
03	- REAR FACE OF CRANKSHAFT ADAPTER

REVISION	CHANGE DESCRIPTION
01	MOVED GMS PANEL TO ACC. MOD.-LEFT SIDE; ADDED GLM SUMP BREATHER OUTLET
01	ADDED 341-3623 LINES GP-WATER AT GENERATOR LUBE MODULE
01	UPDATED GENERATOR GRAPHICS AND LABELING; ADDED CG AND WEIGHT DATA

NOTE	
1E2966B	IDENT
1E2733	DRAWING-AUTOCAD
1E0198R	LETTERS
1E0013Y	CONFIDENTIALITY
1E0011	INTPR & TOL
Caterpillar: Confidential Yellow	

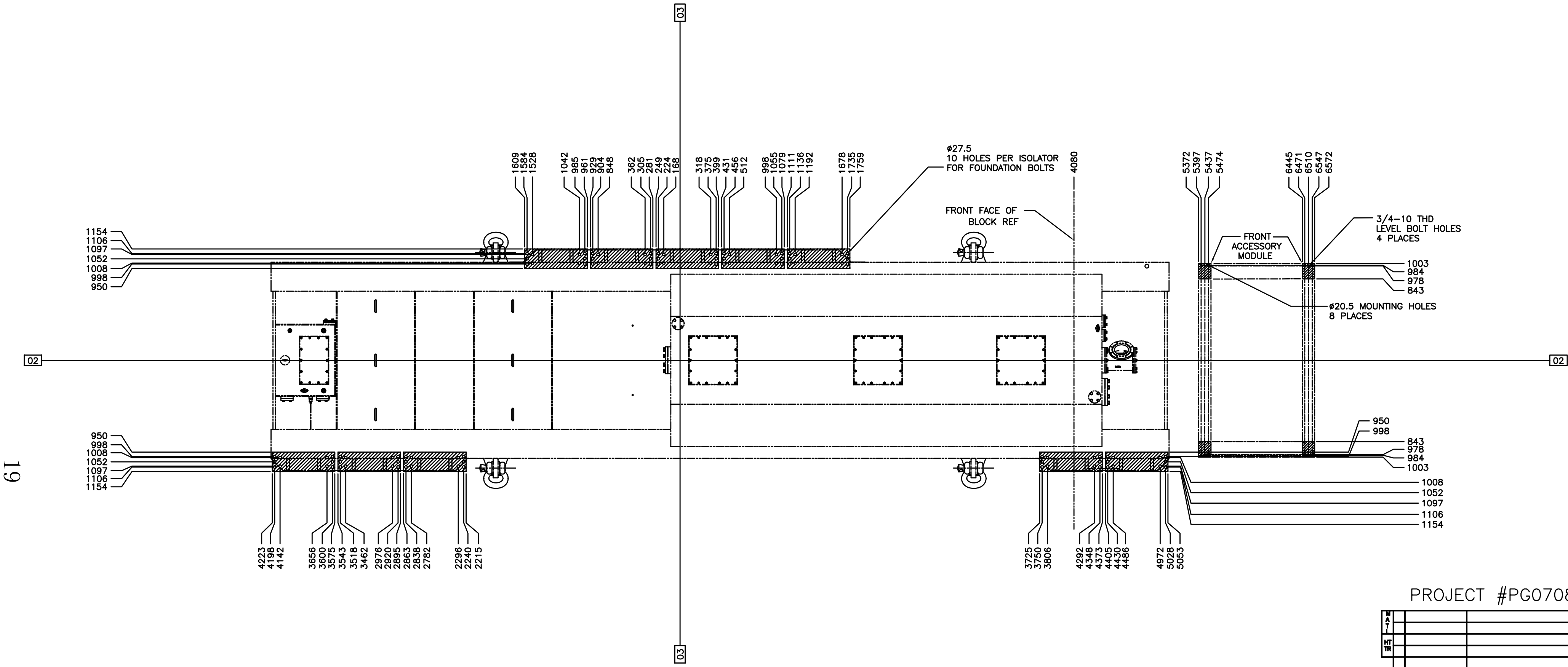
ENGINE MODEL 3616 FMT
CONCEPT | EXP | PRE PROD. | PROD.
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE | THIRD ANGLE PROJECTION
SHEET 4 OF 12

CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 | VER - | DES SUB X | CONTROL W853 | D

METRIC 332-2698



PLAN VIEW
SCALE 1=20

PROJECT #PG0708

NOTE A: ALL DIMENSION TOLERANCES ±13mm.

NOTE B: IF MOUNTS ARE TO BE BOLTED TO THE FOUNDATION, THE PREFERRED METHOD IS TO DRILL ANCHOR BOLT HOLES AFTER THE ENGINE PACKAGE IS ON-SITE, USING THE ISOLATORS FOR DRILLING TEMPLATES. THE ANCHOR BOLTS ARE THEN INSTALLED AND SECURED WITH EPOXY RESIN. CONCRETE ANCHOR BOLTS SHOULD BE TORQUED TO 54-81 N m (40-60 lb-ft). (REFERENCE THE 3600 EPG APPLICATION AND INSTALLATION GUIDE FOR FURTHER DETAIL.)

TO BE ADVISED

THE □-□ LINE IS USED AS A LINEAR DATUM FOR THE VIEW IN WHICH IT APPEARS. DIMENSIONS ARE PRINTED PARALLEL TO THE DATUM LINE TO WHICH THEY PERTAIN. DIMENSIONS WITH ARROWHEADS DO NOT PERTAIN TO THE DATUM LINES EXCEPT IN AUXILIARY VIEWS.

DATUMS	
01	CENTERLINE OF CRANKSHAFT
02	CENTERLINE OF ENGINE
03	REAR FACE OF CRANKSHAFT ADAPTER

REVISION	CHANGE DESCRIPTION
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NOTE	
1E2966B	IDENT
1E2733	DRAWING-AUTOCAD
1E0198R	LETTERS
1E0013Y	CONFIDENTIALITY
1E0011	INTPR & TOL
Caterpillar: Confidential Yellow	

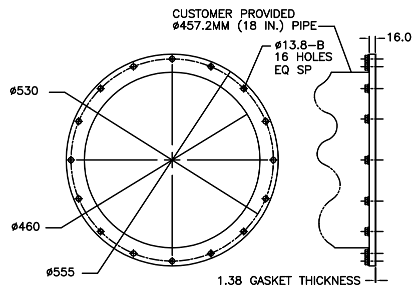
ENGINE MODEL 3616 FMT
CON-CEPT | EXP | PRE PROD. | PROD.
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE
SHEET 5 OF 12
THIRD ANGLE PROJECTION

CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

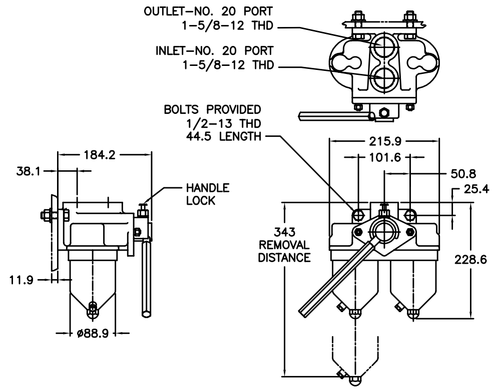
INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 | VER - | DES X SUB | CONTROL W853 | D

METRIC 332-2698



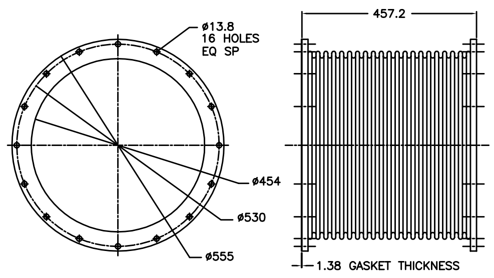
DETAIL OF 2W-2682 EXHAUST FLANGE (18 INCH)
(ATT DIM DWG #7E-6228)
SCALE NONE

(SHIPPED LOOSE)



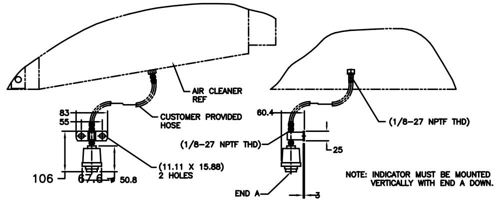
DETAIL OF 2W-2683 FILTER GP-FUEL
(ATT DIM DWG #7E-5051)
SCALE NONE

(SHIPPED LOOSE)



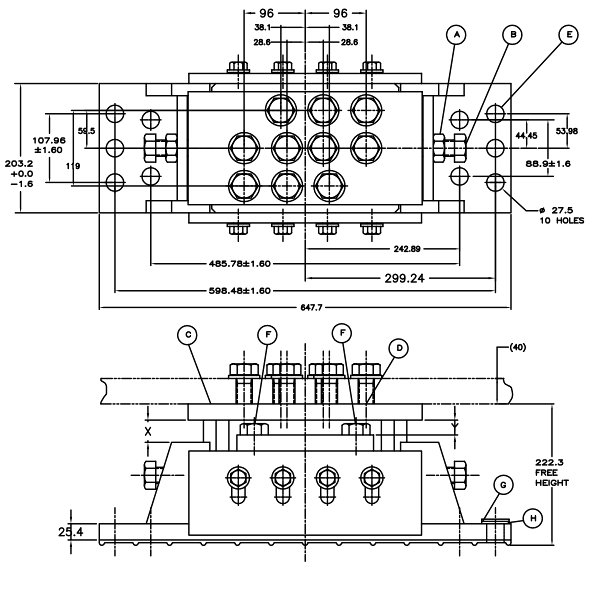
DETAIL OF 2W-7889 EXHAUST BELLOWS
(457.2 / 18 IN. PIPE)
(ATT DIM DWG #7E-6282)
SCALE NONE

(SHIPPED LOOSE)



DETAIL OF PART #4W-5982 GAUGE GP-AIR CLEANER
(ATT DIM DWG #7E-7046)
SCALE NONE

(SHIPPED LOOSE)



DETAIL OF 7C-6537 SHIPPED LOOSE MOBILE ISOLATOR
(ATT DIM DWG #7E-6938)

SCALE NONE

STIFFNESS FACTOR

	METRIC	(INCH)
K =	618.6 KG/mm	(34,640.0 LBS/IN)

INSTALLATION INSTRUCTIONS FOR ISOLATORS

INSTALLATION

1. SHIM OR GROUT, IF REQUIRED, TO PROVIDE FLAT SURFACE FOR ISOLATOR. ISOLATOR CAN TOLERATE 6.35 MM (0.25 IN.) DIFFERENCE IN ELEVATION DUE TO VARIATION IN FLOOR GRADE.
2. LOOSEN NUT "A" AND BOLT "B" SEVERAL TURNS, UNTIL SNUBBERS ARE NOT BINDING.
3. PLACE BASE ON ISOLATORS AND BOLT TO ISOLATION TOP PLATE "C" THROUGH MOUNTING HOLE "D". BOLT MUST NOT PROJECT BELOW LOWER SURFACE OF TOP PLATE "C".
4. ALIGN FLAT STEEL WASHER (G) AND FABRIC REINFORCED WASHER (H) AS SHOWN AND TIGHTEN ANCHOR BOLTS OR NUTS THROUGH ANCHOR BOLT HOLE "E" TO SECURE ISOLATORS TO SUB-STRUCTURE.

ADJUSTMENT PROCEDURE FOR SI ISOLATORS

5. IF CLEARANCE AT "X" IS LESS THAN 6.35 MM (0.25 IN.) ON ANY ISOLATOR, TURN DOWN LEVELING BOLT "F" OF EACH ISOLATOR TWO TURNS, MAKING A COMPLETE CIRCUIT OF ALL ISOLATORS. REPEAT THIS PROCEDURE UNTIL ALL ISOLATORS HAVE AT LEAST 6.35 MM (0.25 IN.) CLEARANCE AT "X". OMIT THIS STEP IF "X" IS OR EXCEEDS 6.35 mm (0.25 IN.).
6. IF EQUIPMENT IS NOT LEVEL AFTER STEP NO. 5, TURN DOWN BOLTS "F" AT LOW END OF ENGINE UNTIL LEVEL.
   INCREASE HEIGHT OF ENGINE, IF REQUIRED, TO MEET CONNECTIONS, BY TURNING DOWN LEVELING BOLTS "F" ON ALL ISOLATORS THE SAME NUMBER OF TURNS.
7. IF THE FLOOR IS LEVEL UNDER A GIVEN SPRING ISOLATOR CLUSTER, ALL ISOLATORS WITHIN THE CLUSTER SHOULD HAVE THE "Y" DIMENSION WITHIN ±10% OF EACH OTHER. THIS EQUALIZES THE LOAD EACH SPRING ISOLATOR SUPPORTS.

HORIZONTAL CHOCK ADJUSTMENT

8. START UP ENGINE. TIGHTEN BOLT "B" AT EACH END OF EACH ISOLATOR UNTIL FINGER TIGHT.
9. TIGHTEN LOCKNUT "A" AND INSTALLATION IS COMPLETE.
10. IT IS NORMAL FOR MOTION OF THE ENGINE TO INCREASE DURING START-UP AND SHUT-DOWN. SHOULD THIS MOTION BE INTOLERABLE, TIGHTEN BOLT "B" SLIGHTLY. HOWEVER, THIS REDUCES ISOLATOR EFFICIENCY AND MUST ONLY BE DONE WHEN ABSOLUTELY NECESSARY.

CERTIFIED TO BUILD

PROJECT #PG0708

1E2966B	IDENT
1E2733	DRAWING-AUTOCAD
1E0198R	LETTERS
1E0013Y	CONFIDENTIALITY
1E0011	INTPR & TOL
Caterpillar: Confidential Yellow	

ENGINE MODEL 3616 FMT
CON-CEPT | EXP | PRE-PROD | PROD.
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE — THIRD ANGLE PROJECTION
SHEET 6 OF 12

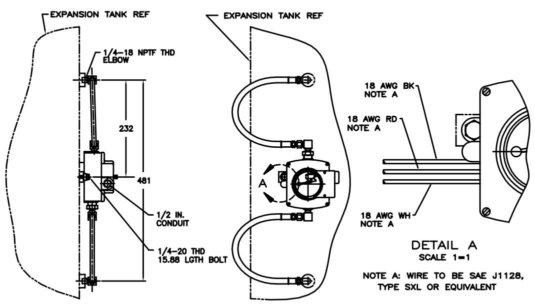
CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

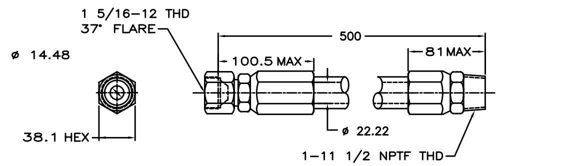
INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 | VER - | DES/SUB X | CONTROL W853 | D

REVISION	CHANGE DESCRIPTION
01	MOVED GMS PANEL TO ACC. MOD.-LEFT SIDE; ADDED GLM SUMP BREATHER OUTLET
01	ADDED 341-3623 LINES GP-WATER AT GENERATOR LUBE MODULE
01	UPDATED GENERATOR GRAPHICS AND LABELING; ADDED CG AND WEIGHT DATA

METRIC 332-2698



DETAIL OF 7N-4885 GAUGE GP- WATER LEVEL
(ATT DIM DWG # 7E6958)
SCALE NONE

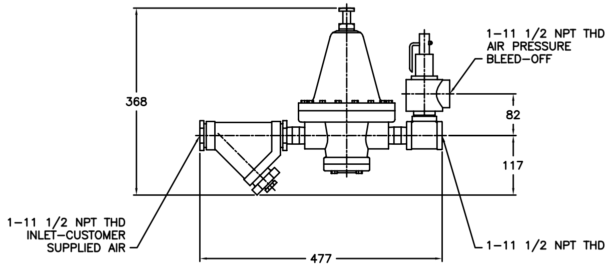


DETAIL OF 7W-1841 FUEL SYSTEM FLEX HOSE
(ATT DIM DWG #7E-6962)
SCALE NONE

(SHIPPED LOOSE)

CERTIFIED TO BUILD

SETTING: INLET PRESSURE - 3100 kPA (450 PSI)
OUTLET PRESSURE - 172-1655 kPA (25-240 PSI)
MAX. INLET PRESSURE - 4137 kPA (600 PSI)

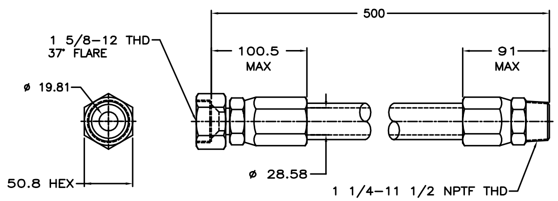


DETAIL OF PART #9Y-9589 AIR REGULATOR

(ATT DIN DWG #7E-6987)

SCALE NONE

(SHIPPED LOOSE)



DETAIL OF 7W-1840 FUEL SYSTEM FLEX HOSE
(PART OF PART #112-5539 FITTING GP-PRIMARY FILTER)

SCALE NONE

(SHIPPED LOOSE)

PROJECT #PG0708

1E2966B	IDENT
1E2733	DRAWING-AUTOCAD
1E0198R	LETTERS
1E0013Y	CONFIDENTIALITY
1E0011	INTPR & TOL
Caterpillar: Confidential Yellow	

ENGINE MODEL 3616 FMT
CON-CEPT | EXP | PRE PROD. | PROD.
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE
SHEET 7 OF 12
THIRD ANGLE PROJECTION

CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

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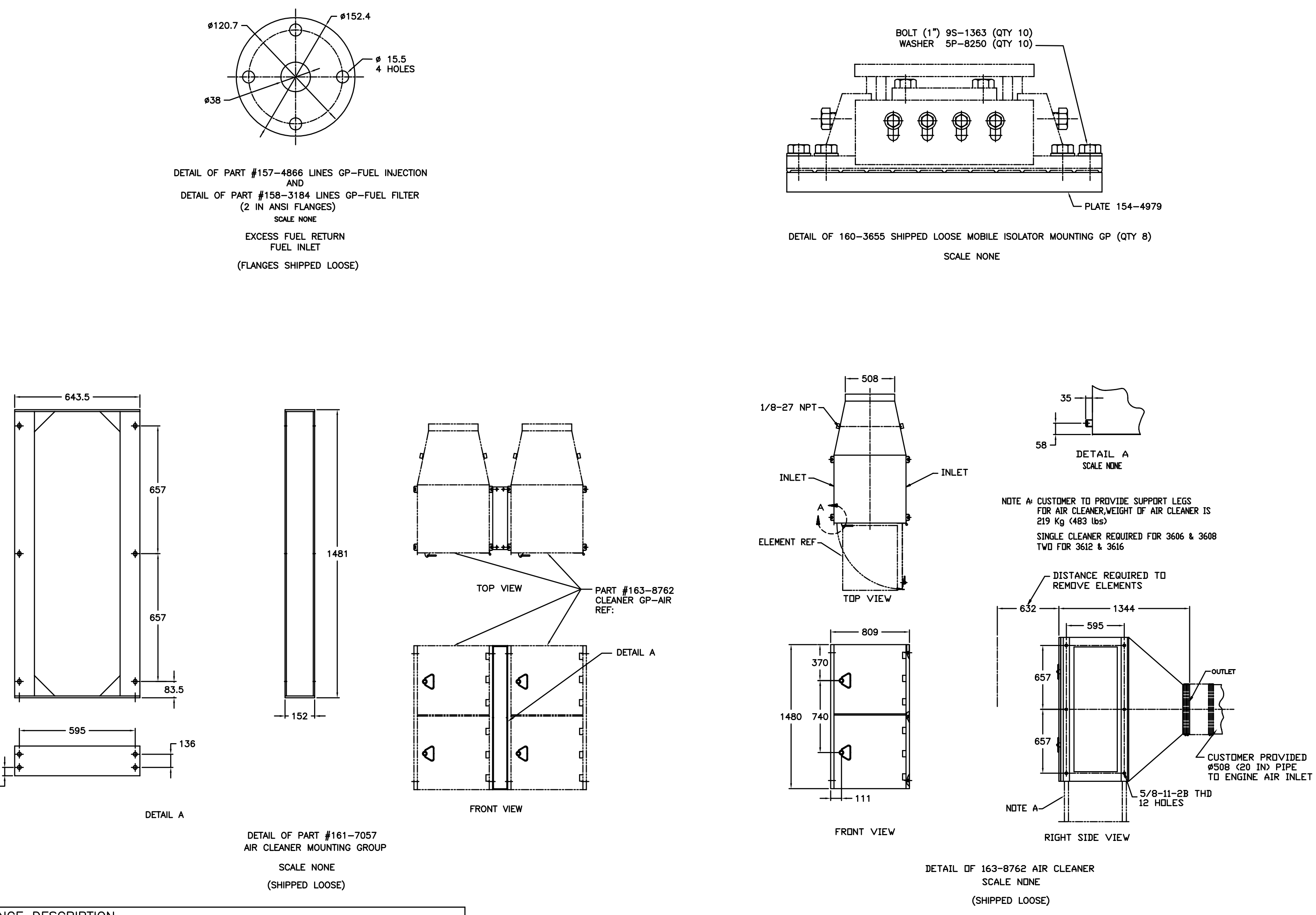
INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 | VER - | DES X SUB | CONTROL W853 | D

REVISION	CHANGE DESCRIPTION
01	MOVED GMS PANEL TO ACC. MOD.-LEFT SIDE; ADDED GLM SUMP BREATHER OUTLET
01	ADDED 341-3623 LINES GP-WATER AT GENERATOR LUBE MODULE
01	UPDATED GENERATOR GRAPHICS AND LABELING; ADDED CG AND WEIGHT DATA

METRIC 332-2698



CERTIFIED TO BUILD

PROJECT #PG0708

1E2966B	IDENT
1E2733	DRAWING-AUTOCAD
1E0198R	LETTERS
1E0013Y	CONFIDENTIALITY
1E0011	INTPR & TOL
Caterpillar: Confidential Yellow	

ENGINE MODEL 3616 FMT
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE
SHEET 8 OF 12
THIRD ANGLE PROJECTION

CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 VER - DES X SUB CONTROL W853 D

REVISION	CHANGE DESCRIPTION
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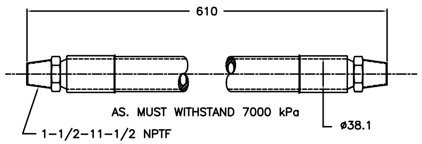
01	UPDATED GENERATOR GRAPHICS AND LABELING; ADDED CG AND WEIGHT DATA

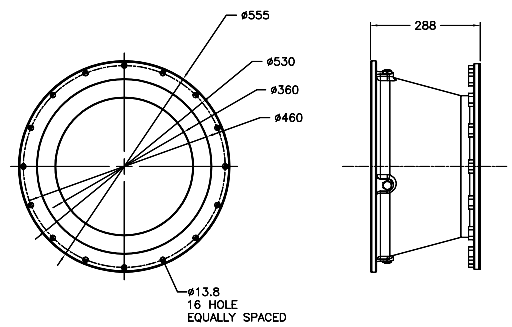
METRIC 332-2698



DETAIL OF 4P-4113 HOSE ASSEMBLY
(PART OF PART #208-6592 LINES GP-AIR START)
FOR AIR STARTING MOTOR INLET

(SHIPPED LOOSE)

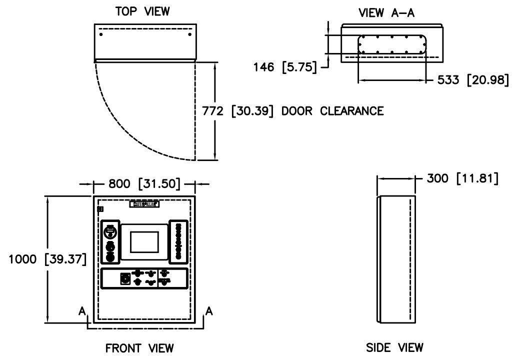
SCALE NONE



DETAIL OF PART #166-2166 EXHAUST FITTING

SCALE NONE

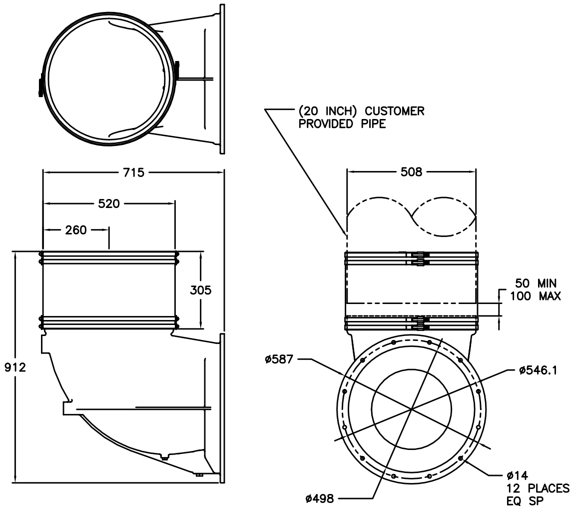
(SHIPPED LOOSE)



DETAIL OF 179-8801 PANEL GP-ELECTRONIC
(GMS MONITORING SYSTEM)
AND
PART #216-9500 SWITCH GP-GOVERNOR

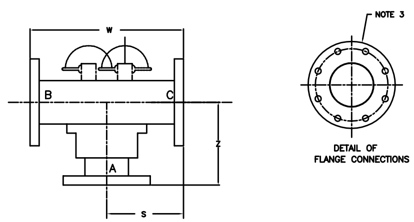
SCALE NONE

CERTIFIED TO BUILD



DETAIL OF PART #190-3600
ADAPTER GP-AIR INLET

SCALE NONE



NOTES:

1. THIS DRAWING IS REPRESENTITIVE OF THE AC/OC THERMOSTATIC VALVE.
2. THE MAXIMUM ALLOWABLE PRESSURE DROP FOR THE EXTERNAL COOLING SYSTEM SHALL NOT EXCEED: AC/OC SYSTEM - 84 kPa ±10%
3. FLANGES SHALL BE PER THE REQUIREMENTS OF ANSI B16.1 (125# CLASS) "FF FLANGES"

THERMOSTATIC VALVE
CONNECTIONS:

A = INLET
B = BYPASS
C = HEAT EXCHANGER

SIZE	"S"	"W"	"Z"	"A"	"B"	"C"
5"	249	489	241	5" ANSI	5" ANSI	5" ANSI

DETAIL OF PART NO. 192-8822
(AMOT THERMOSTATIC VALVE PART NO. 5BMCF18553)
(5 INCH)

SCALE NONE

PROJECT #PG0708

1E2966B	IDENT
1E2733	DRAWING-AUTOCAD
1E0198R	LETTERS
1E0013Y	CONFIDENTIALITY
1E0011	INTPR & TOL
Caterpillar: Confidential Yellow	

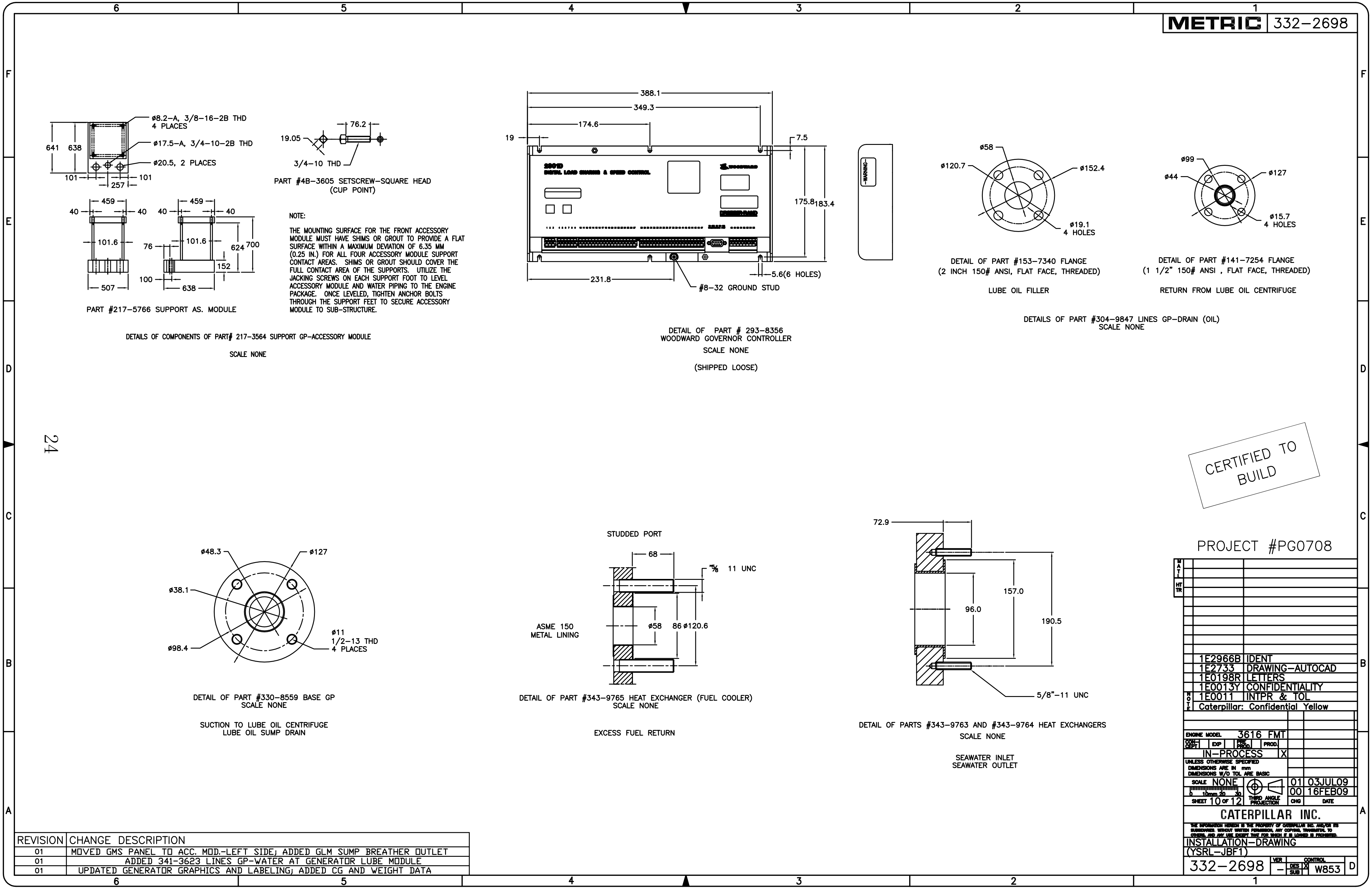
ENGINE MODEL 3616 FMT
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE
SHEET 9 OF 12
THIRD ANGLE PROJECTION

CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 VER - CONTROL W853 D

REVISION	CHANGE DESCRIPTION
01	MOVED GMS PANEL TO ACC. MOD.-LEFT SIDE; ADDED GLM SUMP BREATHER OUTLET
01	ADDED 341-3623 LINES GP-WATER AT GENERATOR LUBE MODULE
01	UPDATED GENERATOR GRAPHICS AND LABELING; ADDED CG AND WEIGHT DATA


METRIC 332-2698
ø8.2-A, 3/8-16-2B THD 4 PLACES
ø17.5-A, 3/4-10-2B THD
ø20.5, 2 PLACES
641 638
101 257 101
459 40 40
101.6
507
76 624 700 152
100 638
PART #217-5766 SUPPORT AS. MODULE
76.2
19.05
3/4-10 THD
PART #4B-3605 SETSCREW-SQUARE HEAD (CUP POINT)
NOTE:
THE MOUNTING SURFACE FOR THE FRONT ACCESSORY MODULE MUST HAVE SHIMS OR GROUT TO PROVIDE A FLAT SURFACE WITHIN A MAXIMUM DEVIATION OF 6.35 MM (0.25 IN.) FOR ALL FOUR ACCESSORY MODULE SUPPORT CONTACT AREAS. SHIMS OR GROUT SHOULD COVER THE FULL CONTACT AREA OF THE SUPPORTS. UTILIZE THE JACKING SCREWS ON EACH SUPPORT FOOT TO LEVEL ACCESSORY MODULE AND WATER PIPING TO THE ENGINE PACKAGE. ONCE LEVELED, TIGHTEN ANCHOR BOLTS THROUGH THE SUPPORT FEET TO SECURE ACCESSORY MODULE TO SUB-STRUCTURE.
DETAILS OF COMPONENTS OF PART# 217-3564 SUPPORT GP-ACCESSORY MODULE
SCALE NONE
388.1
349.3
174.6
19
7.5
175.8 183.4
231.8
5.6(6 HOLES)
#8-32 GROUND STUD
DETAIL OF PART # 293-8356
WOODWARD GOVERNOR CONTROLLER
SCALE NONE
(SHIPPED LOOSE)
ø58 ø120.7 ø152.4
ø19.1 4 HOLES
DETAIL OF PART #153-7340 FLANGE
(2 INCH 150# ANSI, FLAT FACE, THREADED)
LUBE OIL FILLER
ø99 ø44 ø127
ø15.7 4 HOLES
DETAIL OF PART #141-7254 FLANGE
(1 1/2" 150# ANSI , FLAT FACE, THREADED)
RETURN FROM LUBE OIL CENTRIFUGE
DETAILS OF PART #304-9847 LINES GP-DRAIN (OIL)
SCALE NONE
CERTIFIED TO BUILD
ø48.3 ø127 ø38.1 ø98.4
ø11
1/2-13 THD
4 PLACES
DETAIL OF PART #330-8559 BASE GP
SCALE NONE
SUCTION TO LUBE OIL CENTRIFUGE
LUBE OIL SUMP DRAIN
STUDDED PORT
68
⅝ 11 UNC
ASME 150
METAL LINING
ø58 86 ø120.6
DETAIL OF PART #343-9765 HEAT EXCHANGER (FUEL COOLER)
SCALE NONE
EXCESS FUEL RETURN
72.9
96.0 157.0 190.5
5/8"-11 UNC
DETAIL OF PARTS #343-9763 AND #343-9764 HEAT EXCHANGERS
SCALE NONE
SEAWATER INLET
SEAWATER OUTLET
PROJECT #PG0708
1E2966B IDENT
1E2733 DRAWING-AUTOCAD
1E0198R LETTERS
1E0013Y CONFIDENTIALITY
1E0011 INTPR & TOL
Caterpillar: Confidential Yellow
ENGINE MODEL 3616 FMT
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE
SHEET 10 OF 12
THIRD ANGLE PROJECTION
01 03JUL09
00 16FEB09
CHG DATE
CATERPILLAR INC.
INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 - W853 D
REVISION CHANGE DESCRIPTION
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01 ADDED 341-3623 LINES GP-WATER AT GENERATOR LUBE MODULE
01 UPDATED GENERATOR GRAPHICS AND LABELING; ADDED CG AND WEIGHT DATA

METRIC 332-2698

CONNECTION DATA SHEET

RIGHT HAND SERVICE
RIGHT HAND COOLANT CONNECTIONS

	ITEM DESCRIPTION	CONNECTION SPECIFICATIONS	DIMENSIONS 01	DIMENSIONS 02	DIMENSIONS 03	OTHER DETAIL
WATER	CUSTOMER SEAWATER INLET	DETAIL ON DRAWING 332-2698 SHEET 10 4" ASME-150#	1155	816	5899	PARTNER FLANGE NOT PROVIDED
	CUSTOMER SEAWATER OUTLET	DETAIL ON DRAWING 332-2698 SHEET 10 4" ASME-150#	436	816	6439	PARTNER FLANGE NOT PROVIDED
FUEL	FUEL INLET	DETAIL ON DRAWING 332-2698 SHEET 8 PART #164-7576 (2" 150# ANSI)	705	980	4729	PARTNER FLANGE NOT PROVIDED
	EXCESS FUEL RETURN	DETAIL ON DRAWING 332-2698 SHEET 8 PART #164-7576 (2" 150# ANSI)	932	980	4729	PARTNER FLANGE NOT PROVIDED
	AUXILIARY FUEL PUMP CONNECTION	1 5/16-12 THD (37° FLARE)	12	573	3916	PARTNER FLANGE NOT NEEDED
OIL	LUBE OIL FILLER	DETAIL ON DRAWING 332-2698 SHEET 10 PART #153-7340 (2" 150# ANSI)	901	1068	4715	PARTNER FLANGE NOT PROVIDED
	LUBE OIL SUMP DRAIN	DETAIL ON DRAWING 332-2698 SHEET 10 PART #330-8558 (1 1/2" 150# ANSI)	1416	896	580	PARTNER FLANGE NOT PROVIDED
	SUCTION TO LUBE OIL CENTRIFUGE	DETAIL ON DRAWING 332-2698 SHEET 10 PART #330-8558 (1 1/2" 150# ANSI)	1416	896	730	PARTNER FLANGE NOT PROVIDED
	RETURN FROM LUBE OIL CENTRIFUGE	DETAIL ON DRAWING 332-2698 SHEET 10 PART #304-9847 (1 1/2" 150# ANSI)	901	1068	4510	PARTNER FLANGE NOT PROVIDED
AIR	AIR INLET (RIGHT)	DETAIL ON DRAWING 332-2698 SHEET 9 PART #190-3600	2148	440	5543	PARTNER FLANGE NOT NEEDED
	AIR INLET (LEFT)	DETAIL ON DRAWING 332-2698 SHEET 9 PART #190-3600	2148	520	5543	PARTNER FLANGE NOT NEEDED
	EXHAUST (RIGHT)	DETAIL ON DRAWING 332-2698 SHEET 6 PART #2W-2682	2714	440	4553	PARTNER FLANGE PROVIDED
	EXHAUST (LEFT)	DETAIL ON DRAWING 332-2698 SHEET 6 PART #2W-2682	2714	520	4553	PARTNER FLANGE PROVIDED
	BREATHER OUTLET OIL SUMP (FRONT)	FOR 60.3 OD TUBING	785	867	4232	PARTNER FLANGE PROVIDED
	BREATHER OUTLET OIL SUMP (REAR)	FOR 60.3 OD TUBING	1109	1016	28	PARTNER FLANGE PROVIDED
	OIL BREATHER OUTLET GLM SUMP	FOR 60.3 OD TUBING	3879	1552	606	PARTNER FLANGE NOT NEEDED
	CRANKCASE BREATHER OUTLET (FRONT)	FOR 60.3 OD TUBING	1584	801	2574	PARTNER FLANGE NOT NEEDED
	CRANKCASE BREATHER OUTLET (REAR)	FOR 60.3 OD TUBING	1584	801	1654	PARTNER FLANGE NOT NEEDED
	AIR STARTING MOTOR INLET	DETAIL ON DRAWING 332-2698 SHEET 10 PART #4P-4113	711	1069	620	PARTNER FLANGE NOT NEEDED

CERTIFIED TO BUILD

PROJECT #PG0708

REVISION	CHANGE DESCRIPTION
01	MOVED GMS PANEL TO ACC. MOD.-LEFT SIDE; ADDED GLM SUMP BREATHER OUTLET
01	ADDED 341-3623 LINES GP-WATER AT GENERATOR LUBE MODULE
01	UPDATED GENERATOR GRAPHICS AND LABELING; ADDED CG AND WEIGHT DATA

1E2966B IDENT
1E2733 DRAWING-AUTOCAD
1E0198R LETTERS
1E0013Y CONFIDENTIALITY
1E0011 INTPR & TOL
Caterpillar: Confidential Yellow

ENGINE MODEL 3616 FMT
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE
SHEET 11 OF 12
THIRD ANGLE PROJECTION

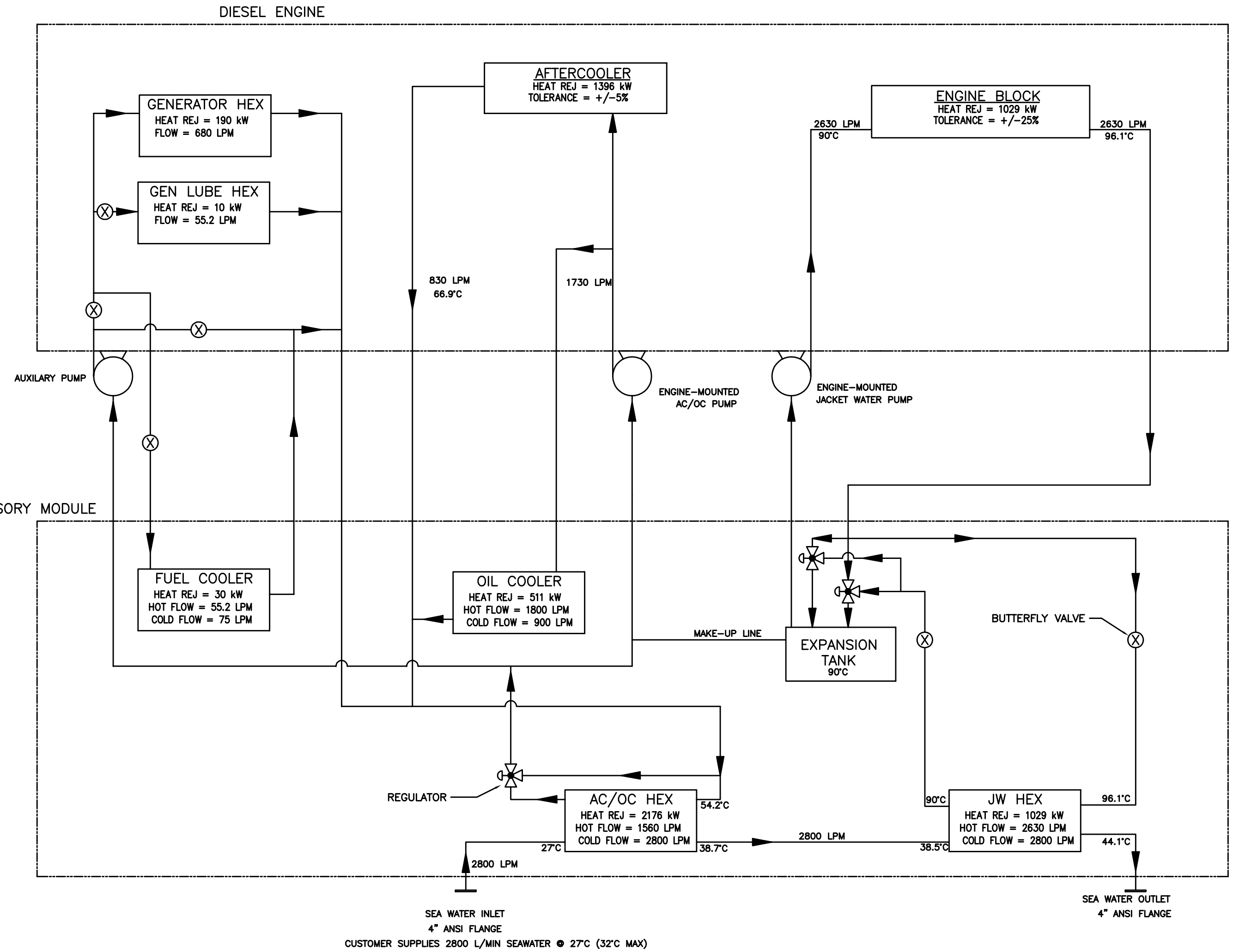
CHG	DATE
01	03JUL09
00	16FEB09

CATERPILLAR INC.

INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 – W853 D

METRIC 332-2698

YRSL-JBF1
3616 COOLING SCHEMATIC



PROJECT #PG0708

CERTIFIED TO BUILD

LEGEND
——— = CATERPILLAR SUPPLIED PARTS
——— = CUSTOMER SUPPLIED PARTS

REVISION	CHANGE DESCRIPTION
01	MOVED GMS PANEL TO ACC. MOD.-LEFT SIDE; ADDED GLM SUMP BREATHER OUTLET
01	ADDED 341-3623 LINES GP-WATER AT GENERATOR LUBE MODULE
01	UPDATED GENERATOR GRAPHICS AND LABELING; ADDED CG AND WEIGHT DATA

1E2966B	IDENT
1E2733	DRAWING-AUTOCAD
1E0198R	LETTERS
1E0013Y	CONFIDENTIALITY
1E0011	INTPR & TOL
Caterpillar: Confidential Yellow	

ENGINE MODEL 3616 FMT
IN-PROCESS X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE NONE
SHEET 12 OF 12 THIRD ANGLE PROJECTION

CHG	DATE
01	03JUL09
00	16FEB09

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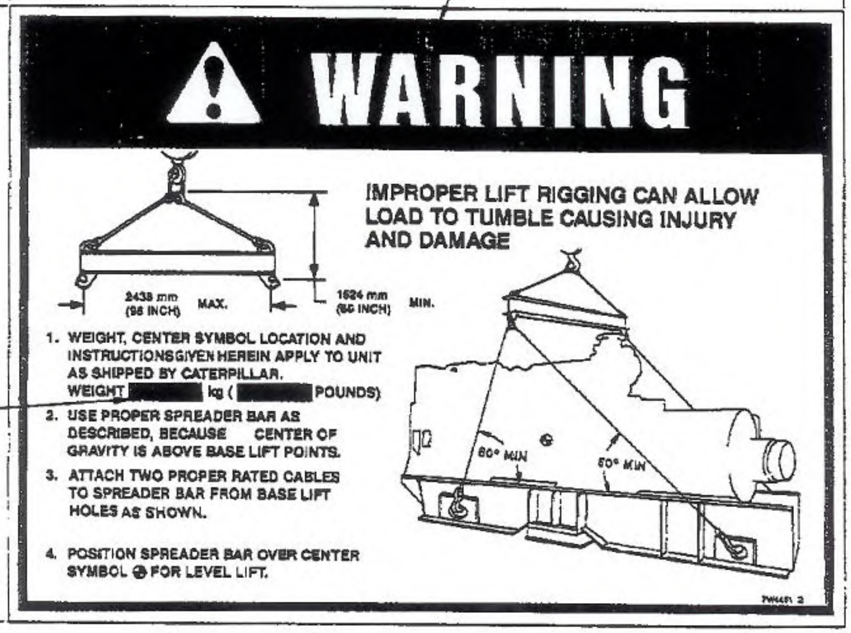
INSTALLATION-DRAWING
(YSRL-JBF1)
332-2698 VER – DES SUB X CONTROL W853 D

NOTE	ITEM	QTY	MEAS UNIT	PART NO.	NAME
			REQUIREMENTS		
D	—	1		6L4502	PROD MARKING SYS

METRIC 7W4451

245.0±0.5

COLOR CONTROL 2



183.0 ±0.5

NOTE C

②

REDUCED SIZE PRINT
mm 0 10 20 30 40 50 mm

(A) ALUMINUM DATA BLOCKS

(B) PS ADHESIVE

(C) STAMP DATA MIN SIZE 3

(D) FOR ADDITIONAL INFORMATION SEE ARTWORK AVAILABLE

MATL		
A	1E2021A	PLATE
B		
HT		
TR		

NOTE	SPEC NO.	NAME
	1E11	INTPR & TOL

DRN L. SCOVILL
CHK L BROOKS
APPD [signature]
CON-CEPT EXP PRE PROD PROD X

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC

SCALE 1=1 — SHEET OF — THIRD ANGLE PROJECTION

CHG	DATE
02	12DEC 86
01	12DEC 85

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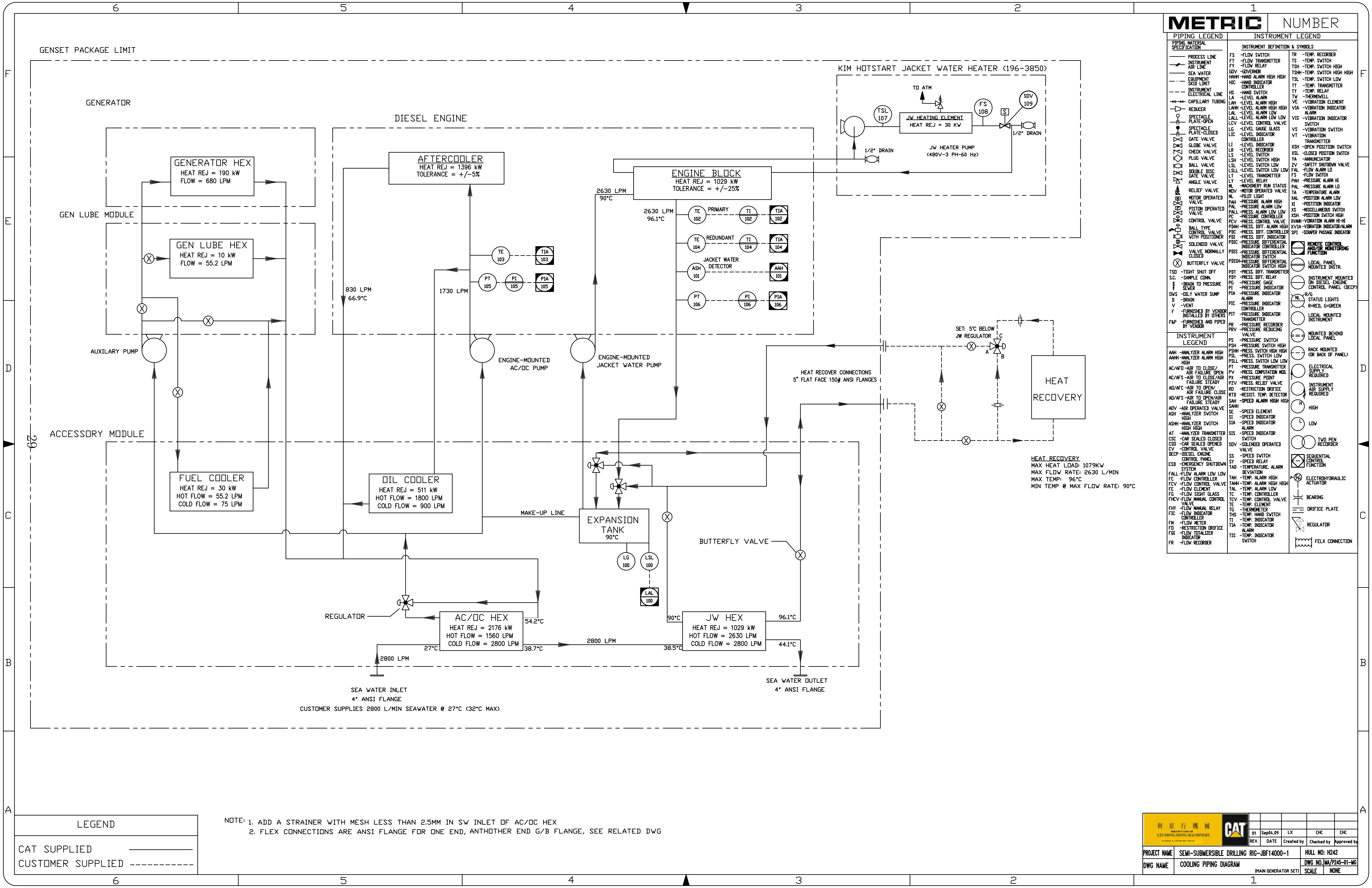
PLATE-WARNING (SUB BASE LIFT)

