GE
Transportation

Marinsa Miami Corp./Cheoy Lee/ Panama Canal (ACP) GE 12V228 Installation Guide

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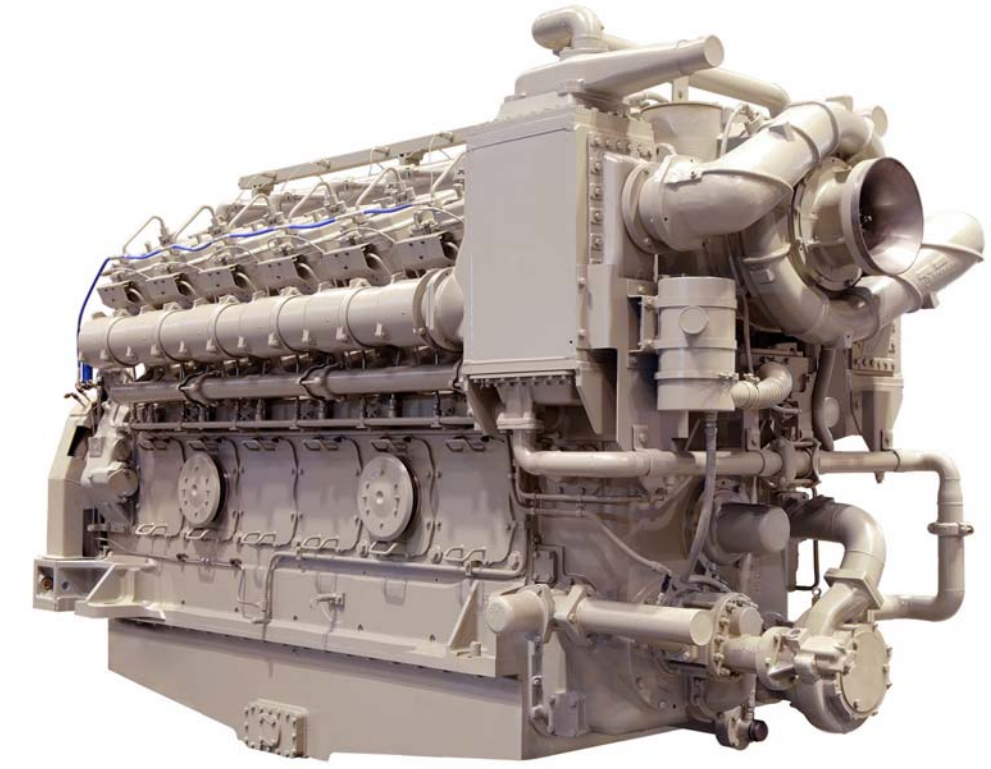

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1. GENERAL INFORMATION

The information contained in this manual is to be used as a guide for installation of GE 12V228 diesel engines. The information has been divided into sections as shown in the Table of Contents, for ease of reference. Figures and Tables are numbered according to the section in which they appear.

CAUTION: All sensors supplied loose by GE and to be installed by the buyer must be wired using a proper conduit and/or cable tray. Never leave the cable loose or route close to heat sources; e.g. exhaust manifold. Failure to observe this may result in cable damage.

1.1. ABBREVIATIONS

The following abbreviations are used in text and drawings throughout this manual:

AC	Alternating Current
CCW	Counterclockwise
CW	Clockwise
DC	Direct Current
DP	Design Pressure
DT	Design Temperature
EFI	Electronic Fuel Injection
GPH	Gallons Per Hour
GPM	Gallons Per Minute
GPS	Gallons Per Second
HT	High Temperature
LPH	Liters Per Hour
LPM	Liters Per Minute
LPS	Liters Per Second
LT	Low Temperature
MFI	Mechanical Fuel Injection
PPM	Parts Per Million
PSI	Pounds per Square Inch
RMS	Root Mean Square
RPM	Revolutions Per Minute
SRLC	Speed Reference Load Control
TB	Terminal Board
WP	Working Pressure
WT	Working Temperature

1.2. DEFINITIONS

The following definitions are used in text and drawings throughout this manual:

Free End – The turbocharger and intercoolers are mounted to this end of the engine.

Drive End – The generator or gearbox is mounted to this end of the engine (also known as the Generator End).

Right and Left Side – The right side or left side of the engine is determined by viewing the engine while facing the drive end.

Cylinder Alignment – The cylinders are numbered from the free end to the drive end. Number one right (1R) and number one left (1L) are nearest the turbocharger on all engines when viewed from the drive end.

Crankshaft Rotation – During engine operation, the crankshaft may rotate clockwise or counterclockwise when viewed from the drive end, depending upon engine configuration. Standard rotation is defined as counterclockwise when viewed from the drive end, and reverse rotation is defined as clockwise when viewed from the drive end.

Specific Fuel Consumption (SFC) – The amount of fuel consumed by the engine in mass per unit of power output or units of g/(kW*hr) or lb./(bhp*hr).

Brake Horsepower (BHP) – The actual or useful horsepower of an engine, usually determined from the force exerted on a friction brake or dynamometer connected to the drive shaft.

Operational Availability – The operational availability includes only the time required to change any failed components.