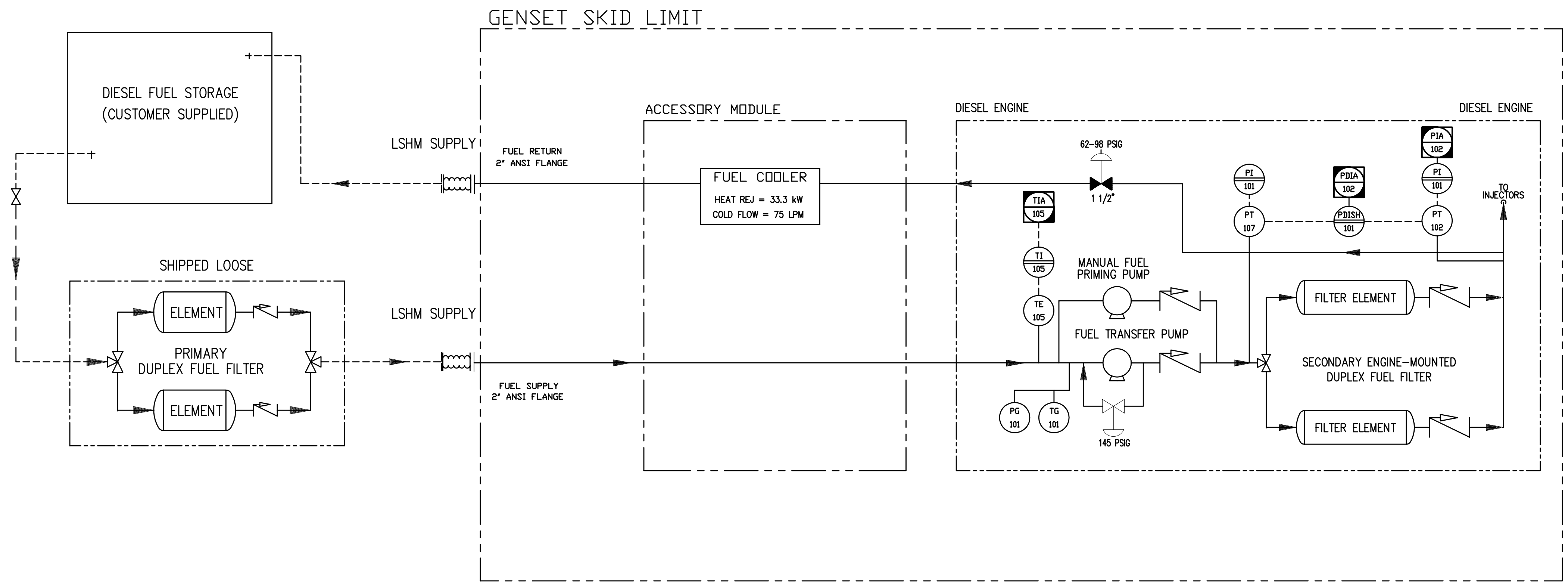
7W4451 — VERSION — CONTROL DES X SUB W412 C

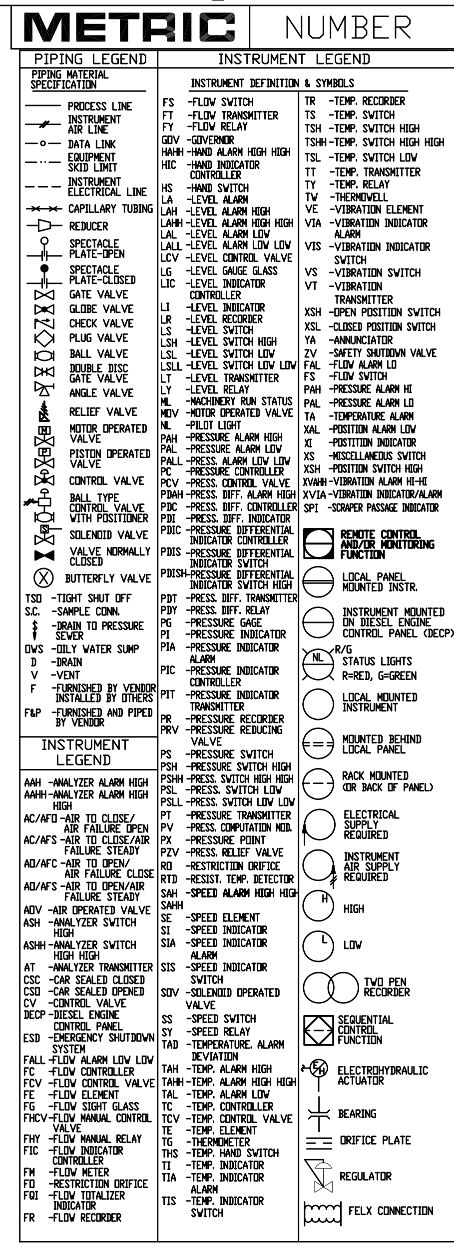
4.0 PIPING & ELECTRICAL DIAGRAMS

No	Drawing No	REV.	Drawing Name	Total Pages
1	MA/P245-01-MG	01	Cooling Piping Diagram	1
2	MA/P245-02-MG	01	Fuel Piping Diagram	1
3	MA/P245-03-MG	01	Generator set Lube Oil Piping Diagram	1
4	MA/P245-04-MG	01	Air Inlet & Exhaust Piping Diagram	1
5	MA/P245-05-MG	01	Starting Air Piping Diagram	1
6	HC090907-001		Custom Fuel and Lube Oil Flexible Hose	1
7	MA/P245-06-MG	01	Electrical Interface Diagram	1
8	888-00218-25		Kato generator wiring diagram	1
9			2301D Outline Drawing & Plant Wiring Drawing	4
10			DVR DECS200 Typical Connections & Dimensions Drawing	3
11	334-3086	01	Wiring Diagram for GMS	25
12				



GENSET PACKAGE LIMIT
GENERATOR
GENERATOR HEX
HEAT REJ = 190 kW
FLOW = 680 LPM
GEN LUBE MODULE
GEN LUBE HEX
HEAT REJ = 10 kW
FLOW = 55.2 LPM
AUXILARY PUMP
DIESEL ENGINE
AFTERCOOLER
HEAT REJ = 1396 kW
TOLERANCE = +/-5%
ENGINE BLOCK
HEAT REJ = 1029 kW
TOLERANCE = +/-25%
2630 LPM
90°C
2630 LPM
96.1°C
PRIMARY
REDUNDANT
JACKET WATER DETECTOR
830 LPM
66.9°C
1730 LPM
ENGINE-MOUNTED AC/OC PUMP
ENGINE-MOUNTED JACKET WATER PUMP
KIM HOTSTART JACKET WATER HEATER (196-3850)
TO ATM
JW HEATING ELEMENT
HEAT REJ = 30 KW
1/2" DRAIN
JW HEATER PUMP
(480V-3 PH-60 Hz)
SET: 5C BELOW JW REGULATOR
HEAT RECOVER CONNECTIONS
5" FLAT FACE 150# ANSI FLANGES
HEAT RECOVERY
HEAT RECOVERY
MAX HEAT LOAD: 1079KW
MAX FLOW RATE: 2630 L/MIN
MAX TEMP: 96°C
MIN TEMP @ MAX FLOW RATE: 90°C
ACCESSORY MODULE
FUEL COOLER
HEAT REJ = 30 kW
HOT FLOW = 55.2 LPM
COLD FLOW = 75 LPM
OIL COOLER
HEAT REJ = 511 kW
HOT FLOW = 1800 LPM
COLD FLOW = 900 LPM
MAKE-UP LINE
EXPANSION TANK
90°C
BUTTERFLY VALVE
REGULATOR
AC/OC HEX
HEAT REJ = 2176 kW
HOT FLOW = 1560 LPM
COLD FLOW = 2800 LPM
54.2°C
27°C
38.7°C
2800 LPM
JW HEX
HEAT REJ = 1029 kW
HOT FLOW = 2630 LPM
COLD FLOW = 2800 LPM
90°C
96.1°C
38.5°C
44.1°C
2800 LPM
SEA WATER INLET
4" ANSI FLANGE
CUSTOMER SUPPLIES 2800 L/MIN SEAWATER @ 27°C (32°C MAX)
SEA WATER OUTLET
4" ANSI FLANGE
METRIC
NUMBER
PIPING LEGEND
INSTRUMENT LEGEND
LEGEND
CAT SUPPLIED
CUSTOMER SUPPLIED
NOTE: 1. ADD A STRAINER WITH MESH LESS THAN 2.5MM IN SW INLET OF AC/OC HEX
2. FLEX CONNECTIONS ARE ANSI FLANGE FOR ONE END, ANTHOTHER END G/B FLANGE, SEE RELATED DWG
LEI SHING HONG MACHINERY
PROJECT NAME SEMI-SUBMERSIBLE DRILLING RIG-JBF14000-1
HULL NO: H242
DWG NAME COOLING PIPING DIAGRAM (MAIN GENERATOR SET)
DWG NO. MA/P245-01-MG
SCALE NONE





NOTE:

1) IF THE DISTANCE BETWEEN THE DAY TANK AND THE ENGINE EXCEEDS 9 M, LARGER PIPES MUST BE INSTALLED TO ENSURE ADEQUATE FLOW.
2) IF NOT SPECIFIED, ALL PIPEWORK, VAVLE AND COMPONENTS OUTSIDE THE DESHED FRAME LINE ARE SHIPYARD SUPPLY.
3) FUELFLEX CONNECTIONS SUPPLIED BY LSHM ARE ANSI FLANGE FOR ONE END, ANOTHER END G/B FLANGE, PLS SEE RELATED DWG

Fuel return flow	51.1 Lpm	Back press. 350kPa
Fuel transfer pump	75 Lpm	Suction head -20 kPa

LEGEND

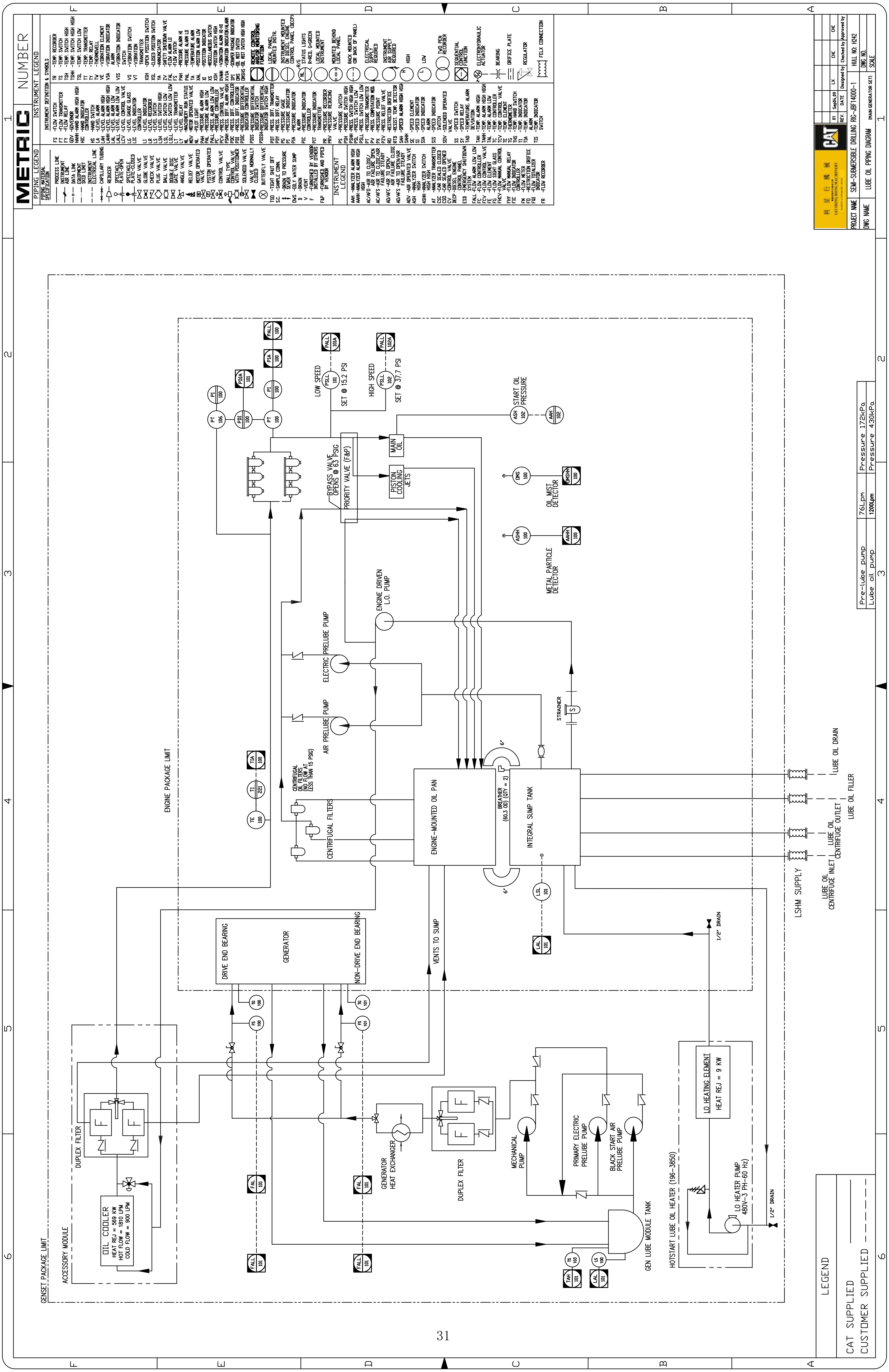
CAT SUPPLIED ————————

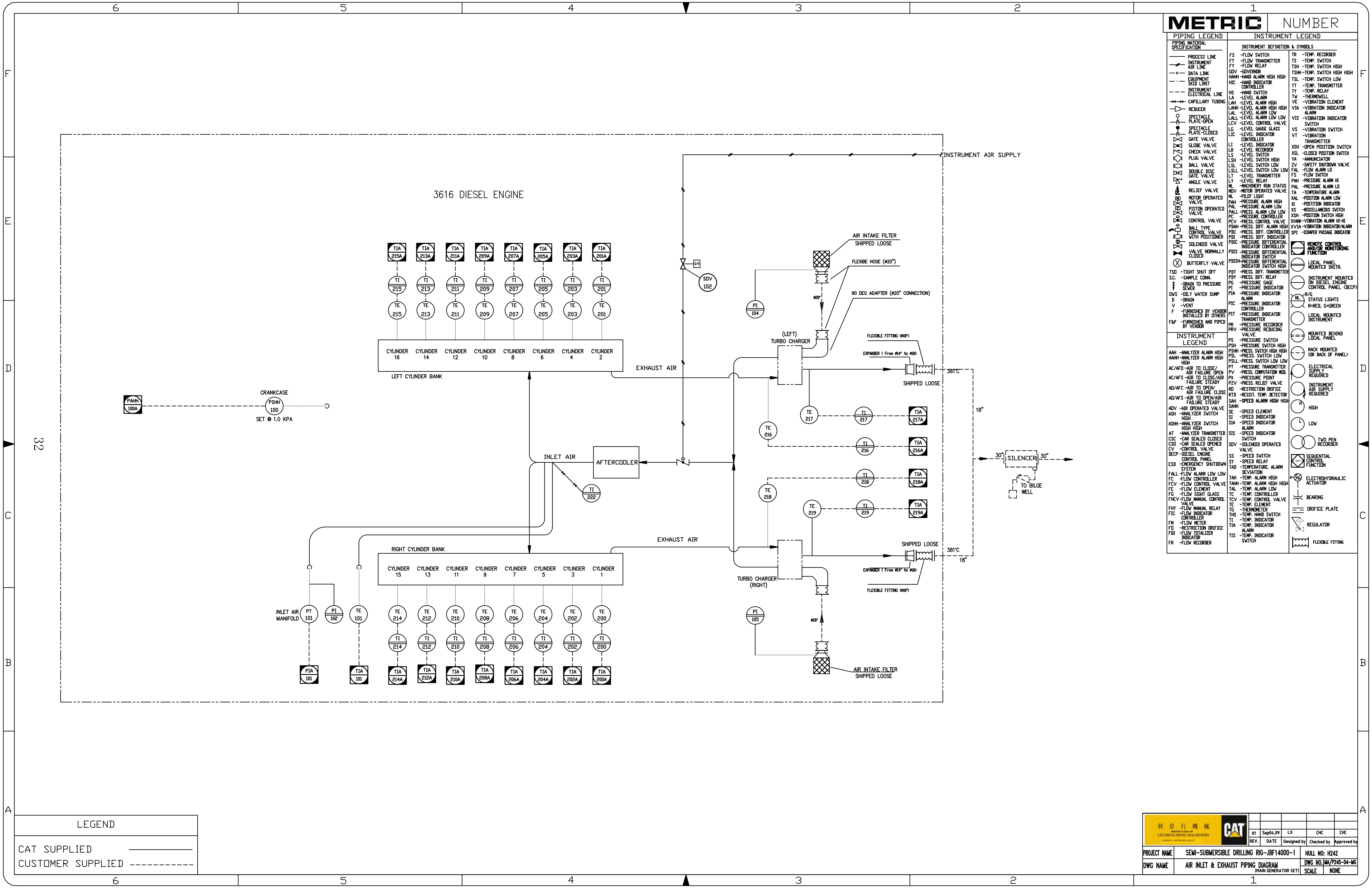
CUSTOMER SUPPLIED — — — — — —

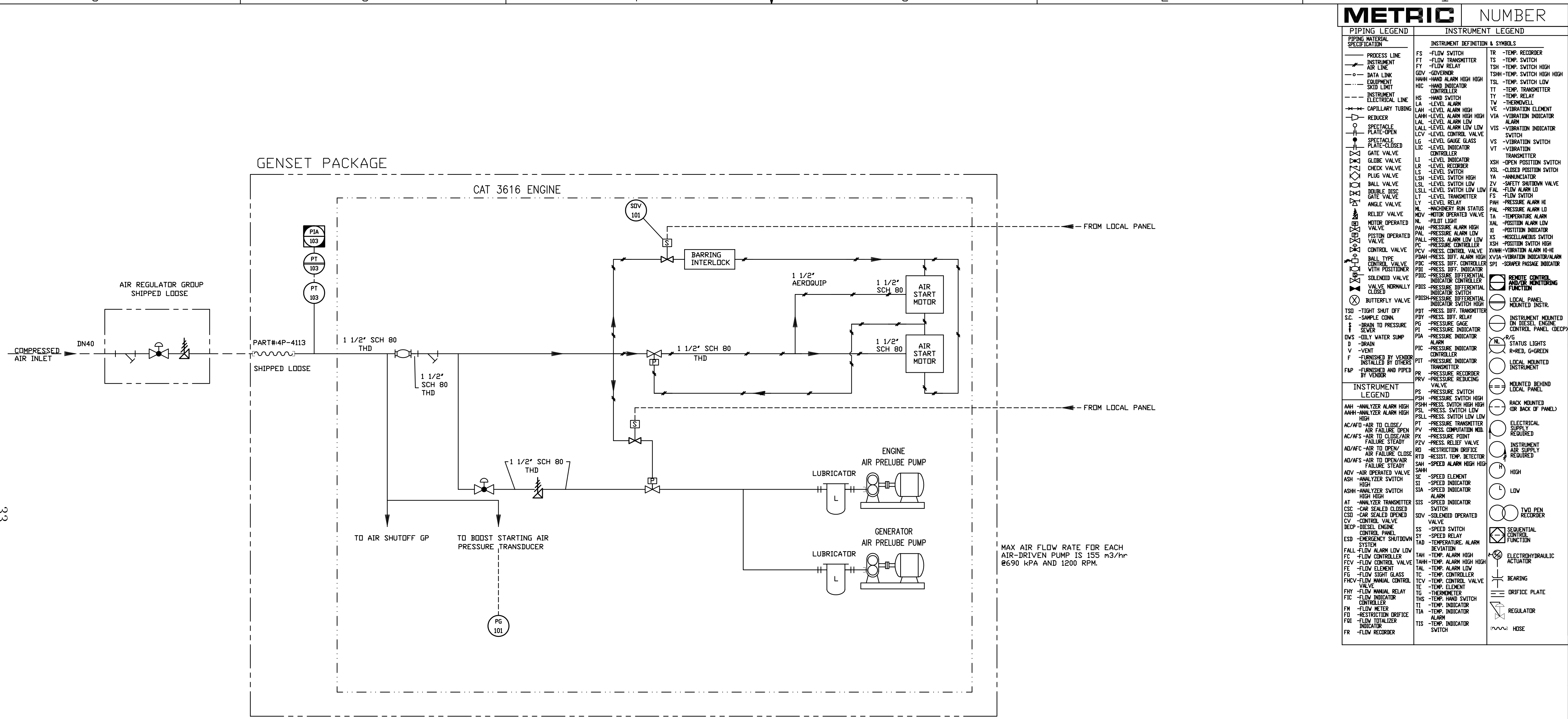
利星行機械 LEI SHING HONG MACHINERY CAT

01	Sep04,09	
REV.	DATE	Designed by

PROJECT NAME	SEMI-SUBMERSIBLE DRILLING RIG-JBF14000-1
DWG NAME	FUEL PIPING DIAGRAM (MAIN GENERATOR SET)


METRIC
NUMBER
PIPING LEGEND
INSTRUMENT LEGEND
ENGINE PACKAGE LIMIT
GENSET PACKAGE LIMIT
ACCESSORY MODULE
LOW SPEED
SET @ 15.2 PSI
HIGH SPEED
SET @ 37.7 PSI
START OIL PRESSURE
MAIN OIL
BYPASS VALVE OPENS @ 63 PSIG
PRIORITY VALVE (F&P)
PISTON COOLING JETS
OIL MIST DETECTOR
METAL PARTICLE DETECTOR
ENGINE DRIVEN L.O. PUMP
ELECTRIC PRELUBE PUMP
AIR PRELUBE PUMP
STRAINER
CENTRIFUGAL OIL FILTERS (NO FLOW AT LESS THAN 15 PSIG)
CENTRIFUGAL FILTERS
ENGINE-MOUNTED OIL PAN
BREATHER (60.3 OD) (QTY = 2)
INTEGRAL SUMP TANK
LUBE OIL DRAIN
LUBE OIL FILLER
LUBE OIL CENTRIFUGE OUTLET
LUBE OIL CENTRIFUGE INLET
LSHM SUPPLY
1/2" DRAIN
DRIVE END BEARING
GENERATOR
NON-DRIVE END BEARING
VENTS TO SUMP
DUPLEX FILTER
OIL COOLER
HEAT REJ = 569 KW
HOT FLOW = 1810 LPM
COLD FLOW = 900 LPM
GENERATOR HEAT EXCHANGER
MECHANICAL PUMP
PRIMARY ELECTRIC PRELUBE PUMP
BLACK START AIR PRELUBE PUMP
GEN LUBE MODULE TANK
LO HEATING ELEMENT
HEAT REJ = 9 KW
LO HEATER PUMP
480V-3 PH-60 Hz
HOTSTART LUBE OIL HEATER (196-3850)
Pre-lube pump 76Lpm Pressure 172kPa
Lube oil pump 1200lpm Pressure 430kPa
LEGEND
CAT SUPPLIED
CUSTOMER SUPPLIED
PROJECT NAME SEMI-SUBMERSIBLE DRILLING RIG-JBF14000-1
DWG NAME LUBE OIL PIPING DIAGRAM (MAIN GENERATOR SET)
HULL NO: H242


METRIC
NUMBER
PIPING LEGEND
INSTRUMENT LEGEND
INSTRUMENT DEFINITION & SYMBOLS
3616 DIESEL ENGINE
INSTRUMENT AIR SUPPLY
AIR INTAKE FILTER SHIPPED LOOSE
FLEXIBE HOSE (#20")
90 DEG ADAPTER (#20" CONNECTION)
(LEFT) TURBO CHARGER
TURBO CHARGER (RIGHT)
FLEXIBLE FITTING (#18")
EXPANDER (From #14" to #18)
SHIPPED LOOSE
381°C
18"
30"
SILENCER
TO BILGE WELL
EXHAUST AIR
INLET AIR
AFTERCOOLER
LEFT CYLINDER BANK
RIGHT CYLINDER BANK
CYLINDER 16
CYLINDER 14
CYLINDER 12
CYLINDER 10
CYLINDER 8
CYLINDER 6
CYLINDER 4
CYLINDER 2
CYLINDER 15
CYLINDER 13
CYLINDER 11
CYLINDER 9
CYLINDER 7
CYLINDER 5
CYLINDER 3
CYLINDER 1
CRANKCASE
PSHH 100
SET @ 1.0 KPA
PAHH 100A
INLET AIR MANIFOLD
PT 101
PI 102
TE 101
PIA 101
TIA 101
PI 104
PI 105
SDV 102
TI 222
TE 216
TE 217
TE 218
TE 219
TI 216
TI 217
TI 218
TI 219
TIA 216A
TIA 217A
TIA 218A
TIA 219A
LEGEND
CAT SUPPLIED
CUSTOMER SUPPLIED
LEI SHING HONG MACHINERY
01 Sep04,09 LX CHC CHC
REV. DATE Designed by Checked by Approved by
PROJECT NAME SEMI-SUBMERSIBLE DRILLING RIG-JBF14000-1
HULL NO: H242
DWG NAME AIR INLET & EXHAUST PIPING DIAGRAM (MAIN GENERATOR SET)
DWG NO. MA/P245-04-MG
SCALE NONE



Note A: The vane air starter operate on air inlet pressure from 700kPa to 1550kPa

Note B: Air is compressed to Max 30 bar and is stored in storage tanks. Stored air is regulated to 860kPa and piped to the air motor.

Note C: Air supply piping should be short and direct and at least equal in size to the engine inlet connection, which is 38mm. It should be piped by shipyard.

Note D: The accumulation of oil and water must be removed daily to prevent damage to the starting motor.

LEGEND

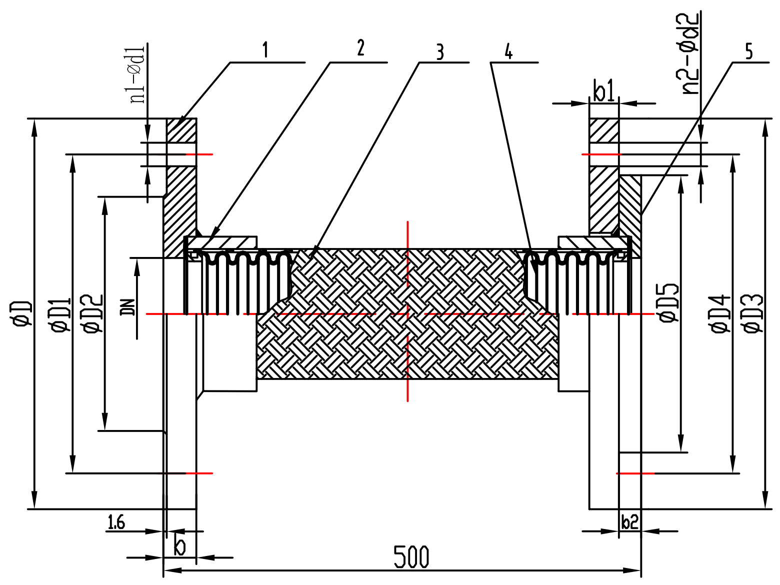
CAT SUPPLIED ————

CUSTOMER SUPPLIED – – – – –

REV.	DATE	Designed by	Checked by	Approved by
01	Sep04,09	LX	CHC	CHC

PROJECT NAME: SEMI-SUBMERSIBLE DRILLING RIG-JBF14000-1 — HULL NO: H242

DWG NAME: STARTING AIR PIPING DIAGRAM (MAIN GENERATOR SET) — DWG NO. MA/P245-05-MG — SCALE: NONE



Technologcal data

1.Design pressure:≤1.0MPa
2.Design temperature:≤100℃
3.Manufacture standard:Flexible connection:GB/T14525,Flange:GB2506 ANSI
4.The corrugate appearance of bellows must be homogeneous,No.obvious uneven surface and scratches.
5.No.flaws on the surface of all welding lines,such as scratches,gas holes ,inclusions spatters and so on.
6.The pressure test should be carried out at 1.5times design pressure and design pressure
7.Fluid carrier: oil or sea water .
8.Kind of ship:Semi-submersible drilling platform,ship No:YRO-2007-242, builded by YANTAI RAFFES OFFSHORE CO.LTD

技术要求

1.设计压力：≤1.0MPa
2.设计温度:≤100℃
3.执行标准:软管制造标准GB/T14525, 法兰标准一端GB2506 一端ANSI
4.波纹管表面不允许有剥层，气泡、氧化皮、锈斑、裂纹、尖角凹坑、尖锐折叠等缺陷、也不允许有深度大于壁厚的压痕，深度大于壁厚下偏差的划伤。
5.网套与波纹管应贴合，波纹管表面不允许有碰伤，焊渣等缺陷。
6.软管在1.5倍公称压力下进行试验，不允许有渗漏或零件损坏等现象。软管在公称压力下进行试验，不允许有渗漏现象。
7.工作介质：油、水
8.船类型：钻井平台,船号:YRO-2007-242；烟台来福士海洋工程有限公司制造

FOR LUBE OIL FILLER
FOR LUBE OIL DRAIN, TO CENTRIFUGE
FOR FROM CENTRIFUGE

DN	øD	øD1	øD2	b	n1-ød1	øD3	øD4	øD5	n2-ød2	b1	b2	介质	数量
DN50	ø152.4	ø120.7	ø95	19	4-ø15.5	ø165	ø125	ø100	4-ø18	18	10	FUEL	16
DN50	ø152.4	ø120.7	ø95	19	4-ø19.1	ø165	ø125	ø100	4-ø18	18	10	OIL	8
DN40	ø127	ø98.4	ø73	17	4-ø15	ø150	ø110	ø85	4-ø18	16	10	OIL	16
DN40	ø127	ø99	ø73	17	4-ø15.7	ø150	ø110	ø85	4-ø18	16	10	OIL	8

序号	代号	名称	数量	材料	单件重量	总计重量	备注
5		挡环	1	SUS304			
4		管体	1	SUS304			
3		网体	1	SUS304			
2		护套	2	SUS304			
1		法兰	2	Q235			

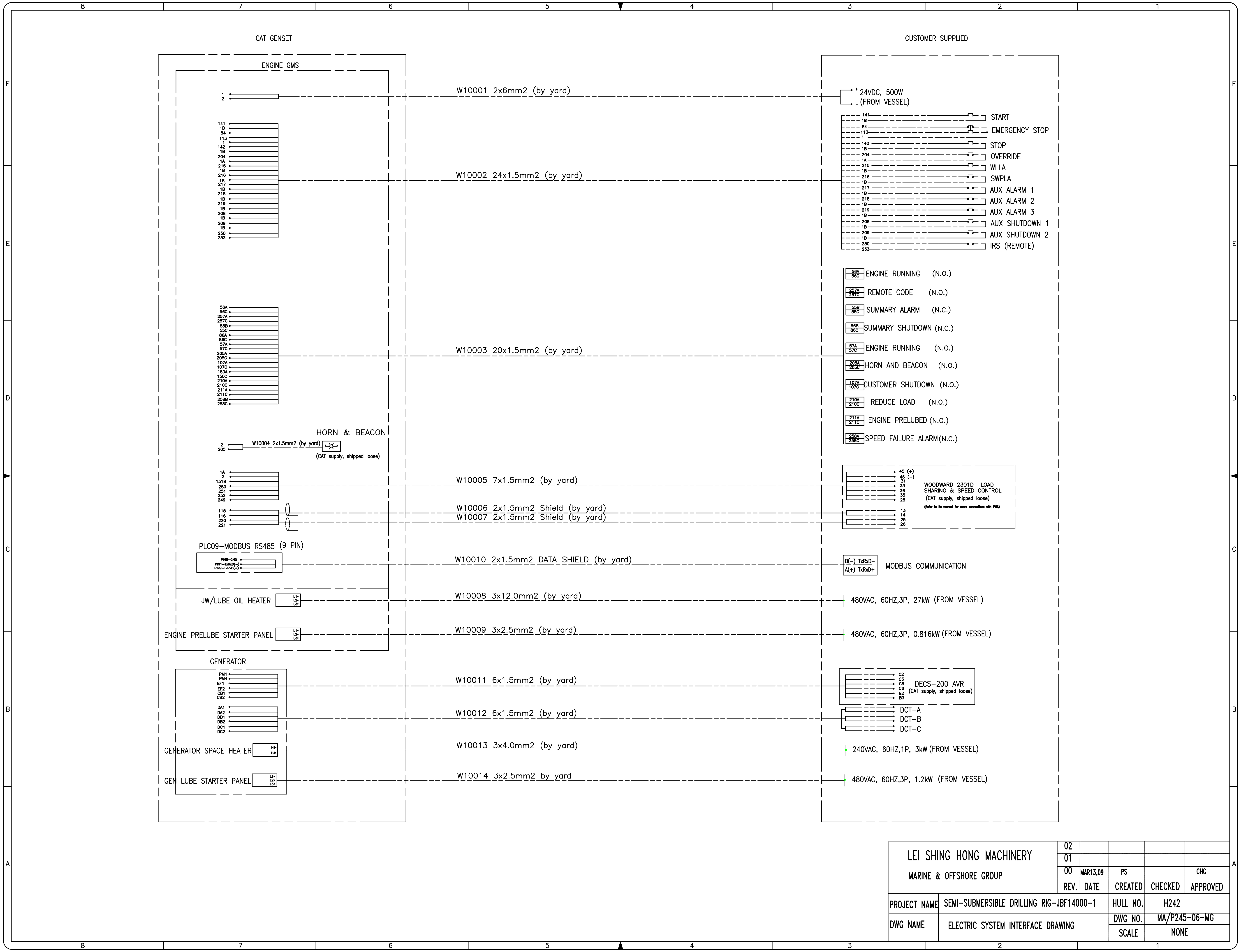
装配图

江苏鸿程管业公司

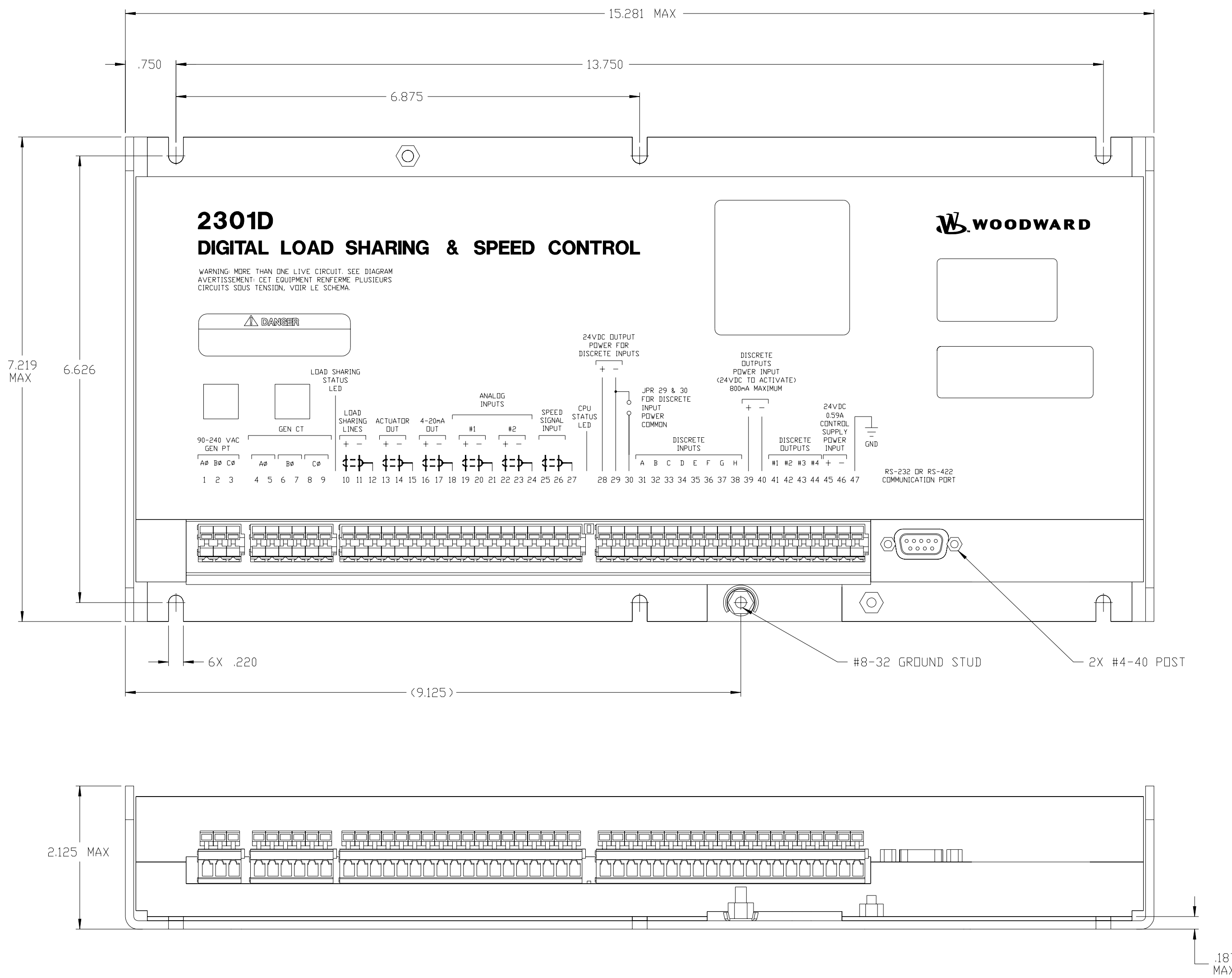
主机燃油/滑油用金属软管

HC090907-001

标记 处数 更改文件号 签字 日期
设计 标准化
核对 审定
校对 批准
工艺 日期
图样标记 数量 重量 比例
共 页 第 页


CAT GENSET
ENGINE GMS
HORN & BEACON
W10004 2x1.5mm2 (by yard)
(CAT supply, shipped loose)
PLC09-MODBUS RS485 (9 PIN)
JW/LUBE OIL HEATER
ENGINE PRELUBE STARTER PANEL
GENERATOR
GENERATOR SPACE HEATER
GEN LUBE STARTER PANEL
W10001 2x6mm2 (by yard)
W10002 24x1.5mm2 (by yard)
W10003 20x1.5mm2 (by yard)
W10005 7x1.5mm2 (by yard)
W10006 2x1.5mm2 Shield (by yard)
W10007 2x1.5mm2 Shield (by yard)
W10010 2x1.5mm2 DATA SHIELD (by yard)
W10008 3x12.0mm2 (by yard)
W10009 3x2.5mm2 (by yard)
W10011 6x1.5mm2 (by yard)
W10012 6x1.5mm2 (by yard)
W10013 3x4.0mm2 (by yard)
W10014 3x2.5mm2 by yard
CUSTOMER SUPPLIED
24VDC, 500W
(FROM VESSEL)
START
EMERGENCY STOP
STOP
OVERRIDE
WLLA
SWPLA
AUX ALARM 1
AUX ALARM 2
AUX ALARM 3
AUX SHUTDOWN 1
AUX SHUTDOWN 2
IRS (REMOTE)
ENGINE RUNNING (N.O.)
REMOTE CODE (N.O.)
SUMMARY ALARM (N.C.)
SUMMARY SHUTDOWN (N.C.)
ENGINE RUNNING (N.O.)
HORN AND BEACON (N.O.)
CUSTOMER SHUTDOWN (N.O.)
REDUCE LOAD (N.O.)
ENGINE PRELUBED (N.O.)
SPEED FAILURE ALARM (N.C.)
WOODWARD 2301D LOAD SHARING & SPEED CONTROL
(CAT supply, shipped loose)
B(-) TxRxD-
A(+) TxRxD+
MODBUS COMMUNICATION
480VAC, 60HZ,3P, 27kW (FROM VESSEL)
480VAC, 60HZ,3P, 0.816kW (FROM VESSEL)
DECS-200 AVR
(CAT supply, shipped loose)
DCT-A
DCT-B
DCT-C
240VAC, 60HZ,1P, 3kW (FROM VESSEL)
480VAC, 60HZ,3P, 1.2kW (FROM VESSEL)
LEI SHING HONG MACHINERY
MARINE & OFFSHORE GROUP
02
01
00 MAR13,09 PS CHC
REV. DATE CREATED CHECKED APPROVED
PROJECT NAME SEMI-SUBMERSIBLE DRILLING RIG-JBF14000-1
HULL NO. H242
DWG NAME ELECTRIC SYSTEM INTERFACE DRAWING
DWG NO. MA/P245-06-MG
SCALE NONE

THIS PAGE FOR KATO DRAWING: 888-00218-25



15.281	388.0
13.750	349.2
7.219	183.3
6.875	174.6
6.626	168.3
2.125	54.0
.750	19.0
.220	5.6
INCH	MM
INCH TO MM CONVERSION	

260-038
00-08-04

Figure 1-1a. 2301D Outline Drawing (Ordinary Locations)

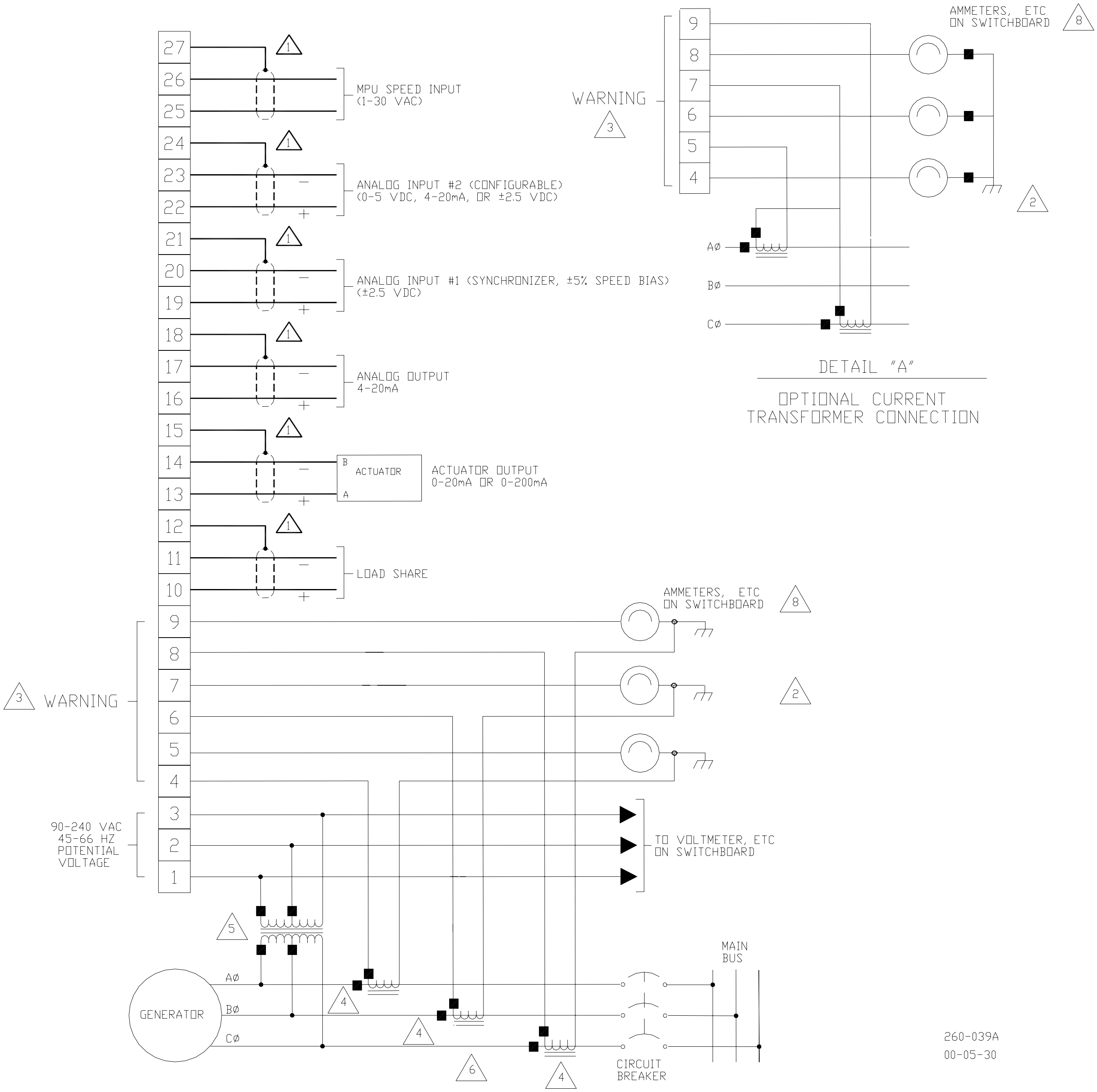


Figure 1-2a. 2301D Plant Wiring Diagram (sheet 1)

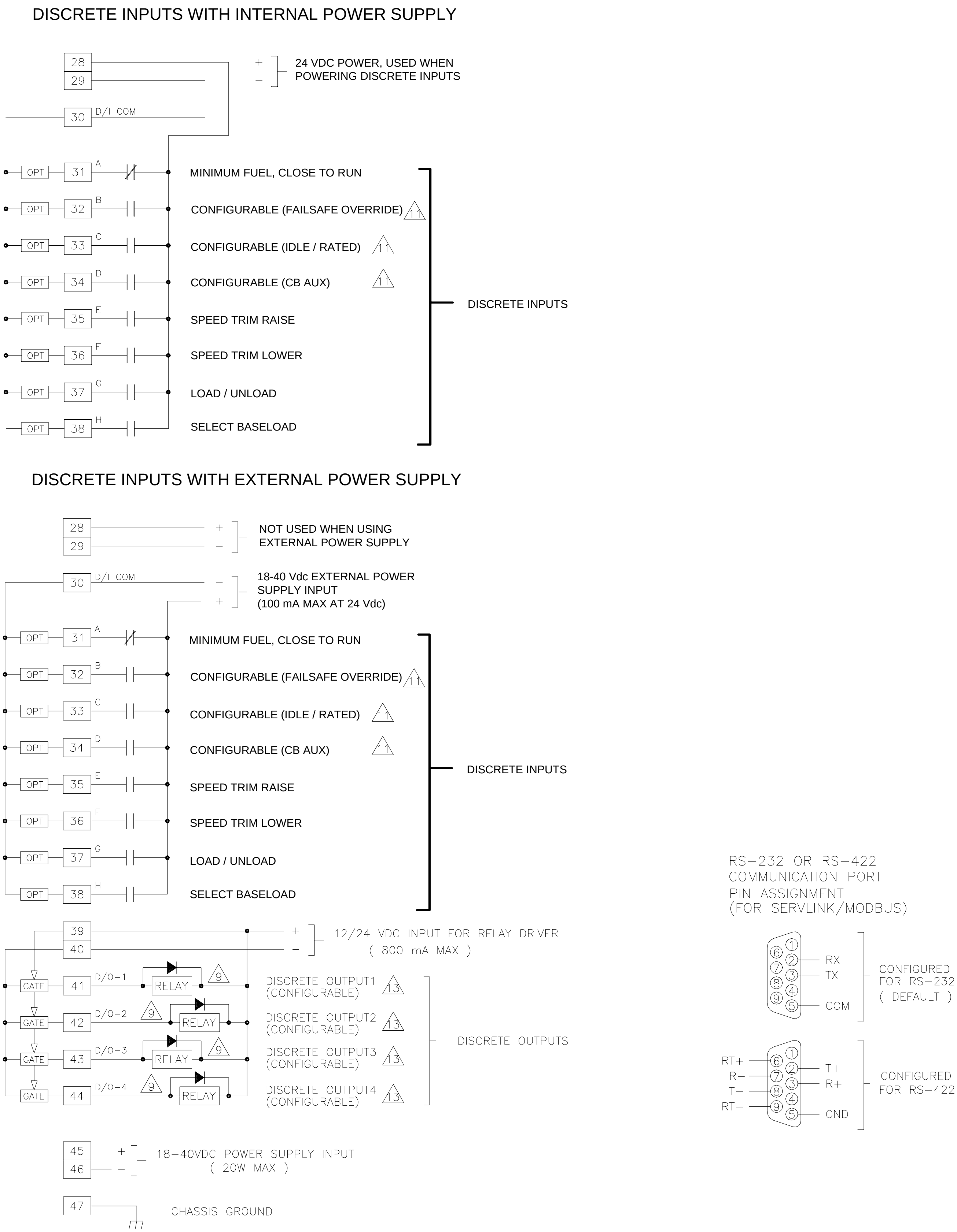


Figure 1-2b. 2301D Plant Wiring Diagram (sheet 2)

NOTES:

1. SHIELDED WIRES TO BE TWISTED PAIRS, WITH SHIELD GROUNDED AT CONTROL END ONLY.

2. POINT OF GROUNDING IF REQUIRED BY WIRING CODE.

3. INTERNAL CURRENT TRANSFORMER BURDEN MUST BE CONNECTED ACROSS POWER SOURCE CURRENT TRANSFORMER AT ALL TIMES, TO PREVENT LETHAL HIGH VOLTAGES.

4. POWER SOURCE CURRENT TRANSFORMERS SHOULD BE SIZED TO PRODUCE 5 A SECONDARY CURRENT WITH MAXIMUM GENERATOR CURRENT, CURRENT TRANSFORMER BURDEN IS LESS THAN 0.1 VA PER PHASE.

5. WITH A BALANCED THREE PHASE LOAD AND UNITY POWER FACTOR, THE CURRENT TRANSFORMERS SHOULD BE WIRED IN THE CORRECT POTENTIAL LEG AND MUST BE PHASED AS FOLLOWS:

   PHASE A: POTENTIAL TERMINAL 1, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 4 ( ) TO 5.
   PHASE B: POTENTIAL TERMINAL 2, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 6 ( ) TO 7.
   PHASE C: POTENTIAL TERMINAL 3, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 8 ( ) TO 9.

6. FOR OPTIONAL CURRENT TRANSFORMER CONNECTION, SEE DETAIL "A".

7. WARNING: DO NOT USE FOR EMERGENCY SHUTDOWN. THE PRIME MOVER SHOULD BE EQUIPPED WITH SEPARATE OVERSPEED, OVERTEMPERATURE OR OVERPRESSURE SHUTDOWN DEVICE(S) TO PROTECT AGAINST RUNAWAY OR DAMAGE TO THE PRIME MOVER WITH POSSIBLE PERSONAL INJURY OR LOSS OF LIFE.

8. IF METERS ARE NOT USED, JUMPERS MUST BE INSTALLED IN PLACE OF METERS SHOWN.

9. INDICATES RELAY COIL OR LAMP, 200 MA MAXIMUM PER CHANNEL.

10. OPTIONAL SEE BOM

11. DISCRETE INPUTS WITH CABLE LENGTHS GREATER THAN 30 METERS THAT ARE USED FOR CRITICAL FUNCTIONS, SUCH AS EMERGENCY STOP, SHOULD NOT BE FLOATED IN EITHER AN ON OR OFF STATE. THESE INPUTS SHOULD BE SWITCHED TO +24 VDC OR GROUND.

260-039C
00-07-26

Figure 1-2c. 2301D Plant Wiring Diagram (notes)

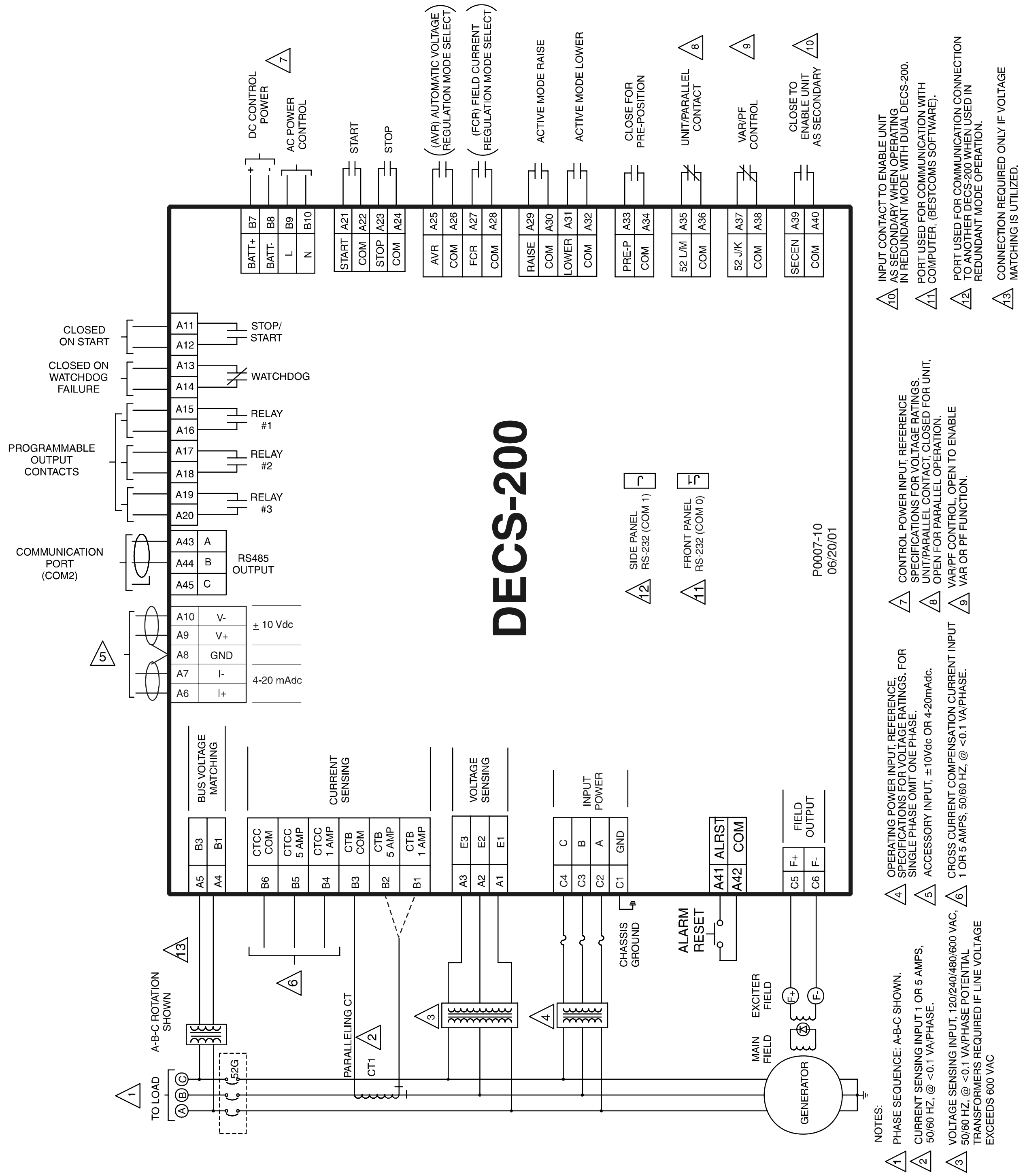


Figure 4-9. Typical Connections

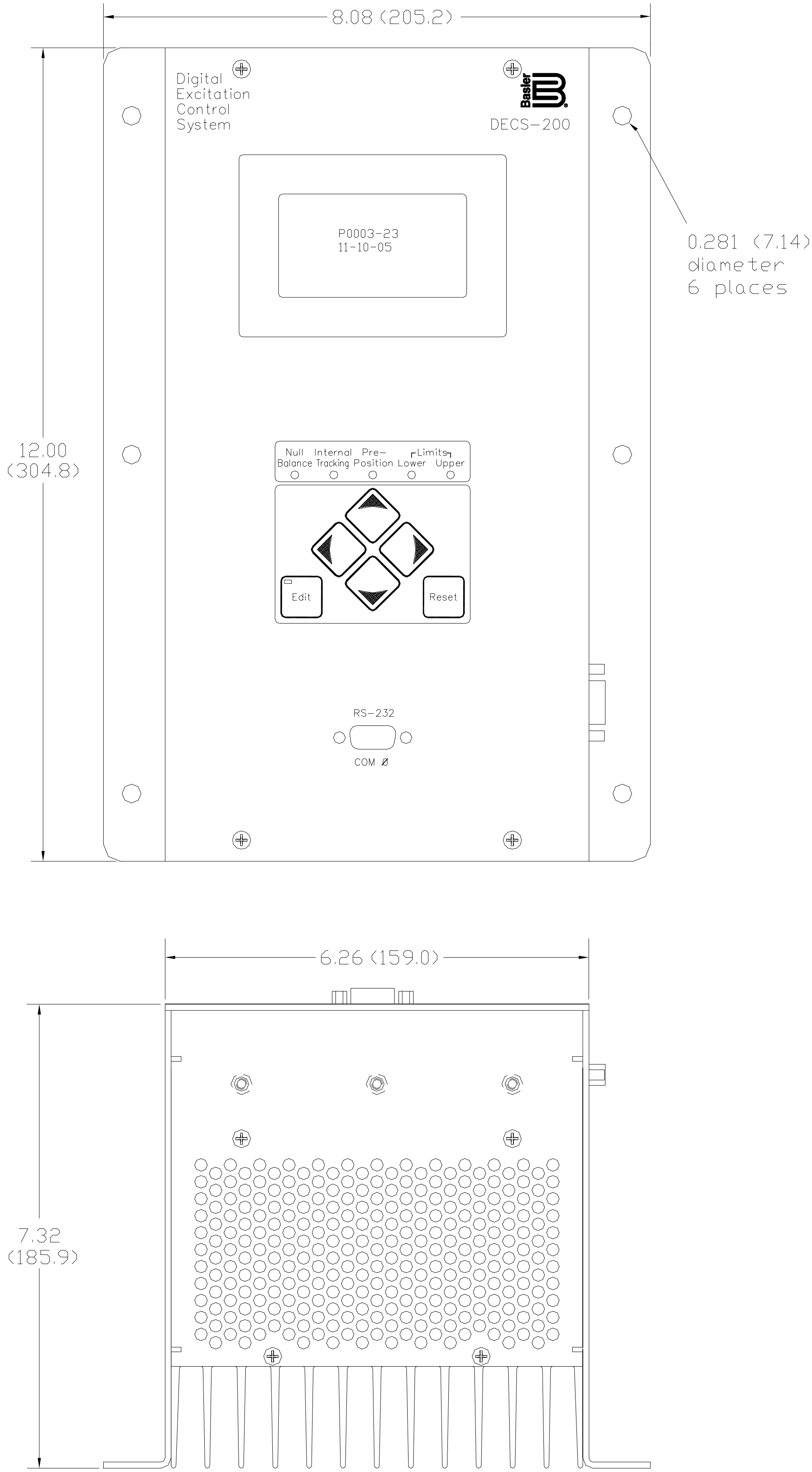


Figure 4-1. Overall Dimensions

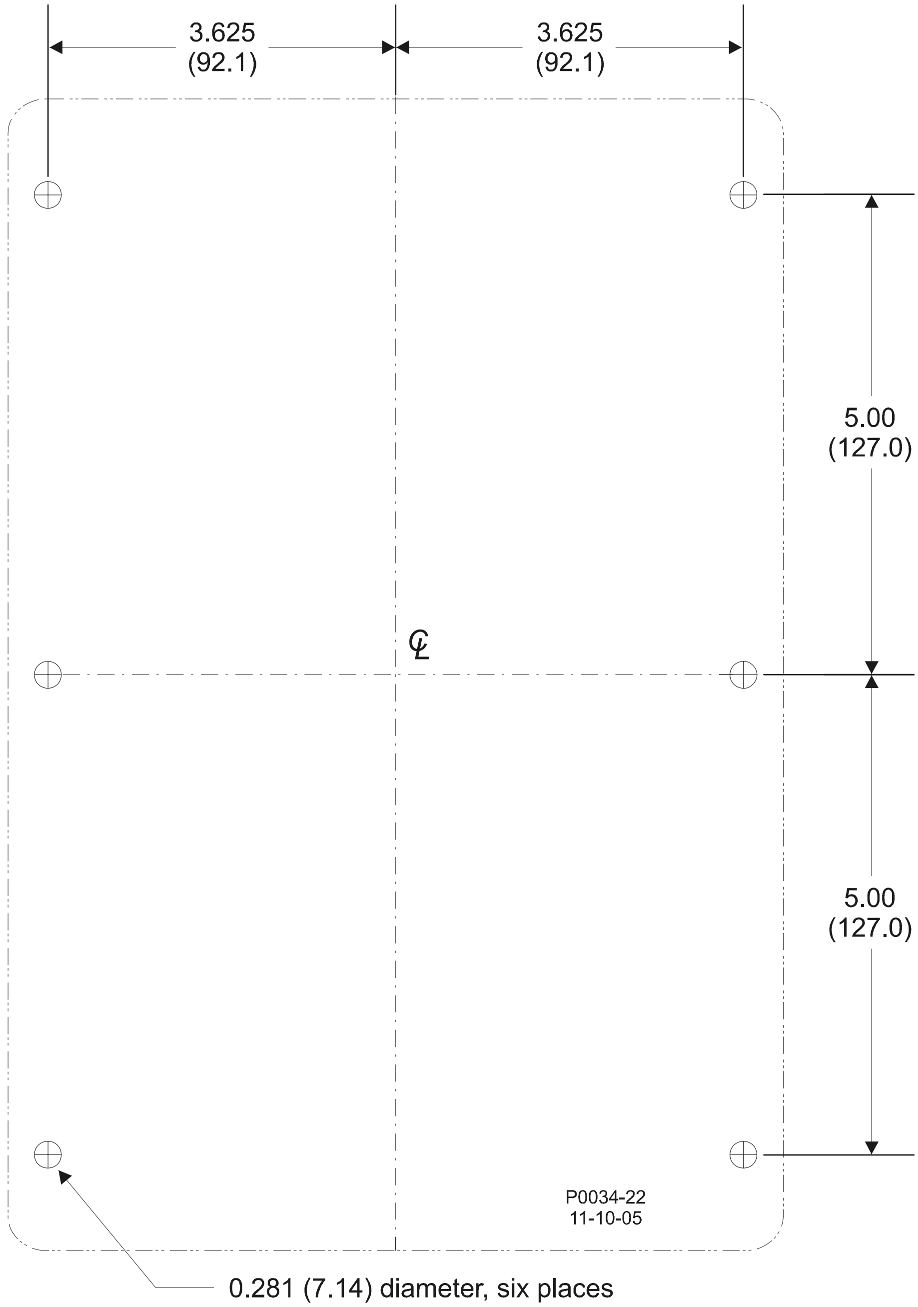


Figure 4-2. Panel Drilling Diagram, Projection Mount

TB #	LINE #
G	313
GND	300
SH	344
1	300
2	300
3	320
1A	306
1B	310
1C	341
1D	323
1E	315
14A	1188
14B	1192
14C	1190
30A	1151
30C	1151
55A	1181
55B	1186
55C	1183
56A	1175
56B	1179
56C	1177
57A	1181
57B	1186
57C	1183
67	617
68	620
70	635
71	632
72	632
73	718
74	620
75	620
80	511
81	438
82	723
82A	720
82B	729
83	441
84	444
85	438
86	444
86A	1175
86B	1179
86C	1177
87	547
88	549
90	504
91	517
92	501
93	505

TB #	LINE #
101	508
102	508
102A	1161
102B	1165
102C	1163
103	514
104	520
105	520
105A	1161
105B	1165
105C	1163
106	507
107	529
107A	1168
107B	1172
107C	1170
108	529
109	538
109A	1154
109B	1158
109C	1156
110	538
111	543
113	449
114	944
115	845
116	846
140	1013
141	1016
142	1019
146	607
147	611
148	607
149	614
150	609
150A	1188
150B	1192
150C	1190
151	620
151A	824
151B	827
151C	824
152	626
153	626
153A	1154
153B	1158
153C	1156
161	638
162	642
163	642
164	645
164A	1168

TB #	LINE #
164B	1172
164C	1170
165	648
167	723
168	729
169	723
173	430
174	436
175	430
200	400
201	400
202	602
203	741
204	708
205	711
205A	1194
205B	1199
205C	1196
208	980
209	983
210	952
210A	1194
210B	1199
210C	1196
211	955
211A	1154
211B	1158
211C	1156
212	957
212A	1161
212B	1165
212C	1163
213	960
214	963
215	966
216	969
217	971
218	974
219	977
220	838
221	840
222	1222
223	1223
230	1214
231	1216
233	1205
234	1207
235	991
236	994
248	807
249	818
250	807

TB #	LINE #
251	817
253	810
257A	1175
257B	1179
257C	1177
258A	1168
258B	1172
258C	1170
452	746
500	329
501	328
502	326
511	1040
512	1036
513	1039
514	1041
515	1044

TABLE OF CONTENTS

UNLESS OTHERWISE SPECIFIED, RECOMMENDED STANDARD WIRE SIZE IS 16 AWG ENGINE, 18 AWG MMS PANEL.

SHIELD TWISTED PAIR WIRE SIZE IS 18 AWG MINIMUM.

USE K-TYPE THERMOCOUPLE WIRE FOR THERMOCOUPLE CONNECTIONS.

DRY CONTACTS ARE RATED FOR 5 AMPS AT 30 VDC, 3 AMPS AT 120 VAC

ALL PRESSURE SWITCHES SHOWN WITHOUT PRESSURE PRESENT.

ALL LEVEL SWITCHES SHOWN WITHOUT FLUID PRESENT.

ALL RELAY CONTACTS SHOWN IN THE DE-ENERGIZED MODE.

INTERCONNECT WIRING, UNLESS OTHERWISE SPECIFIED, RECOMMENDED STANDARD WIRE SIZE IS 16 AWG, FACTORY PROVIDED FOR ACCESSORY MODULE MOUNTED GMS OR MMS II, CUSTOMER PROVIDED IF SHIP LOOSE.

ALL COMMON TERMINALS FOR ENGINE WIRING ARE JUMPERED IN ENGINE TERMINAL BOX FOR INTERCONNECT WIRING TO GMS OR MMS II PANELS.

CONFIGURATION/NOTES

1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 1 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CHG DATE

CATERPILLAR INC.

DIAGRAM-WIRING
(YRSL-JBF1)
334-3086 - W867 D

METRIC 334-3086

LEGEND

ABR.	DESCRIPTION	LINE#
AAI1	AUXILIARY ANALOG INPUT #1	1634
AAI2	AUXILIARY ANALOG INPUT #2	1638
ACOC	AFTER COOLER/OIL COOLER	1575
ASOS	AIR SHUTOFF SOLENIOD VALVE	439
ASPG	AIR STARTING PRESSURE GAUGE	739
ASPLA	AIR STARTING PRESSURE LOW ALARM	954
ASPSU	AIR STARTING PRESSURE SENDING UNIT	742
ASR	AUTOMATIC START RELAY	1110
ASSV	AIR START SOLENOID VALVE	620
AT1	AUXILIARY TEMPERATURE #1 RTD	1583
AT2	AUXILIARY TEMPERATURE #2 RTD	1588
AUX	AUXILIARY	971
AWG	AMERICAN WIRE GAUGE	
BBMAR	BALL HEAD BACKUP MODE ALARM RELAY	1033
BBMS	BALL HEAD BACKUP MODE SWITCH	1031
CB#	CIRCUIT BREAKER NUMBER	305
CHL	CHANNEL	344
COM	BATTERY COMMON	309
CPHSR	CRANK PRESSURE HIGH SHUTDOWN RELAY	535
CPHSS	CRANK PRESSURE HIGH SHUTDOWN SWITCH	540
CSDR	CUSTOMER SHUTDOWN RELAY	531
CTR	CRANK TERMINATE RELAY	432
CTRX	CRANK TERMINATE RELAY AUXILIARY	435
DC	DIRECT CURRENT	409
ECS	ENGINE CONTROL SWITCH	511
ECTR	ENGINE CRANK TERMINATE RELAY	425
ECTTDR	ENGINE CRANK TERMINATE TIME DELAY	423
EMTB	ENGINE MOUNTED TERMINAL BOX	
EOSSR	ENGINE OVERSPEED RELAY	427
EOSTR	ENGINE OIL PRESSURE STEP RELAY	421
ES	EMERGENCY STOP	444
ESS	ELECTRONIC SPEED SWITCH	411
FCR	FUEL CONTROL RELAY	611
FCRX	FUEL CONTROL AUXILIARY RELAY	614
FCS	FUEL CONTROL SWITCH	611
FCTDR	FUEL CONTROL TIME DELAY RELAY	624
FLEX#	FLEX I/O MODULE NUMBER	1251
FLEXASB	FLEX REMOTE I/O ADAPTER	320
FSOS	FUEL SHUTOFF SOLENOID	723

ABR.	DESCRIPTION	LINE#
GND	GROUND	300
HB	HORN AND BEACON	711
HBR	HORN AND BEACON RELAY	1113
HM	HOUR METER	436
IPR	INTERMITTENT PRELUBING RELAY	629
IPSV	INTERMITTENT PRELUBE START SOLENOID VALVE	717
IRS	IDLE/RATED SWITCH	807
JWDAR	JACKET WATER DETECTOR ALARM RELAY	602
JWDS	JACKET WATER DETECTOR SWITCH	602
LBVAR	LOW BATTERY VOLTAGE ALARM RELAY	303
MPU	MAGNETIC PICK UP	401
NC	NORMALLY CLOSED	905
NO	NORMALLY OPEN	902
OLLA	OIL LEVEL LOW ALARM	952
OMDR	OIL MIST DETECTOR RELAY	991
OMDS	OIL MIST DETECTOR SHUTDOWN	994
OPLS1	OIL PRESSURE LOW SHUTDOWN (>170 RPM)	516
OPLS1R	OIL PRESSURE LOW SHUTDOWN RELAY #1	522
OPLS2	OIL PRESSURE LOW SHUTDOWN (>75% OF RPM)	504
OPLS2R	OIL PRESSURE LOW SHUTDOWN RELAY #2	511
OVR	OVERRIDE RELAY	708
PAOP	AC/OC PUMP PRESSURE TRANSDUCER	1412
PASOR	PLC AIR SHUTOFF RELAY	1135
PCTR	PLC CRANK TERMINATE RELAY	1128
PCTTDR	PLC CRANK TERMINATE TIME DELAY RELAY	1131
PDA	PARTICLE DETECTOR ALARM	963
PFE	FUEL TO ENGINE PRESSURE TRANSDUCER	1616
PFF	FUEL TO FILTER PRESSURE TRANSDUCER	1626
PIAM	INLET AIR MANIFOLD PRESSURE TRANSDUCER	1612
PJW	JACKET WATER PRESSURE TRANSDUCER	1422
PLC	PROGRAMMABLE LOGIC CONTROLLER	448
PLCFAR	PLC FALIURE ALARM RELAY	1138
PLCFL	PLC FAILURE ALARM LAMP	645
PLCPS	PLC POWER SUPPLY	310
POE	OIL TO ENGINE PRESSURE TRANSDUCER	1607
POF	OIL TO FILTER PRESSURE TRANSDUCER	1621
POSTR	PLC OIL PRESSURE STEP RELAY	1133
PSA	STARTING AIR PRESSURE TRANSDUCER	1417
PSCR1	PROGRAMMABLE SPEED CONTROL RELAY 1	1125
PSCR2	PROGRAMMABLE SPEED CONTROL RELAY 2	1140
PSS	PRELUBE START SWITCH	620
PSW	SEAWATER PRESSURE TRANSDUCER	1408

ABR.	DESCRIPTION	LINE#
RLR	REDUCE LOAD RELAY	1108
RMAR	REMOTE MODE ACTIVE RELAY	606
RTD	RESISTIVE TEMPERATURE DETECTOR	1508
SAL	SUMMARY ALARM LAMP	1117
SAR	SUMMARY ALARM RELAY	1115
SCS	SPEED CONTROL RELAY	817
SFAR	SPEED FAILURE(SENSOR) ALARM RELAY	418
SFL	SPEED FAILURE(SENSOR) LIGHT	648
SLS	ACKNOWLEDGE/LAMP TEST SWITCH	1024
SOL	STARTING OIL PRESSURE LIGHT	642
SOS	STARTING OIL SENSOR SWITCH	632
SOSR	STARTING OIL SENSOR RELAY	632
SOSRX	STARTING OIL PRESSURE AUXILIARY RELAY	638
SSL	SUMMARY SHUTDOWN LAMP	1120
SSR	SUMMARY SHUTDOWN RELAY	546
SSRX	SUMMARY SHUTDOWN AUXILIARY RELAY	550
SWPLA	SEAWATER PRESSURE LOW ALARM	968
TAOI	AC/OC INLET TEMPERATURE	1575
TB	TERMINAL BLOCK	350
TBST	INLET AIR MANIFOLD(BOOST) TEMPERATURE RTD	1562
TEITL	EXHAUST INLET TO TURBO LEFT	1256
TEITR	EXHAUST INLET TO TURBO RIGHT	1334
TEP#	EXHAUST PORT NUMBER	1266
TESL	EXHAUST STACK LEFT	1260
TESR	EXHAUST STACK RIGHT	1339
TF	FUEL TO ENGINE TEMPERATURE RTD	1566
TGDEB	GENERATOR DRIVE END BEARING TEMP RTD	1511
TGNDEB	GENERATOR NON DR END BEARING TEMP RTD	1506
TGSA	GENERATOR STATOR A TEMPERATURE RTD	1516
TGSB	GENERATOR STATOR B TEMPERATURE RTD	1520
TGSC	GENERATOR STATOR C TEMPERATURE RTD	1525
TJWO	JACKET WATER TEMPERATURE RTD	1570
TJWO2	REDUNDANT JACKET WATER TEMP RTD	1579
TM	TACHOMETER	402
TO	OIL TEMPERATURE RTD	1557
VDC	VOLTAGE DIRECT CURRENT	414
WLLA	WATER LEVEL LOW ALARM	966

SYMBOLS

- INTERNAL WIRING
- FACTORY WIRING
- CUSTOMER PROVIDED WIRING
- INTERCONNECT WIRING
- ENGINE MOUNTED TERMINAL BOX TERMINAL BLOCK
- GMS PANEL TERMINAL BLOCK
- GENERATOR LUBE CONTROL PANEL TERMINAL BLOCK
- TD — TIME DELAY
- BATTERY
- LIQUID LEVEL SWITCH
- CIRCUIT BREAKER
- DIODE
- STANDARD RELAY COIL/SOLENIOD
- OPEN RELAY CONTACTS
- CLOSED RELAY CONTACTS
- PRESSURE SWITCH
- TEMPERATURE SWITCH
- ENGINE SOLENOID
- LAMP
- THERMOCOUPLE
- RESISTIVE TEMPERATURE DEVICE (RTD)
- F/I — FREQUENCY TRANSDUCER
- P/I — PRESSURE TRANSDUCER
- SOS — STARTING OIL SENSOR SWITCH
- EMERGENCY STOP
- METER
- NORMALLY CLOSED SWITCH
- NORMALLY OPEN SWITCH
- JWDS — JACKET WATER DETECTION SWITCH
- MPU — MAGNETIC PICKUP
- GROUND CONNECTION
- PARTICLE DETECTOR

1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL

Caterpillar: Confidential YELLOW

DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC

SCALE 1 = 1 — THIRD ANGLE PROJECTION — SHEET 2 OF 25

CHG	DATE
01	03FEB09
00	30JUN08

CATERPILLAR INC.

DIAGRAM-WIRING (YRSL-JBF1)

334-3086 VER - DES X SUB CONTROL W867 D

LEGEND

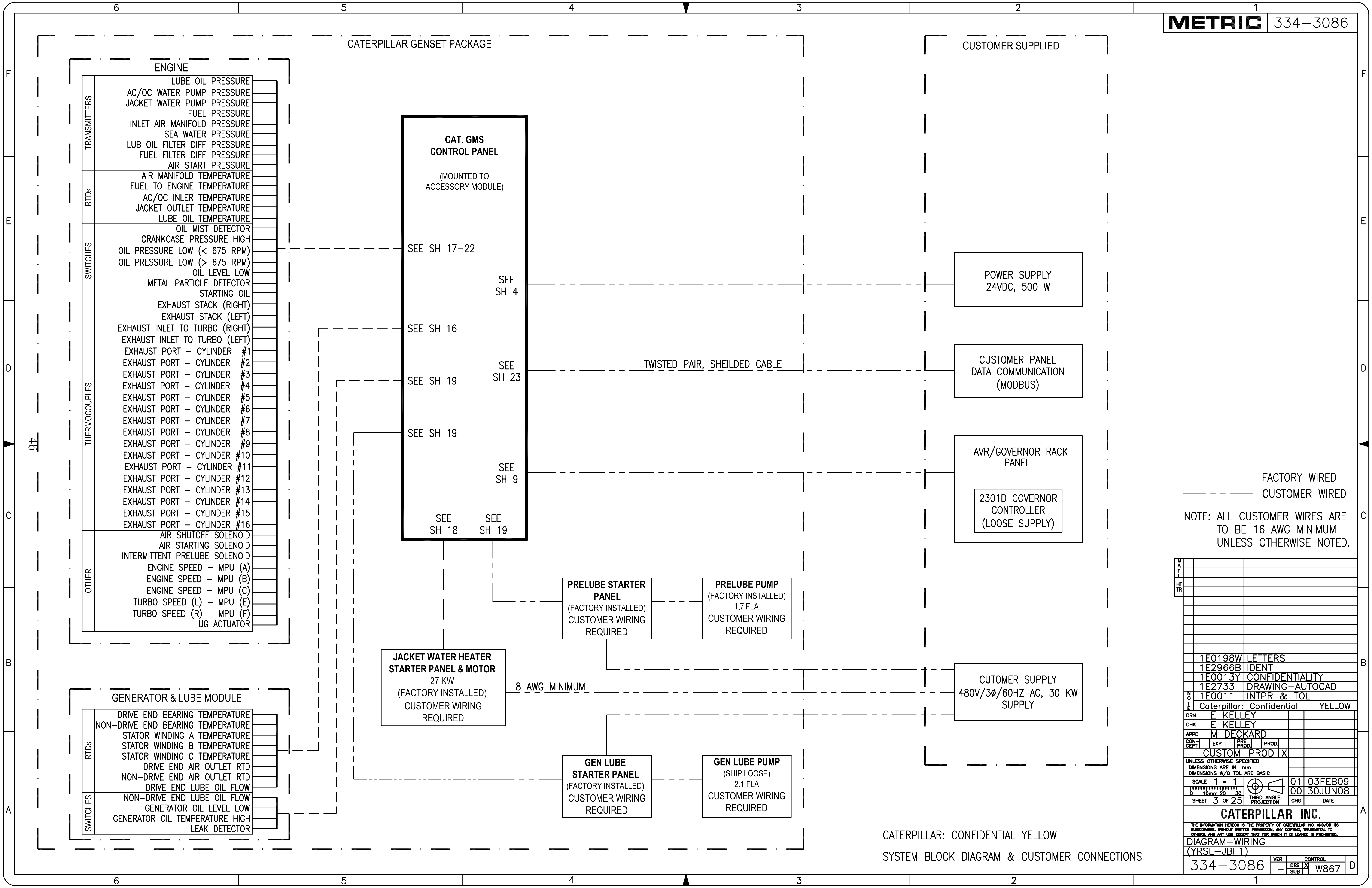

METRIC 334-3086
CATERPILLAR GENSET PACKAGE
ENGINE
TRANSMITTERS
LUBE OIL PRESSURE
AC/OC WATER PUMP PRESSURE
JACKET WATER PUMP PRESSURE
FUEL PRESSURE
INLET AIR MANIFOLD PRESSURE
SEA WATER PRESSURE
LUB OIL FILTER DIFF PRESSURE
FUEL FILTER DIFF PRESSURE
AIR START PRESSURE
RTDs
AIR MANIFOLD TEMPERATURE
FUEL TO ENGINE TEMPERATURE
AC/OC INLER TEMPERATURE
JACKET OUTLET TEMPERATURE
LUBE OIL TEMPERATURE
SWITCHES
OIL MIST DETECTOR
CRANKCASE PRESSURE HIGH
OIL PRESSURE LOW (< 675 RPM)
OIL PRESSURE LOW (> 675 RPM)
OIL LEVEL LOW
METAL PARTICLE DETECTOR
STARTING OIL
THERMOCOUPLES
EXHAUST STACK (RIGHT)
EXHAUST STACK (LEFT)
EXHAUST INLET TO TURBO (RIGHT)
EXHAUST INLET TO TURBO (LEFT)
EXHAUST PORT – CYLINDER #1
EXHAUST PORT – CYLINDER #2
EXHAUST PORT – CYLINDER #3
EXHAUST PORT – CYLINDER #4
EXHAUST PORT – CYLINDER #5
EXHAUST PORT – CYLINDER #6
EXHAUST PORT – CYLINDER #7
EXHAUST PORT – CYLINDER #8
EXHAUST PORT – CYLINDER #9
EXHAUST PORT – CYLINDER #10
EXHAUST PORT – CYLINDER #11
EXHAUST PORT – CYLINDER #12
EXHAUST PORT – CYLINDER #13
EXHAUST PORT – CYLINDER #14
EXHAUST PORT – CYLINDER #15
EXHAUST PORT – CYLINDER #16
OTHER
AIR SHUTOFF SOLENOID
AIR STARTING SOLENOID
INTERMITTENT PRELUBE SOLENOID
ENGINE SPEED – MPU (A)
ENGINE SPEED – MPU (B)
ENGINE SPEED – MPU (C)
TURBO SPEED (L) – MPU (E)
TURBO SPEED (R) – MPU (F)
UG ACTUATOR
GENERATOR & LUBE MODULE
RTDs
DRIVE END BEARING TEMPERATURE
NON-DRIVE END BEARING TEMPERATURE
STATOR WINDING A TEMPERATURE
STATOR WINDING B TEMPERATURE
STATOR WINDING C TEMPERATURE
DRIVE END AIR OUTLET RTD
NON-DRIVE END AIR OUTLET RTD
DRIVE END LUBE OIL FLOW
SWITCHES
NON-DRIVE END LUBE OIL FLOW
GENERATOR OIL LEVEL LOW
GENERATOR OIL TEMPERATURE HIGH
LEAK DETECTOR
CAT. GMS CONTROL PANEL
(MOUNTED TO ACCESSORY MODULE)
SEE SH 17-22
SEE SH 4
SEE SH 16
SEE SH 23
SEE SH 19
SEE SH 19
SEE SH 9
SEE SH 18
SEE SH 19
TWISTED PAIR, SHEILDED CABLE
JACKET WATER HEATER STARTER PANEL & MOTOR
27 KW
(FACTORY INSTALLED)
CUSTOMER WIRING REQUIRED
8 AWG MINIMUM
PRELUBE STARTER PANEL
(FACTORY INSTALLED)
CUSTOMER WIRING REQUIRED
PRELUBE PUMP
(FACTORY INSTALLED)
1.7 FLA
CUSTOMER WIRING REQUIRED
GEN LUBE STARTER PANEL
(FACTORY INSTALLED)
CUSTOMER WIRING REQUIRED
GEN LUBE PUMP
(SHIP LOOSE)
2.1 FLA
CUSTOMER WIRING REQUIRED
CUSTOMER SUPPLIED
POWER SUPPLY 24VDC, 500 W
CUSTOMER PANEL DATA COMMUNICATION (MODBUS)
AVR/GOVERNOR RACK PANEL
2301D GOVERNOR CONTROLLER (LOOSE SUPPLY)
CUTOMER SUPPLY 480V/3Ø/60HZ AC, 30 KW SUPPLY
FACTORY WIRED
CUSTOMER WIRED
NOTE: ALL CUSTOMER WIRES ARE TO BE 16 AWG MINIMUM UNLESS OTHERWISE NOTED.
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN mm
DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 3 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
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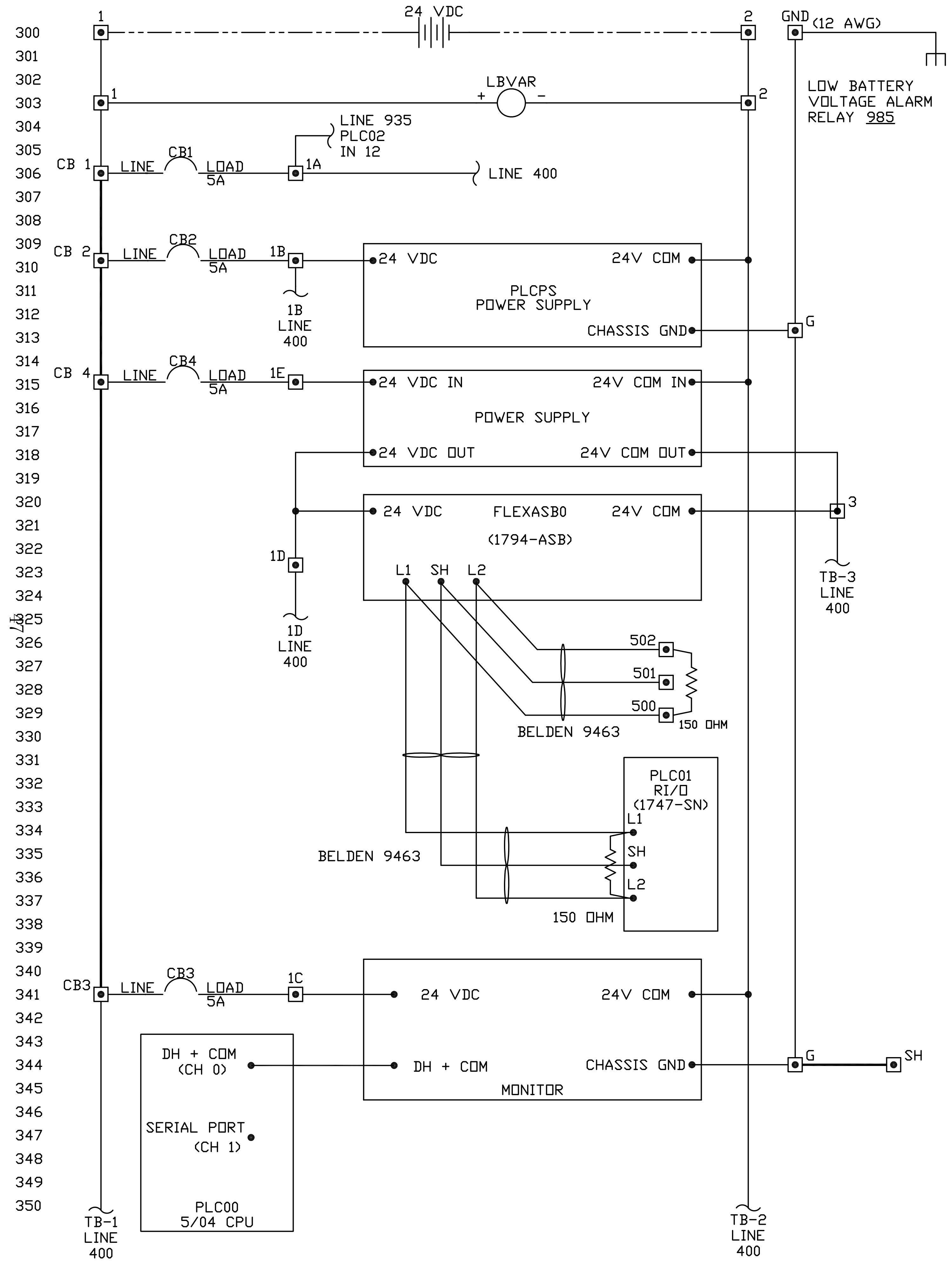
DIAGRAM-WIRING
(YRSL-JBF1)
334-3086
W867
CATERPILLAR: CONFIDENTIAL YELLOW
SYSTEM BLOCK DIAGRAM & CUSTOMER CONNECTIONS

METRIC 334-3086



ENGINE CONTROL SWITCH (ECS)

CONTACT BLOCKS	CONTACTS	OFF/ RESET	LOCAL	REMOTE	LINE NO.
LEFT	L11–L12	□	X	X	510
	L23–L24	X	□	□	607
	L31–L32	□	X	X	620
RIGHT	R11–R12	X	X	□	620
	R23–R24	□	□	X	606

SCHEMATIC INDICATES STATES OF ECS CONTACTS IN THE <u>OFF</u> POSITION.

PRELUBE / START SWITCH (PSS)

CONTACT BLOCKS	CONTACTS	PRELUBE	↑	START	LINE NO.
LEFT	L13–L14	X	□	□	629
RIGHT	R13–R14	□	□	X	620

SCHEMATIC INDICATES STATES OF PSS CONTACTS IN THE <u>CENTER</u> POSITION.

SILENCE/LAMP TEST SWITCH (SLS)

CONTACT BLOCKS	CONTACTS	SILENCE	↑	TEST	LINE NO.
LEFT	L13–L14	X	□	□	1025
RIGHT	R13–R14	□	□	X	1028
RIGHT	R23–R24	□	□	X	642

SCHEMATIC INDICATES STATES OF ARS CONTACTS IN THE <u>CENTER</u> POSITION.

IDLE/RATED SWITCH (IRS)

CONTACT BLOCKS	CONTACTS	IDLE	RATED	LINE NO.
RIGHT	R13–R14	□	X	807

SCHEMATIC INDICATES STATES OF IRS CONTACTS IN THE <u>IDLE</u> POSITION.

FUEL CONTROL SWITCH (FCS)

CONTACT BLOCKS	CONTACTS	OFF	ON	LINE NO.
LEFT	L11–L12	X	□	611
RIGHT	R13–R14	□	X	1005

SCHEMATIC INDICATES STATES OF FCS CONTACTS IN THE <u>OFF</u> POSITION.

EMERGENCY STOP SWITCH (ES)

CONTACT BLOCKS	CONTACTS	DEACTIVATED	ACTIVATED	LINE NO.
LEFT	L13–L14	□	X	445
RIGHT	R13–R14	□	X	446

SCHEMATIC INDICATES STATES OF ES CONTACTS IN THE <u>DEACTIVATED</u> POSITION.

SPEED CONTROL SWITCH (SCS)

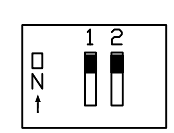
CONTACT BLOCKS	CONTACTS	DECREASE	↑	INCREASE	LINE NO.
LEFT	L13–L14	X	□	□	817
RIGHT	L13–L14	□	□	X	820

SPRING RETURN FROM LEFT AND RIGHT TO CENTER. SCHEMATIC INDICATES STATES OF SCS CONTACTS IN THE <u>CENTER</u> POSITION.

X INDICATES A CLOSED CONTACT
□ INDICATES AN OPEN CONTACT

LEFT AND RIGHT SIDE OF SWITCH ARE VIEWED FROM REAR OF PANEL DOOR.

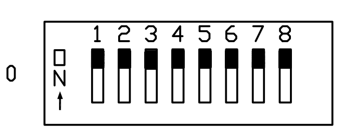
<u>DIP SWITCHES 1747-SN</u>



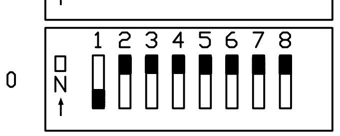
1	2	
ON	ON	56K
ON	OFF	115.2K
OFF	ON	230.4K
OFF	OFF	230.4K

<u>DIP SWITCHES 1794-ASB</u>

SWITCH 1 - RACK 0



SWITCH 2 - RACK 0



1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL

Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 4 OF 25
THIRD ANGLE PROJECTION

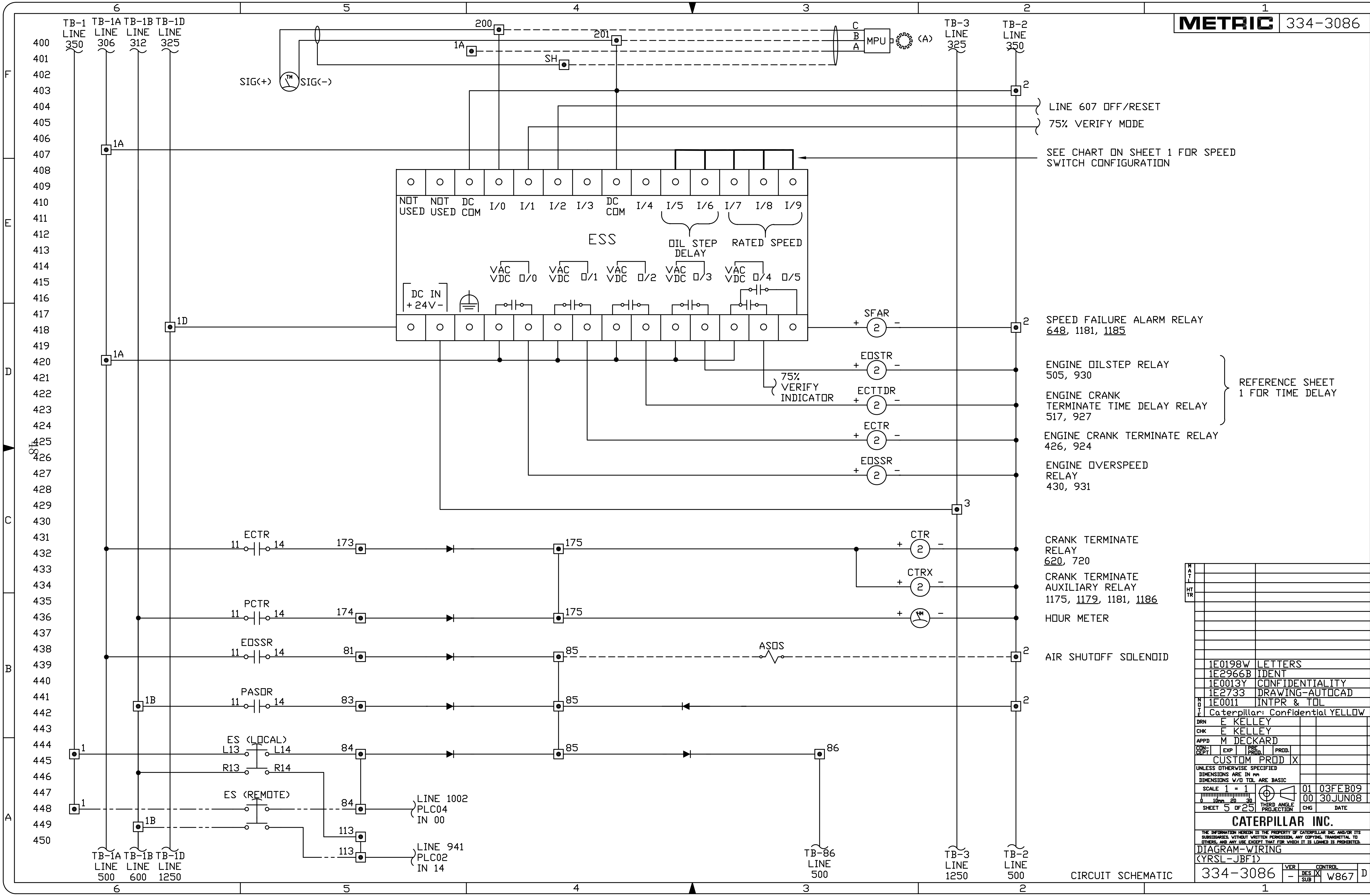
CHG	DATE
01	03FEB09
00	30JUN08

CATERPILLAR INC.

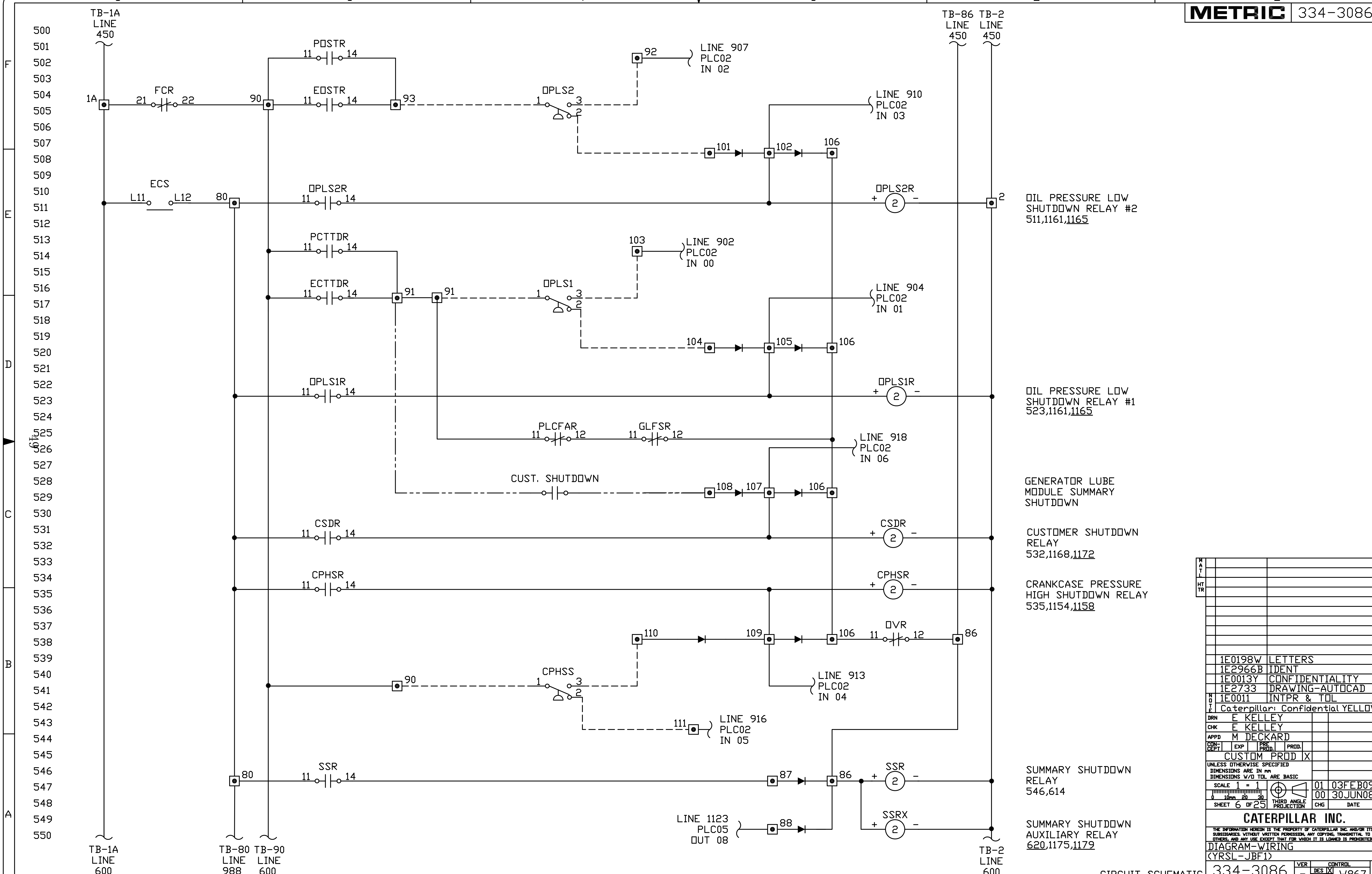
DIAGRAM-WIRING (YRSL-JBF1)

CIRCUIT SCHEMATIC

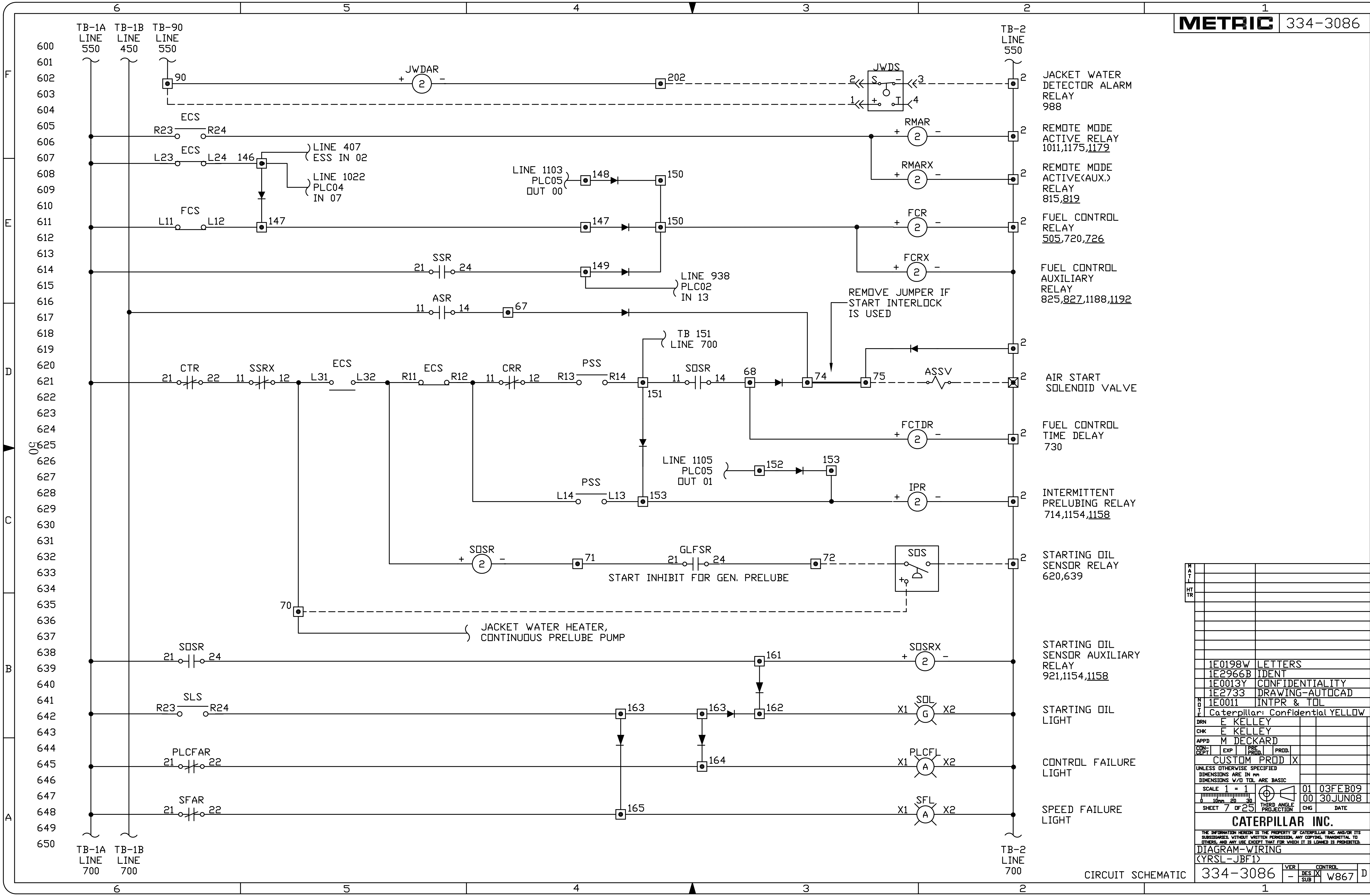
334-3086 VER - DES X SUB CONTROL W867 D

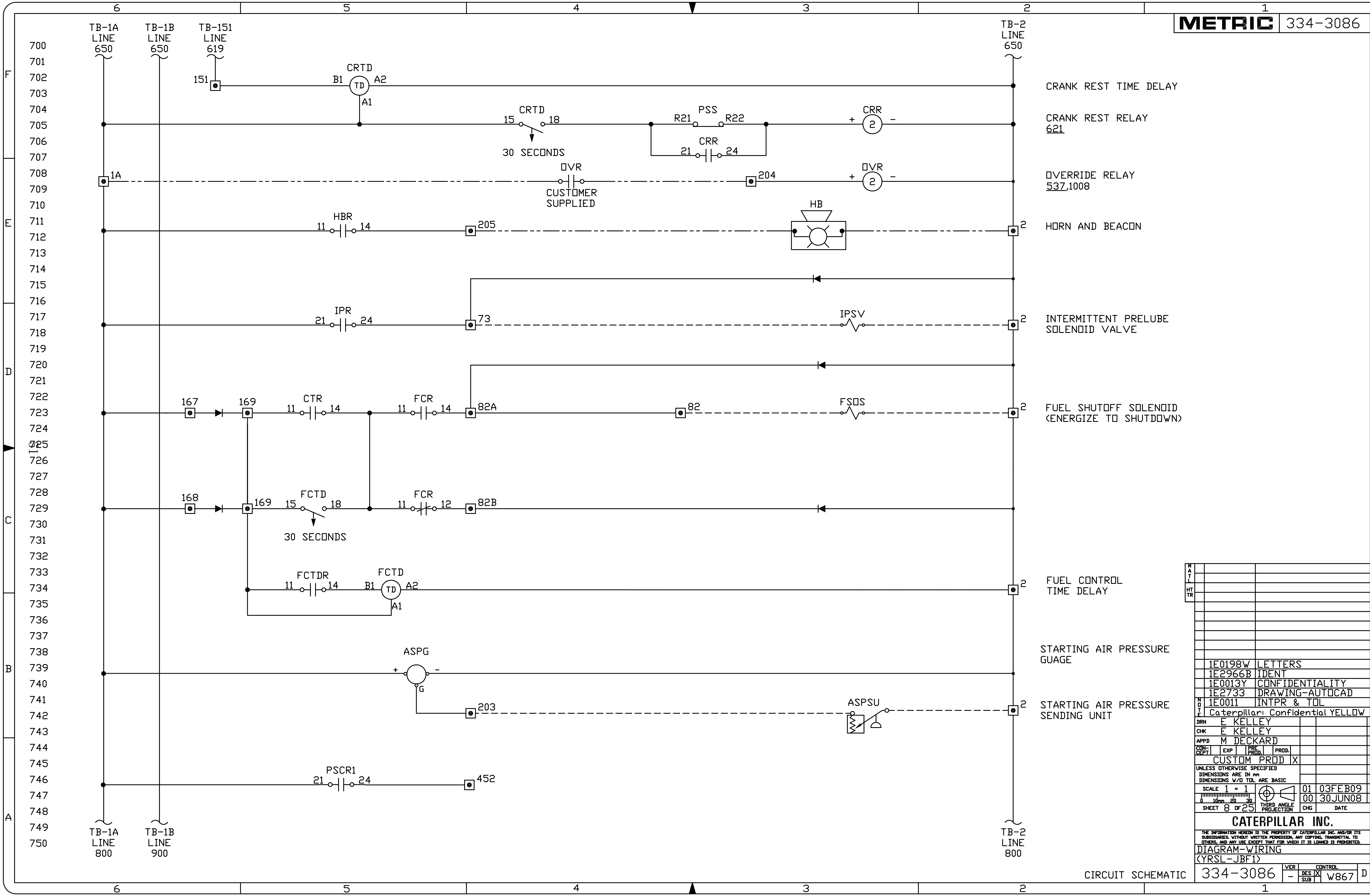


METRIC 334-3086
TB-1 LINE 350
TB-1A LINE 306
TB-1B LINE 312
TB-1D LINE 325
TB-3 LINE 325
TB-2 LINE 350
MPU
(A)
SIG(+)
SIG(-)
200
201
1A
SH
LINE 607 OFF/RESET
75% VERIFY MODE
SEE CHART ON SHEET 1 FOR SPEED SWITCH CONFIGURATION
NOT USED
NOT USED
DC COM
I/0
I/1
I/2
I/3
DC COM
I/4
I/5
I/6
I/7
I/8
I/9
ESS
OIL STEP DELAY
RATED SPEED
VAC VDC O/0
VAC VDC O/1
VAC VDC O/2
VAC VDC O/3
VAC VDC O/4
O/5
DC IN +24V-
SFAR
SPEED FAILURE ALARM RELAY 648, 1181, 1185
EOSTR
ENGINE OILSTEP RELAY 505, 930
75% VERIFY INDICATOR
ECTTDR
ENGINE CRANK TERMINATE TIME DELAY RELAY 517, 927
REFERENCE SHEET 1 FOR TIME DELAY
ECTR
ENGINE CRANK TERMINATE RELAY 426, 924
EOSSR
ENGINE OVERSPEED RELAY 430, 931
CTR
CRANK TERMINATE RELAY 620, 720
CTRX
CRANK TERMINATE AUXILIARY RELAY 1175, 1179, 1181, 1186
HOUR METER
ASOS
AIR SHUTOFF SOLENOID
PCTR
EOSSR
PASOR
ES (LOCAL)
L13
L14
R13
R14
ES (REMOTE)
173
174
81
83
84
175
85
86
113
LINE 1002 PLC04 IN 00
LINE 941 PLC02 IN 14
TB-1A LINE 500
TB-1B LINE 600
TB-1D LINE 1250
TB-86 LINE 500
TB-3 LINE 1250
TB-2 LINE 500
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 5 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CATERPILLAR INC.
DIAGRAM-WIRING (YRSL-JBF1)
CIRCUIT SCHEMATIC
334-3086
W867
D