Warning Alarm – A warning alarm is an alarm sent from the GE V228 engine controller to the local display panel to indicate to the operator that one of the engine operating parameters is not within its expected range.

Shutdown Alarm – A shutdown alarm is a signal sent from the GE V228 engine controller to the control panel indicating that one of the engine operating parameters is at a value that is considered dangerous to engine operation and the engine should be shut down.

EPA – United States Environmental Protection Agency

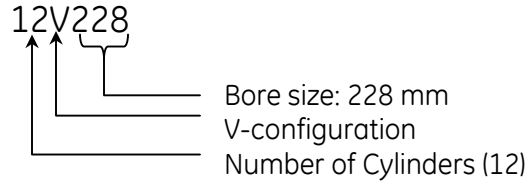
ISO – International Standardization Organization

IACS – International Association of Classification Societies

1.3. ENGINE NAMING

GE V228 diesel engines are named for their number of cylinders, "V" configuration, and bore size (mm), for example:

Model Designation



1.4. DRAWING SYMBOLS

Instrumentation function symbols and other drawing symbols used in the drawings throughout this manual are shown in Figure 1-1.

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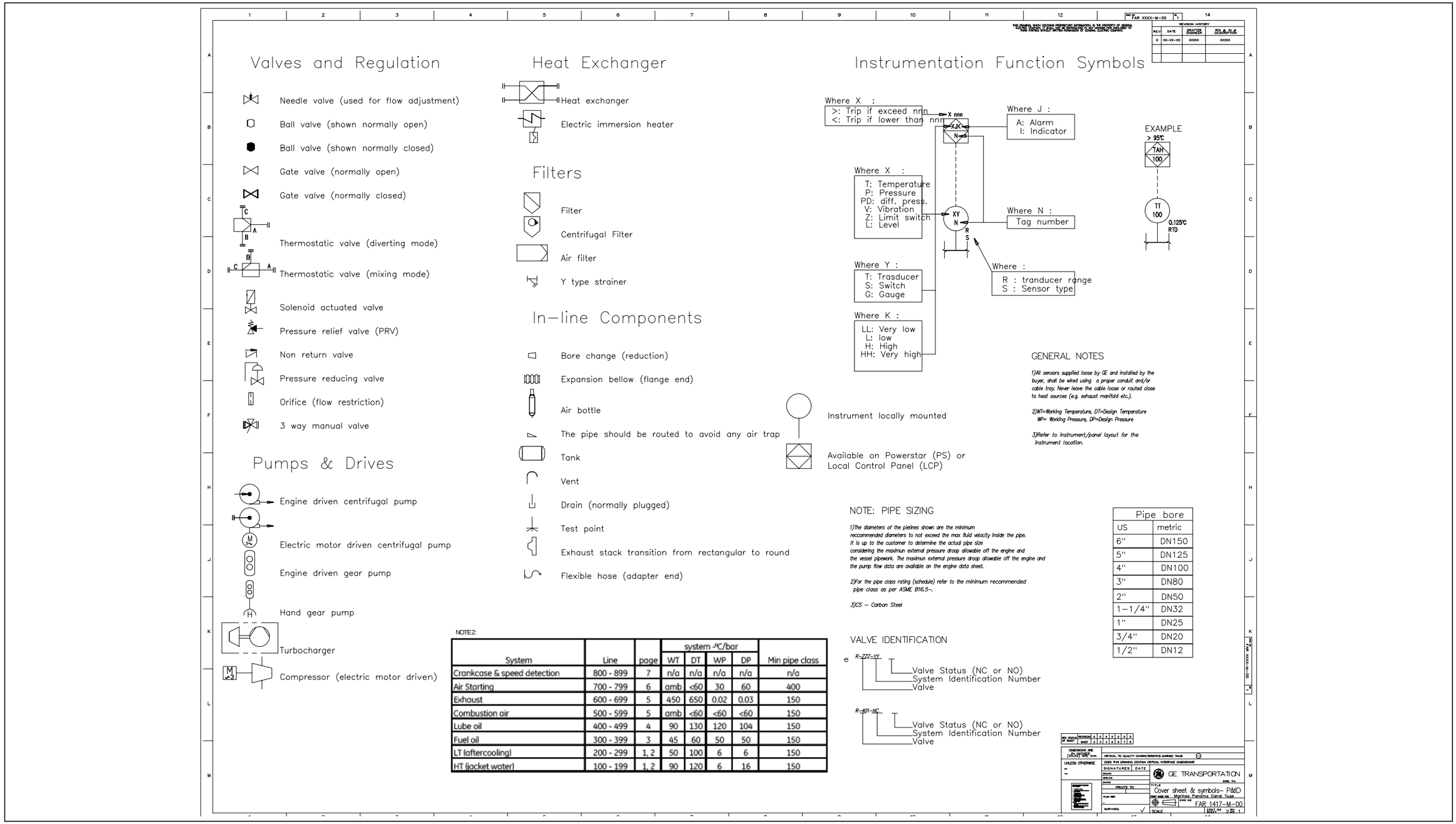