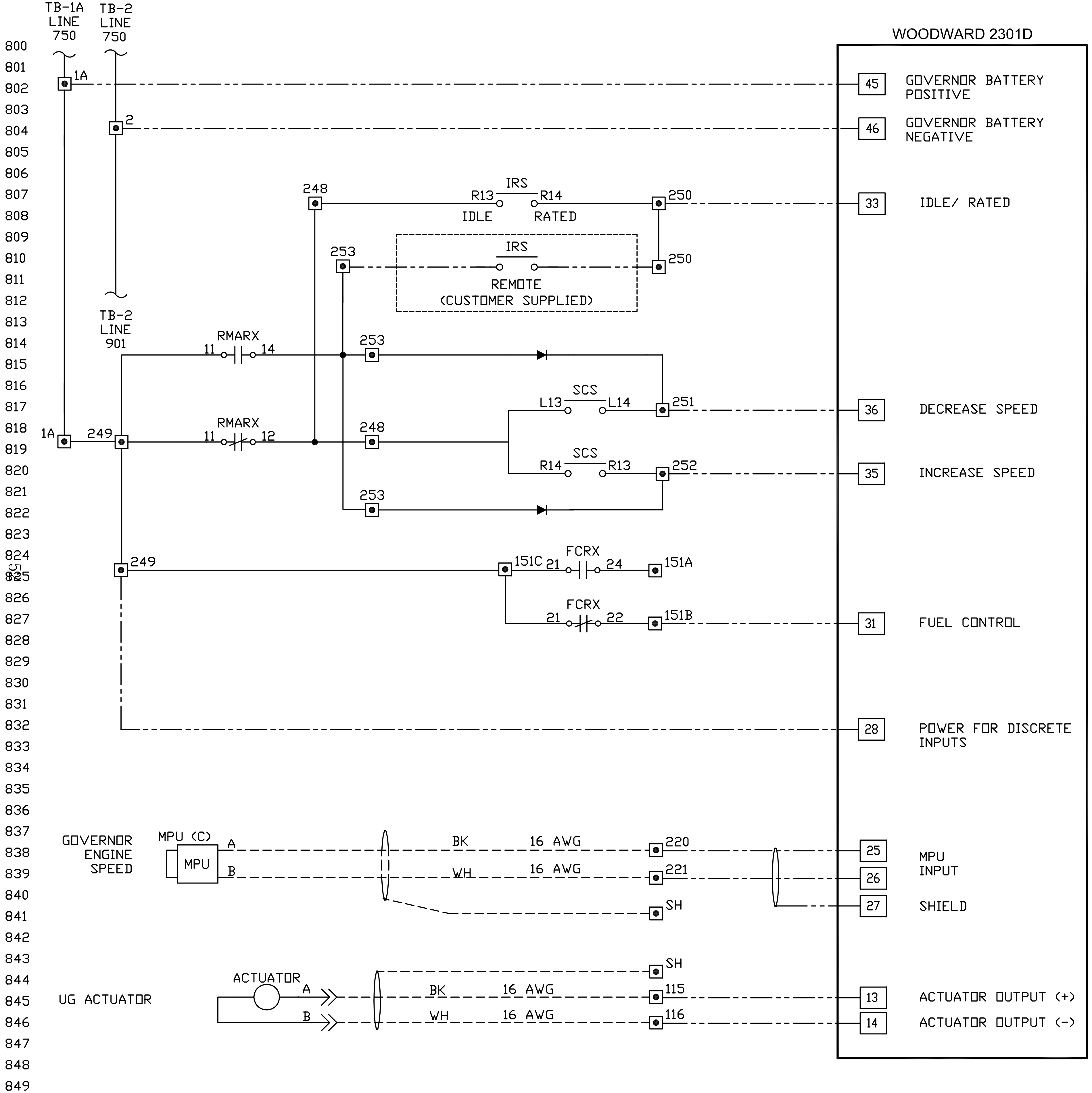


METRIC 334-3086
TB-1A LINE 450
TB-86 LINE 450
TB-2 LINE 450
POSTR
FCR
EOSTR
OPLS2
LINE 907 PLC02 IN 02
LINE 910 PLC02 IN 03
ECS
OPLS2R
OIL PRESSURE LOW SHUTDOWN RELAY #2 511,1161,1165
PCTTDR
ECTTDR
OPLS1
LINE 902 PLC02 IN 00
LINE 904 PLC02 IN 01
OPLS1R
OIL PRESSURE LOW SHUTDOWN RELAY #1 523,1161,1165
PLCFAR
GLFSR
LINE 918 PLC02 IN 06
CUST. SHUTDOWN
GENERATOR LUBE MODULE SUMMARY SHUTDOWN
CSDR
CUSTOMER SHUTDOWN RELAY 532,1168,1172
CPHSR
CRANKCASE PRESSURE HIGH SHUTDOWN RELAY 535,1154,1158
OVR
CPHSS
LINE 913 PLC02 IN 04
LINE 916 PLC02 IN 05
SSR
SUMMARY SHUTDOWN RELAY 546,614
LINE 1123 PLC05 OUT 08
SSRX
SUMMARY SHUTDOWN AUXILIARY RELAY 620,1175,1179
TB-1A LINE 600
TB-80 LINE 988
TB-90 LINE 600
TB-2 LINE 600
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 6 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CATERPILLAR INC.
DIAGRAM-WIRING (YRSL-JBF1)
CIRCUIT SCHEMATIC
334-3086
W867 D


METRIC 334-3086
TB-1A LINE 550
TB-1B LINE 450
TB-90 LINE 550
TB-2 LINE 550
JWDAR
JWDS
JACKET WATER DETECTOR ALARM RELAY 988
ECS
RMAR
REMOTE MODE ACTIVE RELAY 1011,1175,1179
LINE 407 ESS IN 02
LINE 1022 PLC04 IN 07
LINE 1103 PLC05 OUT 00
RMARX
REMOTE MODE ACTIVE(AUX.) RELAY 815,819
FCS
FCR
FUEL CONTROL RELAY 505,720,726
SSR
FCRX
LINE 938 PLC02 IN 13
FUEL CONTROL AUXILIARY RELAY 825,827,1188,1192
ASR
REMOVE JUMPER IF START INTERLOCK IS USED
TB 151 LINE 700
CTR
SSRX
CRR
PSS
SOSR
ASSV
AIR START SOLENOID VALVE
FCTDR
FUEL CONTROL TIME DELAY 730
LINE 1105 PLC05 OUT 01
IPR
INTERMITTENT PRELUBING RELAY 714,1154,1158
GLFSR
START INHIBIT FOR GEN. PRELUBE
SOS
STARTING OIL SENSOR RELAY 620,639
JACKET WATER HEATER, CONTINUOUS PRELUBE PUMP
SOSRX
STARTING OIL SENSOR AUXILIARY RELAY 921,1154,1158
SLS
SOL
STARTING OIL LIGHT
PLCFAR
PLCFL
CONTROL FAILURE LIGHT
SFAR
SFL
SPEED FAILURE LIGHT
TB-1A LINE 700
TB-1B LINE 700
TB-2 LINE 700
CIRCUIT SCHEMATIC
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 7 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CATERPILLAR INC.
DIAGRAM-WIRING (YRSL-JBF1)
334-3086
W867 D


METRIC 334-3086
TB-1A LINE 650
TB-1B LINE 650
TB-151 LINE 619
TB-2 LINE 650
CRANK REST TIME DELAY
CRANK REST RELAY 621
OVERRIDE RELAY 537,1008
HORN AND BEACON
INTERMITTENT PRELUBE SOLENOID VALVE
FUEL SHUTOFF SOLENOID (ENERGIZE TO SHUTDOWN)
FUEL CONTROL TIME DELAY
STARTING AIR PRESSURE GUAGE
STARTING AIR PRESSURE SENDING UNIT
CRTD
CRR
PSS
OVR
CUSTOMER SUPPLIED
HBR
HB
IPR
IPSV
CTR
FCR
FSOS
FCTD
FCTDR
30 SECONDS
ASPG
ASPSU
PSCR1
TB-1A LINE 800
TB-1B LINE 900
TB-2 LINE 800
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 8 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CATERPILLAR INC.
DIAGRAM-WIRING (YRSL-JBF1)
CIRCUIT SCHEMATIC
334-3086
W867
D

METRIC 334-3086



1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL

Caterpillar: Confidential YELLOW

DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC

SCALE 1 = 1
SHEET 9 OF 25
THIRD ANGLE PROJECTION

CHG	DATE
01	03FEB09
00	30JUN08

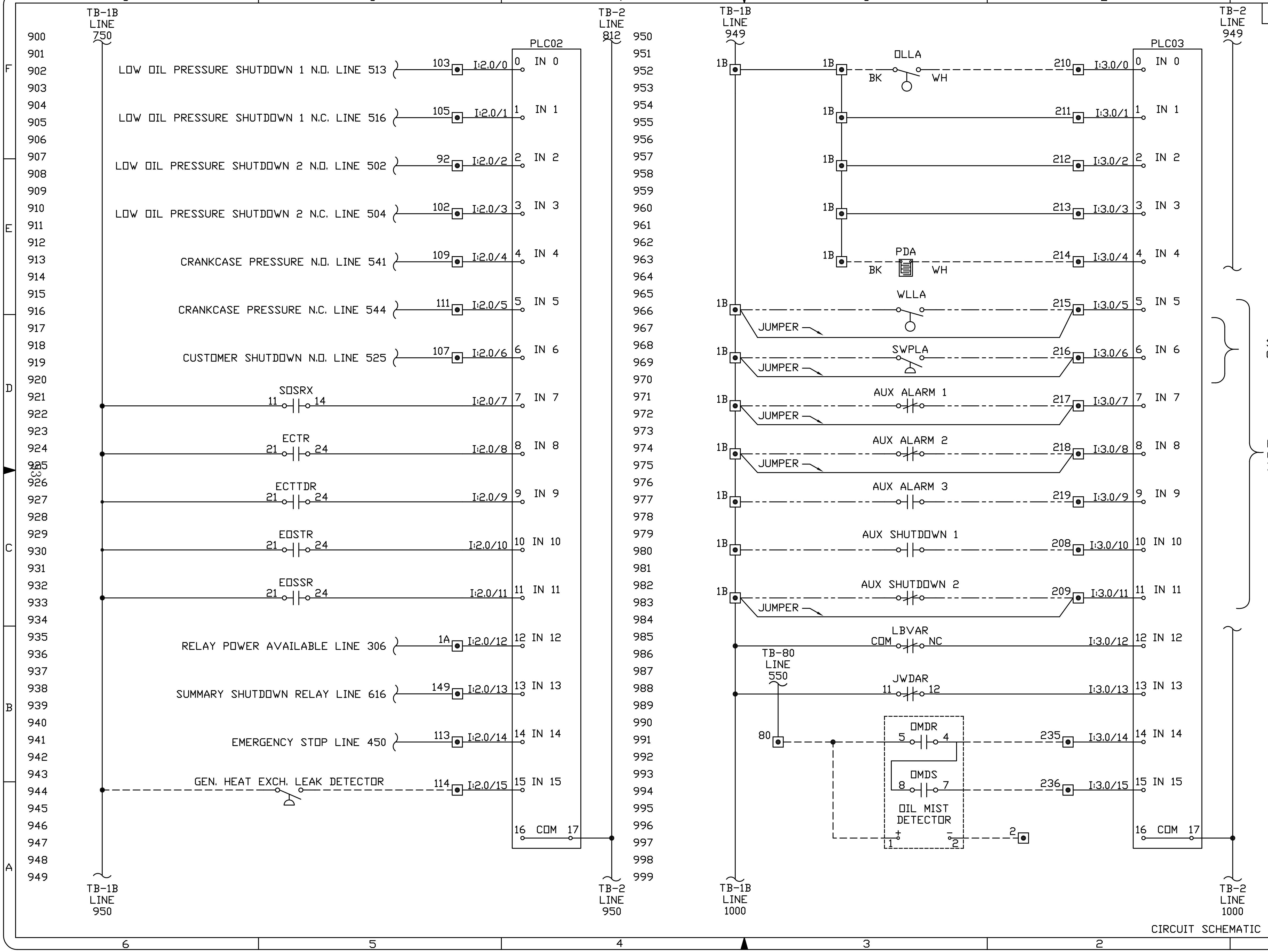
CATERPILLAR INC.

DIAGRAM-WIRING (YRSL-JBF1)

GOVERNOR SCHEMATIC

334-3086 VER - DES X CONTROL W867 D

METRIC 334-3086



1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL

Caterpillar: Confidential Yellow

DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC

SCALE 1 = 1
SHEET 10 OF 25
THIRD ANGLE PROJECTION

CHG	DATE
01	03FEB09
00	30JUN08

CATERPILLAR INC.

DIAGRAM-WIRING
(YRSL-JBF1)

CIRCUIT SCHEMATIC

334-3086 - DES X W867 D

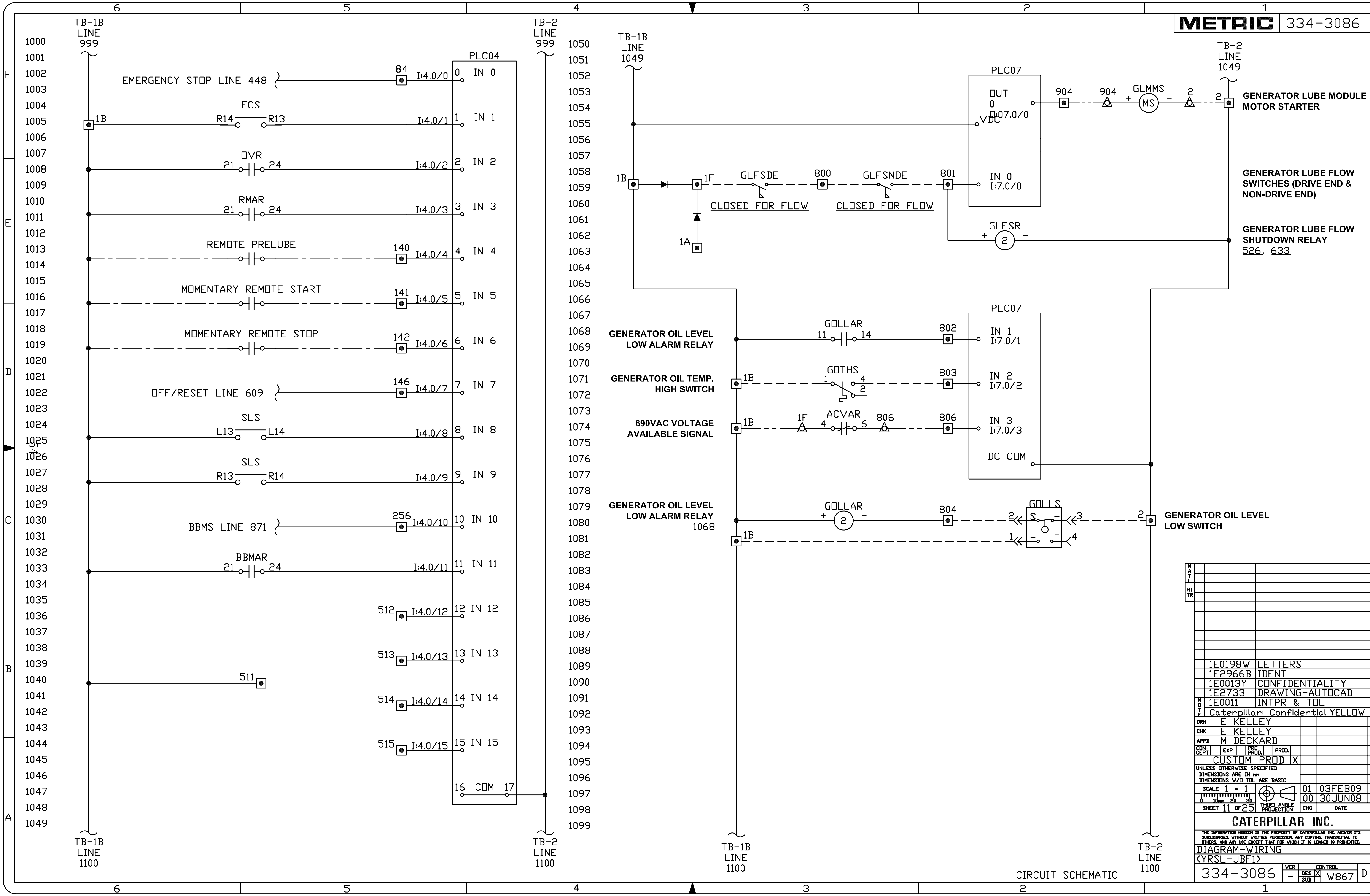

METRIC 334-3086
TB-1B LINE 999
TB-2 LINE 999
TB-1B LINE 1100
TB-2 LINE 1100
PLC04
EMERGENCY STOP LINE 448
FCS
R14
R13
OVR
RMAR
REMOTE PRELUBE
MOMENTARY REMOTE START
MOMENTARY REMOTE STOP
OFF/RESET LINE 609
SLS
L13
L14
BBMS LINE 871
BBMAR
I:4.0/0
I:4.0/1
I:4.0/2
I:4.0/3
I:4.0/4
I:4.0/5
I:4.0/6
I:4.0/7
I:4.0/8
I:4.0/9
I:4.0/10
I:4.0/11
I:4.0/12
I:4.0/13
I:4.0/14
I:4.0/15
IN 0
IN 1
IN 2
IN 3
IN 4
IN 5
IN 6
IN 7
IN 8
IN 9
IN 10
IN 11
IN 12
IN 13
IN 14
IN 15
COM
TB-1B LINE 1049
TB-2 LINE 1049
PLC07
OUT 0
O:07.0/0
VDC
IN 0
I:7.0/0
GLMMS
MS
GENERATOR LUBE MODULE MOTOR STARTER
GLFSDE
GLFSNDE
CLOSED FOR FLOW
GENERATOR LUBE FLOW SWITCHES (DRIVE END & NON-DRIVE END)
GLFSR
GENERATOR LUBE FLOW SHUTDOWN RELAY
526, 633
GOLLAR
GOTHS
ACVAR
IN 1
I:7.0/1
IN 2
I:7.0/2
IN 3
I:7.0/3
DC COM
GENERATOR OIL LEVEL LOW ALARM RELAY
GENERATOR OIL TEMP. HIGH SWITCH
690VAC VOLTAGE AVAILABLE SIGNAL
GENERATOR OIL LEVEL LOW ALARM RELAY 1068
GOLLS
GENERATOR OIL LEVEL LOW SWITCH
TB-1B LINE 1100
TB-2 LINE 1100
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 11 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
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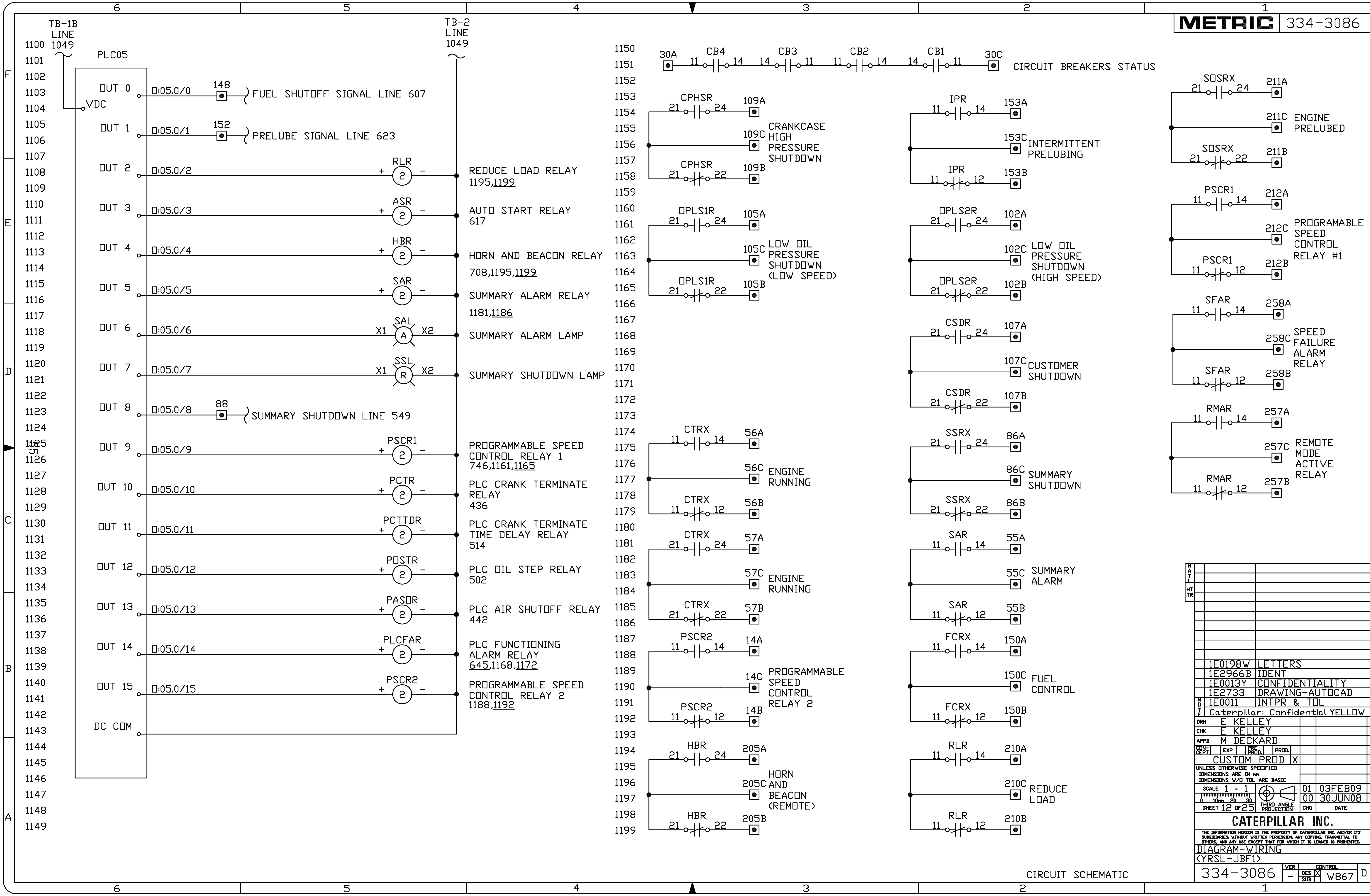
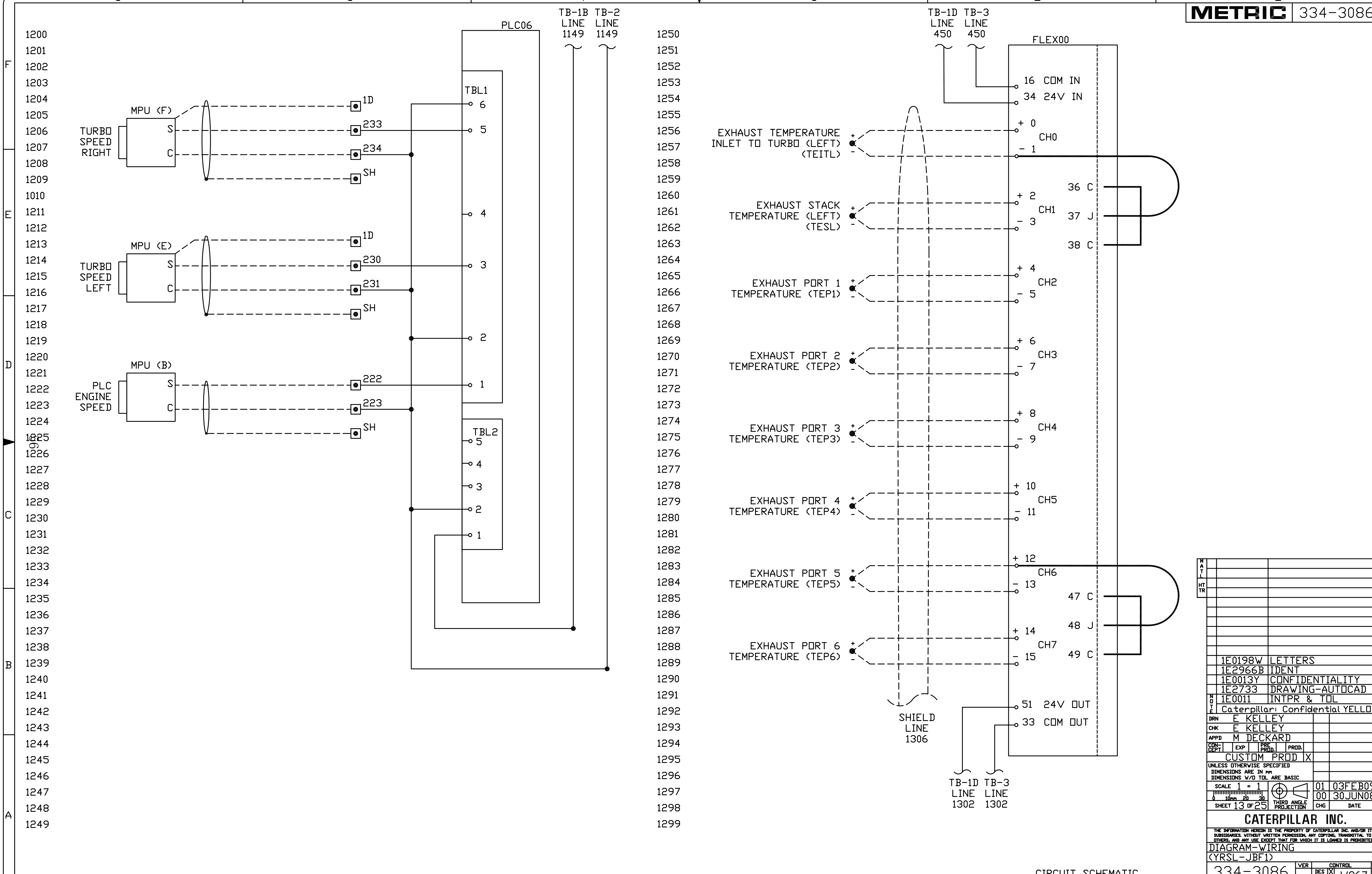
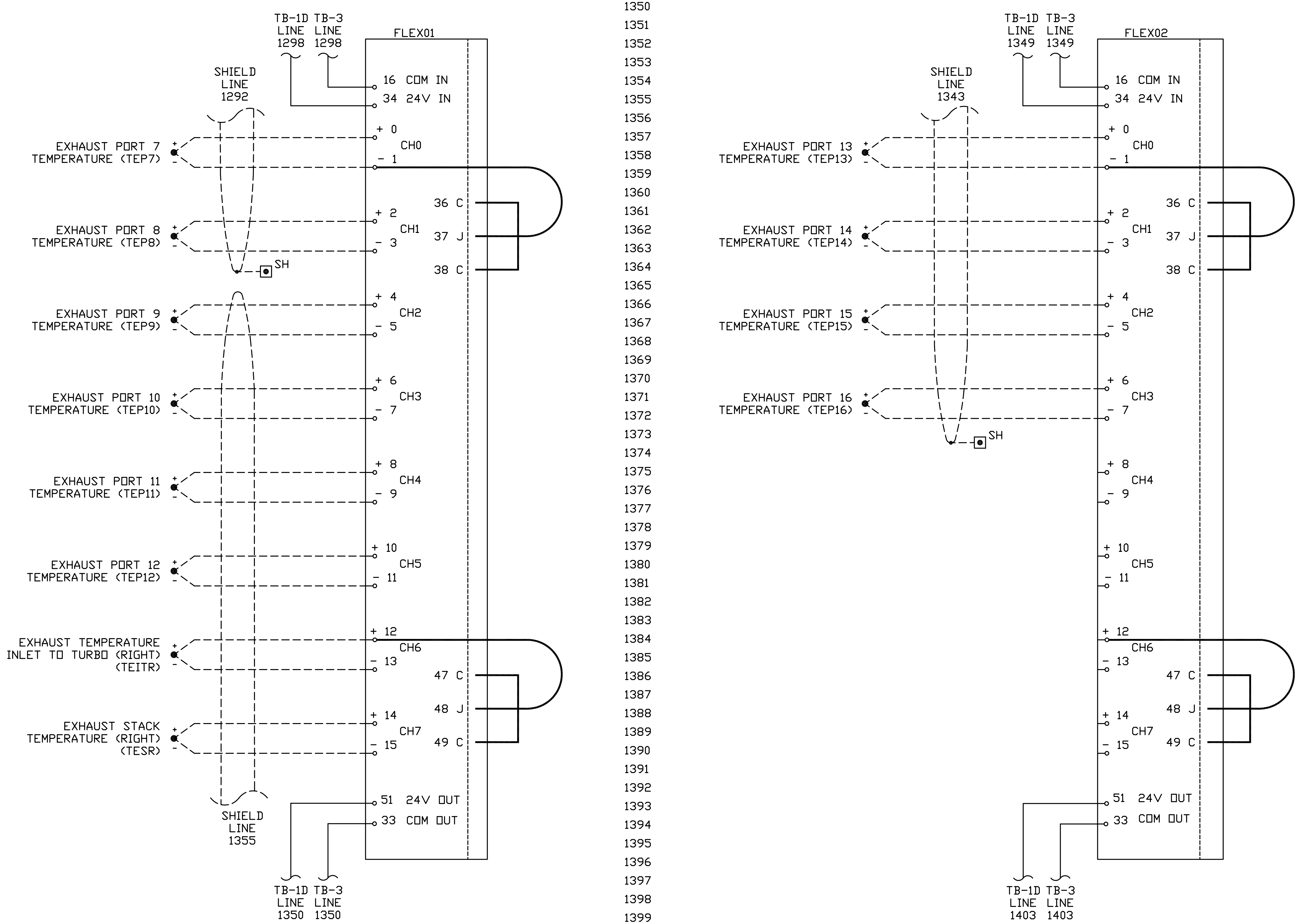
DIAGRAM-WIRING
(YRSL-JBF1)
334-3086
W867
D
CIRCUIT SCHEMATIC


METRIC 334-3086
TB-1B LINE 1049
PLC05
VDC
OUT 0 O:05.0/0 148 FUEL SHUTOFF SIGNAL LINE 607
OUT 1 O:05.0/1 152 PRELUBE SIGNAL LINE 623
OUT 2 O:05.0/2 RLR REDUCE LOAD RELAY 1195,1199
OUT 3 O:05.0/3 ASR AUTO START RELAY 617
OUT 4 O:05.0/4 HBR HORN AND BEACON RELAY 708,1195,1199
OUT 5 O:05.0/5 SAR SUMMARY ALARM RELAY 1181,1186
OUT 6 O:05.0/6 SAL SUMMARY ALARM LAMP
OUT 7 O:05.0/7 SSL SUMMARY SHUTDOWN LAMP
OUT 8 O:05.0/8 88 SUMMARY SHUTDOWN LINE 549
OUT 9 O:05.0/9 PSCR1 PROGRAMMABLE SPEED CONTROL RELAY 1 746,1161,1165
OUT 10 O:05.0/10 PCTR PLC CRANK TERMINATE RELAY 436
OUT 11 O:05.0/11 PCTTDR PLC CRANK TERMINATE TIME DELAY RELAY 514
OUT 12 O:05.0/12 POSTR PLC OIL STEP RELAY 502
OUT 13 O:05.0/13 PASOR PLC AIR SHUTOFF RELAY 442
OUT 14 O:05.0/14 PLCFAR PLC FUNCTIONING ALARM RELAY 645,1168,1172
OUT 15 O:05.0/15 PSCR2 PROGRAMMABLE SPEED CONTROL RELAY 2 1188,1192
DC COM
TB-2 LINE 1049
30A CB4 CB3 CB2 CB1 30C CIRCUIT BREAKERS STATUS
CPHSR 109A 109C CRANKCASE HIGH PRESSURE SHUTDOWN 109B
OPLS1R 105A 105C LOW OIL PRESSURE SHUTDOWN (LOW SPEED) 105B
CTRX 56A 56C ENGINE RUNNING 56B
CTRX 57A 57C ENGINE RUNNING 57B
PSCR2 14A 14C PROGRAMMABLE SPEED CONTROL RELAY 2 14B
HBR 205A 205C HORN AND BEACON (REMOTE) 205B
IPR 153A 153C INTERMITTENT PRELUBING 153B
OPLS2R 102A 102C LOW OIL PRESSURE SHUTDOWN (HIGH SPEED) 102B
CSDR 107A 107C CUSTOMER SHUTDOWN 107B
SSRX 86A 86C SUMMARY SHUTDOWN 86B
SAR 55A 55C SUMMARY ALARM 55B
FCRX 150A 150C FUEL CONTROL 150B
RLR 210A 210C REDUCE LOAD 210B
SOSRX 211A 211C ENGINE PRELUBED 211B
PSCR1 212A 212C PROGRAMABLE SPEED CONTROL RELAY #1 212B
SFAR 258A 258C SPEED FAILURE ALARM RELAY 258B
RMAR 257A 257C REMOTE MODE ACTIVE RELAY 257B
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 12 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CATERPILLAR INC.
DIAGRAM-WIRING (YRSL-JBF1)
CIRCUIT SCHEMATIC
334-3086 - W867 D


METRIC 334-3086
PLC06
TBL1
TBL2
TB-1B LINE 1149
TB-2 LINE 1149
MPU (F)
TURBO SPEED RIGHT
MPU (E)
TURBO SPEED LEFT
MPU (B)
PLC ENGINE SPEED
1D
233
234
SH
230
231
222
223
FLEX00
TB-1D LINE 450
TB-3 LINE 450
16 COM IN
34 24V IN
CH0
CH1
CH2
CH3
CH4
CH5
CH6
CH7
36 C
37 J
38 C
47 C
48 J
49 C
51 24V OUT
33 COM OUT
TB-1D LINE 1302
TB-3 LINE 1302
SHIELD LINE 1306
EXHAUST TEMPERATURE INLET TO TURBO (LEFT) (TEITL)
EXHAUST STACK TEMPERATURE (LEFT) (TESL)
EXHAUST PORT 1 TEMPERATURE (TEP1)
EXHAUST PORT 2 TEMPERATURE (TEP2)
EXHAUST PORT 3 TEMPERATURE (TEP3)
EXHAUST PORT 4 TEMPERATURE (TEP4)
EXHAUST PORT 5 TEMPERATURE (TEP5)
EXHAUST PORT 6 TEMPERATURE (TEP6)
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 13 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CATERPILLAR INC.
DIAGRAM-WIRING (YRSL-JBF1)
CIRCUIT SCHEMATIC
334-3086
W867

METRIC 334-3086



CIRCUIT SCHEMATIC

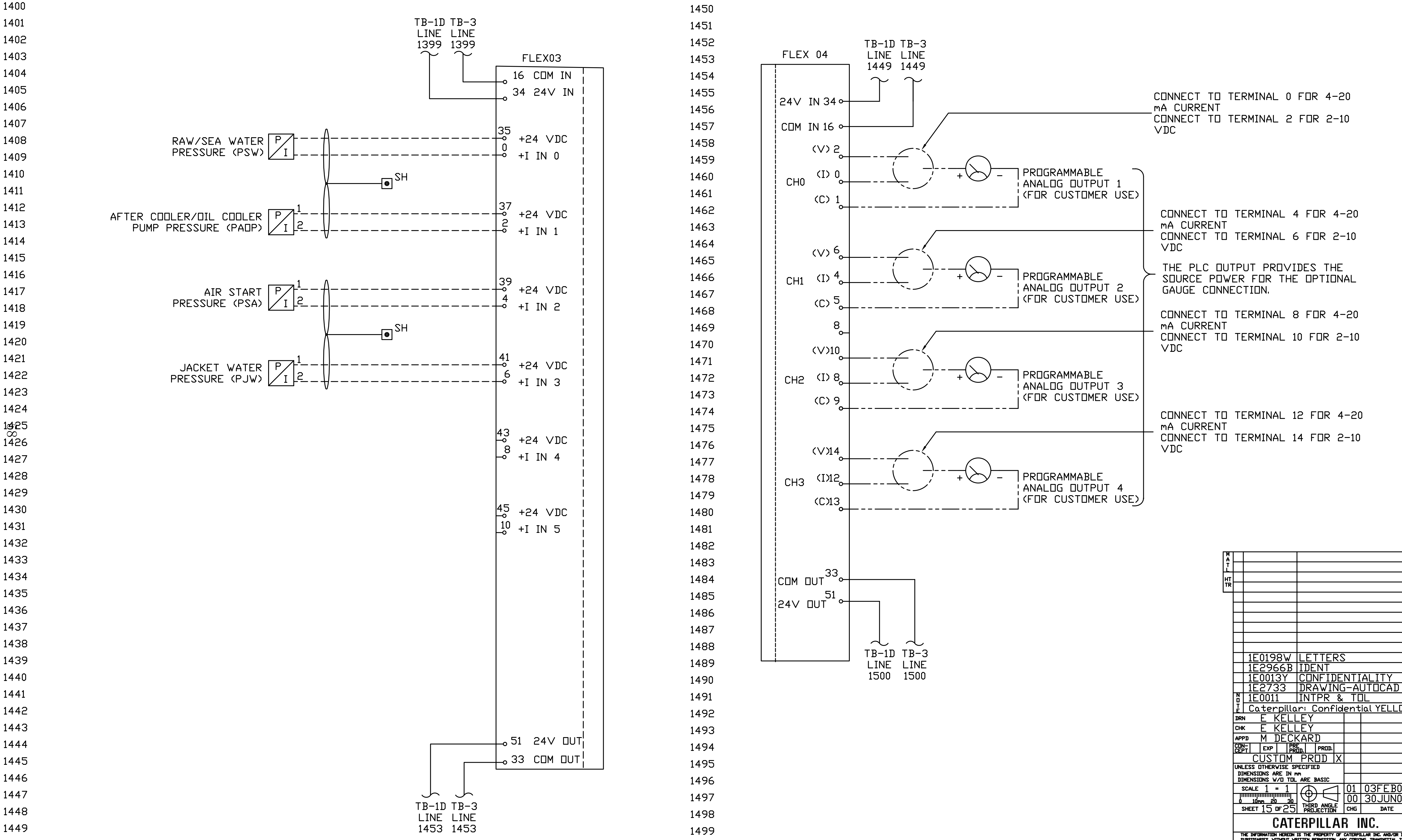
1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL
Caterpillar: Confidential YELLOW	
DRN	E KELLEY
CHK	E KELLEY
APPD	M DECKARD
CUSTOM PROD	X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC	
SCALE 1 = 1	THIRD ANGLE PROJECTION
SHEET 14 OF 25	
01	03FEB09
00	30JUN08

CATERPILLAR INC.

DIAGRAM-WIRING (YRSL-JBF1)

334-3086 VER - CONTROL W867 D

METRIC 334-3086



CIRCUIT SCHEMATIC

1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL

Caterpillar: Confidential YELLOW

DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC

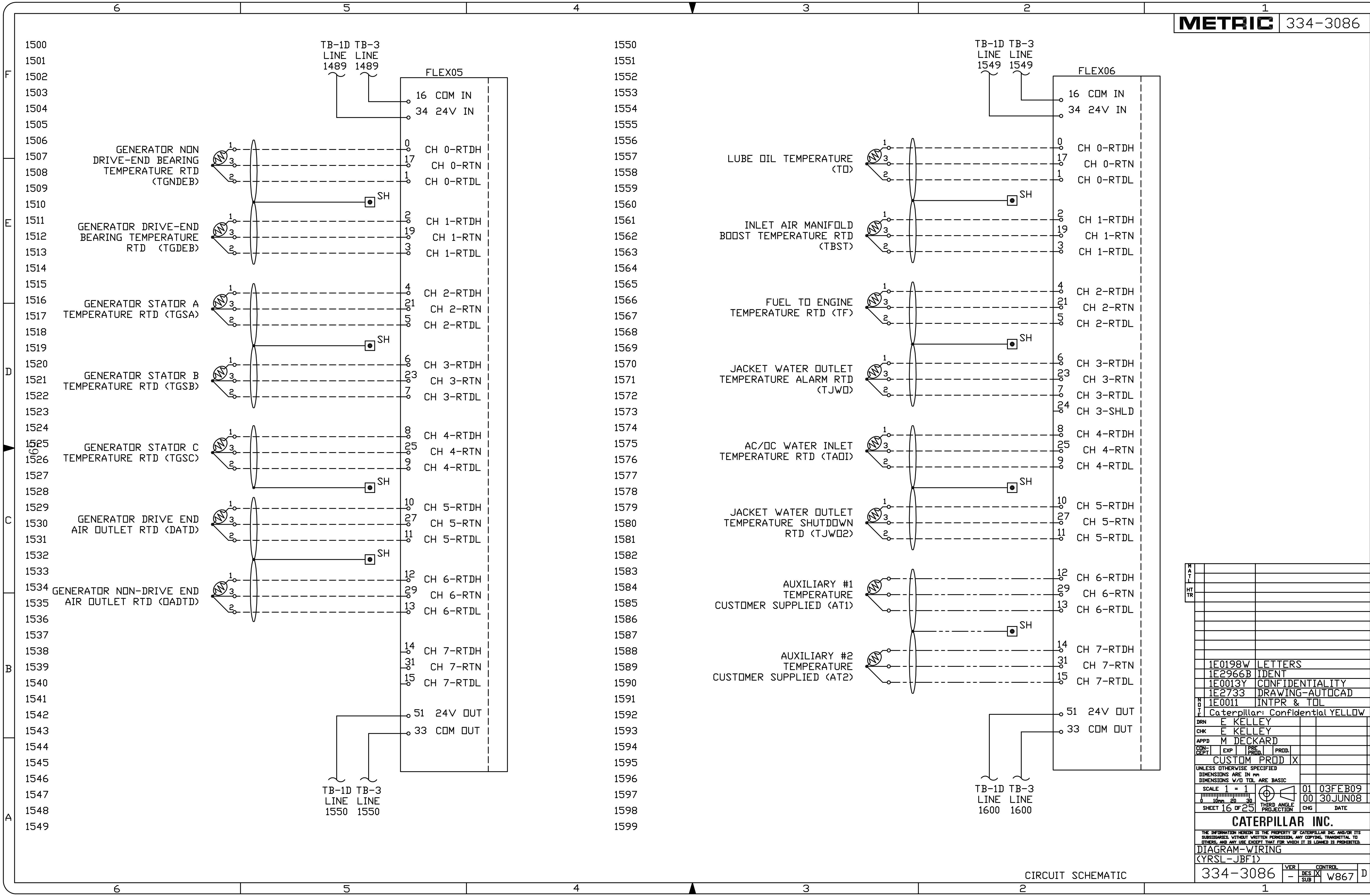
SCALE 1 = 1
SHEET 15 OF 25
THIRD ANGLE PROJECTION

CHG	DATE
01	03FEB09
00	30JUN08

CATERPILLAR INC.

DIAGRAM-WIRING (YRSL-JBF1)

334-3086 VER - DES X SUB CONTROL W867 D



METRIC 334-3086
TB-1D LINE 1489
TB-3 LINE 1489
FLEX05
16 COM IN
34 24V IN
GENERATOR NON DRIVE-END BEARING TEMPERATURE RTD (TGNDEB)
GENERATOR DRIVE-END BEARING TEMPERATURE RTD (TGDEB)
GENERATOR STATOR A TEMPERATURE RTD (TGSA)
GENERATOR STATOR B TEMPERATURE RTD (TGSB)
GENERATOR STATOR C TEMPERATURE RTD (TGSC)
GENERATOR DRIVE END AIR OUTLET RTD (DATD)
GENERATOR NON-DRIVE END AIR OUTLET RTD (DADTD)
0 CH 0-RTDH
17 CH 0-RTN
1 CH 0-RTDL
2 CH 1-RTDH
19 CH 1-RTN
3 CH 1-RTDL
4 CH 2-RTDH
21 CH 2-RTN
5 CH 2-RTDL
6 CH 3-RTDH
23 CH 3-RTN
7 CH 3-RTDL
8 CH 4-RTDH
25 CH 4-RTN
9 CH 4-RTDL
10 CH 5-RTDH
27 CH 5-RTN
11 CH 5-RTDL
12 CH 6-RTDH
29 CH 6-RTN
13 CH 6-RTDL
14 CH 7-RTDH
31 CH 7-RTN
15 CH 7-RTDL
51 24V OUT
33 COM OUT
SH
TB-1D LINE 1550
TB-3 LINE 1550
TB-1D LINE 1549
TB-3 LINE 1549
FLEX06
LUBE OIL TEMPERATURE (TO)
INLET AIR MANIFOLD BOOST TEMPERATURE RTD (TBST)
FUEL TO ENGINE TEMPERATURE RTD (TF)
JACKET WATER OUTLET TEMPERATURE ALARM RTD (TJWO)
AC/OC WATER INLET TEMPERATURE RTD (TAOI)
JACKET WATER OUTLET TEMPERATURE SHUTDOWN RTD (TJWO2)
AUXILIARY #1 TEMPERATURE CUSTOMER SUPPLIED (AT1)
AUXILIARY #2 TEMPERATURE CUSTOMER SUPPLIED (AT2)
24 CH 3-SHLD
TB-1D LINE 1600
TB-3 LINE 1600
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 16 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
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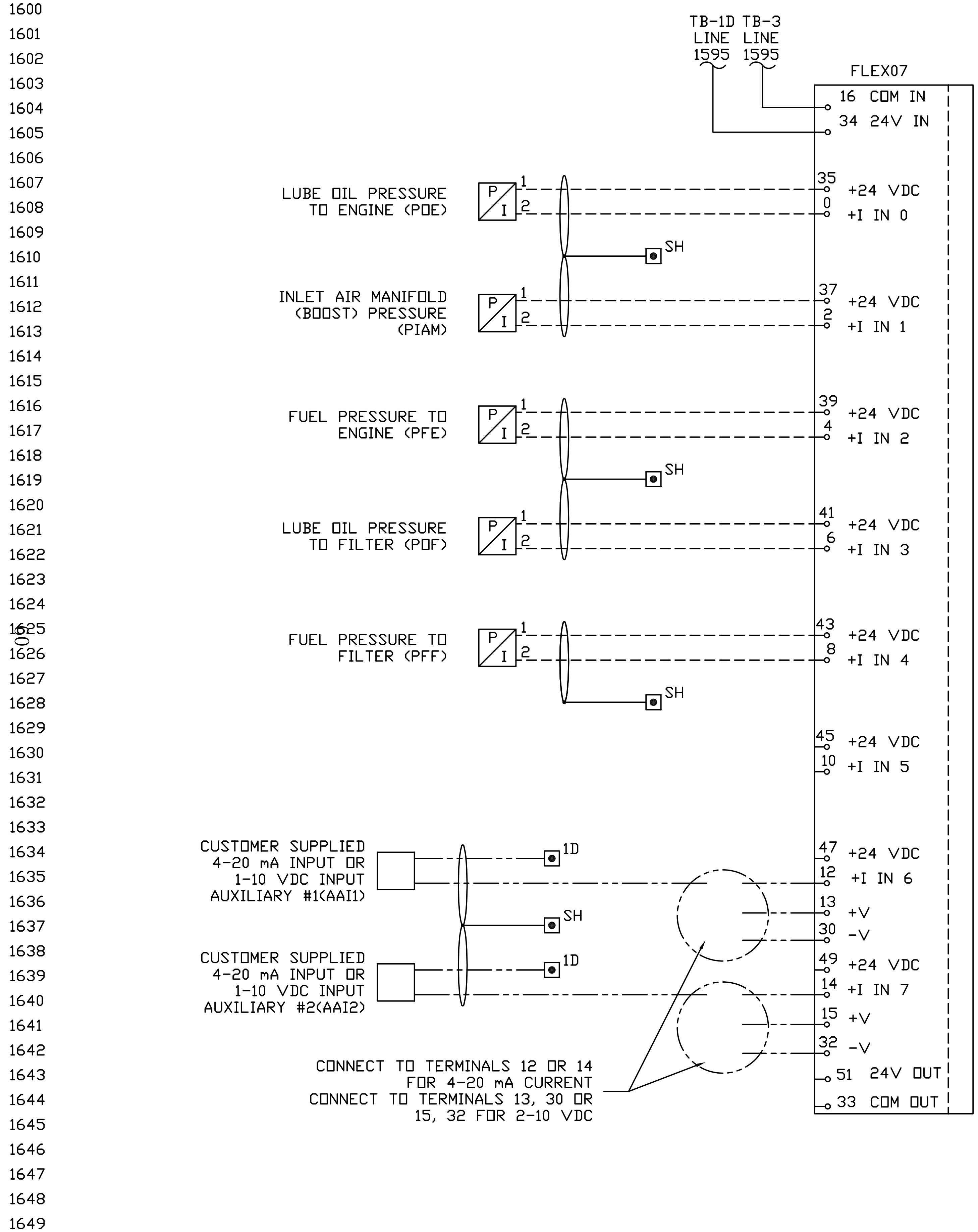
DIAGRAM-WIRING
(YRSL-JBF1)
334-3086
W867
D
CIRCUIT SCHEMATIC

METRIC 334-3086



1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL

Caterpillar: Confidential YELLOW

DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC

SCALE 1 = 1
SHEET 17 OF 25
THIRD ANGLE PROJECTION

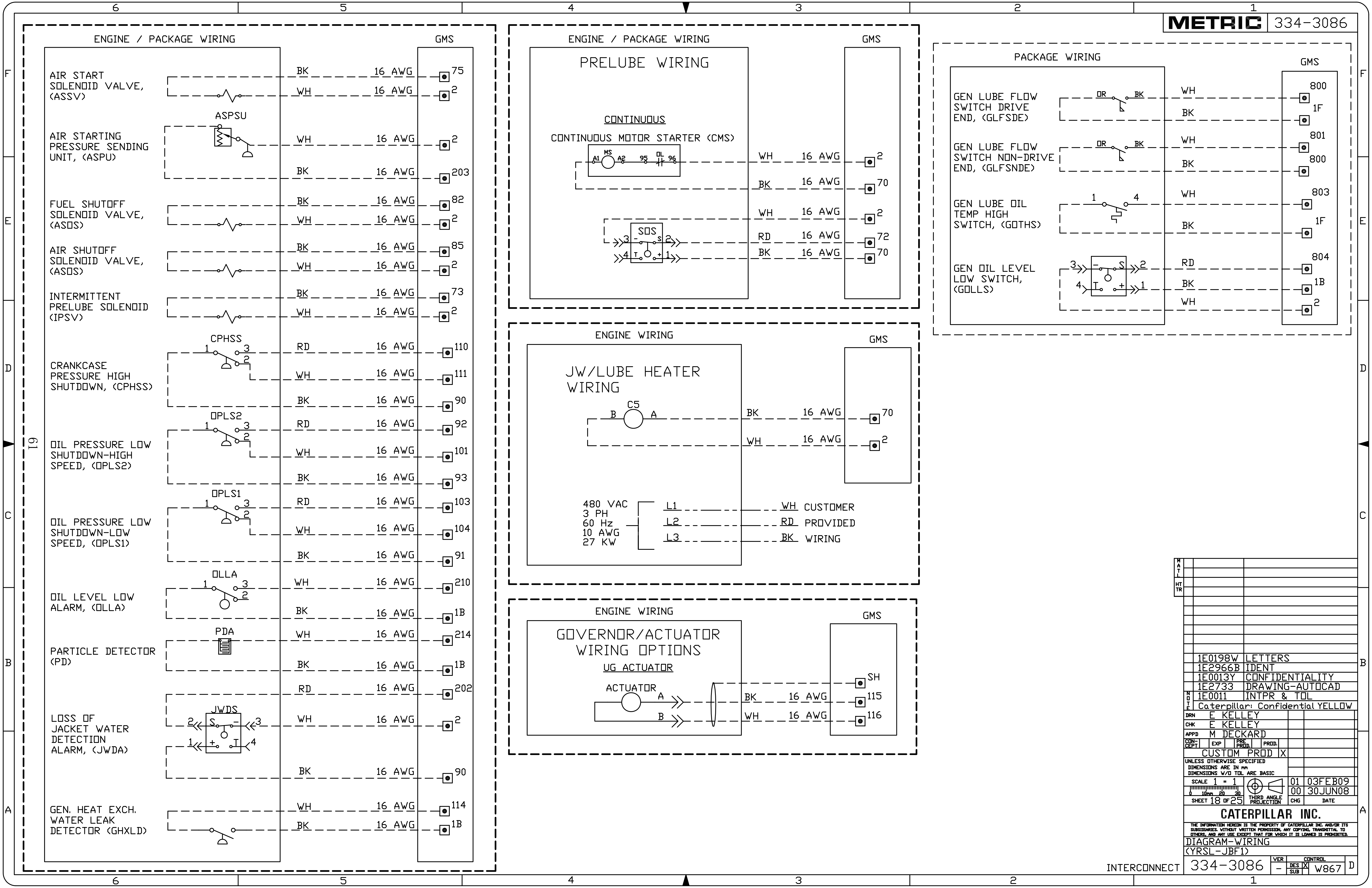
CHG	DATE
01	03FEB09
00	30JUN08

CATERPILLAR INC.

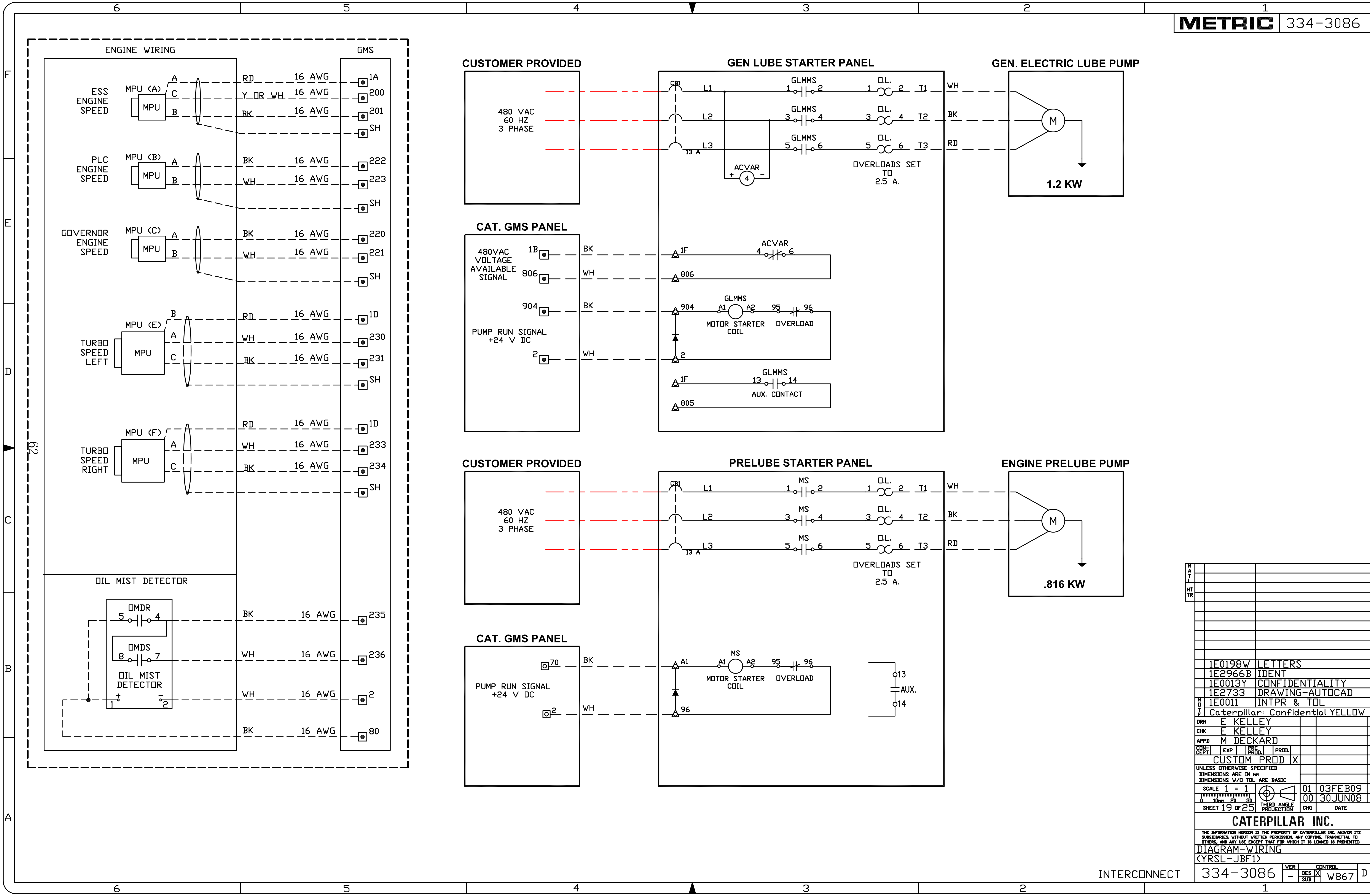
DIAGRAM-WIRING
(YRSL-JBF1)

334-3086 VER - CONTROL W867 D

CIRCUIT SCHEMATIC



METRIC 334-3086
ENGINE / PACKAGE WIRING
GMS
AIR START SOLENOID VALVE, (ASSV)
AIR STARTING PRESSURE SENDING UNIT, (ASPU)
ASPSU
FUEL SHUTOFF SOLENOID VALVE, (ASOS)
AIR SHUTOFF SOLENOID VALVE, (ASOS)
INTERMITTENT PRELUBE SOLENOID (IPSV)
CRANKCASE PRESSURE HIGH SHUTDOWN, (CPHSS)
CPHSS
OIL PRESSURE LOW SHUTDOWN-HIGH SPEED, (OPLS2)
OPLS2
OIL PRESSURE LOW SHUTDOWN-LOW SPEED, (OPLS1)
OPLS1
OIL LEVEL LOW ALARM, (OLLA)
OLLA
PARTICLE DETECTOR (PD)
PDA
LOSS OF JACKET WATER DETECTION ALARM, (JWDA)
JWDS
GEN. HEAT EXCH. WATER LEAK DETECTOR (GHXLD)
16 AWG
BK WH RD
75 2 203 82 85 73 110 111 90 92 101 93 103 104 91 210 1B 214 202 114
PRELUBE WIRING
CONTINUOUS
CONTINUOUS MOTOR STARTER (CMS)
MS A1 A2 95 OL 96
SOS
72 70
ENGINE WIRING
JW/LUBE HEATER WIRING
C5
480 VAC
3 PH
60 Hz
10 AWG
27 KW
L1 L2 L3
WH CUSTOMER
RD PROVIDED
BK WIRING
GOVERNOR/ACTUATOR WIRING OPTIONS
UG ACTUATOR
ACTUATOR
SH 115 116
PACKAGE WIRING
GEN LUBE FLOW SWITCH DRIVE END, (GLFSDE)
GEN LUBE FLOW SWITCH NON-DRIVE END, (GLFSNDE)
GEN LUBE OIL TEMP HIGH SWITCH, (GOTHS)
GEN OIL LEVEL LOW SWITCH, (GOLLS)
OR
800 1F 801 803 804
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 18 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CATERPILLAR INC.
DIAGRAM-WIRING
(YRSL-JBF1)
INTERCONNECT
334-3086
W867



METRIC 334-3086
ENGINE WIRING
GMS
ESS ENGINE SPEED
MPU (A)
PLC ENGINE SPEED
MPU (B)
GOVERNOR ENGINE SPEED
MPU (C)
TURBO SPEED LEFT
MPU (E)
TURBO SPEED RIGHT
MPU (F)
MPU
RD
Y OR WH
BK
WH
16 AWG
1A
200
201
SH
222
223
220
221
1D
230
231
233
234
OIL MIST DETECTOR
OMDR
OMDS
OIL MIST DETECTOR
235
236
2
80
CUSTOMER PROVIDED
480 VAC
60 HZ
3 PHASE
CAT. GMS PANEL
480VAC VOLTAGE AVAILABLE SIGNAL
1B
806
904
PUMP RUN SIGNAL +24 V DC
GEN LUBE STARTER PANEL
CB1
L1
L2
L3
13 A
GLMMS
ACVAR
O.L.
T1
T2
T3
OVERLOADS SET TO 2.5 A.
1F
805
MOTOR STARTER COIL
OVERLOAD
AUX. CONTACT
GEN. ELECTRIC LUBE PUMP
M
1.2 KW
PRELUBE STARTER PANEL
MS
AUX.
ENGINE PRELUBE PUMP
.816 KW
70
A1
A2
95
96
13
14
1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
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CATERPILLAR INC.
DIAGRAM-WIRING
(YRSL-JBF1)
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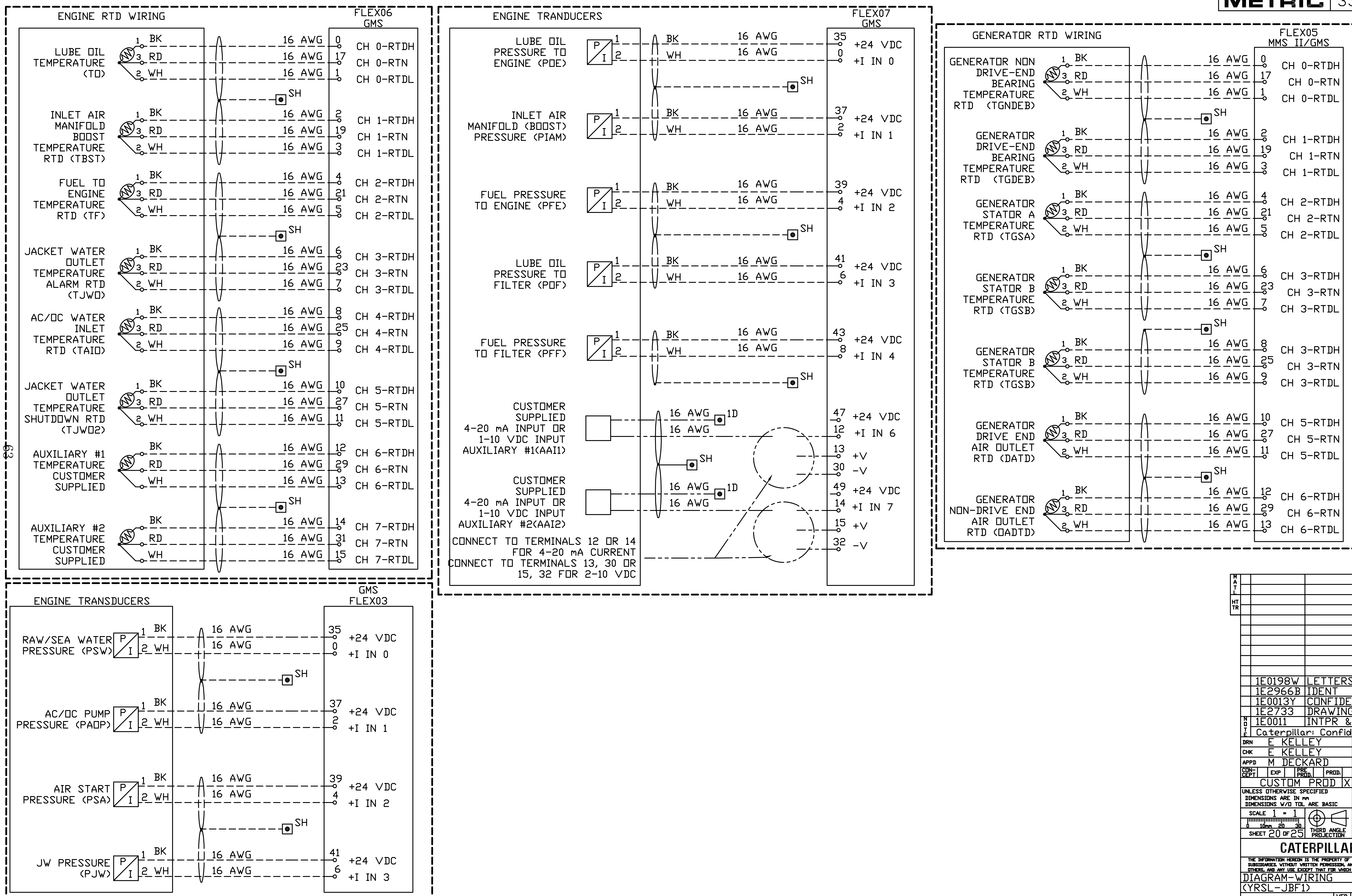
334-3086
VER -
CONTROL W867
D



1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL

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SHEET 20 OF 25 THIRD ANGLE PROJECTION

CHG	DATE
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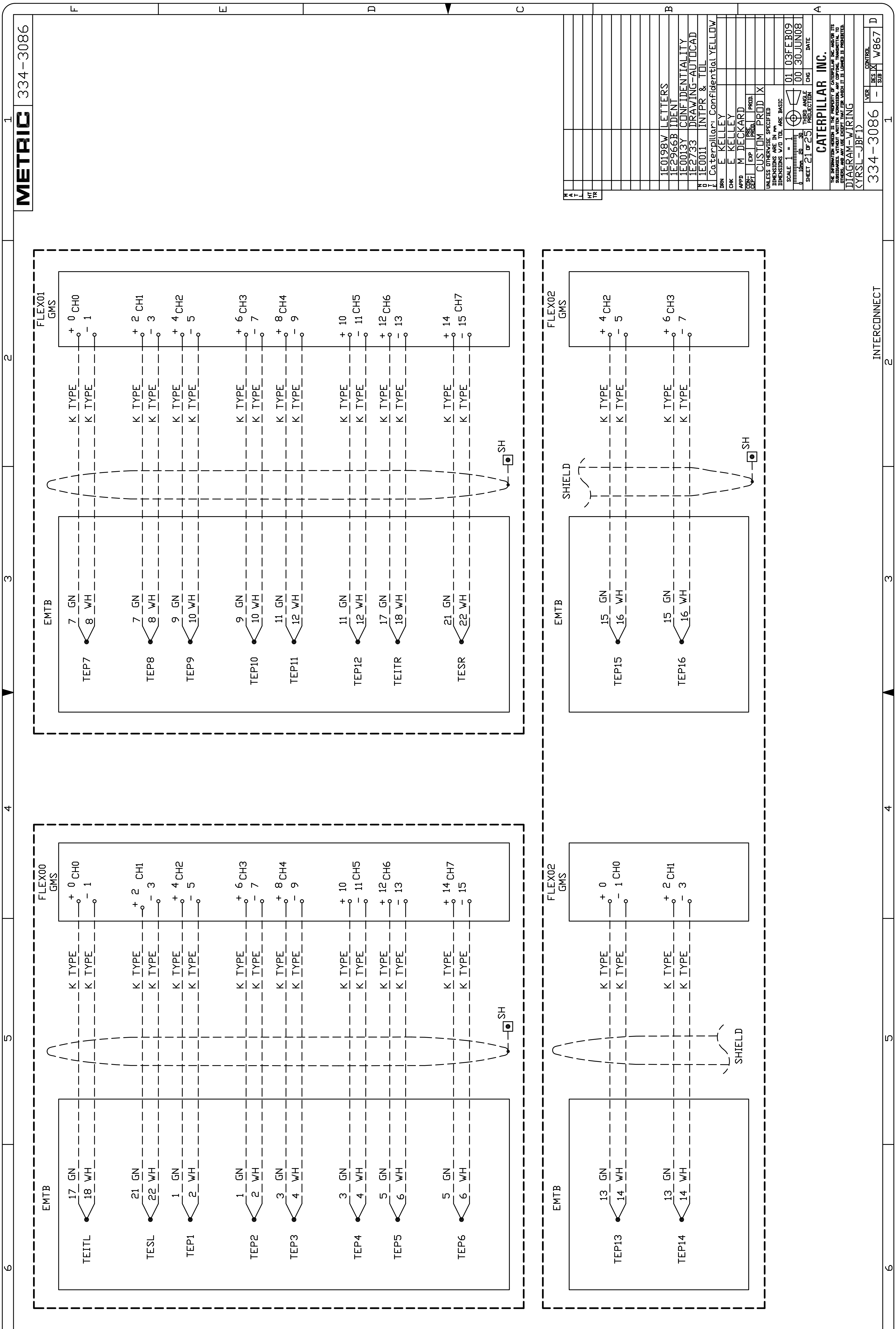
DIAGRAM-WIRING
(YRSL-JBF1)
INTERCONNECT 334-3086 VER - DES X SUB CONTROL W867 D


METRIC
334-3086
FLEX01 GMS
FLEX00 GMS
FLEX02 GMS
EMTB
CH0
CH1
CH2
CH3
CH4
CH5
CH6
CH7
K TYPE
GN
WH
SH
SHIELD
TEP7
TEP8
TEP9
TEP10
TEP11
TEP12
TEITR
TESR
TEP15
TEP16
TEITL
TESL
TEP1
TEP2
TEP3
TEP4
TEP5
TEP6
TEP13
TEP14
INTERCONNECT
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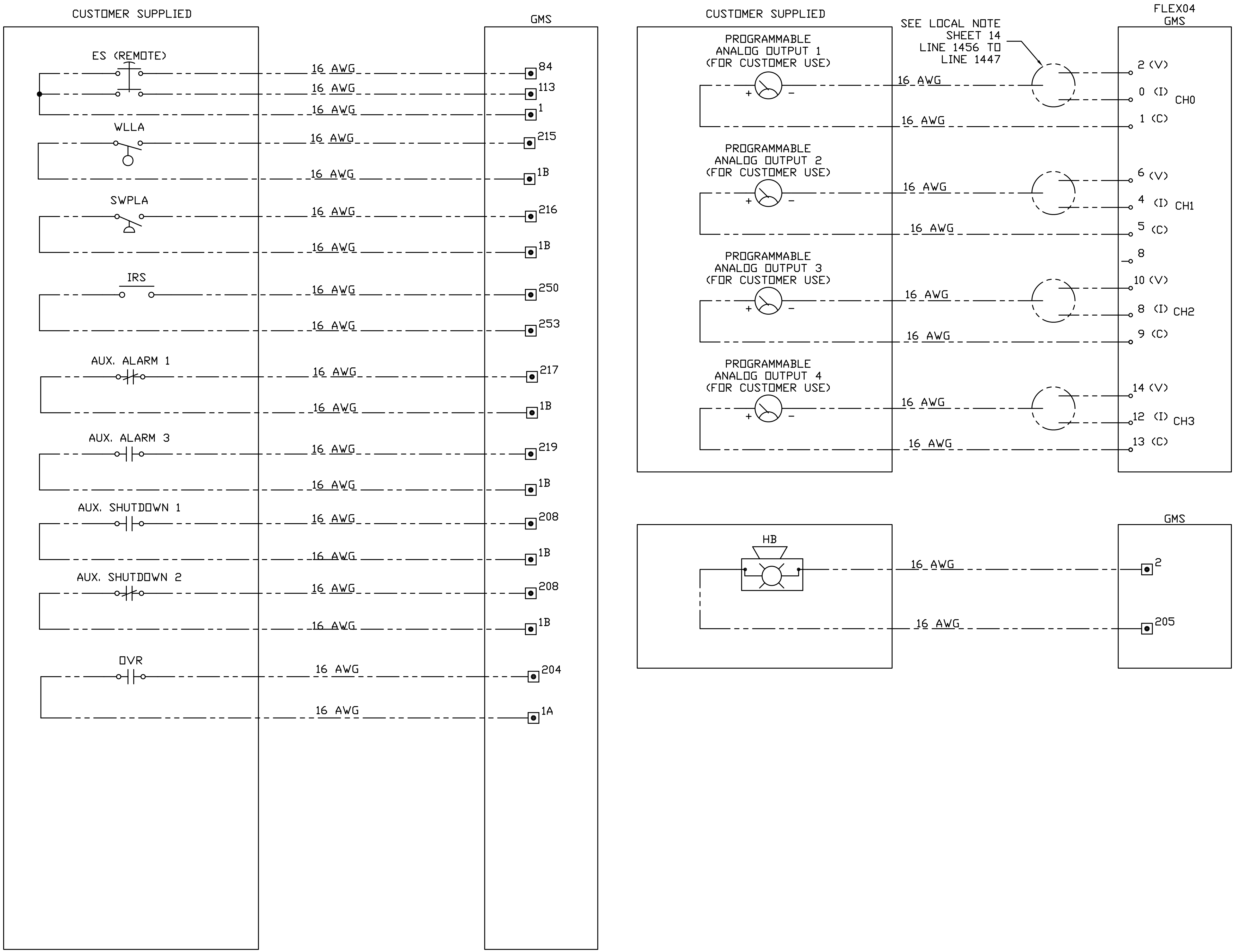
SHEET 21 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CATERPILLAR INC.
DIAGRAM-WIRING
(YRSL-JBF1)
334-3086
W867
D



1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL
Caterpillar: Confidential YELLOW	

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APPD M DECKARD
CUSTOM PROD X

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC

SCALE 1 = 1
SHEET 22 OF 25
THIRD ANGLE PROJECTION

CHG	DATE
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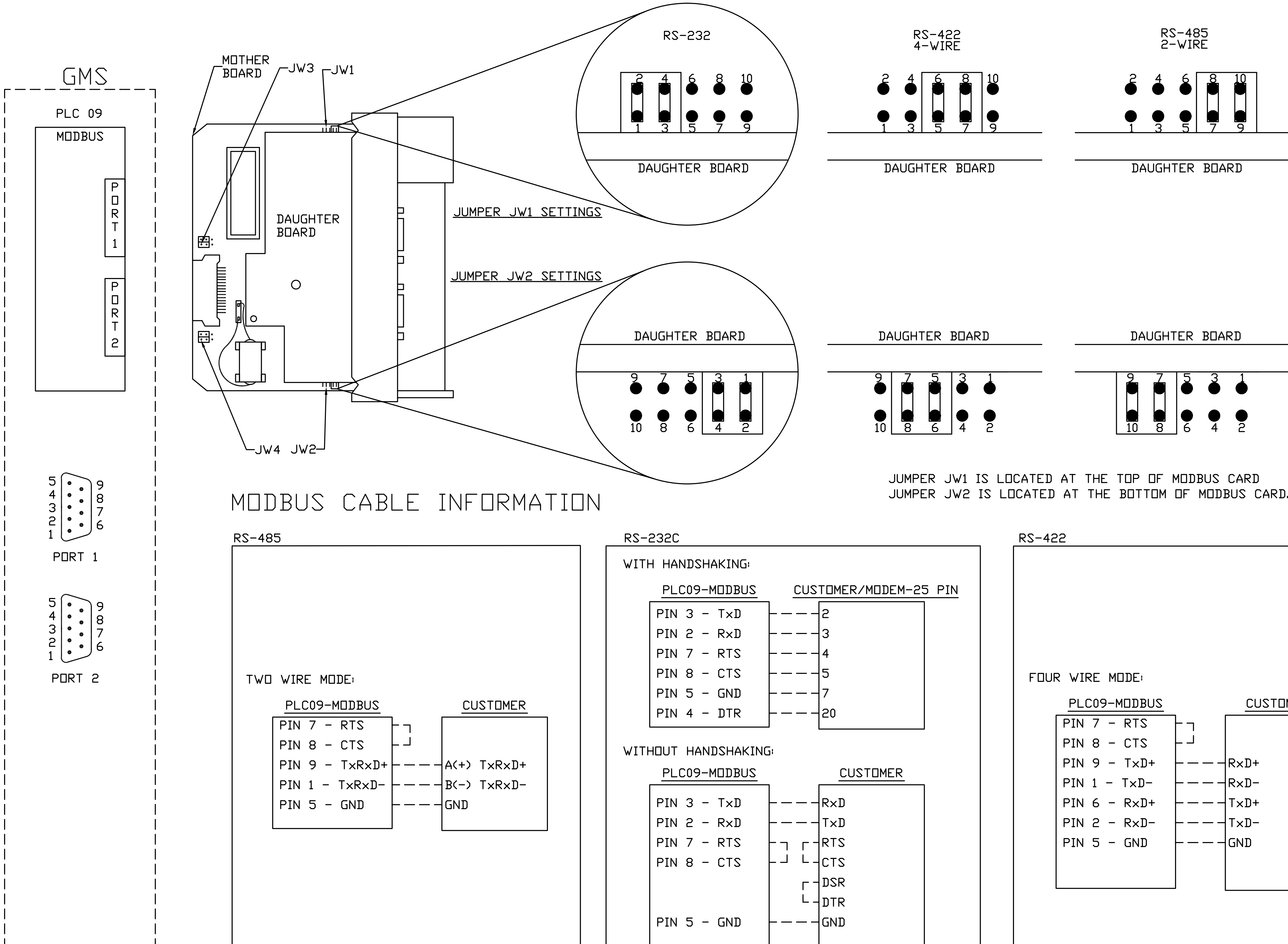
CATERPILLAR INC.

DIAGRAM-WIRING
(YRSL-JBF1)

334-3086 VER - DES X CONTROL W867 D

MODBUS JUMPER CONFIGURATION



JUMPER JW1 IS LOCATED AT THE TOP OF MODBUS CARD
JUMPER JW2 IS LOCATED AT THE BOTTOM OF MODBUS CARD.

MODBUS CABLE INFORMATION

RS-485

TWO WIRE MODE:

PLC09-MODBUS	CUSTOMER
PIN 7 - RTS	(jumpered to PIN 8)
PIN 8 - CTS	
PIN 9 - TxRxD+	A(+) TxRxD+
PIN 1 - TxRxD-	B(-) TxRxD-
PIN 5 - GND	GND

RS-232C

WITH HANDSHAKING:

PLC09-MODBUS	CUSTOMER/MODEM-25 PIN
PIN 3 - TxD	2
PIN 2 - RxD	3
PIN 7 - RTS	4
PIN 8 - CTS	5
PIN 5 - GND	7
PIN 4 - DTR	20

WITHOUT HANDSHAKING:

PLC09-MODBUS	CUSTOMER
PIN 3 - TxD	RxD
PIN 2 - RxD	TxD
PIN 7 - RTS	RTS
PIN 8 - CTS	CTS
	DSR
	DTR
PIN 5 - GND	GND

RS-422

FOUR WIRE MODE:

PLC09-MODBUS	CUSTOMER
PIN 7 - RTS	(jumpered to PIN 8)
PIN 8 - CTS	
PIN 9 - TxD+	RxD+
PIN 1 - TxD-	RxD-
PIN 6 - RxD+	TxD+
PIN 2 - RxD-	TxD-
PIN 5 - GND	GND

IF COMMUNICATION IN RS-485 DOES NOT WORK, DESPITE ALL ATTEMPTS, TRY SWITCHING TERMINATION POLARITIES. SOME MANUFACTURERS INTERPRET (+) AND (-) DIFFERENTLY.

MODBUS INTERCONNECT

METRIC 334-3086

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SHEET 23 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08

DIAGRAM-WIRING
(YRSL-JBF1)
334-3086 - W867 D

METRIC 334-3086

SHIELDED WIRES TO BE TWISTED PAIRS, WITH SHIELD GROUNDED AT CONTROL END ONLY.

INDICATES RELAY COIL OR LAMP, 200 mA MAXIMUM PER CHANNEL.

WARNING: DO NOT USE FOR EMERGENCY SHUTDOWN.
THE PRIME MOVER SHOULD BE EQUIPPED WITH SEPERATE OVERSPEED, OVERTEMPERATURE OR OVERPRESSURE SHUTDOWN DEVICE(S) TO PROTECT AGAINST RUNAWAY OR DAMAGE TO THE PRIME MOVER WITH POSSIBLE PERSONAL INJURY OR LOSS OF LIFE.

SHIELDED WIRES TO BE TWISTED PAIRS, WITH SHIELD GROUNDED AT CONTROL END ONLY.

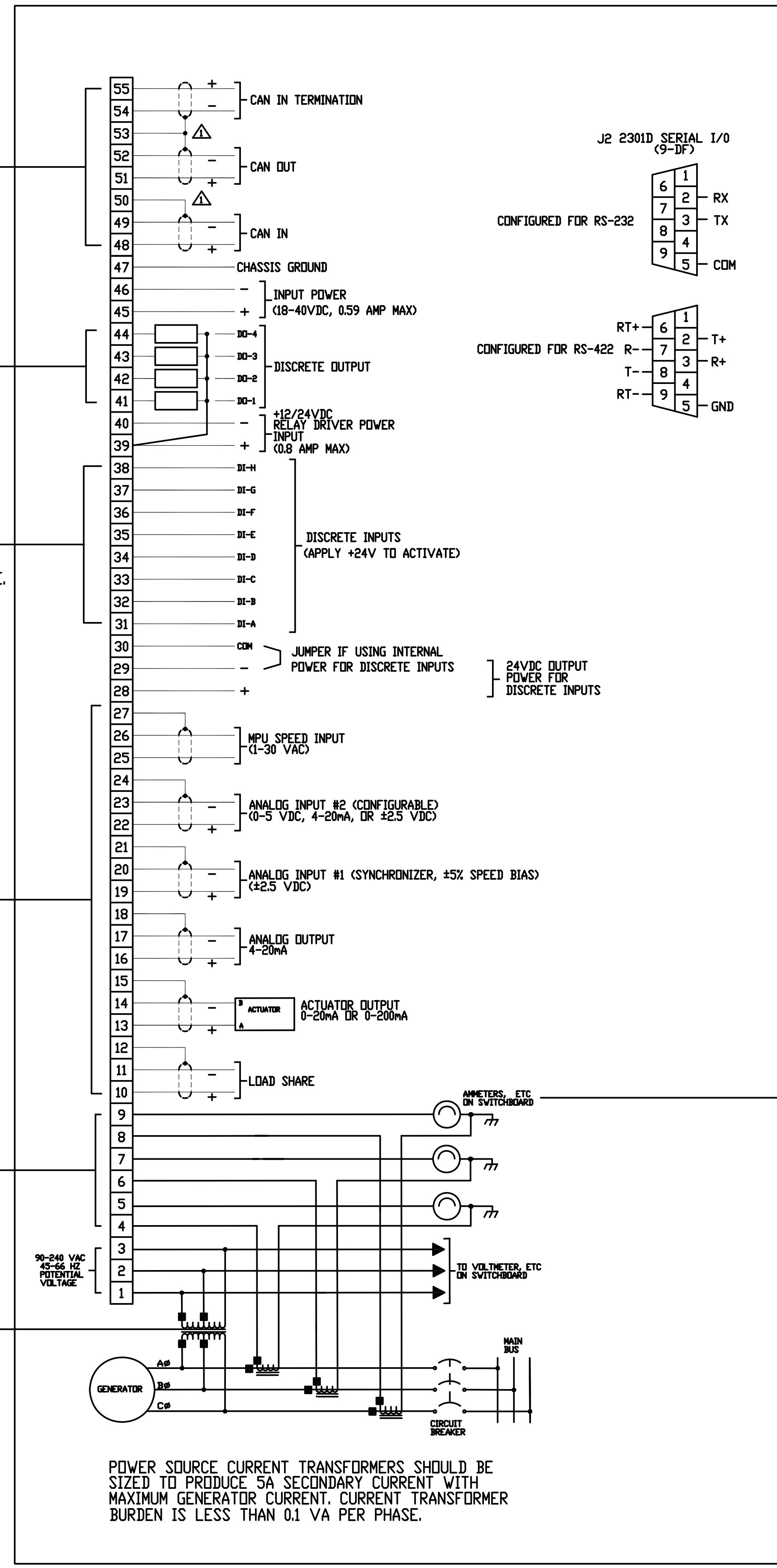
INTERNAL CURRENT TRANSFORMER BURDEN MUST BE CONNECTED ACROSS POWER SOURCE CURRENT TRANSFORMER AT ALL TIMES, TO PREVENT LETHAL HIGH VOLTAGES.

WITH A BALANCED THREE PHASE LOAD AND UNITY POWER FACTOR, THE CURRENT TRANSFORMERS SHOULD BE WIRED IN THE CORRECT POTENTIAL LEG AND MUST BE PHASED AT THE CONTROL AS FOLLOWS:

PHASE A: POTENTIAL TERMINAL 1, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 4 ( ) TO 5.

PHASE B: POTENTIAL TERMINAL 2, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 6 ( ) TO 7.

PHASE C: POTENTIAL TERMINAL 3, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 8 ( ) TO 9.



POWER SOURCE CURRENT TRANSFORMERS SHOULD BE SIZED TO PRODUCE 5A SECONDARY CURRENT WITH MAXIMUM GENERATOR CURRENT. CURRENT TRANSFORMER BURDEN IS LESS THAN 0.1 VA PER PHASE.

IF METERS ARE NOT USED, JUMPERS MUST BE INSTALLED IN PLACE OF METERS SHOWN.

DIGITAL INPUT AND ANALOG OUTPUTS	
DI-A	MINIMUM FUEL, CLOSE TO RUN
DI-B	FAILSAFE OVERRIDE
DI-C	IDLE/RATED
DI-D	LOAD SHARING ENABLE, CB AUX
DI-E	SPEED TRIM RAISE
DI-F	SPEED TRIM LOWER
DI-G	LOAD
DI-H	SELECT BASE LOAD
DO-1	SPEED SWITCH #1
DO-2	SPEED SWITCH #2
DO-3	LOAD SWITCH #1
DO-4	LOAD SWITCH #2
ANALOG OUT	CONFIGURABLE (SEE SOFTWARE)
ANALOG IN #1	SYN IN
ANALOG IN #2	CONFIGURABLE (SEE SOFTWARE)
J2	RS232

1E0198W	LETTERS
1E2966B	IDENT
1E0013Y	CONFIDENTIALITY
1E2733	DRAWING-AUTOCAD
1E0011	INTPR & TOL

Caterpillar: Confidential YELLOW
DRN E KELLEY
CHK E KELLEY
APPD M DECKARD
CUSTOM PROD X
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN mm DIMENSIONS W/O TOL ARE BASIC
SCALE 1 = 1
SHEET 24 OF 25 THIRD ANGLE PROJECTION

CHG	DATE
01	03FEB09
00	30JUN08

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DIAGRAM-WIRING (YRSL-JBF1)

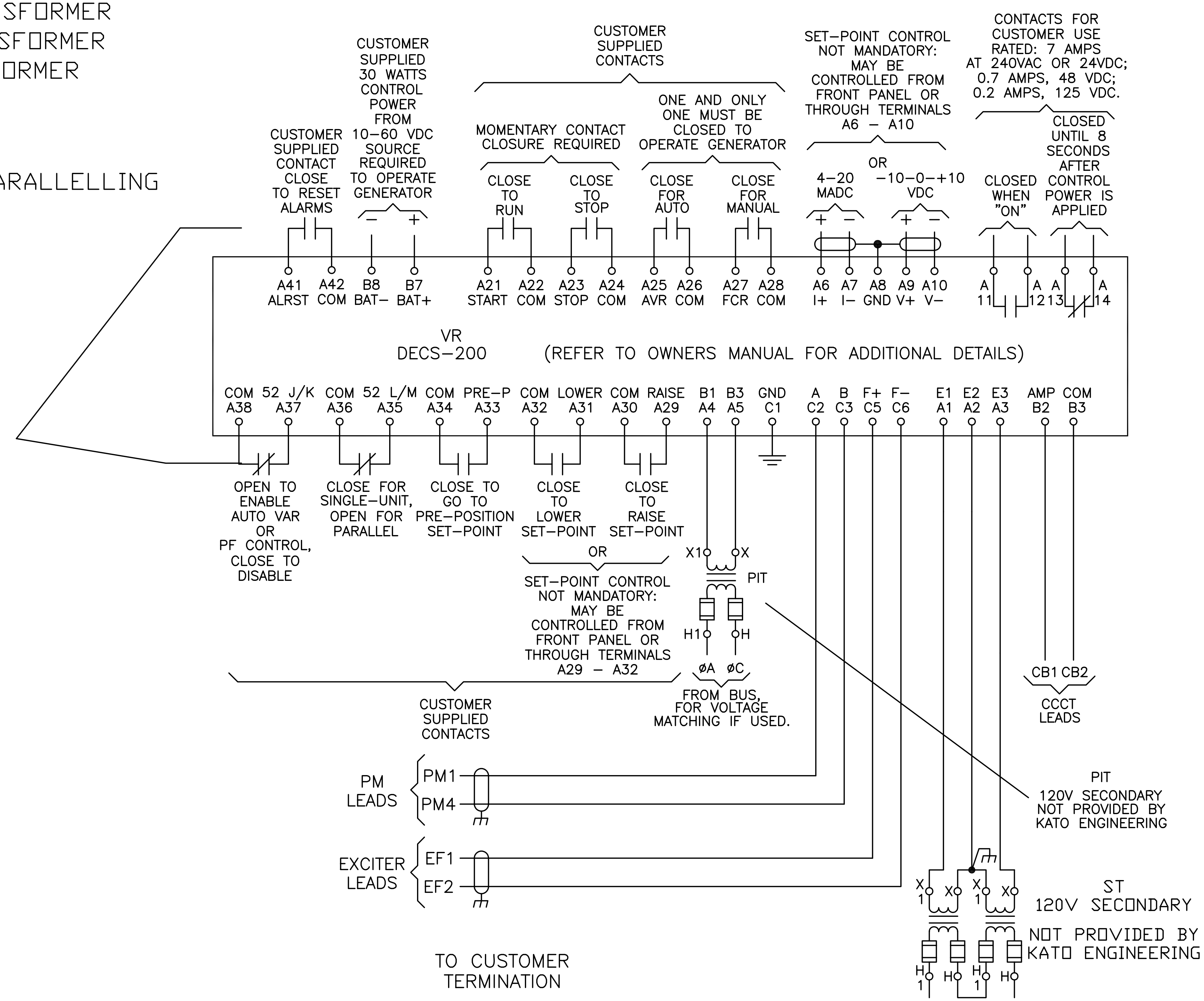
LOADSHARE

334-3086 VER - DES X SUB CONTROL W867 D

LEGEND

CCCT - PARALLELING CURRENT TRANSFORMER
DCT - DIFFERENTIAL CURRENT TRANSFORMER
PIT - POTENTIAL ISOLATION TRANSFORMER
WITH UNDERFREQUENCY LIMIT
ST - SENSING TRANSFORMER
VR - VOLTAGE REGULATOR
WITH VAR/PF CONTROLLER, PARALLELLING
AND VOLTAGE WATCHING

NOTE: ALL CUSTOMER-SUPPLIED CONTACTS SHOWN HERE MUST BE "DRY" (VOLTAGE-FREE) TO OPERATE IN A 12 VDC CIRCUIT.



1E0198W LETTERS
1E2966B IDENT
1E0013Y CONFIDENTIALITY
1E2733 DRAWING-AUTOCAD
1E0011 INTPR & TOL
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SCALE 1 = 1
SHEET 25 OF 25
THIRD ANGLE PROJECTION
01 03FEB09
00 30JUN08
CHG DATE

CATERPILLAR INC.

DIAGRAM-WIRING
(YRSL-JBF1)
VOLTAGE REGULATOR
334-3086 VER - DES X SUB CONTROL W867 D

5.0 APPLICATION & INSTALLATION GUIDE

LIST OF GUIDE

- ~~Corrosion: A polished copper strip is immersed in fuel~~ for ~~three hours at 50°C (122°F).~~ ~~Fuel imparting more than slight discoloration is rejected.~~

Diesel Fuel Selection

The fuels recommended for use in Caterpillar diesel engines are normally No. 2-D diesel fuel and No. 2 fuel oil, although No. 1 grades are also acceptable. **Table 1** lists the worldwide fuel standards which meet Caterpillar requirements.

Standard	Name	Description
American	ASTM D975	No. 1-D & No. 2-D Diesel Fuel Oils
	ASTM D396	No. 1 & No. 2 Fuel Oils
	ASTM D2880	No. 1-GT & No. 2-GT Gas Turbine Fuels
British	BS 2869	Classes A1, A2 & B2 Engine Fuels
	BS 2869	Classes C2 & D Burner Fuels
West German	DIN 51601	Diesel Fuel
	DIN 51603	Heating Oil El
Australian	AS 3570	Automotive Diesel Fuel
Japanese	JIS K2204	Types 1 (spl), 1, 2, 3, & 3 (spl) Gas Oil
U.S. Government	W-F-800C	DF-1, DF-2 Conus & DF-20 Conus Diesel Fuel
	W-F-815C	FS-1 & FS-2 Burner Fuel Oil
U.S. Military	MIL-L-16884G	Marine Oil

Table 1

Table 2 lists acceptable aircraft jet fuels and kerosene type fuels.

Name	Description
ASTM D 1655-80	Aviation Turbine Fuel (JET A-1)
MIL-T-5624L	Aviation Turbine Fuel (JP-5) (NATO Code No. F-44)
MILT-T-83133B	Aviation Turbine Fuel (JP-8) (NATO Code No. F-34)

Table 2

Diesel Fuel System Design Considerations

Diesel fuel supply systems must ensure continuous and clean supply of fuel to the engine's fuel system. The recommended diesel fuel supply system typically has three major components: a fuel storage system, a fuel transfer system and a fuel filtration system. The three component systems provide clean operating fuel to the engine.

Fuel Storage Systems

Bulk fuel is usually stored in large main storage tanks and transferred to smaller auxiliary tanks (service tanks or day tanks) near engines by electric motor-driven pumps as shown in **Figure 3**.

If auxiliary tanks are not necessary, the main fuel tank must provide a ready fuel supply to the engine-mounted transfer pump.

Main Fuel Tank

The main fuel tank represents the primary fuel reservoir in all applications, and must have adequate capacity for the intended application. Rule of thumb for tank size is to find the fuel consumption rate at 100% load factor (depending on application: Prime, stand-by etc.) and multiply it with the number of hours between refills. Fuel consumption rates are shown on the Engine Technical Data Sheets for the specific engine. Additionally, 10% should be added to the result; 5% for expansion at the top of the tank, and 5% for sediment settlements at the bottom.

Example:

A power plant with one (1) 3516B diesel generator set, rated for 1145 bkW (1560 bhp) at 100% load. The fuel rate for the engine is 284 L/hr (75 G/hr) as found in TMI.

The time between tank refills is based on weekly fuel tanker truck deliveries, so refill time is 168 hours.

Solution:

Tank vol. = 284 x 168 x 1.1 = 52,583 L

Tank vol. = 75 x 168 x 1.1 = 12,600 gal

Installation Example with Main and Auxiliary Fuel Tanks

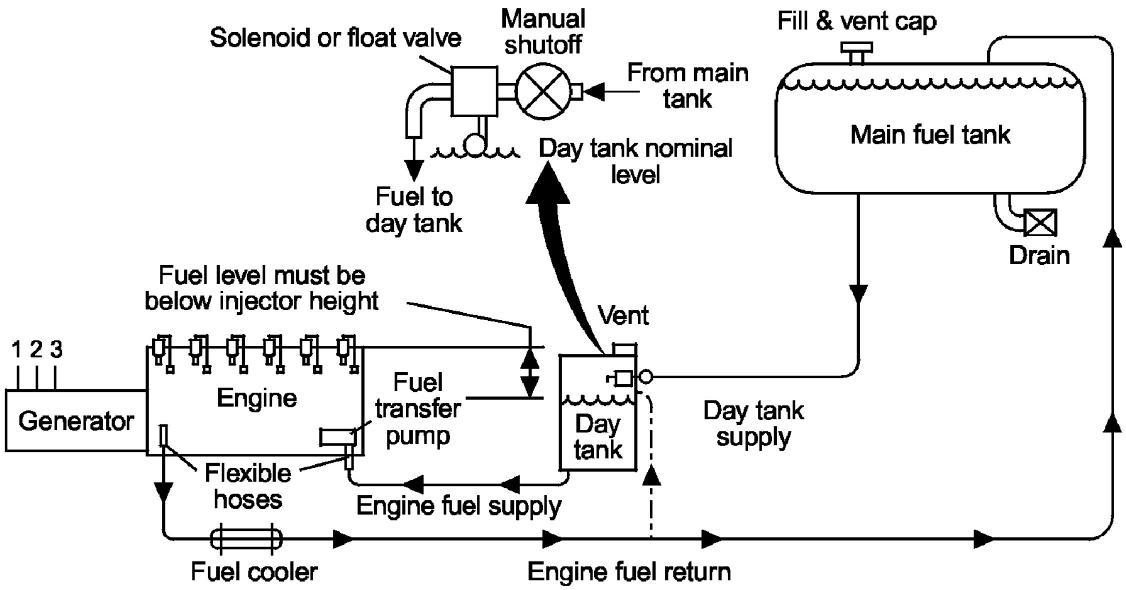


Figure 3

Auxiliary Fuel Tanks

Auxiliary fuel tanks, service tanks and day tanks are secondary fuel tanks located between the main fuel tank and the engine. These tanks are required in the following situations.

- The main fuel tank is located on the same level but more than 15 m (50 ft) away.
- The main fuel tank is located 3.7 m (12 ft) or more below the engine.
- The main fuel tank is located above the engine fuel injectors.

Any of the above conditions can cause unsatisfactory engine starting and operation. The purpose of an auxiliary tank is to relieve the fuel pressure "head" from the fuel transfer pump and injection equipment for efficient fuel flow.

A manual fuel priming pump, offered as an attachment, or an electric motor-driver boost pump may allow operation under conditions more severe than those previously described; but where starting dependability is required, Caterpillar recommends the use of an auxiliary fuel tank.

Auxiliary tanks offer convenient and ready fuel storage while providing a settling reservoir for water, sediment and sludge. An example of an auxiliary fuel tank is shown in **Figure 4**.

Typical Auxiliary Fuel Tank

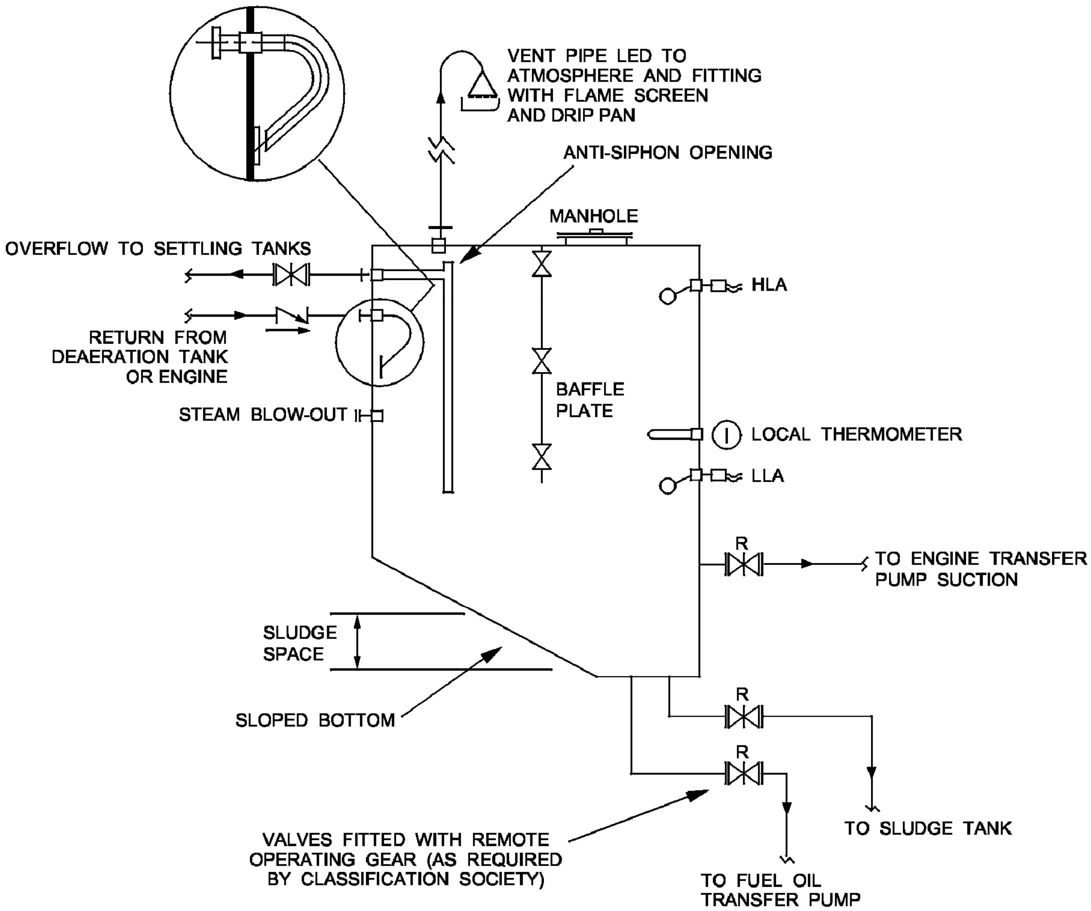


Figure 4

Fuel Service Tank or Day Tank

Auxiliary tanks such as fuel service tanks or day tanks can be quite simple. It usually consists of a small metal tank, either floor or wall mounted, in the immediate vicinity of the engine. The tank is usually sized to hold approximately eight hours of fuel, based on the engine's fuel consumption rate at full load.

Refilling can be accomplished by gravity, a hand pump, or with a motor-drive pump. Motor-drive pumps can be either manually or automatically controlled. For convenience and safety, automatic control is usually employed using a float-actuated, electric motor-drive pump. The refilling pump can be positioned either at the auxiliary tank or at the main tank outlet. The performance capability of the pump must be considered during placement.

Features of the auxiliary tank, as shown in **Figure 5**, should include the following.

- Fill line - Located above the high fuel level, with outlet baffled to prevent agitation of sediment in the tank.
- Delivery line - Located near the bottom but not so low as to pick up collected sediment or condensation.
- Return line - To carry excess fuel back to the auxiliary tank. Should have its outlet baffled for the reason described above.
- Overflow line - Allows excess fuel to return to the main tank in event of overfilling of the auxiliary tank.
- Vent line - Allows air pressure to equalize as tank is drained or filled (vent cap should be located away from open flame or sparks).
- Drain valve - Allows removal of condensate and sediment.
- Sight glass or float-type gauge - Provides a positive check on fuel level.

To prevent damage to the fuel filter housings, the return line should have no valves or restrictions to allow dangerous pressure buildups.

Flexible rubber hoses, used as fuel return lines, should be supported to prevent closing off over time due to weight of the hose and fuel. Hard fuel lines prevent this problem, but a flexible connection is still required to isolate vibration between the line and the tank.

A nonflammable tank mounting will maximize fire protection.

The overflow line should be at least two pipe sizes larger than the fill line. To simplify engine maintenance, a shut-off valve in the supply line is useful.

The delivery line, carrying the fuel to the engine-mounted fuel transfer pump, and the return line, carrying excess fuel back to the tank, should be no smaller in size than the respective fittings on the engine.

Larger fuel supply and return lines ensure adequate flow if the fuel tank supplies multiple engines over 9 m (30 ft.) away from the tank or when temperatures are low. Consult general dimension drawings for the sizes for each model.

It is important that the fuel return line is sloped down to the tank with no traps or obstructions in the line. If this is not done, the fuel system is prone to air-lock with consequent hard-starting.

The auxiliary tank should be located so that the level of the fuel when the tank is full is no higher than the injection valves. Static pressure would allow fuel to leak into the combustion chambers in the event of injection valve leakage. The tank should be close enough to the engine so that the total suction lift to the transfer pump with the fuel at low level, plus the line loss of the supply line, is less than the fuel pump's maximum suction lift capability. This figure should be minimized for better starting. A float valve or solenoid valve in this type of day tank regulates the fuel level to keep it below the level of the injectors.

Lubrication Oil System

General

The lube system is designed to supply 85°C (185°F) filtered oil at 430 kPa (62 psi) pressure under all engine operating conditions. For engines with front-mounted turbochargers, the lube oil system is designed to supply 70°C (158°F) filtered oil at 430 kPa (62 psi) under all engine operating conditions. The major feature of the 3600 lube system is a priority valve to regulate the oil pressure at the oil manifold rather than at the oil pump. The oil manifold pressure thus becomes independent of the oil filter and oil cooler under pressure drop.

The other major features of the 3600 lube system are as follows:

Internal Lubrication System

Oil Coolers

The engines are equipped with a two-element lube oil tube cooler with the water flow arranged in series. As an option, a three-element oil cooler is available if additional cooling capacity is required. For engines with front-mounted turbochargers, a fresh water cooled plate-type cooler is shipped loose.

Thermostats

Four thermostats in the lube system control the oil inlet temperature to 85°C (185°F) for engines with rear-mounted turbochargers and 70°C (158°F) for engines with front-mounted turbochargers. The thermostat is mounted on the plate-type cooler for engines with front-mounted turbochargers.

Oil Filters

The oil pan is equipped with a 650-micron suction screen. The two final 20-micron lube oil filters can be changed while the engine is operating. The normal procedure specifies the filters to be changed at 100 kPa (14.5 psi) pressure drop across the filters.

Centrifugal Bypass Filters

Engine-mounted centrifugal bypass oil filters are installed as standard. The filters receive three to four percent of the oil pump flow to remove solid, micron size particles and can extend the oil filter change periods. The centrifugal filters each have a dirt capacity of 3.6 kg (8 lb). Cleaning intervals are discussed in the Caterpillar Operation & Maintenance Manual.

Oil Pumps

On-line connections are identical for all pumps. The pumps provide more than the required engine oil flow at rated conditions. This allows high oil pressure early in the operating speed range and provides flow margin.

Prelubrication

All 3600 engines must be lubricated prior to starting. The pump is electrically driven. Prelubrication prior to starting may take several minutes depending upon oil viscosity, temperature, engine condition, and configuration. When the engine oil manifold pressure reaches 10 kPa (1.5 psi), the starter interlock allows the engine to be cranked. A prelubrication system supplied by Caterpillar is integrated with the engine and starting controls. An engine-mounted, air-driven prelube pump is available as an option.

Oil Requirements

Caterpillar recommends the use of **Cat DEO CF** lubrication oil for the 3600 family engines operating on distillate diesel fuel. Caterpillar does not recommend other lubrication oils by brand name as the formulations are not controlled by Caterpillar and the lube oil properties may vary geographically.

To be acceptable in a 3600 engine, the oil must demonstrate satisfactory performance in the following areas:

1. **API category:** The oil must have an API classification of CF. Specifications Mil-L-2104D oils also meet this requirement.
   API CC oils are unacceptable.
2. Caterpillar **Micro-Oxidation Test (MOT):** The oil must pass the Caterpillar Micro-Oxidation Test. For additional information on this test, contact a Caterpillar dealer. The test must be performed on samples from the supplier's facility supporting the engine.
3. **Field experience:** In addition to the above items, the oil must show its performance in the field with good results, demonstrated through a test program.

Lubricant Viscosity

The primary recommendation for the 3600 family of engines is an SAE 40-grade oil. SAE 30 and some multigrade oils may be used if the application requires. SAE 30 is preferable to a multigrade oil.

Total Base Number (TBN)

Always consult a Caterpillar dealer for the latest lubricant recommendations.

3600 engines operating on distillate Marine Diesel Oil require a TBN of 10 times the sulfur level measured in percent of weight. (Example: For a sulfur content of one percent weight, the TBN would be 10.) The minimum TBN level regardless of the sulfur content is 10. Excessively high TBN or high ash oils should not be used in 3600 family engines on distillate fuel, as these oils may lead to excessive piston deposits and loss of oil control. Successful operation of 3600 family engines has generally been obtained with new TBN levels between 10 and 15.

Ultra low sulfur content: Caterpillar has not experienced any detrimental effects operating on 0.05 percent sulfur fuel in the 3600 family engine.

Ambient Temperature Range	
Oil Viscosity	Ambient Temp. Range °C
SAE 40 SAE 30 SAE 20W/40 SAE 15W/40	+5 to +50 +0 to +40 -10 to +40 -15 to +40

Refer to the engine model specific price lists for the various options available.

Note: Remote mounted prelube pumps must be located and piped to prevent excessive inlet restriction.

Several automatic prelubrication systems available for Caterpillar engines are:

- Intermittent Prelube System
- Continuous Prelube System
- Redundant Prelube System
- Quick Start Prelube System

Intermittent Prelube System

The intermittent prelube system provides suitable performance for applications not requiring quick start capability.

The intermittent prelube system uses an engine mounted pump and is engaged immediately prior to engine start-up.

Figure 5 is a schematic of a prelube system for a 3600/G3600 engine. The type of prelube pump determines whether the system is intermittent or continuous.

Intermittent prelube time will vary with engine model as well as oil temperature. A well-designed system must include a prelube pump shutdown capability to prevent the pump from operating too long. Since the intermittent prelube pump operates at a higher flow rate and pressure than the continuous pump, operating the pump for extended time periods is not recommended. This can result in excessive oil in the cylinders and potentially cause hydraulic lock at start-up.

Continuous Prelube System

Continuous prelubrication is for immediate starting applications and is typically used in conjunction with jacket water and lube oil heating.

Used mostly on the 3600 family of engines, a continuous prelube system eliminates the delay of waiting for the completion of an intermittent prelube cycle. This system is operating continuously when the engine is not running. This ensures that lube oil will be available at the bearings at all times, allowing immediate starting of the engine. The continuous prelube systems utilize pumps with lower flow rates than intermittent prelube systems. This system relies on an engine oil level start permissive, in lieu of the pressure switch permissive used with the intermittent prelube system. A minimum level of oil in the engine is required to fulfill the starting system interlock.

Redundant Prelube System

The redundant prelube system combines the continuous and intermittent prelube systems, offering the benefits of both. Under normal circumstances, the continuous prelube pump keeps the engine ready for immediate start-up by maintaining the level of oil in the engine. The intermittent prelube pump will only operate if the continuous pump fails. This system is typically selected for black start or emergency generator applications, when it is critical that an engine is able to start.

When an engine equipped with a continuous prelube system shuts down, the intermittent pump will postlubricate the engine. After postlubrication the oil pressure decreases and the pilot controlled spill valve opens and the prelube pressure switch opens. When the pressure switch opens the continuous pump will energize and maintain the oil level in the engine.

Quick Start Prelube System

The quick start prelube system consists of two electric prelube pumps, a continuous pump and a booster pump. This system is similar to the redundant prelube system, except that the booster pump is not just a back-up for the continuous pump, it is an integral part of the system.

Figure 6 and **Figure 7** are schematic examples of quick start prelube systems.

While the engine is not operating, the continuous pump maintains the oil level near the top of the cylinder block via the spill valve. When the engine is started, the continuous pump will stop and the booster pump will start in order to raise the pressure to a sufficient level to permit cranking.

When the engine shuts down, the booster pump will postlubricate. After postlubrication, the oil pressure decreases and the pilot controlled spill valve opens and the prelube pressure switch opens. When the pressure switch opens the continuous pump will energize and maintain the oil level in the engine.

Quick start prelube time will vary little with oil temperature. Typical quick start prelube times, measured from the start initiate signal to starter engagement, are 5 to 7 seconds with 25°C (77°F) oil.

Postlubrication

3600/G3600 engines have a standard postlubrication cycle. Postlubrication maintains oil flow after engine shutdown to protect the turbocharger bearings.

Engine postlubrication will not function if the Emergency Stop (E-Stop) button is used to shutdown the engine. Since an oil leak could potentially require the use of the E-Stop button, the postlubrication is disabled to stop oil flow to a possible leak. An E-Stop button is located on the control panel, junction box and the customer terminal strip. Since no postlubrication occurs with the use of the E-Stop button, the E-Stop should only be used for emergency shutdowns.

3600/G3600 Engine Lubricating Oil System with Intermittent or Continuous Prelube

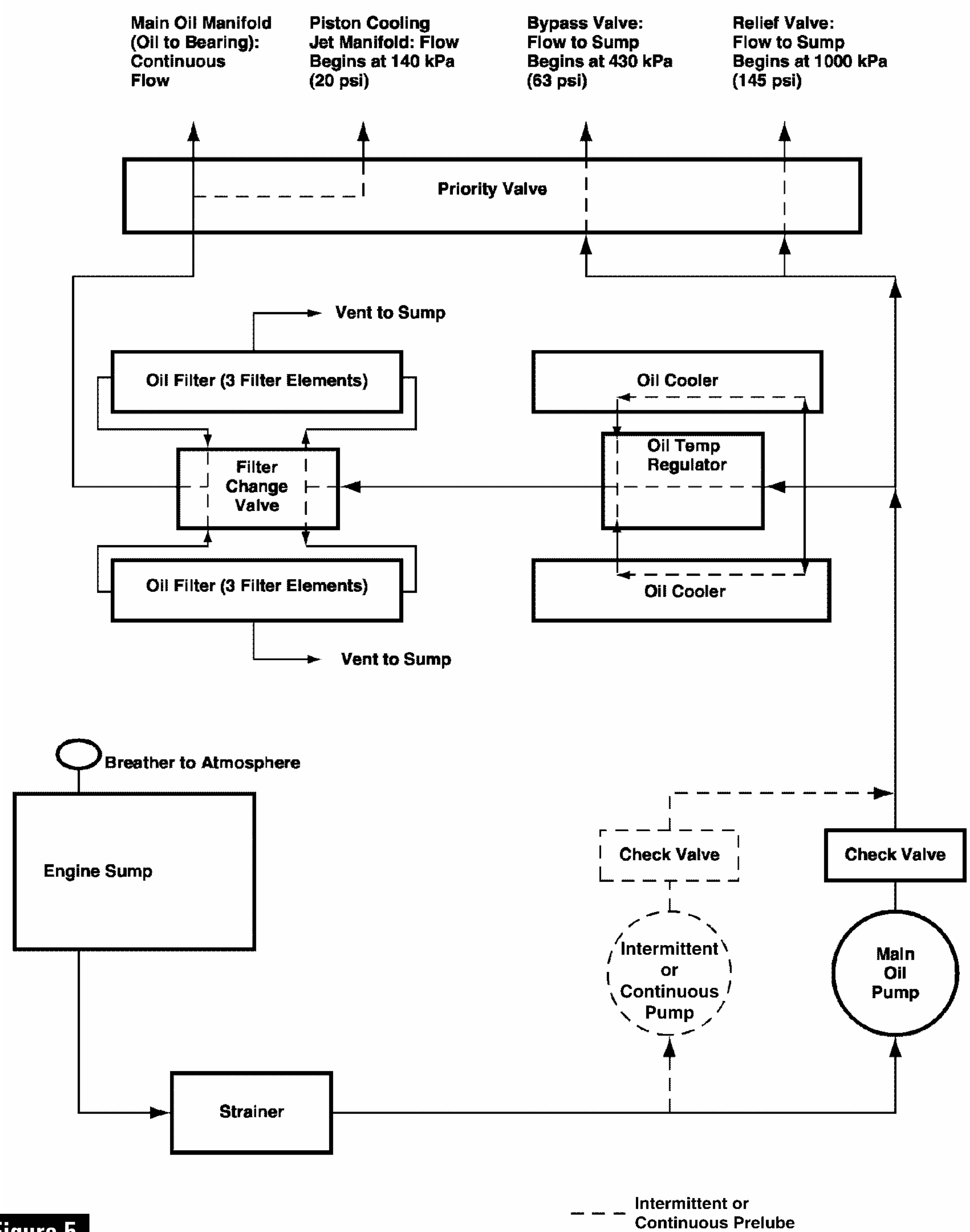


Figure 5

G3600 Engine Lubricating Oil System with Optional Quick Start Prelube

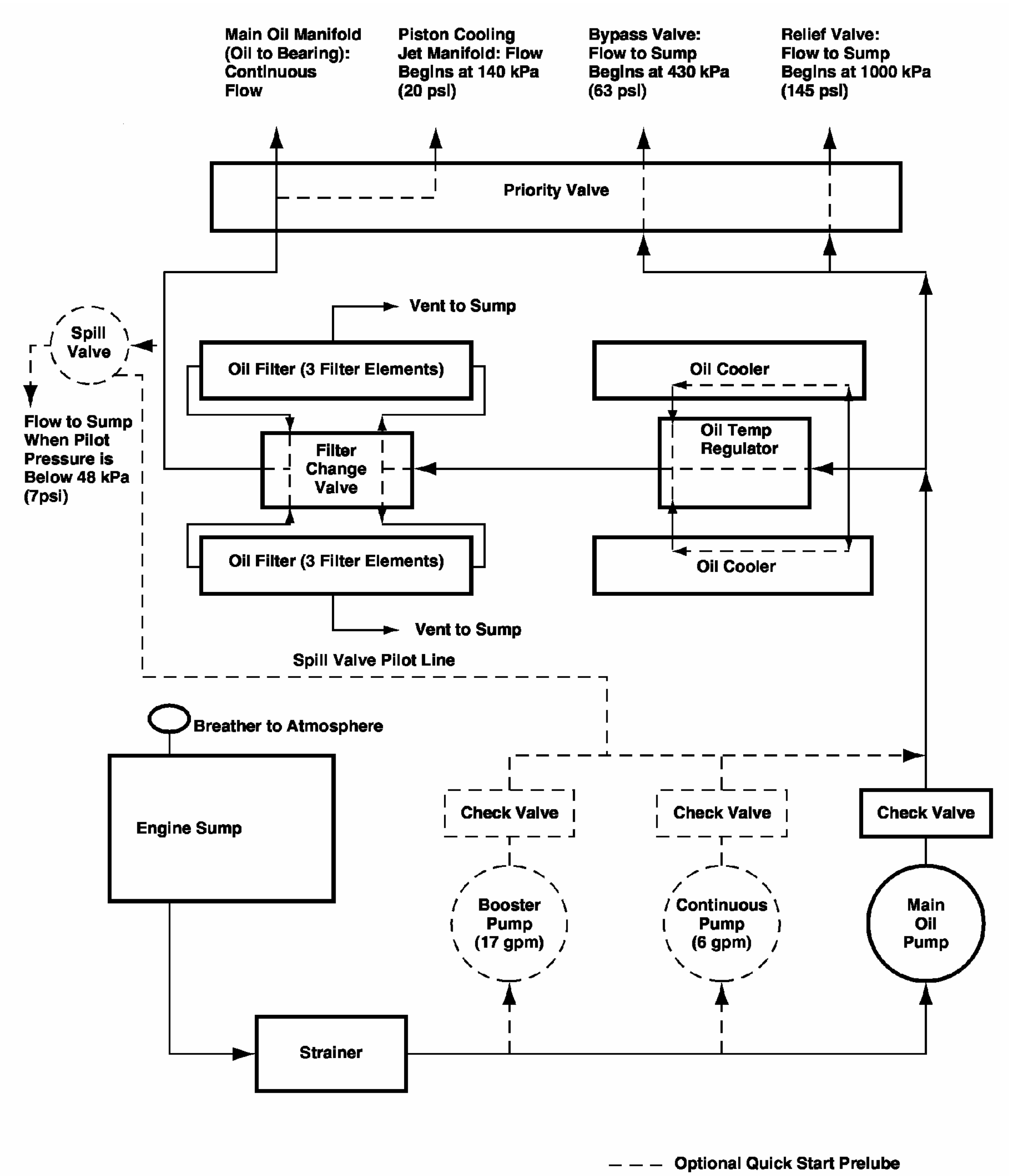


Figure 6

3600/G3600 Air Prelube

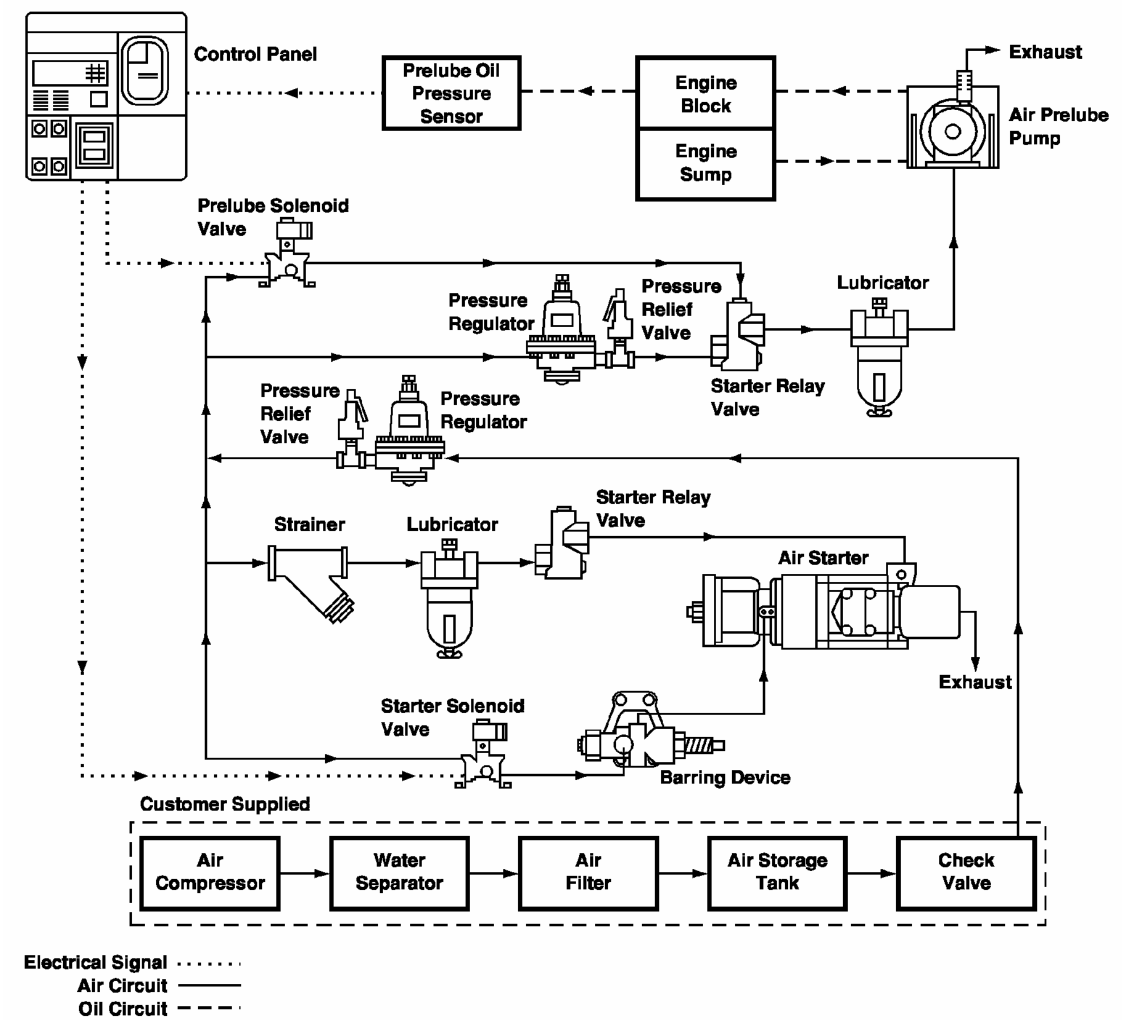
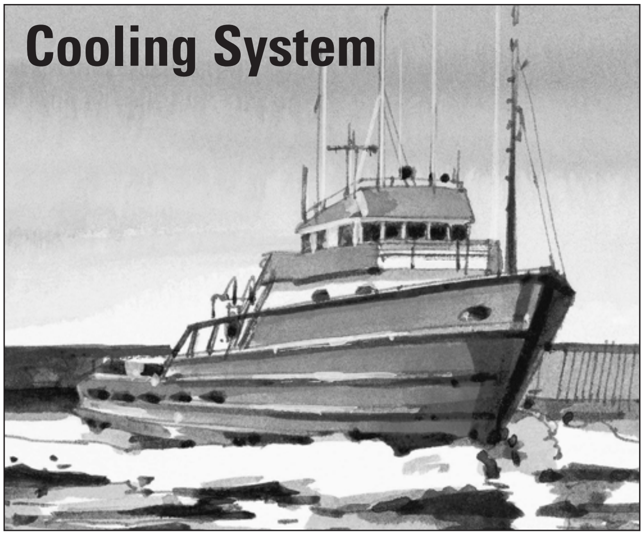


Figure 7

Cooling System



Introduction

The cooling system configuration for the 3612/3616 engine in marine propulsion applications is identified as a combined or single-circuit system. It is also referred to as the single-circuit – two-pump system.

The cooling system is laid out for the following temperature levels:

1. *32°C (90°F) nominal [38°C (100°F) maximum] water temperature to the aftercooler and oil cooler.*
2. *90°C (194°F) nominal jacket water temperature to the cylinder block.*
3. *85°C (185°F) nominal oil temperature to bearings.*

The heat rejection data in this project guide are based on 32°C (90°F) nominal water [38°C (100°F) maximum] to the aftercooler and 25°C (77°F) air to the turbocharger inlet. The thermostatic valve for the low temperature control circuit has 32°C (90°F) nominal elements installed. However, with sea water at 32°C (90°F), the inlet temperature is allowed to go to 38°C (100°F) max. Thus a 6°C (10°F) approach temperature is available for sizing the heat exchanger.

Coolant Flow Control

Correct coolant flows are obtained by factory installed orifices on the engine, combined with proper external circuit resistance set at each site during commissioning. The external circuit resistance setting establishes the total circuit flow by balancing total circuit losses with the characteristic pump performance curves. *Correct external resistance is very important.* Too high a resistance will result in reduced flows to the aftercooler and oil cooler, and their effectiveness will decrease. If there is too low a resistance, the fluid velocity limits may be exceeded, and cavitation/early wear could be the result.

The chart below shows the recommended external resistance maximum pressure drop for a 3612/3616 engine with combined circuit cooling systems.

Coolant Temperature Control

The 3612/3616 engine uses fluid inlet control temperature regulators to provide uniform coolant temperature to the aftercooler, oil cooler, and cylinder block. For the combined system, the AC/OC circuit is externally regulated to provide a nominal 32°C (90°F) coolant temperature. The high temperature jacket water system uses the AC/OC outlet water to maintain 90°C (194°F) inlet water to the block. Jacket water temperature regulation is always required for all configurations and operating conditions.

Fresh Water Pumps

The 3612/3616 engine has two identical gear-driven centrifugal water pumps mounted on the front housing. The right-hand pump (viewed from the flywheel end) supplies coolant to the block and heads. The left-hand pump supplies coolant to the aftercooler, oil cooler, and ultimately supplies the required cooling water needed to control the jacket water inlet temperature.

Engine Speed rpm	3612/3616 Differential Pressure kPa (psi) Full Cooler Flow	3612/3616 Differential Pressure kPa (psi) Full Bypass Flow
1000	85 (12)	130% of 85 (12)
900	66 (9.6)	130% of 66 (9.6)

Heat Exchanger Sizing

The **minimum** acceptable heat exchanger configuration for a combined circuit system must provide 38°C (100°F) **maximum** coolant temperature at the AC/OC pump inlet at the following conditions:

1. **maximum** expected ambient temperature
2. **maximum** engine power capability (rack stop setting)
3. **maximum** expected sea water temperature
4. expected sea water fouling factor
5. anticipated coolant composition (i.e. 50% glycol).

In addition to the above criteria, the combined circuit heat exchanger should provide 32°C (90°F) coolant at normal load conditions, average summer ambient temperature, and normal sea water temperatures. See the technical data section of this manual for specific heat rejection figures.

Typical Heat Balance of the 3600 Engine	
Total energy input	100%
Mechanical work energy	44%
Exhaust gas	29%
Aftercooler cooling water	12%
Cyl block, heads cool water	9%
Lube oil cooling water	4%
Radiation	2%

Jacket Water Heater Sizing

Caterpillar recommends using a separate heater and circulation pump. *An immersion-type heater is not recommended.* The pump should be sized to 150 L/min (39 gal/min) at 120 kPa (17 psi), and the heater is recommended to be minimum 24 kW or as required by the actual application.

System Pressures and Velocities

The following pressure and velocity limits apply to 3600 family of engines:

Water Pump Pressures		
Maximum allowable static head	kPa (psi)	145 (21)
Minimum AC/OC inlet pressure (dynamic)	kPa (psi)	-5 (-0.7)
Minimum JW inlet pressure (dynamic)	kPa (psi)	30 (4)
Minimum sea water inlet pressure (dynamic)	kPa (psi)	-5 (-0.7)
Maximum Operating Pressures		
Engine cooling circuits	kPa (psi)	500 (73)
Caterpillar expansion tanks	kPa (psi)	150 (22)
Heat exchangers		type specific
Water Velocities		
Pressurized lines	m/s (ft/s)	4.5 (14.7)
Pressurized thin walled tubes	m/s (ft/s)	2.0-2.5 (6.6-8.2)
Suction lines (pump inlet)	m/s (ft/s)	1.5 (4.9)
Low velocity de-aeration line	m/s (ft/s)	0.6 (1.9)

Weld Flange Sizes

All external cooling water connections of 100 mm (3.9 in.) diameter or above are supplied with DIN flanges, drilled to DIN 2501. Available in CAT standard, ANSI standard, or DIN standard. CAT standard weld flanges are provided at every connection point; ANSI or DIN can be furnished.

Starting Air System

Air Starters

The Caterpillar supplied air starting system includes air starters, lubricator, air relay valve, strainer, shutoff valve, and pressure regulator, if required. The engine uses two vane-type starters as standard equipment. Turbine starters are optional.

System Requirements

The standard vane air starters operate on air inlet pressures from 700 to 1550 kPa (102 to 225 psi). The turbine starters operate on pressures from 480 to 1040 kPa (70 to 151 psi). These pressures are required at the starter inlet port. An air tank pressure of 700 kPa (102 psi) [480 kPa (70 psi) for turbine] will not start the engine because of the pressure drop associated with the air supply lines. For initial system evaluation, assume a 200 kPa (29 psi) pressure drop between the tank and the air starter inlet.

A pressure regulator is necessary when the supply pressure exceeds the starter operating pressure. The pressure regulator should be set from 860 to 1550 kPa (125 to 225 psi). It should have the capacity to flow 300 L/sec (78 gal/sec) per starter at regulator inlet pressures above 860 kPa (125 psi).

The quantity of air required for each start and the size of the air receiver depend upon cranking time and air-starter consumption. A typical first start at 25°C (77°F) ambient will take five to seven seconds. Restarts of warm engines normally take place in two to three seconds. The control system will shut off the air to the air starters at 170 rpm engine speed. At this firing speed, the governor is activated to allow fuel to the engine.

Receiver Sizing

The chart on page 58 is for typical air receiver sizing. The chart shows the number of starts available with an initial starting air receiver pressure as shown on the curves. This chart assumes: Caterpillar vane-type starters, reduction valve outlet pressure of 860 kPa (125 psi), and a minimum pressure of 690 kPa (100 psi) at the starter inlet port. An average cranking time of three seconds has been used. The starting air receiver size is normally determined by the requirements of the classification society for the number of starts or start attempts.

The size of the air receivers should be increased if the starting air receiver also supplies air for purposes other than the main engine starting (e.g., engine air prelube, work air, auxiliary gen sets). The Caterpillar intermittent air prelube pump consumption rate is 28.2 L/sec (7.3 gal/sec) based on free air at 21°C (70°F) at 100 kPa (70°F at 14.5 psi). The pump motor operating pressure is 690 kPa (100 psi). The prelube pump will normally operate one to five minutes before the engine begins to crank.

Customer Connections

Vane-type starters must be supplied with clean air. Deposits of oil-water mixture must be removed by traps installed in the lines. Lines should slope toward the traps and away from the engine. The air supply pipes should be short and at least equal in size to the engine inlet connection, which is 38 mm (1-1/2 in). Locate the pressure reducing valve as close to the engine as possible to minimize the air pressure reduction valve supply pipe diameter.

Starting Air System Schematic

A typical starting air system is illustrated on page 59.

Pneumatic Starting (Air)

Air starting, either manual or automatic, is highly reliable. Torque available from air motors accelerates the engine to twice the cranking speed in about half the time required by electric starters.

Pneumatic starting is generally applied to large engines in work-boats, on land where facilities have existing plant air, or where a combustible gases may be present in the atmosphere.

The air system can be quickly recharged; but air storage tanks are prone to condensation problems and must be protected against internal corrosion and freezing.

Typical Pneumatic Starter

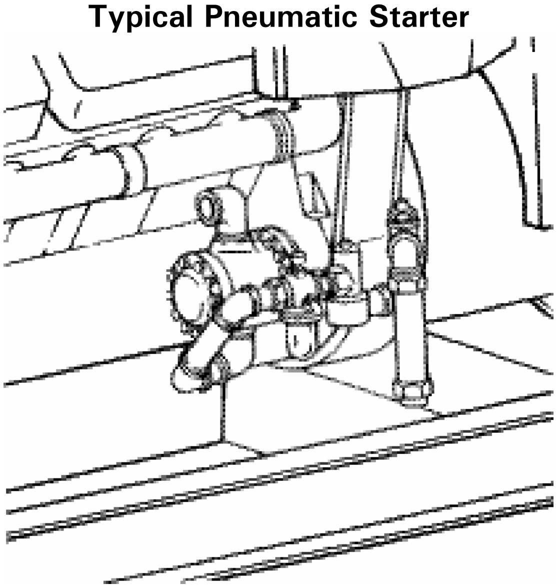


Figure 7

Air is usually compressed to 758 to 1723 kPa (110 to 250 psi) and is stored in storage tanks. Stored air is regulated to from 620 kPa (90 psi) to a maximum of 1550 kPa (225 psi) depending on the engine and starter and piped to the air motor. Consult the Owners manual for the recommended regulation pressure for the engine model you are using. A check valve between the compressor and the air receiver is good practice, to protect against a failure of plant air that might deplete the air receivers' supply.

The air compressors that supply pneumatic starters are driven by external power sources such as electric motors and diesel or gasoline engines. A small emergency receiver (not supplied by Caterpillar) can be hand pumped to starting pressure under emergency conditions. A more common emergency backup will include an auxiliary diesel engine-driven air compressor package.

Air Tank

Air tanks are required to meet specific characteristics, such as the specifications of the American Society of Mechanical Engineers (ASME). Compressed air storage tanks must be equipped with a maximum pressure valve and a pressure gauge. Check the maximum pressure valve and pressure gauge often to confirm proper operation. A drain cock must be provided in the lowest part of the air receiver tank for draining condensation.

Air Storage Tank Sizing

Many applications require sizing air storage tanks to provide a specified number of starts without recharging.

This is accomplished using the following formula:

$$V_T = \frac{V_S \times T \times P_A}{P1 - P_{MIN}}$$

Where:

V_T = Air storage tank capacity (cubic feet or cubic meters)

V_S = Air consumption of the starter motor (m^3/sec or ft^3/sec) —

Air Starting Requirements are in the TMI for model engine used.

If prelube is used its consumption must be added to V_S also.

T = Total cranking time required (seconds): If six consecutive starts are required, use seven seconds for first start (while engine is cold), and two seconds each for remaining five starts, or a total cranking time of seventeen seconds.

P_A = Atmospheric pressure (psi or kPa): Normally, atmospheric pressure is 101 kPa (14.7 psi).

P_T = Air storage tank pressure (psi or kPa): This is the storage tank pressure at the start of cranking.

P_{MIN} = Minimum air storage tank pressure required to sustain cranking at 100 rpm (psi or kPa) — Air Starting Requirements are in TMI for model used.

Example:

A 3516 Diesel Engine with electric prelube has the following:

Maximum air tank pressure = 1241 kPag (180 psig)

Minimum air to starter pressure = 620.5 kPag (90 psig)

Expected air line pressure drop = 207 kPag (30 psig)

Six consecutive starts. First start = 7 seconds the other 5 starts = 2 seconds

Average barometric pressure at this location = 100 kPa (14.5 psi)

Preconditioned engine installation.

(cfm x 0.02832 = m^3/min)

Solution:

V_S = 0.40 m^3/sec (14.1 ft^3/sec)

T = 7 + (5 x 2) = 17 sec

P_A = 100 kPa (14.5 psi)

P_T = 1241 – 207 = 1034 kPag (180 – 30 = 150 psig)

P_{MIN} = 620.5 kPag (90 psig)

Therefore:

$$V_T = \frac{0.4 \times 17 \times 100}{1034 - 620.5} = 1.64\ m^3$$

$$V_T = \frac{14.1 \times 17 \times 14.5}{150 - 190} = 57.93\ ft^3$$

Air Starting Motor

Cranking Time Required

The cranking time depends on the engine model, engine condition, ambient air temperature, oil viscosity, fuel type, and design cranking speed. Five to seven seconds is typical for an engine at 26.7°C (80°F). Restarting hot engines usually requires less than two seconds. Most marine societies require a minimum of six consecutive starts for propulsion

Combustion Air Flow Requirements

Combustion air flow requirements will vary, depending on the specific engine model and rating. Specific air flow data for Caterpillar engines is given in both volumetric [m^3/min (cfm)] and mass [kg/hr (lb/hr)] flow terms, at standard reference conditions.

Reference conditions for temperature and pressure are used to provide a basis for consistent measure of combustion air quantities. However, different parts of the world subscribe to different standards, thus it is important to note that the metric and English conditions are not equivalent. Caterpillar practice is to use ISO "normal" conditions of 0°C (32°F) and 101.3 kPaa (14.7 psia) when providing values in metric units and ASME "standard" conditions of 25°C (77°F) and 101.3 kPaa (14.7 psia) when providing values in English units.

To convert from mass airflow to volumetric airflow at reference conditions, use the following formula:

$$\frac{M_R}{S_R} = Q_R$$

Where:

M_R = Mass air flow at reference conditions (kg/hr), (lb/hr)

Q_R = Volumetric air flow at reference conditions (m^3/min), (cfm)

S_R = Density of air at reference conditions (kg/m^3), (lb/ft^3). (Density of air = 1.292 kg/Nm^3 (0.074 lb/ft^3))

To convert both mass airflow and volumetric air flow from reference conditions to site conditions, use the following formulas:

$$M_R \times \frac{T_S}{T_R} = M_S$$

$$Q_R \times \frac{T_S}{T_R} = Q_S$$

Where:

M_R = Mass flow at reference conditions (kg/hr), (lb/hr).

M_S = Mass flow at site conditions (kg/hr), (lb/hr).

Q_R = Air flow at reference conditions (m^3/min), (cfm).

Q_S = Air flow at site conditions (m^3/min), (cfm).

T_R = Air temperature at reference conditions (°K), (°R).

T_S = Air temperature at site conditions (°K), (°R).

°K = °C + 273.

°R = °F + 460.

Air Intake Ducting

General

When ducting is necessary to obtain cooler or cleaner air, the filters should remain on the engine to prevent harmful dirt from leaking into the engine through ducting joints. When air cleaners must be remote-mounted it is extremely important that all joints be air tight to prevent ingestion of dirt.

When designing air intake ducting, consideration must be given to appropriate routing, duct support and system restriction, especially on the larger engines, where overhead cranes are used to service the engines. Proper support for duct work adjacent to the engine is critical, so that its weight is not borne by the turbocharger or other engine-mounted components.

Locate the air piping away from the vicinity of the exhaust piping so that the air provided to the engine is as cool as possible. Air temperature to the air inlet should be no more than 11°C (20°F) above ambient air temperature. Inlet air temperature should not exceed 45°C (113°F) for standard ratings.

Avoid abrupt transitions in the intake ducting to provide the smoothest possible air flow path. When unavoidable, transitions should be made as far upstream of the turbocharger as possible. Keep total duct head loss (restriction) below 0.5 kPa (2 in. H_2O) for maximum filter life. Any additional restriction will reduce filter life.

To allow for minor misalignment due to manufacturing tolerances, engine-to-enclosure relative movement and isolate vibrations, segments of the piping should consist of flexible rubber fittings. These are designed for use on diesel engine air intake systems and are commercially available. These fittings include hump hose connectors and reducers, rubber elbows and a variety of special shapes.

Wire-reinforced flexible hose should not be used. Most material available is susceptible to damage from abrasion and abuse and is very difficult to seal effectively at the clamping points unless special ends are provided on the hose.

Inlet ducting should be designed to withstand a minimum vacuum of 12.5 kPa, (50 in. H_2O) which is also the structural capability of the Caterpillar air cleaner filter element.

Piping diameter should be equal to or larger than the air cleaner inlet/outlet and the engine air inlet. A rough guide for pipe size selection is to keep maximum air velocity in the piping to 10 m/s (2,000 fpm). Higher velocities will cause high noise levels and excessive flow restrictions. Refer to the Air Intake Restriction section for guidance in determining required intake duct sizing.

All piping must be designed and supported to meet any local seismic requirements that may be in force.

The ducting should be of seamless or welded seam piping to minimize the flow restriction. The ducting should also be constructed of materials suitable for local environmental conditions such as offshore or marine applications.

Beaded pipe ends at hose joints are recommended. Sealing surfaces should be round, smooth and free of burrs or sharp edges that can cut the hose. The tubing should have sufficient strength to withstand hose clamping forces. Either T-bolt type or SAE type F hose clamps that provide a 360° seal should be used. High quality clamps must be used. Double clamps are recommended on connections downstream of the air cleaner.

PVC piping has a number of benefits. It is light-weight, provides a good seal without the chance of weld slag coming loose and will not rust. However, it is not well suited for high or low temperature environments. It can lose much of its strength when subjected to temperatures of 150C (300F) or above. It can also become brittle and shatter at low temperatures. If using PVC pipe, use at least schedule 40 pipe and check that it meets local regulations for the area classification.

If ferrous material is necessary, it must be properly cleaned after fabrication and treated to prevent rust and scale from accumulating. Stainless steel ducting should be treated in the same manner. Flanged connections with gaskets are preferred over threaded connections. Fasteners such as rivets should not be used.

Unsupported weight on clamp-type joints should not exceed 1.3 kg (3 lb).

Marine Intake Air Piping Examples

Figure 4 shows a 3600 marine application configured to use a remote mounted air cleaner and outside air for combustion. An intake air heater may be required for cold weather operation.

Figure 5 shows a 3600 marine application configured to use a remote mounted air cleaner and engine room air for combustion.

Remote Mounted Air Cleaner with Outside Air Intake

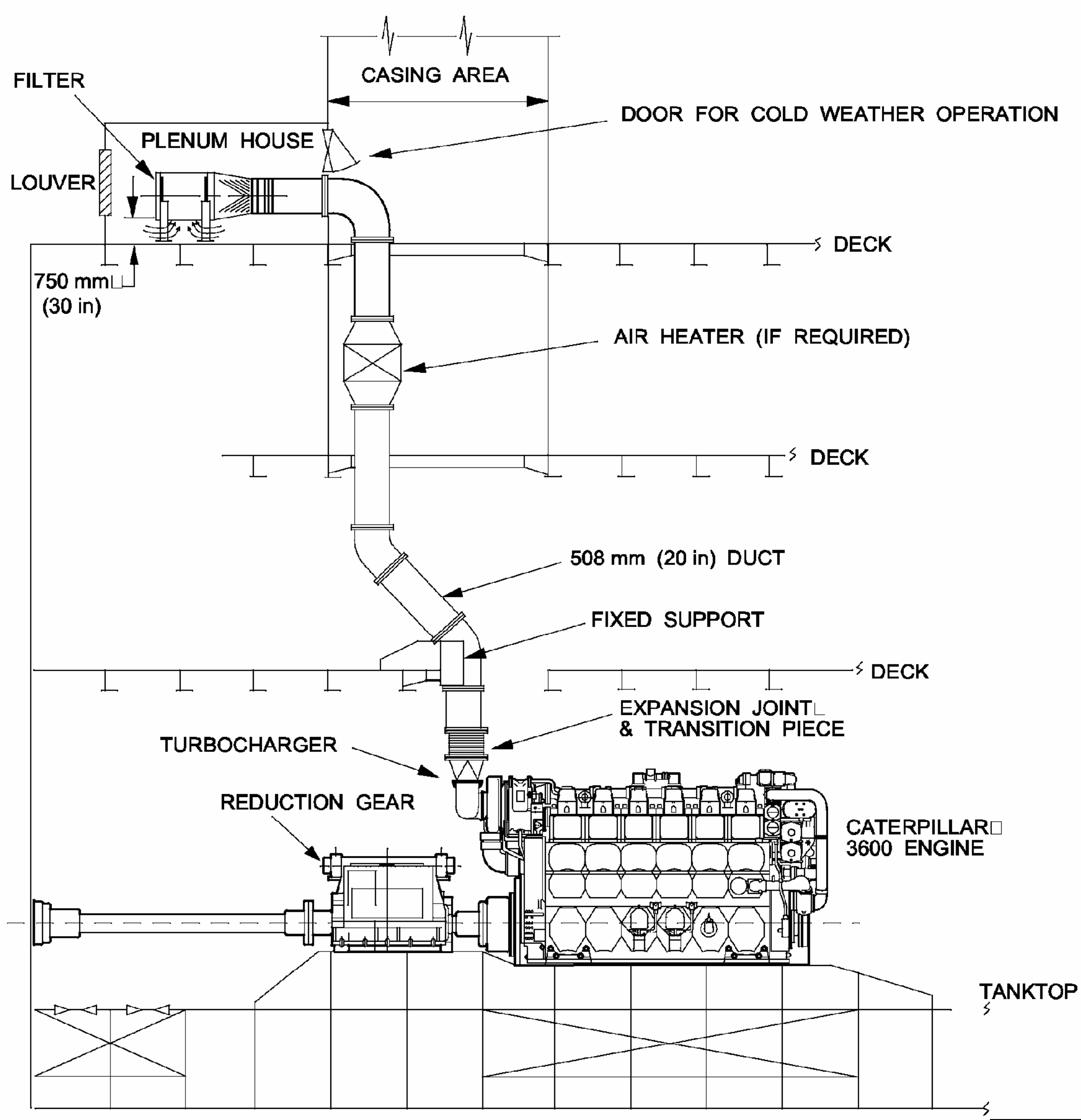


Figure 4

Remote Mounted Air Cleaner with Engine Room Air Intake

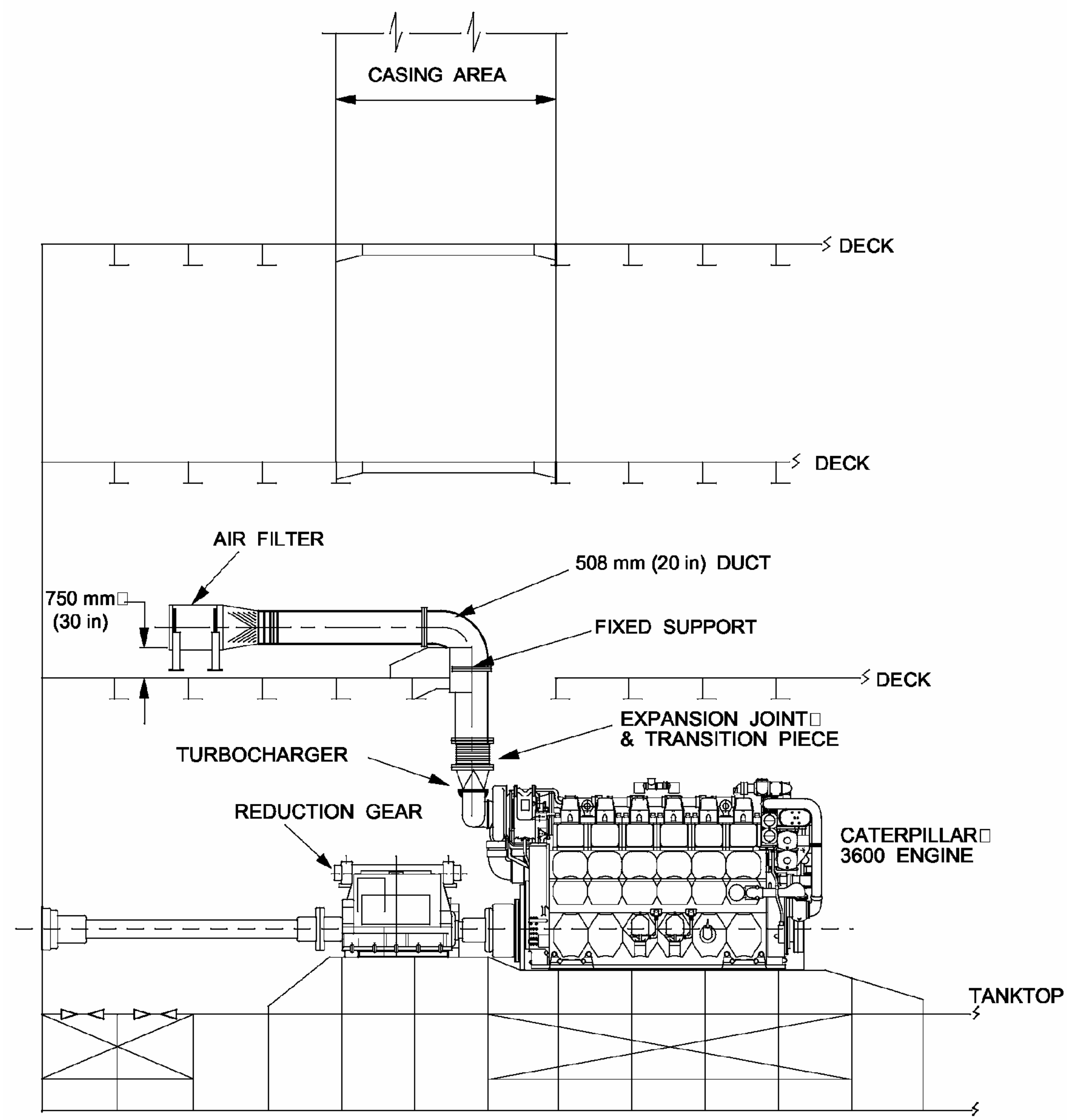


Figure 5

Air Inlet Adapters

Caterpillar offers various air inlet adapters for connecting to turbocharger air inlets. The adapters are part of the system to provide an efficient transition from the engine room intake air ducting to the engine turbocharger. Adapters are typically shipped loose and include gaskets and mounting hardware.

CAUTION: Turbocharger performance may be adversely affected if appropriate air intake components are not used (They are designed to provide the proper air flow pattern ahead of the turbocharger).

Connections to Inlet Adapters and Turbochargers

The piping connected to the turbocharger inlet should be designed to ensure that air is flowing in a straight, uniform direction into the turbocharger compressor. This is typically achieved by installing a straight section of pipe, equal in length to at least two or three times pipe diameter, to the inlet. This arrangement reduces the possibility of premature compressor wheel failure due to pulsations created by air striking the compressor wheel at an angle. Transitional ducting immediately preceding the straight section of pipe should consider the following guidelines:

- The duct between the straight pipe and elbow cannot have protruding edges.
- The bend can be designed as a circular arc or with sections of mitered pipe with rectangular or round flow cross sections, or as transition from round to rectangular cross section.
- An accelerated flow is expected to occur in the bend. The flow area (F) should be: $F_1 > 1.5 \times F_2$, as shown in **Figure 6**.

Turbocharger Vertical Inlet Design Options

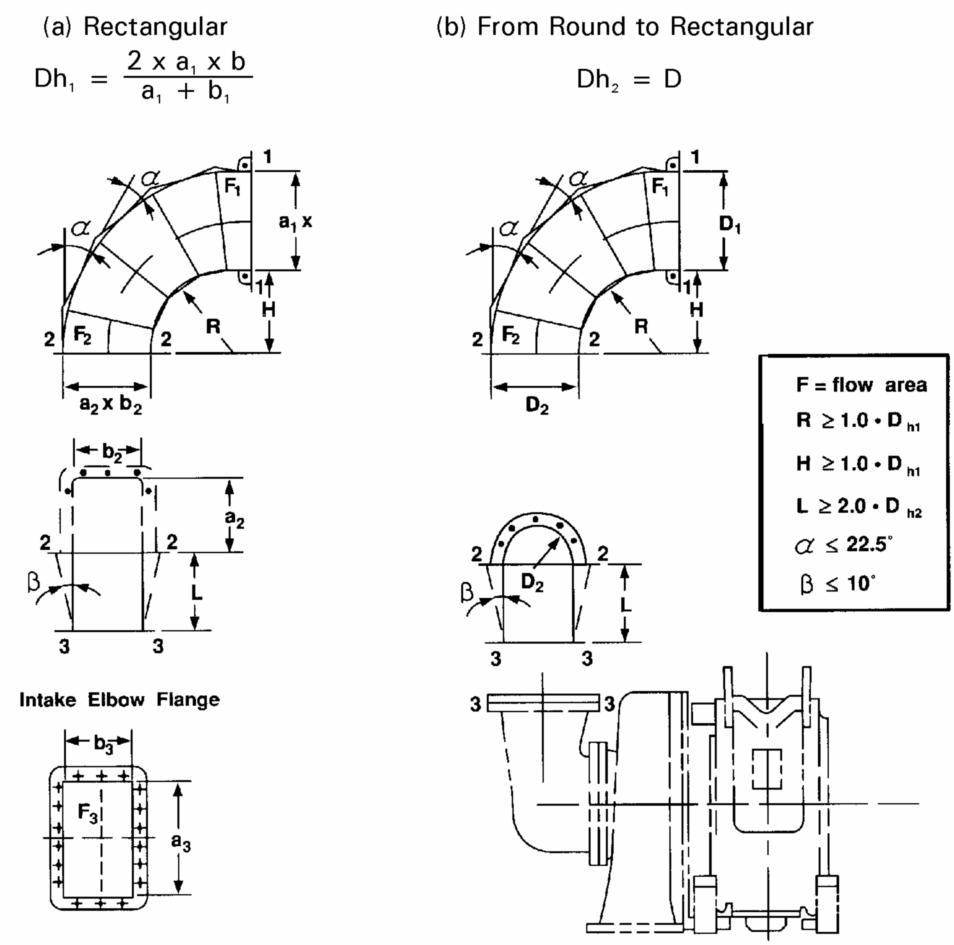


Figure 6

Inlet Pipe Design Joining Two Turbochargers

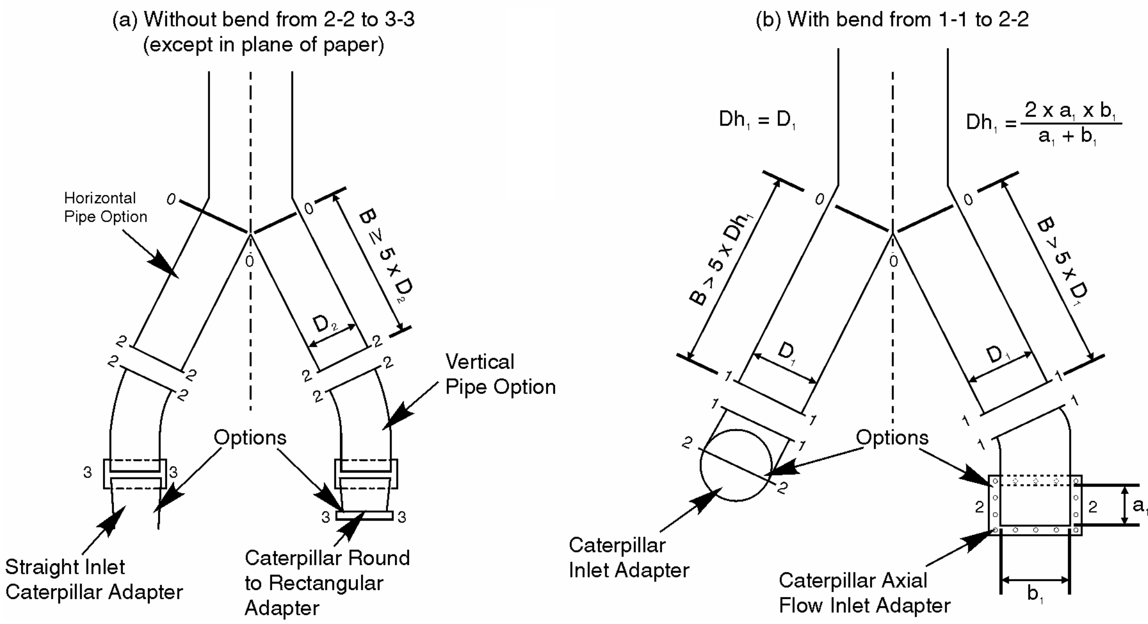


Figure 7

Joining Two Turbochargers

When ductwork feeding two turbochargers is combined to form a single duct, a steadying zone must be provided after the dividing joint; as shown in **Figure 7**. The steadying zone B must be a minimum of 5 times the pipe diameter:

$B > 5 \times Dh_1$

The flow area is:

$F_0 = 1.0 \div 2.0 \times F_1$

The transitions from Sections 0-0 to 1-1 and from 1-1 to 2-2 will have many circular or rectangular variations due to turbocharger hardware and installation site design. Regardless of the transition selected, the steadying zone must be provided.

The transitions used to combine multiple ducts must also follow typical design standards described in this guide. Ducts should have smooth transitions and not cause disturbance in the air flow. Piping designs that use a Tee, as shown in **Figure 8**, should not be used to connect multiple ducts.

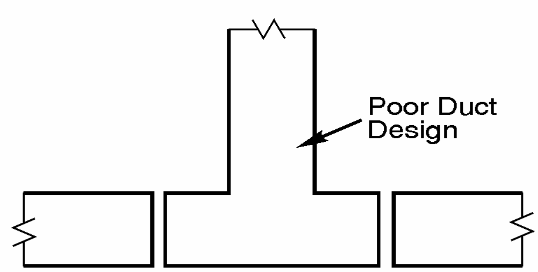


Figure 8

Turbocharger Loading

When remote-mounted air cleaners are used, turbocharger loading from the weight of the air inlet components becomes a concern. The turbochargers are not designed to support any additional weight beyond standard factory attachments. When possible, make the flexible connection directly to the turbocharger air inlet, as shown in **Figure 9**. All duct work to that point must be supported off-engine.

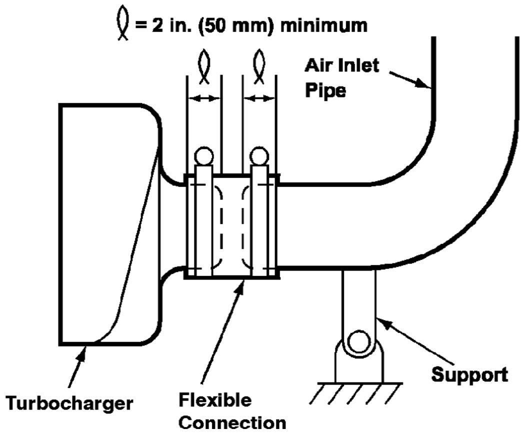
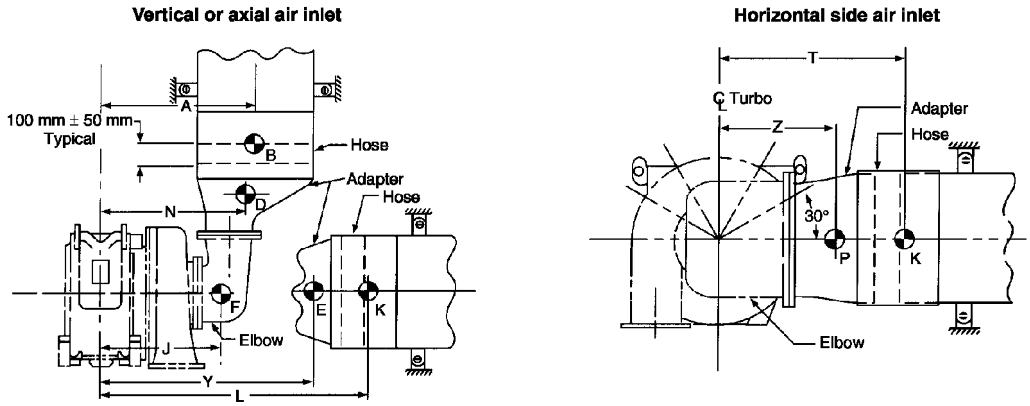


Figure 9

The maximum allowable turbocharger load will vary, depending on the engine model, the inlet adapter and the adapter orientation. In the example below, **Figure 10**, the 90° inlet adapter can be rotated in 30° increments. Turbochargers for 3600/G3600 engines are designed to withstand a maximum moment of 294 N•m (217 ft-lb). **Figure 10** shows how the moment can be calculated.

Models that provide a mounting bracket for the turbocharger inlet adapter, such as the C15, can support up to 11.3 kg (25 lb) of duct weight.

Maximum Loads for Turbocharger Intake



D, F & E = Adapter Weight
B & K = 1/2 Hose Weight
Moment (Vertical Inlet):
$M_V = JF + ND + AB$
Moment (Axial Inlet):
$M_A = YE + LK$

Allowable
Max Moment = 30 mkg

With Caterpillar Supplied Hardware

J = 548 mm	N = 625	A = 700 mm
Y = 705 mm	L = 945 mm	
D = 13 kg	E = 14 kg	F = 16 kg
B = $\frac{3\ kg}{2}$	K = $\frac{3\ kg}{2}$	

$M_V = 0.548\ (16) + 0.625\ (13) + 0.700\ (1.5)$
M_V = 18 mkg which is less than 30 mkg/OK
$M_A = 0.705\ (14) + 0.945\ (1.5) = 11$ mkg which is less than 30 mkg/OK

P = Adapter Weight
K = 1/2 Hose Weight
$M_S = ZP + TK \leq 7$ mkg

With Caterpillar Hardware
P = 13 kg K = $\frac{3\ kg}{2}$

Z = 420 mm T = 500 mm
$M_S = 0.420\ (13) + 0.500\ (3/2) = 6.21 < 7$/OK

Figure 12.

Figure 10

Flex Connections

Flexible connections are required to isolate engine vibration and noise from the ducting system. The connections should be configured for maximum allowable offset and compression to prevent early failure and excess forces on the turbocharger and air inlet components. The flexible connection should be as close to the engine as practical and installed in such a way to not induce stress on the ducting system. The flex engagement with the air intake duct should be a minimum of 50 mm (2 in.) and a maximum of 200 mm (8 in.). Care must be used to prevent exhaust piping heat from deteriorating rubber flex connections.

Cleanliness During Installation

The air intake ducting must be cleaned of all debris. Fabricated ducting, utilizing fasteners such as rivets, should not be used. The ducting should be made of material such that prolonged operation will not result in debris coming loose and entering the turbocharger.

An identifiable blanking plate should be installed ahead of the turbocharger to prevent debris from entering during initial installation of the unit. The plate should have a warning tag indicating it has to be removed prior to starting the engine. The Caterpillar supplied shipping cover can be used for this purpose.

Provisions should be made to inspect the ducting for cleanliness just prior to initial start up. If the piping is not clean, it must be cleaned before the engine is started at commissioning. This may require removal of the piping from its installed position.

Inlet Air Duct Insulation

Insulation may be needed on the intake ducting for remote mounted air cleaners. Insulation reduces turbocharger noise emitted into the engine room and will minimize pre-heating of intake air.

Air Intake Restriction

Excessive vacuum on the inlet side of the turbocharger (or the air inlet on naturally aspirated engines) can result in reduced engine power capability and degrade engine performance.

Air intake restriction is also an emissions critical parameter declared to obtain EPA non-road certification. Therefore, the air intake system's total restriction (including dirty filters, duct work, vents, silencers, etc.) is limited depending on engine model, rating and air configuration. The air intake restriction limits for Caterpillar engines can be found in the Technical Information Appendix or TMI.

In order to maximize air filter life, it is important to keep total duct restriction below 0.5 kPa (2 in. H_2O). Every additional restriction caused by the air inlet system subtracts from air filter life. Maximum filter life is partially dependent on the absolute pressure differential between the turbocharger compressor inlet and atmosphere.

Inlet air restriction includes the pressure losses between the air cleaner and the engine air inlet connection. For remote mounted air cleaners, the following formulas can be used to calculate duct restriction.

$$P(\text{kPa}) = \frac{L \times S \times Q^2 \times 3.6 \times 10^6}{D^5}$$

$$P(\text{in. } H_2O) = \frac{L \times S \times Q^2}{187 \times D^5}$$

Where:

P = Restriction (kPa), (in. H_2O)

psi = 0.0361 x in. water column

kPa = 6.3246 x mm water column

L = Total equivalent length of pipe, measured in (m), (ft)

Q = Inlet air flow, measured in (m^3/min), (cfm). - (found in TMI or performance book, and corrected for site conditions when necessary)

D = Inside diameter of pipe, measured in (mm), (inches)

If the duct is rectangular, as shown in **Figure 11**:

Then:

$$D = \frac{2 \times a \times b}{a + b}$$

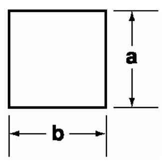


Figure 11

S = Density of air kg/m^3 (lb/ft^3)

$$S(kg/m^3) = \frac{352.5}{\text{Air Temperature} + 273°C}$$

$$S(lb/ft^3) = \frac{39.6}{\text{Air Temperature} + 460°F}$$

Use the following formulas to obtain equivalent lengths of straight pipe for various elbows.

Standard Elbow (radius = diameter) $L = \frac{33D}{X}$

Long Radius Elbow (radius = 1.5 diameter) $L = \frac{20D}{X}$

45° Elbow (radius = 1.5 diameter) $L = \frac{15D}{X}$

Square Elbow (radius = 1.5 diameter) $L = \frac{66D}{X}$

Where:

x = 1000 mm (12 in.)

As shown above, if 90° bends are required, long radius elbows, with a radius of 1.5 times the pipe diameter, offer lower resistance than standard elbows.

Example

Below is an example of an air intake duct restriction calculation.

A 3412 packaged genset has an inlet air flow of 36.7 m^3/min (1292 cfm) with duct configuration consisting of 3 m (10 ft) of straight length duct along with 2 standard elbows and a long radius elbow. The pipe has a diameter of 152.4 mm (6 in) and the temperature of the air is 55°C (131°F).

First calculate the total equivalent length of the ducting.

$$L = \frac{3 + 2 \times (33 \times 152.4)}{1000\text{ mm}} + \frac{20 \times 152.4}{1000\text{ mm}}$$

$$L = 16.1\text{ m}$$

$$L = \frac{10 + 2 \times (33 \times 6)}{12\text{ in.}} + \frac{20 \times 6}{12\text{ in.}}$$

$$L = 53\text{ ft}$$

Next, calculate the density of the air.

$$S = \frac{352.5}{55 + 273°C}$$

$$S = 1.075\text{ kg/m}^3$$

$$S = \frac{39.6}{131 + 460°F}$$

$$S = 0.067\text{ lb/ft}^3$$

Lastly, insert the previous results into the duct restriction formula and calculate.

$$P = \frac{16.1 \times 1.075 \times 36.72 \times 3598805.2}{152^5}$$

$$P = 1.02\text{ kPa or }104\text{ mm }H_2O$$

$$P = \frac{53 \times 0.067 \times 12922}{5184 \times 6^5}$$

$P = 0.147$ psi or 4.07 in H_2O

Total duct restriction should be below 0.5 kPa (2 in. H_2O). The duct restriction in this example is above the desired value, therefore this duct configuration is unacceptable.

~~flow slows the turbocharger to avoid overspeed and excessive boost pressure.~~

~~On some natural gas engines, the wastegate may be manually adjusted for site conditions to optimize the throttle position for efficiency or improved response.~~

~~**Note:** The exhaust flow by-passing the two turbochargers of a G3600 vee engine via the wastegate are plumbed together and exit on one exhaust outlet. Therefore, if measuring exhaust flow, you will notice an uneven exhaust gas flow through the two exhaust outlets when the wastegate is open. Typically, the right side flow will be 15% higher than the left side.~~

~~**CAUTION:** Tampering with the boost line to the wastegate will raise aftercooler heat rejection, increase turbocharger speed and peak engine cylinder pressure. This will negatively affect engine reliability, durability, stability, emissions and overall performance.~~

Flexible Exhaust Connections

The exhaust piping system must be isolated from the engine with flexible connections, designed for zero leakage and flexible in all directions. Two types of flexible connections are normally used a flexible metal hose type and a bellows type.

Flexible Metal Hose and Bellows

Flexible metal hose is commonly used for exhaust systems with a diameter of 150 mm (6 in) and smaller. Bellows are typically used for exhaust systems with a diameter of 200 mm (8 in) and larger.

Flexible connections should be installed as close as possible to the engine exhaust outlet. A flexible exhaust connection has three primary functions.

- To isolate the weight of the exhaust piping from the engine. The amount of weight which the exhaust outlet for each engine model can withstand varies.
- To relieve exhaust components of excessive vibrational fatigue stresses.
- To allow relative shifting of exhaust components. This has numerous causes. It may result from expansion and contraction due to temperature changes, by creep processes that take place throughout the life of any structure, or by torque reactions.

A typical piping layout with flexible connections is shown in **Figure 3**.

Flexible pipe connections, when insulated, must expand and contract freely within the insulation. This generally requires a soft material or insulated sleeve to encase the connection.

Typical Exhaust Piping With Flexible Connection

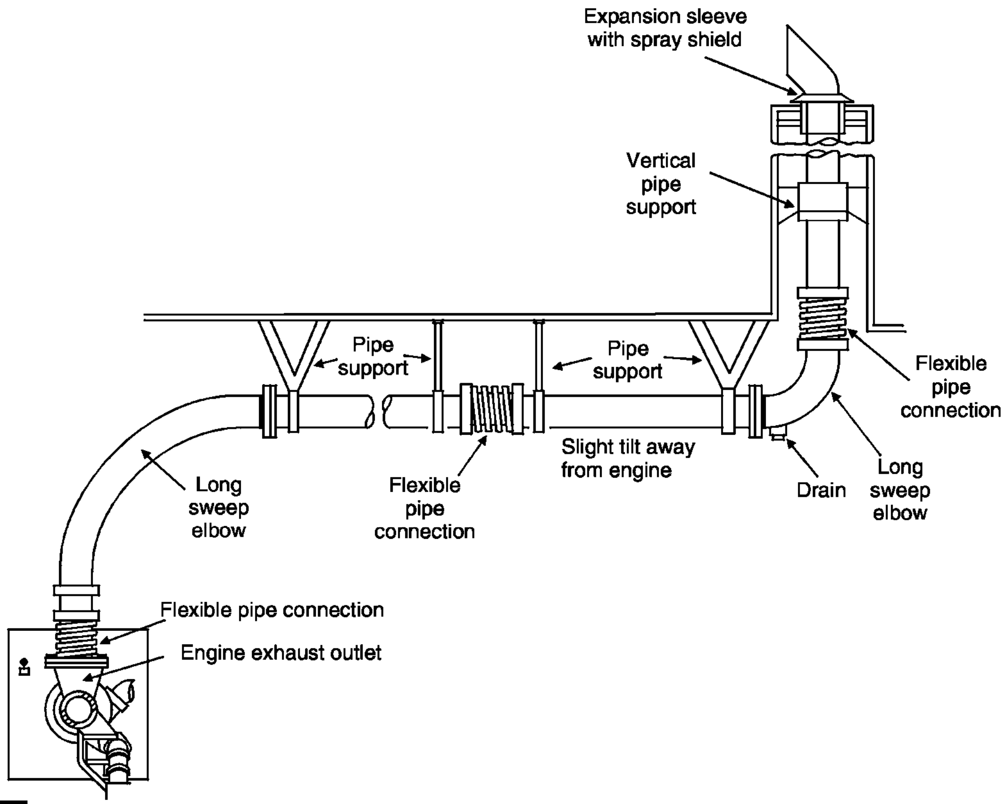


Figure 3

The flexible connections should be pre-stretched during installation to allow for expected thermal growth. Four small straps can be tack-welded between the two end flanges to hold the engine exhaust flexible connections or bellows in a rigid position during exhaust piping installation. This will prevent the bellows from being installed in a flexed condition. Attach a warning tag to the bellows noting that the weld straps must be removed prior to starting the engine.

Any flexible connector must have good fatigue resistance. It should give acceptable service life while withstanding vibratory stress and it should be soft enough to prevent transmission of vibration beyond the connection.

The installation limitations of Caterpillar supplied flexible exhaust fittings are shown in the table below. For maximum durability, allow the bellows to operate as close as possible to its free state.

Slip Joints

Slip joints are another method of handling the expansion and contraction of exhaust systems. Slip joints are designed to have controlled leakage when the system is cold. When the engine starts and the exhaust pipes warm up, the joints will expand and make a gas-tight fit. The slip joints are flexible in only one direction and require good support on each side.

However, Caterpillar does not normally recommend the use of slip joints due to disadvantages such as leaking exhaust fumes, exhaust slobber and the inability of the joint to flex in more than one direction.

Installation Limits of Flexible Exhaust Fittings – Flexible Metal Hose-Type						
Hose Diameter	A Maximum Offset Between Flanges		B Maximum Compression From Free Length		C Maximum Extension From Free Length	
	mm	in.	mm	in.	mm	in.
4 & 5 in.	25.4	1.0	6.25	.25	6.25	2.5
6 in.	38.1	1.5	6.25	.25	6.25	2.5

Installation Limits of Flexible Exhaust Fittings - Bellows-Type						
Hose Diameter	A Maximum Offset Between Flanges		B Maximum Compression From Free Length		C Maximum Extension From Free Length	
	mm	in.	mm	in.	mm	in.
8 & 12 in.	19.05	0.75	38.1	1.50	25.40	1.00
14 in.	19.05	0.75	76.2	3.00	25.40	1.00
18 in.	22.86	0.90	76.2	3.00	44.45	1.75

Spring Rate for Flexible Fittings - Bellows-Type		
Diameter	Spring Rate	
	kN/m	lb/in.
8 in.	29.7	170
12 in.	33.9	194
14 in.	68.5	391
18 in.	19.3	110

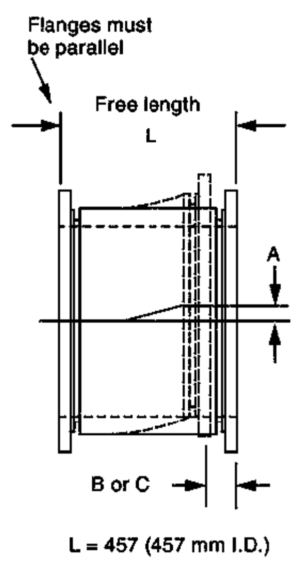


Figure 4

Exhaust System Piping

The function of the exhaust piping is to convey the exhaust gases from the engine exhaust outlet to the silencer and other exhaust system components, terminating at the system outlet. Piping is a key feature in overall exhaust system layout.

Exhaust System Design

The physical characteristics of the engine room or engine bay will determine the exhaust system layout. Exhaust piping should be designed to minimize the exhaust backpressure while keeping engine serviceability in mind. The exhaust piping should be securely supported. Allowances should be made for system movement and vibration isolation by using suitable flexible components such as rubber dampers or springs.

Piping must be designed with engine service in mind. In many cases, an overhead crane will be used to service the heavier engine components on the larger engines.

The following recommendations should be followed when designing an exhaust piping system.

Typical Silencer Details

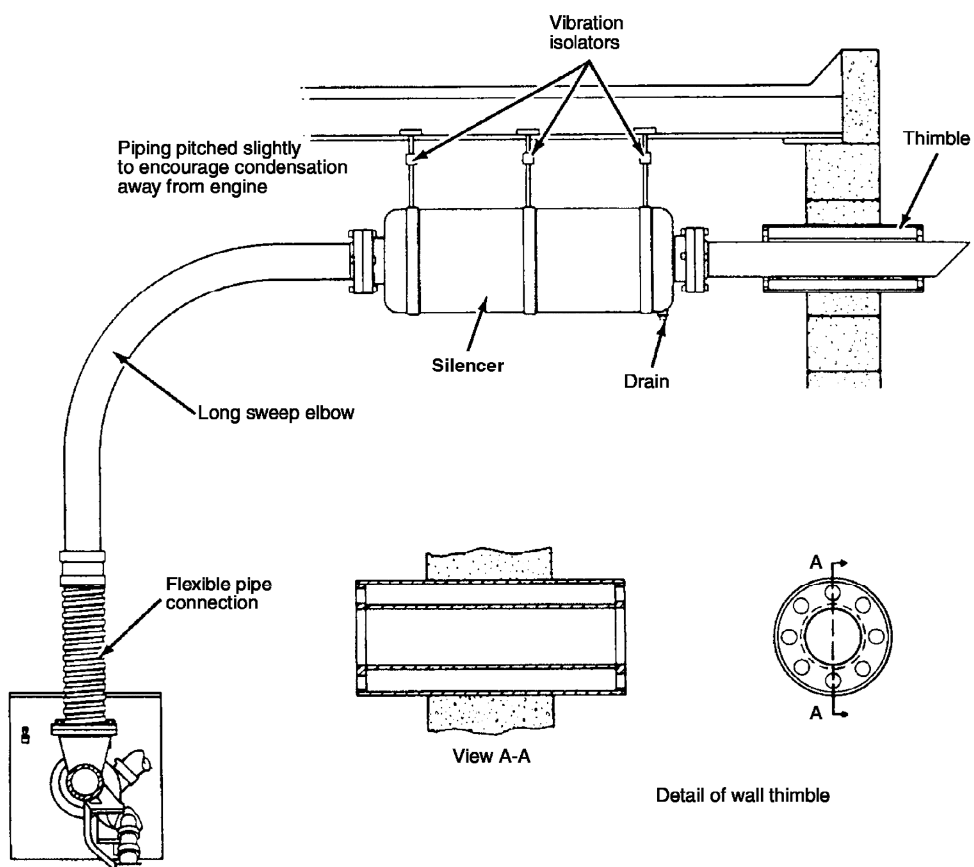


Figure 5

- All piping should be installed with a minimum clearance of 229 mm (9 in) from combustible materials.
- The exhaust piping must be properly supported, especially adjacent to the engine, so that its weight is not borne by the engine or the turbocharger. This is discussed in more detail later in this section.
- Exhaust piping should be sized according to the maximum backpressure limit for the engine.
- Where appropriate, heat radiation may be reduced by covering the off-engine exhaust piping with suitable, high temperature insulation.
- Install metal thimble guards for exhaust piping passing through wooden walls or roofs. The thimble guards should be 305 mm (12 in) greater in diameter than the exhaust pipes, see **Figure 5**.
- When exhaust stacks are used, extend them upward and away from the engine room to avoid heat, fumes and odors.
- Locate the exhaust pipe outlets away from the air intake system. Engine air cleaners, turbochargers and aftercoolers contaminated with exhaust products can induce premature failures.
- Avoid routing exhaust piping close to fuel pumps, fuel lines, fuel filters, fuel tanks and other combustible materials.
- Exhaust pipe outlets cut at 30° to 45° angles, rather than 90° angles, will reduce exhaust gas turbulence and noise. Refer to **Figure 6**.
- Exhaust outlets should be arranged to keep water from entering the piping system. Rain caps forced open by exhaust pressure will accomplish this; however, they will also introduce additional backpressure into the system and should be carefully evaluated.

Pipe Design Joining Two Turbochargers

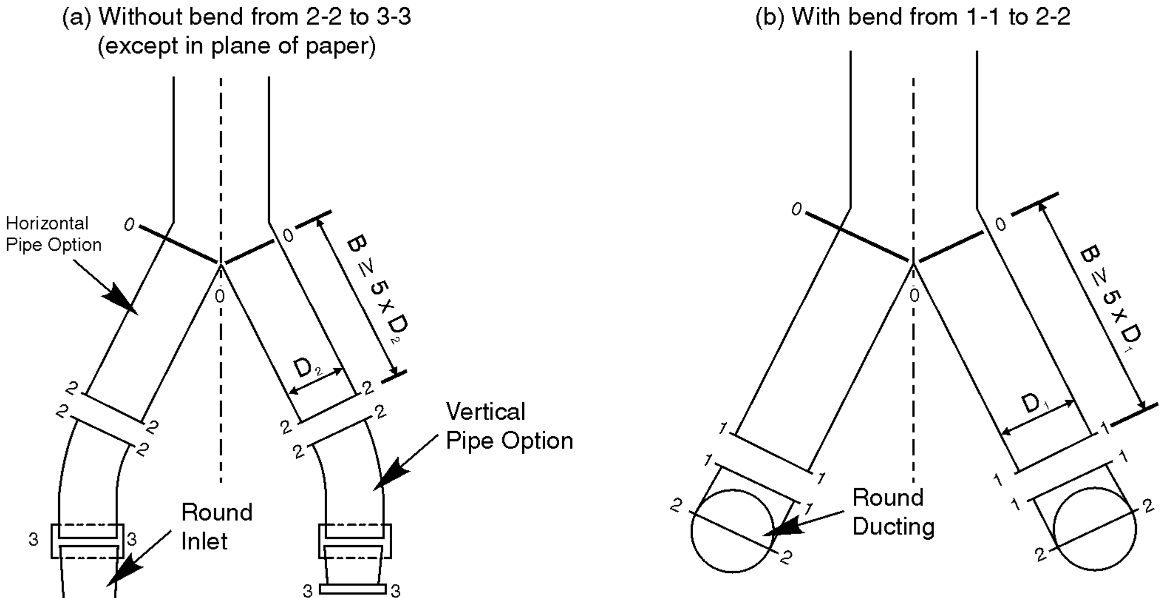


Figure 6

The exhaust system can accumulate a considerable amount of condensed moisture. For example, gas engines burning natural gas create one pound of water for each 10 ft^3 of natural gas burned. For this reason, long runs of exhaust piping require traps to drain moisture. Traps should be installed at the lowest point of the line, near the exhaust outlet, to prevent rain water from reaching the engine. Exhaust lines should be sloped away from engine, toward the trap, so condensation will properly drain, see **Figure 3** in the previous section.

Exhaust Thimbles

Exhaust thimbles, as illustrated in **Figure 5**, are fabrications used for wall or ceiling penetrations. The thimble provides a separation of the exhaust pipe from walls or ceilings, in order to provide mechanical and thermal isolation. Single sleeve thimbles must have diameters at least 305 mm (12 in) larger than the exhaust pipe. Double thimbles (inner and outer sleeve) should have outside diameters at least 152 mm (6 in) larger than the exhaust pipe.

Exhaust Pipe Insulation

No exposed parts of the exhaust system should be near wood or other combustible material. Exhaust piping inside the engine room or machinery space (and the silencer, if mounted inside) should be covered with suitable insulation materials to protect personnel and to reduce room temperature. A sufficient layer of suitable insulating material surrounding the piping and silencer and retained by a stainless steel or aluminum sheath may substantially reduce heat radiation to the room from the exhaust system. An additional benefit of the insulation is that it provides sound attenuation to reduce noise in the room.

Water Ingress Prevention

Exhaust system outlets must be provided with an appropriate means of preventing snow, rainwater or sea spray from entering the engine through the exhaust piping. This can be accomplished by several methods, but must be given careful consideration. The selected method can impose significant restrictions that must be taken into account when calculating system backpressure.

One simple method, used primarily with horizontal exhaust pipes, is to angle cut the end of the pipe as shown in **Figure 3**, **Figure 5** and **Figure 7**.

A common method used with vertical exhaust pipes is to angle the pipe at 45° or 90° from vertical using an appropriate elbow, then angle cutting the pipe end as previously described.

Another feature that may be used in conjunction with either of the above methods are Rain/Spray Slots as shown in **Figure 6**.

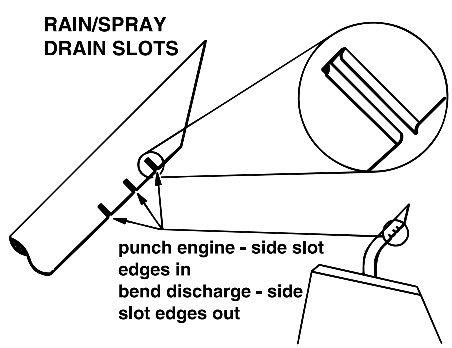


Figure 7

Slots are cut into the exhaust pipe to allow rain/spray to drain harmlessly. The edges of each slot are deformed as shown in the previous graphic. The engine side of the slot is bent inward and the downstream side of the slot is bent outward. No more than a 60° arc of the pipe circumference should be slotted in this way.

For applications where none of the above methods is possible, it may be necessary to fit some form of rain cap to the end of the vertical pipe section. This method can provide a positive means of water ingress prevention, but not without imposing a significant backpressure restriction.

Exhaust System Backpressure

Excessive exhaust restriction can adversely affect performance, resulting in reduced power and increased fuel consumption, exhaust temperatures and emissions. It will also reduce exhaust valve and turbocharger life. It is imperative that exhaust backpressure is kept within specified limits for those engines subject to emissions legislation. To ensure compliance, exhaust system backpressure must be verified to be within the Caterpillar EPA declared maximum value for the engine configuration and rating. Values can be found in the "Systems Data" listed in the Caterpillar Technical Marketing Information (TMI) system.

Backpressure includes restrictions due to pipe size, silencer, system configuration, rain cap and other exhaust-related components.

Excessive backpressure is commonly caused by one or more of the following factors:

- Exhaust pipe diameter too small.
- Excessive number of sharp bends in the system.
- Exhaust pipe too long.
- Silencer resistance too high.

Engines with a vee cylinder configuration should be designed so the exhaust piping gives equal backpressure to each bank.

Measuring Backpressure

Exhaust backpressure is measured as the engine is operating under full rated load and speed conditions. Either a water manometer or a gauge measuring inches of water may be used. Refer to **Figure 8.**

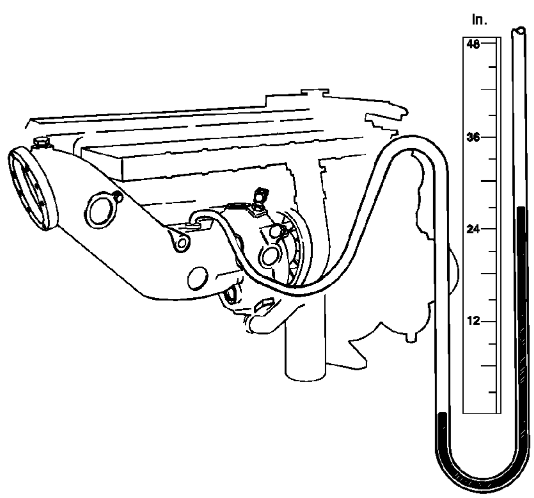


Figure 8

Many engine installations are already equipped with a fitting in the exhaust discharge for measuring backpressure. If the system is not equipped with such a fitting, use the following guidelines, **Figure 9** and **Figure 10** to locate and install a pressure tap.

- Locate the pressure tap in a straight length of exhaust pipe as close to the turbocharger as possible.
- Locate the tap three pipe diameters from any upstream pipe transition.
- Locate the tap two pipe diameters from any downstream pipe transition.

For example, in a 100 mm (4 in) diameter pipe, the tapping would be placed no closer than 300 mm (12 in) downstream of a bend or section change.

Preferred Pressure Tap Location & Installation

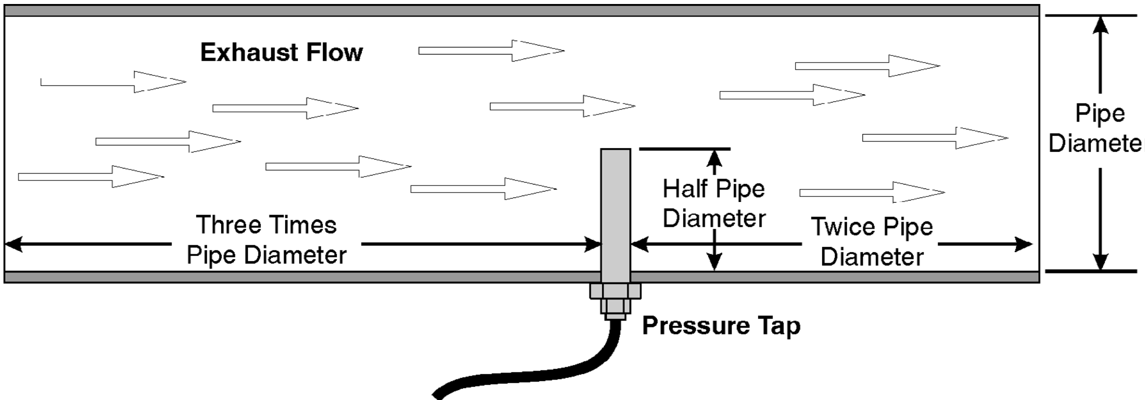


Figure 9

If an uninterrupted straight length of at least five diameters is not available, care should be taken to locate the probe as close as possible to the neutral axis of the exhaust gas flow. This is necessary because measurements taken on the outside of a 90° bend at the pipe surface will be higher than a similar measurement taken on the inside of the pipe bend.

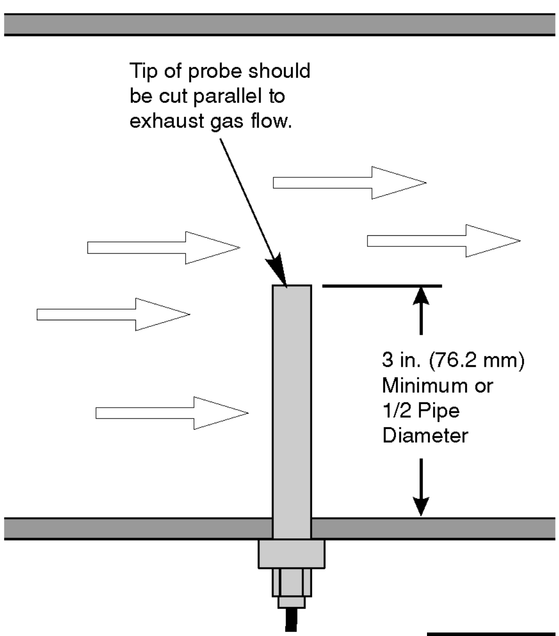


Figure 10

The pressure tapping can be made by using a 1/8 NPT "half coupling" welded or brazed to the desired location on the exhaust pipe. After the coupling is attached, a 3.05 mm (0.12 in) diameter hole is drilled through the exhaust pipe wall. Any burrs on the inside of the pipe wall should be removed so that the gas flow is not disturbed. The gauge or gauge hose can then be attached to the half coupling. The probe should be inserted to a depth equal to half the diameter of the pipe or a minimum of 3 in. (76.2 mm) as shown in **Figure 10**. The tip of the probe should be cut parallel to the exhaust gas flow.

Calculating Backpressure

Backpressure is calculated by:

$$P\ (kPa) = \frac{L \times S \times Q^2 \times 3.6 \times 10^6}{D^5} + P_s$$

$$P\ (in.\ H_2O) = \frac{L \times S \times Q^2 \times 3.6 \times 10^6}{187 \times D^5} + P_s$$

Where:

P = Back pressure (kPa), (in. H_2O)

psi = 0.0361 x in. water column

kPa = 0.00981 x mm water column

L = Total Equivalent Length of pipe (m) (ft)

Q = Exhaust gas flow (m^3/min), (cfm)

D = Inside diameter of pipe (mm), (in.)

S = Density of gas (kg/m^3), (lb/ft^3)

Ps = Pressure drop of silencer/raincap (kPa),(in. H_2O)

Useful conversion factors:

psi = 0.0361 x in. of water column

psi = 0.00142 x mm of water column

psi = 0.491 x in. of mercury column

kPa = 0.0098 x mm of water column

kPa = 0.25 x in. of water column

kPa = 3.386 x in. of mercury column

kPa = 0.145 psi

Equivalent Length of Straight Pipe

To obtain equivalent length of straight pipe for various elbows:

$$L = \frac{33D}{X}$$ Standard Elbow elbow radius = pipe diameter

$$L = \frac{20D}{X}$$ Long Elbow radius = 1.5 diameter

$$L = \frac{15D}{X}$$ 45° elbow

$$L = \frac{66D}{X}$$ square elbow

Where X = 1000 mm or 12 in.

As shown by the equations, if 90° elbows are required, long radius elbows with a radius of 1.5 times the pipe diameter helps to lower resistance.

Combined Exhaust Systems

Although economically tempting, a common exhaust system for multiple installations is not acceptable. Combined exhaust systems with boilers or other engines allow exhaust gases to be forced into engines not operating. Water vapor created during combustion will condense in cold engines and quickly causes engine damage. Duct valves separating engine exhausts is also discouraged. High temperatures warp valve seats causing leakage.

Exhaust draft fans have been applied successfully in combined exhaust ducts, but most operate only whenever exhaust is present. To prevent turbocharger windmilling (without lubrication), draft fans should not be operable when the engine is shut down. The exhaust system of non-running engines must be closed and vented.

3600 vee engines have two exhaust outlets, one for each bank. Combining these together with a Y-type fabrication, while possible, may result in unequal thermal growth and backpressure from one bank to the other. This unequal growth can put unwanted loading onto the turbocharger mounting or the flex bellows. The unequal backpressure can adversely affect the operation and performance of the engine. If the exhaust outlets are joined, these problems can be minimized by providing a flexible connection on each leg and by keeping each leg equal in length.

Pipe Support Considerations

Thermal Growth

Thermal growth of exhaust piping must be taken into account in order to avoid excessive load on supporting structures.

Steel exhaust pipe expands 1.13 mm/m (0.0076 in/ft) for each 100°C (100°F) rise of exhaust temperature. This amounts to 16.5 mm (0.65 in) expansion for each 3.05 m (10 ft) of pipe from 35° to 510°C (100° to 950°F).

Piping systems must be designed so thermal growth expands away from the engine.

A restraint member may be used to keep the ends of a long pipe run fixed in place, forcing all thermal growth towards the expansion joints.

Supports should also be located to allow expansion away from the engine. Supports can reduce strains or distortions to connected equipment and can allow component removal without additional support.

Flexible pipe connection, when insulated, must expand and contract freely within the insulation. This generally requires a soft material or insulated sleeve to encase the connection.

Turbocharger Loading

Careful consideration must be given to the load external piping may induce on the turbocharger. To minimize the load carried by the turbocharger housing, a bellows should be placed as close as possible to the turbocharger outlet and downstream exhaust piping should be self supporting. The thermal growth of horizontal piping connected to the turbocharger exhaust must also be accounted for in the design.

Maximum allowable vertical load and bending moment limits are provided for each engine model. Consult the Technical Information Appendix for the appropriate information.

For 3600/G3600 series engines, the Caterpillar supplied bellows and adapter, or elbow and bellows options, account for the maximum allowable loading on the turbocharger. All other external piping must be self-supporting.

Loading Calculations

The following example illustrates the type of calculation used to determine vertical load and bending moment at the engine exhaust outlet due to the weight of the adapter mounted directly to the exhaust outlet.

Figure 11 shows measurement points for the various distances when calculating the forces and moments on the turbocharger.

This example assumes a Gas 3516 with single exhaust outlet.

Vertical Exhaust

W = Adapter Weight

I = 1/2 Bellows Weight

g = gravity = 9.82 m/s (32.2 ft)

With Caterpillar Hardware:

W = 2.9 kg (6.4 lb)

I = 0.6 kg (1.4 lb)

Forces:

F_W = W x g = 2.9 x 9.82 = 28 N (6.4 lb)

F_I = I x g = 0.6 x 9.82 = 6 N (1.4 lb)

Sum of Vertical Forces:

$F_V = F_W + F_I = 28 + 6 = 34$ N (7.8 lb)

Sum of Moments:

M = (h1 x FW) + (h2 x FI) = (0 x 28) + (0 x b) = 0 N•m (ft-lb)

Since for this particular engine model F_V < 111 N (25 lb) and M < 120 N•m (89.5 ft-lb), the exhaust system meets the load and moment requirements.

Horizontal Exhaust

W = Adapter Weight

J = Elbow Adapter Weight

I = ½ Bellows Weight

With Caterpillar Hardware:

W = 2.9 kg (6.4 lb)

I = 0.6 kg (1.4 lb)

J = 4.8 kg (10.7 lb)

h_1 = 0

h_2 = 100 mm (3.9 in)

h_3 = 580 mm (22.8 in)

Forces:

F_W = 28 N (6.4 lb)

F_I = 6 N (1.4 lb)

F_J = F x g = 4.8 x 9.82 = 47 N (10.7 lb)

Sum of Vertical Forces

FV = FW + FI + FJ = 28 + 6 + 47 = 81 N (18.5 lb)

Sum of Moments

M = (h1 x FW) + (h2 x FI) + (h3 x FJ) = (0 x 28) + (.100 x 6) + (.580 x 47) = 27.9 N•m (20.8 ft-lb)

Since for this particular engine model F_V < 111 N (25 lb) and M < 120 N•m (89.5 ft-lb), the exhaust system meets the load and moment requirements.

Vertical and Horizontal Exhaust

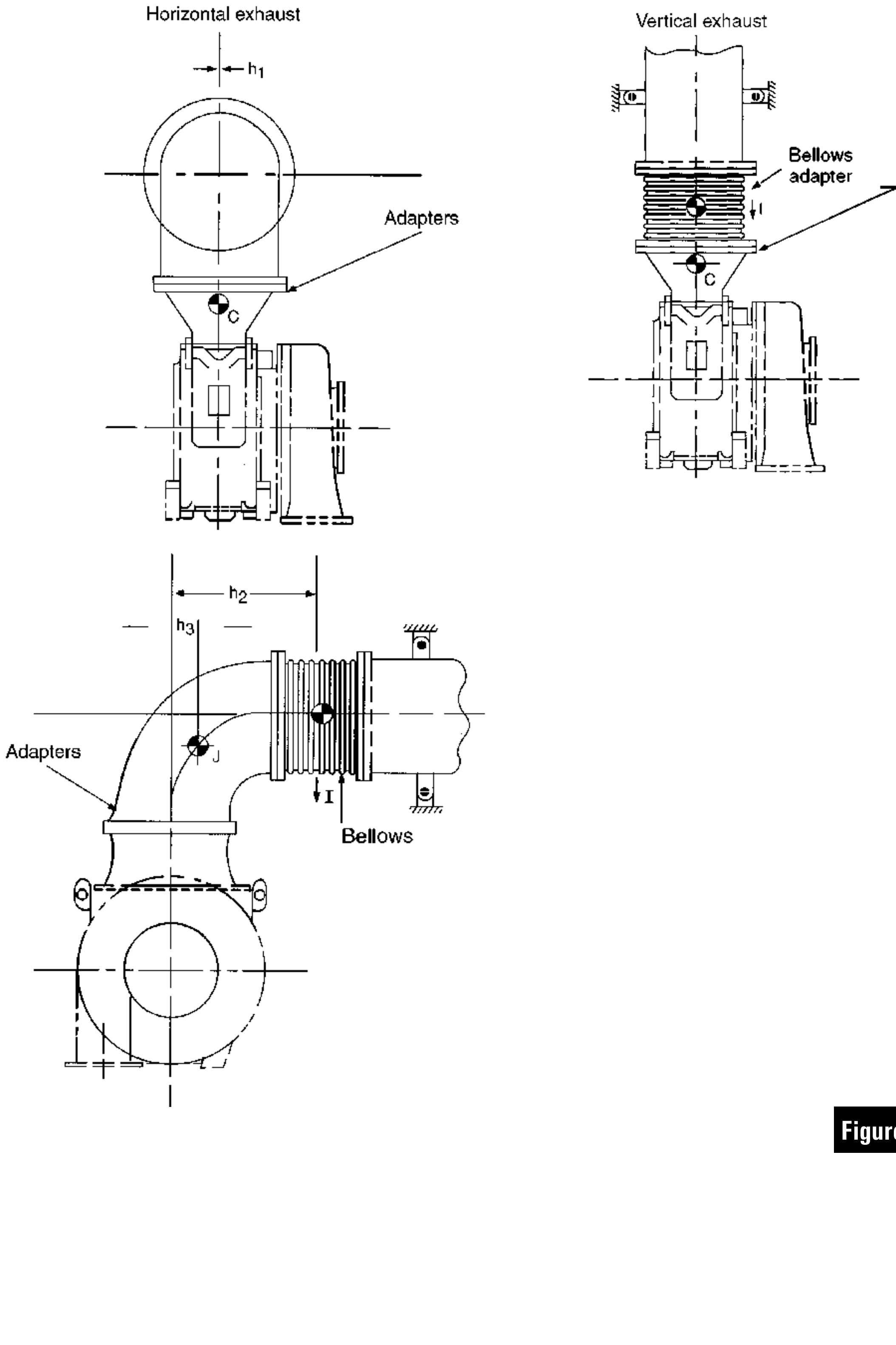


Figure 11

Vibration Transmission

Piping connected to stationary engines requires isolation, particularly when resilient mounts are used. Without isolation, pipes can transmit vibrations long distances. Isolator pipe supports should have springs to attenuate low frequencies and rubber or cork to minimize high frequency transmissions.

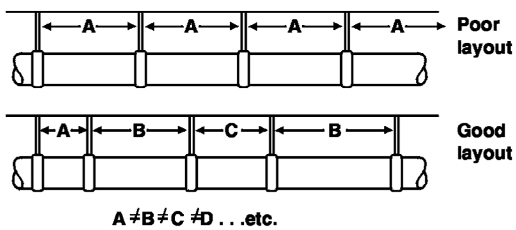


Figure 12

To prevent build up of resonant pipe vibrations, support long piping runs at unequal distances as shown in **Figure 12**.

Exhaust Discharge

Exhaust outlets, whether via an exhaust pipe or stack, must be designed to ensure that engine exhaust is discharged in such a manner that exhaust gas will not recirculate and be drawn back into the engine's environment. Engine air cleaners, turbochargers and aftercoolers may become contaminated with spent combustion products such as hydrocarbons and soot. This contamination can lead to various modes of failure.

Recirculation of hot exhaust gas can also adversely affect the ambient capability of the installation. This can occur when air, significantly above ambient, is drawn through radiator equipped cooling systems. **Figure 13** through **Figure 17** show typical exhaust piping systems that are arranged to avoid recirculation.

Common Exhaust Stack

The exhaust can be directed into a special stack that also serves as the outlet for radiator discharge air and may be sound-insulated. In such instances the radiator discharge air enters below the exhaust gas inlet so that the rising radiator air tends to cool exhaust system components within the stack. Refer to the following two graphics.

The silencer may be located within the stack or in the room with its tail pipe extending through the stack and then outward. Air guide vanes should be installed in the stack to turn radiator discharge airflow upward and to reduce radiator fan air flow restriction. Alternatively the sound insulation lining may have a curved contour to direct air flow upward.

An exhaust stack will remain cooler and cleaner if the engine exhaust is contained within the exhaust piping throughout its run through the stack. If the exhaust pipe terminates short of the stack outlet, the discharged ventilation air will tend to cool the exhaust stack downstream of the point where it mixes with the exhaust gases.

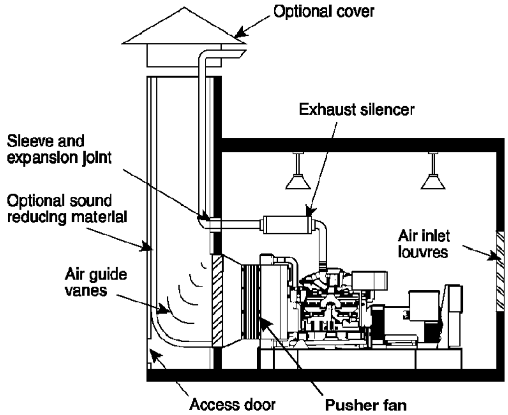


Figure 13

Figure 13 is an example of a horizontally mounted exhaust silencer with the exhaust pipe and radiator air utilizing a common stack.

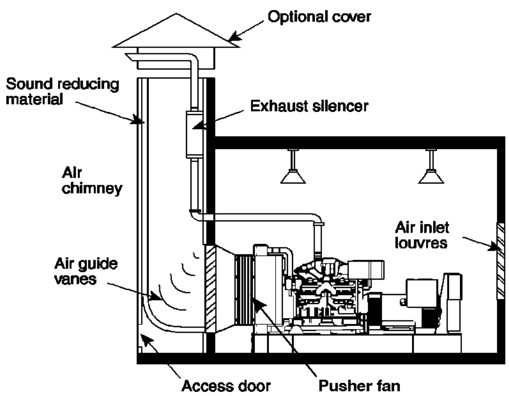


Figure 14

Figure 14 is an example of a vertically mounted exhaust silencer with the exhaust pipe and radiator air utilizing a common stack.

Power Module or Drop-Over Enclosure

For a generator set enclosed in a power module or drop-over enclosure, the exhaust and radiator discharges should flow together, either above or below the enclosure without a stack.

This arrangement, as shown in **Figure 15** and **Figure 16**, will prevent the recirculation of exhaust gases back into the module or enclosure. Sometimes, for this purpose, the radiator can be mounted horizontally and the fan driven by an electric motor to discharge air vertically.

~~Note that the suction fan arrangement in **Figure 17** does not provide adequate cooling air to the generator. A separate source of generator cooling air is required for this configuration.~~

Typical Power Module or Drop-Over Enclosure Exhaust System with Internal Silencer

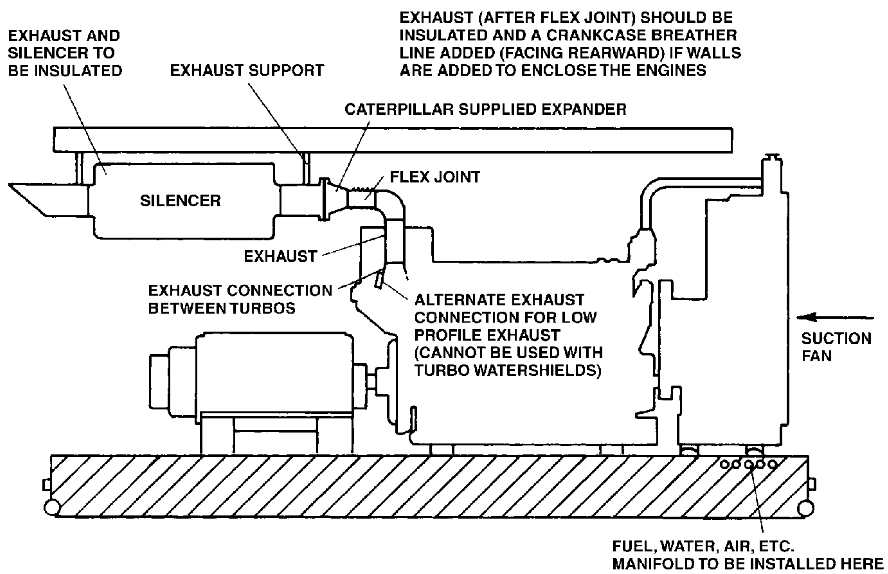


Figure 15

Typical Power Module or Drop-Over Enclosure Exhaust System with External Silencer

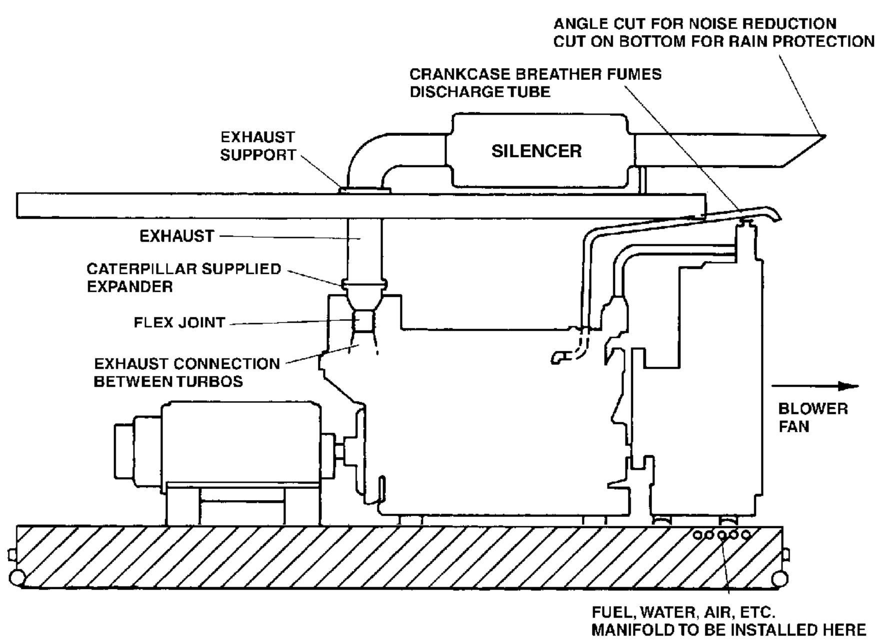


Figure 16

Crankcase pressures should not vary more than 25.4 mm H_2O (1.0 in. H_2O) from ambient barometric pressure for G3300, G3400 and G3500 engines. Some of the engines that monitor crankcase pressure will shutdown if excessive vacuum is sensed.

Restrictions higher than the limit on passive systems will encourage oil leaks. A powered system should draw no more than a 25.4 mm H_2O (1.0 in. H_2O) vacuum, or dirt and dust could be drawn into the engine past the main seals. Measurement should be made at the engine dipstick location with the engine at operating temperature, speed, and load.

Non-Ingestive

In regions that do not include crankcase emissions as part of the total emissions for an engine, a non-ingestive crankcase ventilation system is an acceptable solution. In some situations customers can reduce cost and potential engine threats by venting the blow-by to the atmosphere. **Figure 3** shows a typical non-ingestive crankcase vent arrangement.

One of the goals of a PCV system is to increase the oil life of the engine. The removal of crankcase emissions can reduce the amount of oil degradation. It has been shown that a non-ingestive PCV system can double the oil life of an engine. However, the affects of PCV on oil life will vary with engine size, load, engine hours and ambient conditions.

Typical Non-Ingestive Crankcase Ventilation Arrangement

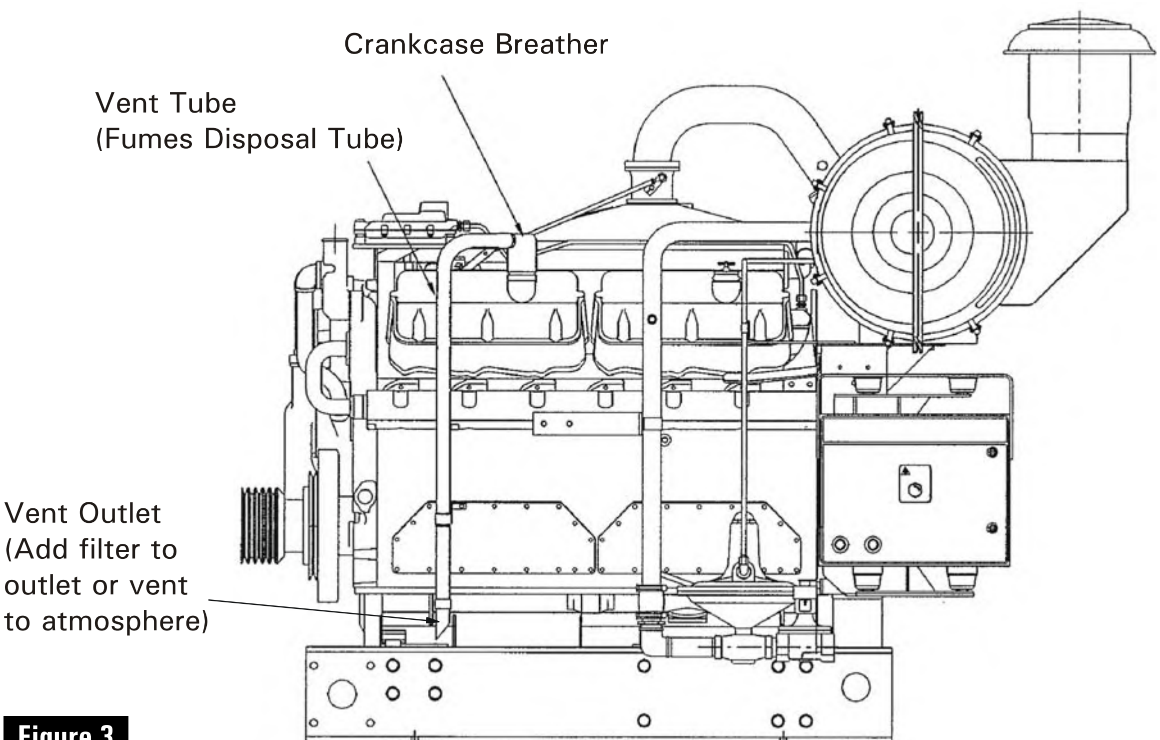


Figure 3

Although a non-ingestive system is less complex than an ingestive system, there are a number of requirements and considerations for the effective venting of crankcase emissions.

Do not vent emissions directly into the engine room without filtration.

- Emissions can clog air filters, consequently causing engine damage.
- Exposure to crankcase emissions can cause problems in electrical equipment.
- Emissions can be a health hazard if discharged in a poorly ventilated room.
- Use a crankcase ventilation system to properly filter and vent emissions to the atmosphere.
- Multiple engines at a site require a separate vent lines for each engine. This prevents fumes and moisture produced by a running engine from entering an idle engine. The addition of moisture into an engine can cause corrosion and buildup of harmful deposits.
- Use appropriately sized vent pipes.

Crankcase vent pipes must be large enough to minimize back pressure. Through the entire life of the engine, blow-by may vary dramatically depending on engine operating temperature and type of oil used. As a general rule, blow-by on a new engine is approximately 0.02 m^3/hr bkW (0.5 ft^3/hr bhp). Adequately size the vent pipes to accommodate a worn engine, with a blow-by rate of 0.04 m^3/hr bkW (1 ft^3/hr bhp). Size the vent pipe with a maximum of 13 mm H_2O (0.5 in. H_2O) pressure drop at full load.

The following formulas allow the crankcase ventilation designer to calculate a pipe diameter that will provide a back pressure of less than 13 mm H_2O (0.5 in. H_2O).

Use the following formulas to calculate back pressure:

$$P\ (\text{kPa}) = \frac{L \times S \times Q^2 \times 3.6 \times 10^6}{D^5}$$

$$P\ (\text{in. } H_2O) = \frac{L \times S \times Q^2}{187 \times D^5}$$

Where:

P = Back pressure (kPa), (in. H_2O)

psi = 0.0361 x in. water column

kPa = 0.00981 x mm water column

L = Total Equivalent Length of pipe (m), (ft)

Q = Exhaust gas flow (m^3/min), (cfm)

D = Inside diameter of pipe (mm), (in.)

S = Density of gas (kg/m^3), (lb/ft^3)

S (kg/m^3) = 1.08

S (lb/ft^3) = 0.067

To obtain equivalent length of straight pipe for various elbows:

Standard Elbow (radius = diameter) $L = \frac{33D}{X}$

Long Radius Elbow (radius = 1.5 diameter) $L = \frac{20D}{X}$

45° Elbow (radius = 1.5 diameter) $L = \frac{15D}{X}$

Square Elbow (radius = 1.5 diameter) $L = \frac{66D}{X}$

Where:

$X = 1000$ mm (12 in)

Calculate the pipe diameter according to the formula, then choose the next larger commercially available pipe size.

As evidenced in the formulas, if 90° bends are required, then using long radius elbows, with a radius of 1.5 times the pipe diameter, helps lower resistance.

Loops or low spots in a crankcase vent pipe must be avoided to prevent condensation from building up in the pipe and restricting the emissions discharge. Where horizontal runs are required, install the pipe with a gradual slope from the engine as shown in **Figure 4**. The slope should be approximately 41.7 mm/m (1/2 in/ft).

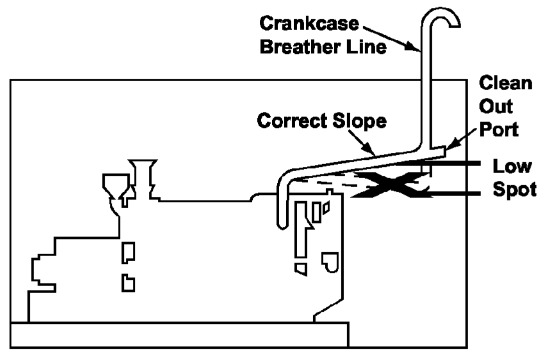


Figure 4

The weight of the vent pipes will require separate off-engine supports as part of the installation design. Any horizontal or vertical run of pipe that cannot be disassembled for cleaning should have clean-out ports installed.

Crankcase emissions from non-ingressive crankcase ventilation systems must not discharge into the air ventilation ducts or exhaust pipes. Ducts and pipes on these engines will become coated with oily deposits that create a fire hazard.

Vent the crankcase pipe directly into the atmosphere and direct it to keep rain or spray from entering the engine. Give consideration to equipment located near the discharge area as well as to the building itself. Over a period of time, very small amounts of oil carry-over can accumulate and become unsightly, even harmful, to auxiliary equipment.

If the mounting beams will be subjected to external bending forces, such as frame flexing of the chassis in mobile applications, the engine and driven equipment must be mounted to the beams using a three point mounting system. This type of mounting system, similar to **Figure 6**, supports the engine at a single point at the front and at two points, one on each side at the rear of the engine or driven unit. This mounting system is capable of efficiently allowing large amounts of frame deflection without imparting stresses to the mounting or engine and driven unit.

Engines and Packaged Units with Mounting Rails

Standard Caterpillar mounting rails must be used for engines and packaged units requiring mounting rails. Two types of standard mounting rails are available, depending on the application.

Three Point Mounting

Three-point mounting rails are used if the rails are to be secured to a base or foundation that may subject the mounting rails to distorting forces.

Suspending the power unit on three points isolates the unit from deflection of the substructure, thus maintaining proper relationship and alignment of all equipment and preventing distortion of the engine block.

More than three mounting points can cause base distortion as shown in **Figure 6**. The three point mounting rails can only be used for close-coupled driven units where the rails are extended for the mounting of these units.

Objectionable vibration can occur if the power unit is not mounted on well-supported structures or is not anchored securely. In addition to the three-point mounting, vibration isolators may be required to isolate objectionable vibrations.

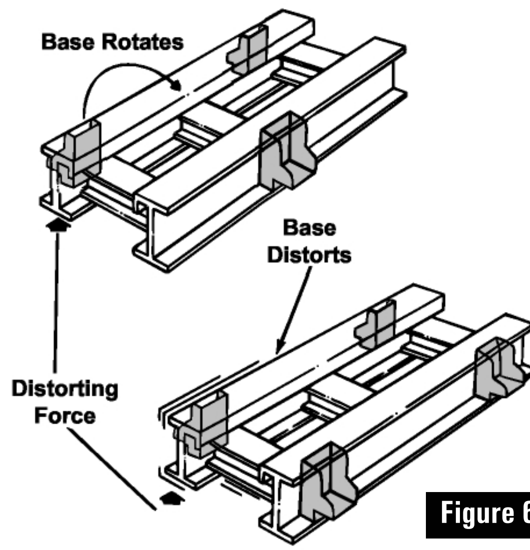


Figure 6

Four Point Mounting

Four-point mounting rails are used if the rails are to be secured to a base or foundation that will not subject the rails to distorting forces. Refer to **Figure 7**. These rails can be used for either remote mounted or close-coupled driven units. For close-coupled driven units, extended mounting rails are available so the driven equipment can be fastened directly to the rails.

Base for Engines with Remote Mounted Driven Equipment

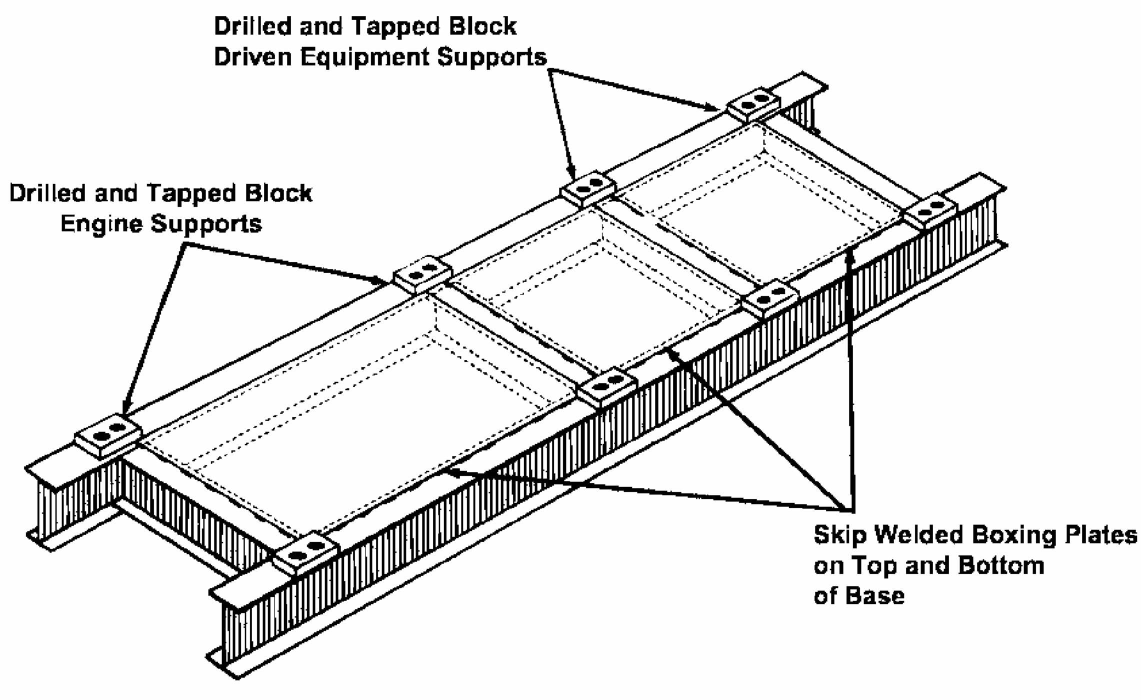


Figure 42

Bases for Engines with Remote-Mounted Loads

The design requirements for bases used on engines with close-coupled units also apply to bases used for engines with remote-mounted units. Bases for use with remote-mounted units must be more rigid. The base must absorb the full-load torque between the engine and driven unit without causing excessive deflection in the coupling.

The base shown in **Figure 42** is a boxed beam design that provides a torsionally rigid base.

Boxing consists of welding steel plates on top and bottom surfaces of machinery base girders. Skip-weld the plates to prevent excessive base distortion during welding. Boxing is done to make the base structure stiffer.

The additional stiffness is necessary to resist torque loads between the engine and remote-mounted driven equipment and to resist possible vibration loads. Vibration-induced base loads are difficult to predict.

Experience has shown boxing is effective in preventing base cracking and misalignment.

Caterpillar Special Duty Bases

Offshore Power Modules

The Caterpillar petroleum offshore base consists of a base-within-a-base. The inner base is three-point mounted, with integral spring isolators and limit stops, to the outer base. The outer base can be welded to the rig support structure. The inner base structure is not the same as engine rails used in other applications. Refer to **Figure 43**.

The outer base must be supported by large girders, and can either be welded or bolted to the rig structure. Inadequate support may result in power module vibrations.

Offshore Power Module

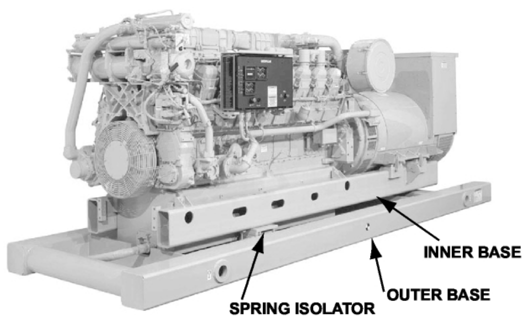


Figure 43

Land Rig Power Modules

The Caterpillar petroleum land rig base uses 460 mm (18 in) wide flange beams, available in lengths of 7.85 m, 9.37 m and 12.42 m (25 ft 9 in, 30 ft 9 in and 40 ft 9 in), to allow matching base length to equipment needs. As with the offshore power modules, alignment integrity is provided by using a base-within-a-base design as shown in **Figure 44** and **Figure 45**.

The 12.42 m (40 ft 9 in) base has no decking provided from the rear of the generator to the rear of the base. Customer-supplied auxiliary equipment is to be mounted here, necessitating customer-supplied decking and reinforcement.

Site preparation is generally required for land rig power modules in order to provide level, firm soil. In some cases, planking or concrete surfacing may be necessary. Certain types of soil, such as fine clay, loose sand, sand near the ground water level, or soil that is freezing or thawing, are particularly unstable under dynamic loads. Loose planking under the power modules may also cause power module vibration.

Because ground conditions may vary from well location to well location, vibrations may result which are not due to misalignment or unbalanced parts. Unstable ground, as previously mentioned, may be reacting to normal forces within the engine/generator combination, whereas at another well location no such reaction may occur.

In addition, rough handling may occur during rig moves, so alignment should be checked after every move.

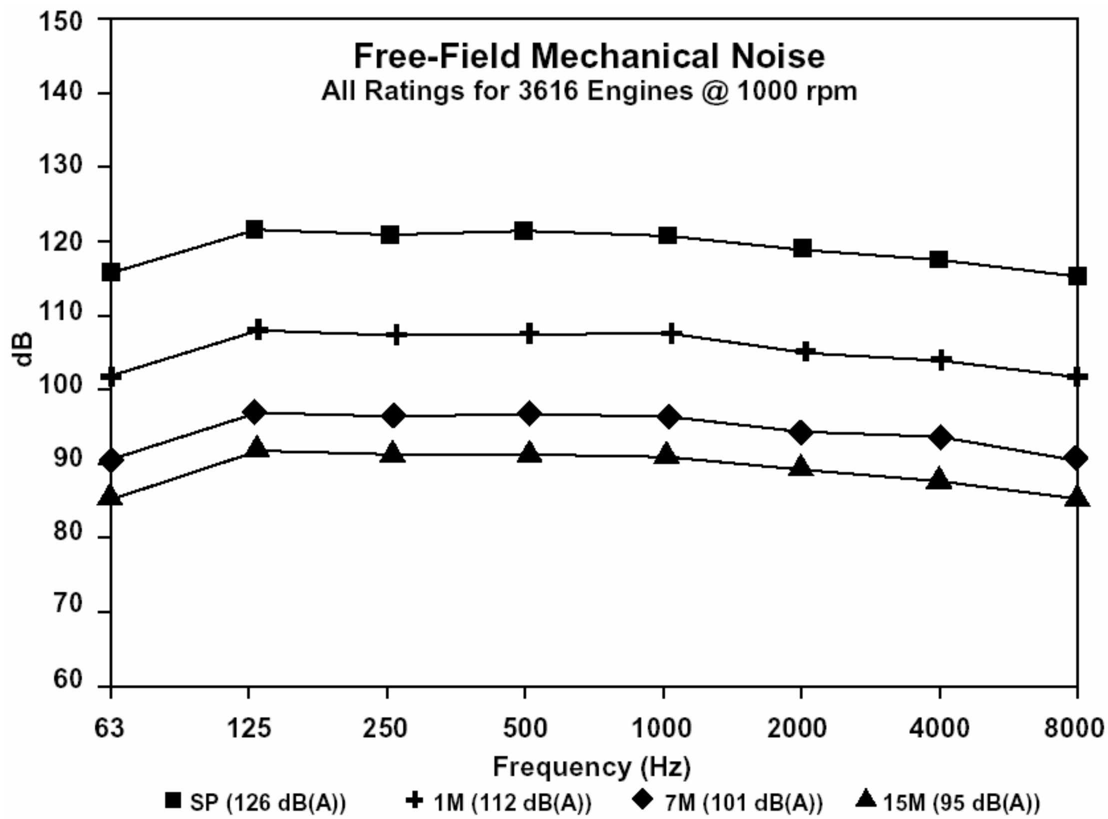
6.0 APPENDIX

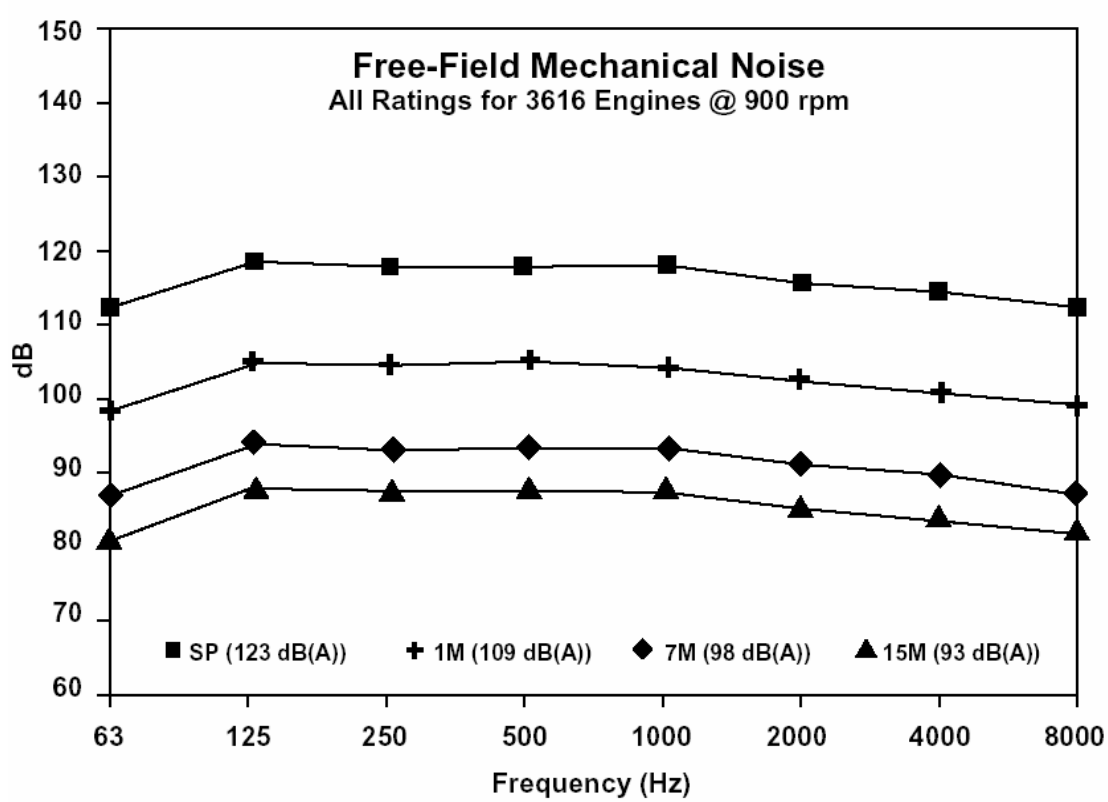
APPENDIX LIST

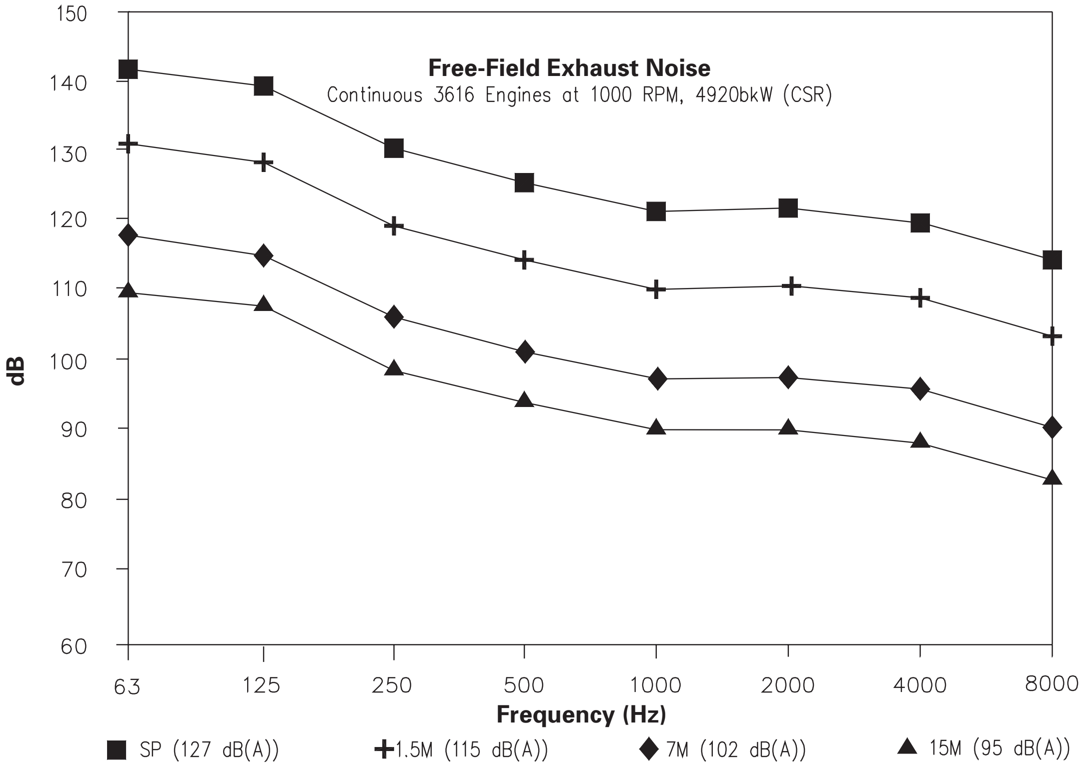
No	Sheet No	Contents	Total Pages
1		3600 diesel Engine General Data	1
2		Engine Mech. Noise Curves	1
3		Engine Exhaust Noise Curves	1
4		Engine Service Envelopes / Components Weights	4
5		Engine Maintenance Interval Schedule	2

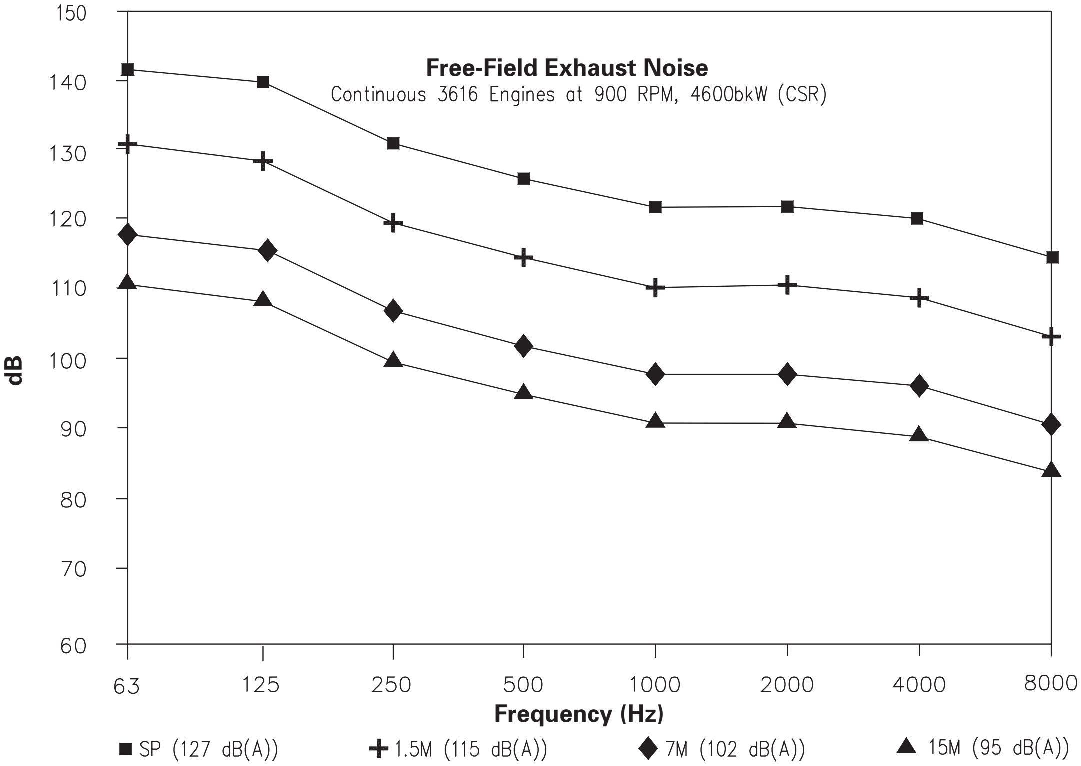
General Data

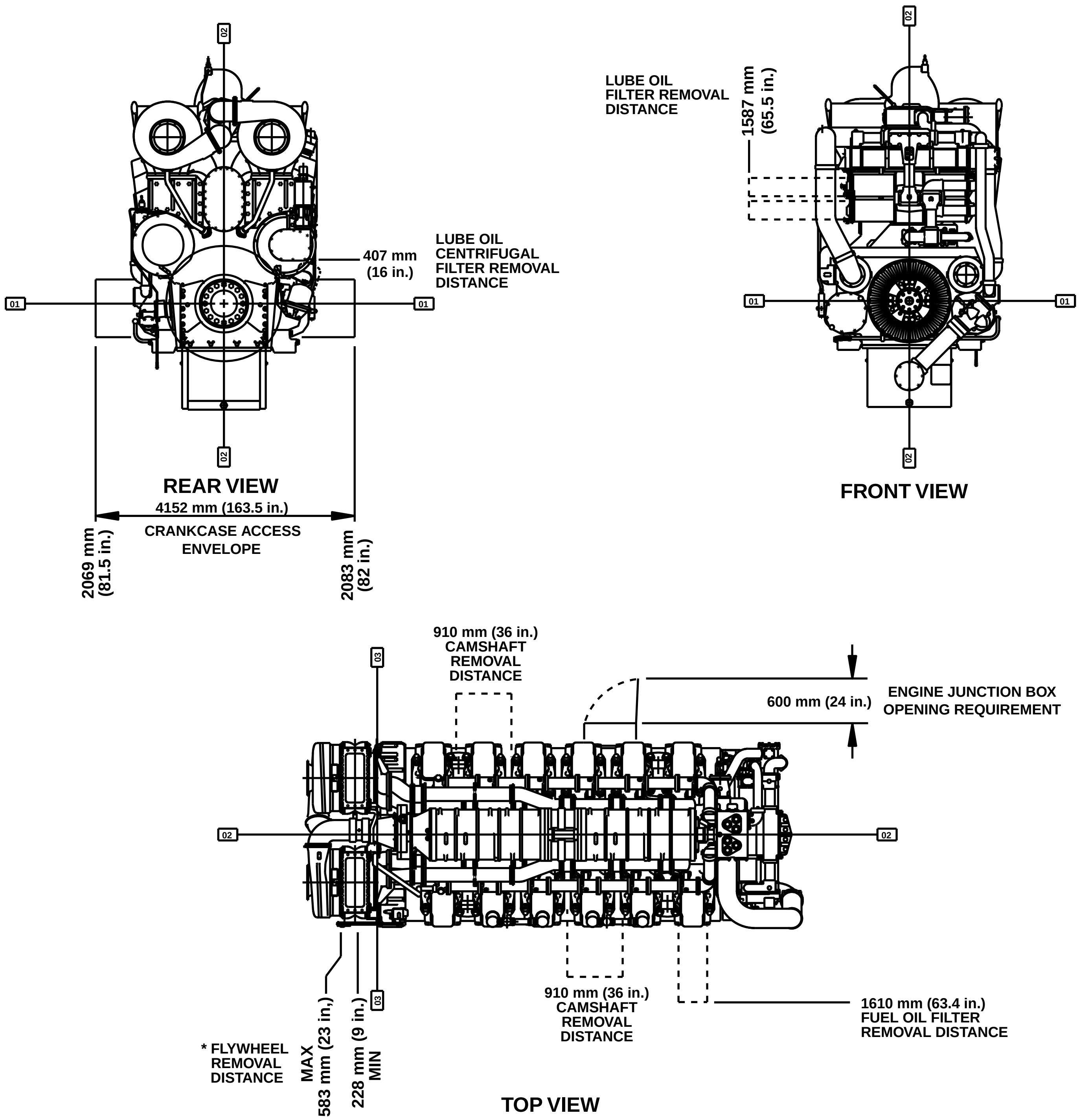
System Description Metric (English)	3606	3608	3612	3616
Cylinder Bore mm (in)	280 (11)	280 (11)	280 (11)	280 (11)
Stroke mm (in)	300 (11.8)	300 (11.8)	300 (11.8)	300 (11.8)
Displacement/Cylinder L (in^3)	18.5 (1127)	18.5 (1127)	18.5 (1127)	18.5 (1127)
Firing Pressure, maximum (Continuous/CSR) kPa (psi)	16,200 (2350)	16,200 (2350)	16,200 (2350)	16,200 (2350)
Firing Pressure, maximum (Prime Power/MCR) kPa (psi)	17,334 (2514)	17,334 (2514)	17,334 (2514)	17,334 (2514)
Firing Pressure, maximum (Standby) kPa (psi)	18,500 (2684)	18,500 (2684)	18,500 (2684)	18,500 (2684)
Rated Speed rpm	700 to 1000	700 to 1000	700 to 1000	700 to 1000
Mean Piston Speed m/s (ft/s)	7.2 – 10.0 (23.6 – 32.8)	7.2 – 10.0 (23.6 – 32.8)	7.2 – 10.0 (23.6 – 32.8)	7.2 – 10.0 (23.6 – 32.8)
Idle speed (low) rpm	300 to 400	300 to 400	300 to 400	300 to 400
Idle speed (high) rpm	720 to 1000	720 to 1000	720 to 1000	720 to 1000
Firing Order – CCW	1-5-3-6-2-4	1-6-2-5-8-3-7-4	1-12-9-4-5-8-11-2-3-10-7-6	1-2-5-6-3-4-9-10 -15-16-11-12-13-14-7-8
Firing Order – CW	1-4-2-6-3-5	1-4-7-3-8-5-2-6	1-6-7-10-3-2-11-8-5-4-9-12	1-8-7-14-13-12-11-15 -16-10-9-4-3-6-5-2
Wet weight kg (lb)	16,804 (36,775)	20,221 (44,486)	26,848 (59,065)	32,104 (70,489)
Dry weight kg (lb)	15,680 (34,500)	19,000 (41,800)	25,140 (55,300)	29,950 (65,900)
Center of Gravity Distance from Cylinder Block Rear Face mm (in)	1290 (50.8)	1700 (66.9)	1411 (55.6)	1858 (73.1)
Vertical Distance Above Crankshaft Centerline mm (in)	350 (13.8)	350 (13.8)	380 (14.9)	380 (14.9)
Transverse Distance from Crankshaft Centerline	On Crank Center	On Crank Center	On Crank Center	On Crank Center
NOTE: Center of gravity locations apply to dry runable engines.				


Free-Field Mechanical Noise
All Ratings for 3616 Engines @ 1000 rpm
dB
150
140
130
120
110
100
90
80
70
60
63
125
250
500
1000
2000
4000
8000
Frequency (Hz)
SP (126 dB(A))
1M (112 dB(A))
7M (101 dB(A))
15M (95 dB(A))


Free-Field Mechanical Noise
All Ratings for 3616 Engines @ 900 rpm
dB
150
140
130
120
110
100
90
80
70
60
SP (123 dB(A))
1M (109 dB(A))
7M (98 dB(A))
15M (93 dB(A))
63
125
250
500
1000
2000
4000
8000
Frequency (Hz)


Free-Field Exhaust Noise
Continuous 3616 Engines at 1000 RPM, 4920bkW (CSR)
dB
150
140
130
120
110
100
90
80
70
60
63
125
250
500
1000
2000
4000
8000
Frequency (Hz)
SP (127 dB(A))
1.5M (115 dB(A))
7M (102 dB(A))
15M (95 dB(A))

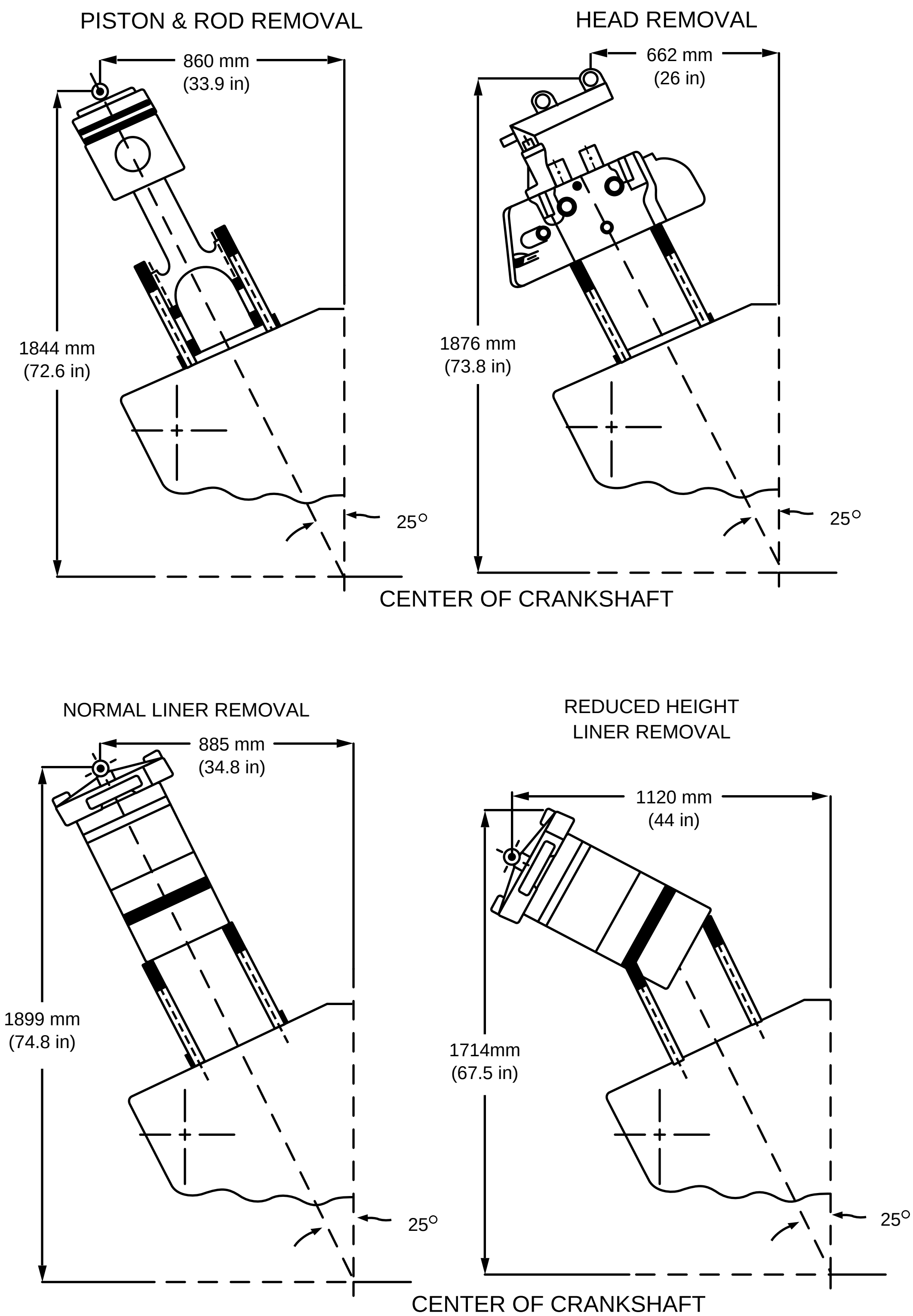

Free-Field Exhaust Noise
Continuous 3616 Engines at 900 RPM, 4600bkW (CSR)
dB
150
140
130
120
110
100
90
80
70
60
63
125
250
500
1000
2000
4000
8000
Frequency (Hz)
SP (127 dB(A))
1.5M (115 dB(A))
7M (102 dB(A))
15M (95 dB(A))



*** If Caterpillar service tool is used.**
355 mm is required if service tool is not used.

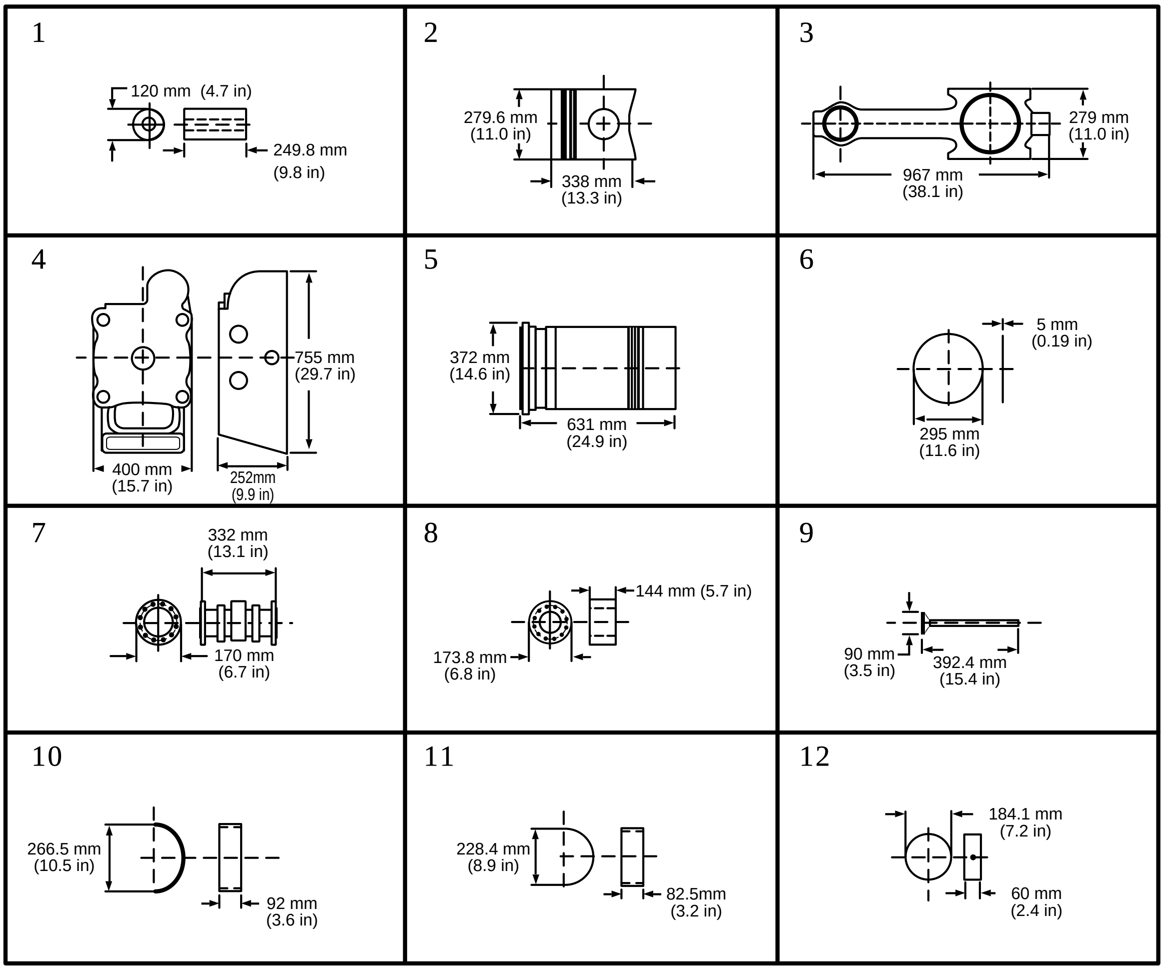
Figure 3

Service Removal Distances
Vee Engine



DISTANCES ARE TO THE CENTER OF LIFTING EYES (30 MM ID)

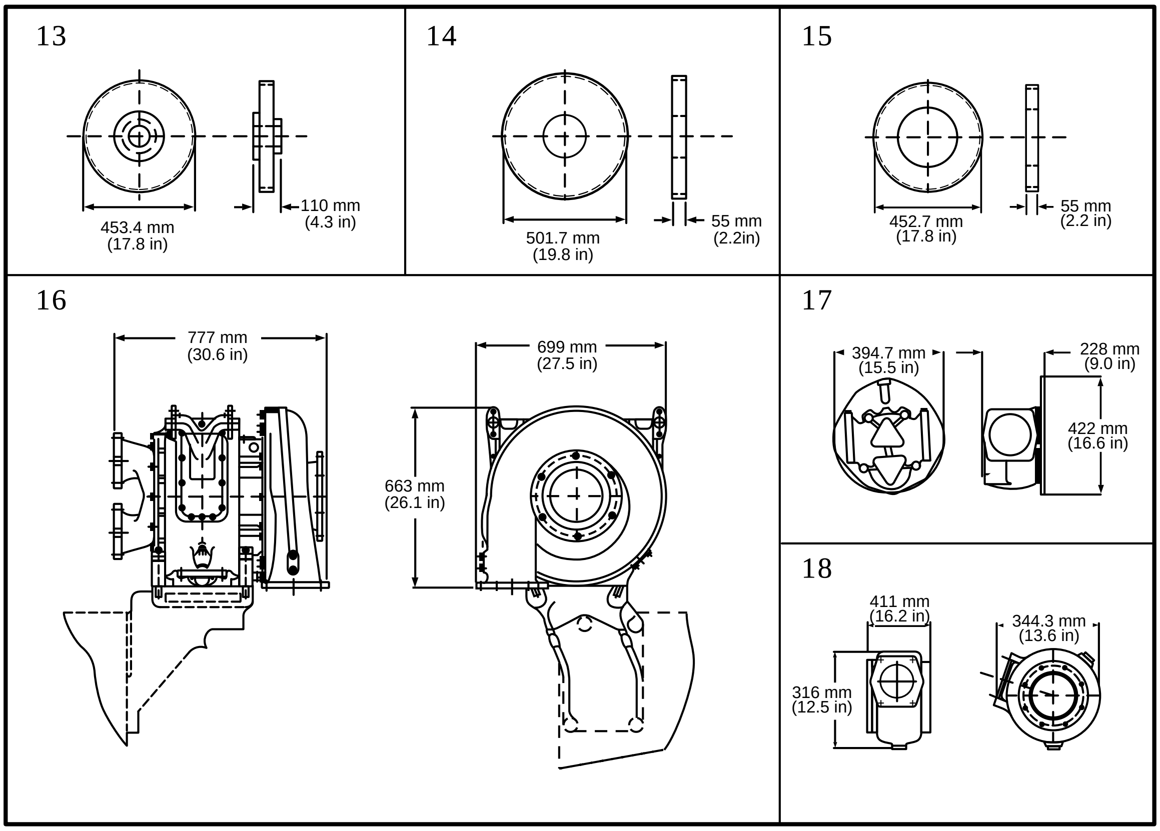
Figure 4



Shipping Weights

Item	Description	kg	(lb)	Item	Description	kg	(lb)
1.	Piston Pin	19.1	(42)	7.	Camshaft Segment	30	(66)
2.	Piston	35.2	(77)	8.	Cam Journal	13.6	(30)
3.	Connecting Rod	56.2	(124)	9.	Valve	1.4	(3)
4.	Cylinder Head Assembly	235	(517)	10.	Main Crankshaft Bearing	4.5	(10)
5.	Cylinder Liner	127.9	(282)	11.	Connecting Rod Bearing	2.3	(5)
6.	Piston Ring	0.3	(0.7)	12.	Cam Bearing	1.4	(3.1)

Figure 5



Shipping Weights

Item	Description	kg	(lb)	Item	Description	kg	(lb)
13.	Camshaft Drive Gear	43.5	(96)	16.	Turbocharger (VTC 254)	500	(1100)
14.	Idler Gear	35.4	(78)	17.	Oil Pump	120	(264)
15.	Crankshaft Gear	37.6	(83)	18.	Water Pump	95	(210)

Figure 6

Maintenance Interval Schedule — CSR and MCR Ratings

Daily Maintenance
- Check oil level for the air starting motors
- Drain air tank moisture and sediment
- Check the cooling system coolant level
- Check the engine oil level
- Drain the fuel filter/water separator
- Inspect engine air cleaner service indicator
- Clean engine air precleaner
- Check governor actuator oil level
- Inspect instrument panel
- Perform walk-around inspection

250 Hour Maintenance (or 6 weeks)
- Clean the air starting motor lines screen
- Test the coolant in the cooling system
- Obtain engine oil sample for analysis
- Check the oil mist detector
- Test air shutoff
- Check governor actuator linkage

500 Hour Maintenance (or 3 months)
- Clean the oil mist detector
- Replace the filter for the oil mist detector
- Inspect the engine mounts

6 Month Maintenance
- Obtain Level II cooling system coolant analysis (ELC)

Initial 1,000 Hour Maintenance
- Inspect the engine valve rotators
- Inspect/Adjust engine valve lash

1,000 Hour Maintenance (or 6 months)
- Check the engine mounts
- Lubricate barring device
- Inspect engine air cleaner service indicator
- Change engine oil filter
- Inspect exhaust piping
- Replace fuel system primary filter/water separator element
- Replace fuel system secondary filter
- Clean/inspect magnetic pick-ups
- Lubricate prelube pump

2,000 Hour Maintenance (or 1 year)
- Drain aftercooler condensation
- Clean/Replace oil mist detector
- Inspect/Adjust engine valve lash

Annual Maintenance
- Obtain Level II cooling system coolant analysis (ELC)

4,000 Hour Maintenance (or 1 year)
- Clean and inspect the aftercooler core
- Clean the lubricator bowl for the air starting motors

8,000 Hour Maintenance (or 1 year)
- Calibrate engine protection devices

8,000 Hour Maintenance (or 3 years)
- Change the coolant in the cooling system (DEAC)
- Replace the water temperature regulator
- Inspect camshaft roller followers
- Add cooling system coolant extender (ELC)
- Inspect crankshaft vibration damper
- Replace engine oil temperature regulator
- Inspect exhaust shields
- Replace governor actuator oil
- Inspect turbochargers
- Inspect water pumps

16,000 Hour Maintenance
- Change cooling system coolant (ELC)

16,000 to 24,000 Hour Maintenance
Top End Overhaul

Remanufacture or Rebuild
- Cylinder heads
- Cylinder head exhaust inserts
- Cylinder head dowels
- Cylinder head inlet inserts
- Cylinder head inner valve springs
- Cylinder head outer valve springs
- Cylinder head valve locks
- Cylinder head valve rotocoils
- Cylinder head valve spring guides
- Exhaust valves
- Inlet air valves

If the valves and seats are not replaced, grind the valves and lap the valves for full face contact.

Replace
- Connecting rod bearings
- Cylinder head gaskets
- Exhaust manifold gaskets
- Fuel transfer pump seals
- Inlet air lines seals
- Oil cooler seals
- Oil pump bearings and seals
- O-ring seals and plugs
- Oil temperature regulators and seals
- Turbocharger bearings, bushings, and seals
- Valve lubricator pump
- Water pump bearings and seals
- Water temperature regulators and seals
- Unit injectors

Clean and Inspect
- Oil cooler core
- Oil suction screen

Inspect/Replace
- Cylinder sleeves
- Exhaust shields
- Starting motor

36,000 to 44,000 Hour Maintenance

Major Overhaul

Remanufacture or Rebuild
- Centrifugal oil filter bearings
- Cylinder heads
- Starting motor

Replace
- Accessory group bearings
- Cylinder head valves and valve guides
- Cylinder head valve spring guides
- Exhaust manifold seals and bellows
- Exhaust shields
- Front gear train bearings
- Inlet air lines seals
- Oil temperature regulators and seals
- Unit injectors
- Water temperature regulators and seals
- Grind the valves and lap the valves for full face contact.

Inspect/Replace
- Aftercooler core
- Alarm and shutoff controls
- Camshafts
- Camshaft bearings
- Connecting rod bearings
- Crankshaft
- Cylinder liners
- Cylinder sleeves
- Exhaust manifolds
- Front gear group
- Main bearings
- Oil pump bushings and seals
- O-ring seals and plugs
- Pistons and piston rings
- Priority valve
- Rear gear train bearings and seals
- Rocker arm bearings
- Thrust bearings
- Turbocharger bearings, bushings, and seals
- Valve lubricator pump
- Valve mechanism group

If the crankshaft or the camshaft is removed for any reason, use the magnetic particle inspection process to check the component for cracks.

Clean and Inspect
- Oil cooler core
- Oil suction screen

Replace gaskets and seals

Replace the gaskets and seals for the following components:
- Camshaft front covers
- Camshaft drive gear covers
- Central structure covers
- Crankcase side covers
- Crankshaft
- Crankshaft vibration damper
- Front housing group
- Fuel lines
- Fuel transfer pump
- Gear inspection group
- Oil cooler
- Oil lines
- Power take-off covers
- Priority valve group
- Rear housing group
- Rear structure covers
- Valve covers
- Water lines