System	Line	page	system °C/bar WT	DT	WP	DP	Min pipe class
Crankcase & speed detection	800 - 899	7	n/a	n/a	n/a	n/a	n/a
Air Starting	700 - 799	6	amb	<60	30	60	400
Exhaust	600 - 699	5	450	650	0.02	0.03	150
Combustion air	500 - 599	5	amb	<60	<60	<60	150
Lube oil	400 - 499	4	90	130	120	104	150
Fuel oil	300 - 399	3	45	60	50	50	150
LT (aftercooling)	200 - 299	1, 2	50	100	6	6	150
HT (jacket water)	100 - 199	1, 2	90	120	6	16	150

Figure 1-1. Cover/Drawing Symbols (AutoCAD)

2. ENGINE SPECIFICATIONS

The following sections provide specifications for GE 12V2228 diesel engines for stationary applications.

2.1. ENGINE TECHNICAL DATA

Refer to Figure 2-1, Engine Component Identification, for cylinder identification and free/drive end designations.

Operating Speed	1000 rpm
Idle Speed	440 rpm
Low Idle Speed	350 rpm
Number of Cylinders	12
Stroke Cycle	4
Aspiration	Turbocharged – Intercooled
Piston Displacement	10.95 L (668 in^3)
Mean Piston Speed	8.89 m/sec (1750 ft/min)
Number of Valves	2 Inlet, 2 Exhaust
V-Angle	45 degree
Compression Ratio	15.7:1
Direction of Rotation (Facing Flywheel)	
Standard	Counterclockwise
Reverse	Clockwise
Firing Order (rotation)	
Standard (CCW)	1R-1L-5R-5L-3R-3L-6R-6L-2R-2L-4R-4L
Reverse (CW)	1L-1R-4L-4R-2L-2R-6L-6R-3L-3R-5L-5R
Number of Main Bearings	7

2.2. REFERENCE CONDITIONS

The reference conditions for the maximum continuous output ratings are according to ISO 3046-1, i.e.:

Total Barometric Pressure	1.0 bar (14.5 psi)
Air Temperature	25°C (77°F)
Relative Humidity	30%
Charge Air Coolant Temperature	25°C (77°F)
Raw Water Temperature	27°C (81°F)

The output is also available at a charge air coolant temperature of 38°C (100°F) maximum and an air temperature of 45°C (113°F) maximum. For higher temperatures, the output ratings have to be reduced according to the rules stated in ISO 3046/I.

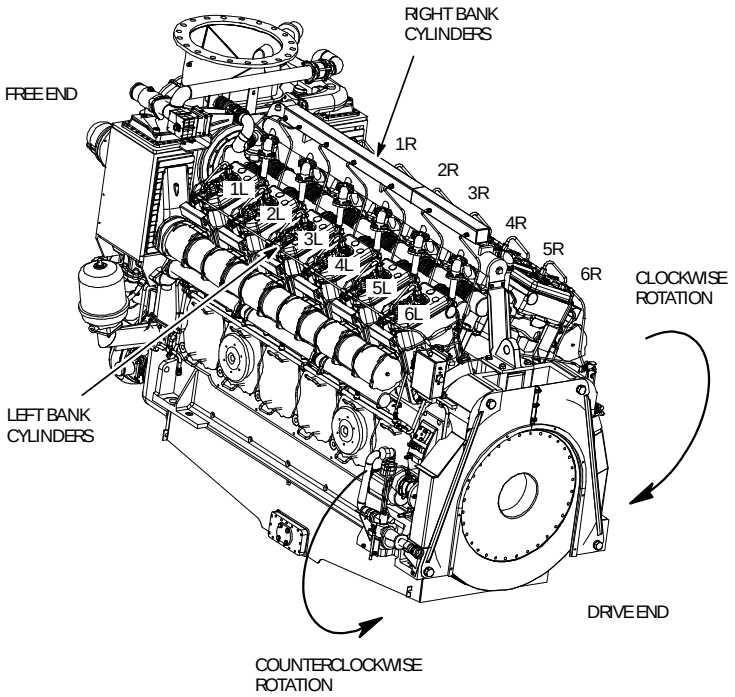


Figure 2-1. GE V228 Engine Component Identification. (E-49537)

2.3. ENGINE OPERATION AT LOW AIR TEMPERATURE

When planning specialized applications for arctic conditions, the following operational restrictions must be considered:

- To ensure engine starting, the inlet air temperature should be minimum 5°C (41°F)
- For engine idling, the inlet air temperature should be minimum 5°C (41°F)

The lowest permissible inlet air temperature at high load is -5°C (23°F). At engine loads between 0-40%, the air must be preheated. For lower temperatures, special provisions must be made. Contact your GE representative.

2.4. FUEL CHARACTERISTICS

GE V2228 diesel engines are qualified to run on diesel fuel defined by ASTM D-2 S5000. For questions on recommended fuels, contact your GE representative.

Refer to *SECTION 5.3, FUEL OIL* for additional information.

2.5. ENGINE DIMENSIONS

Refer to Figure 2-2 for the designations for dimensions shown in **Table 2-1, Engine Dimensions**. Refer to Figure 2-3 for the GE 12V228 diesel engine outline drawing.

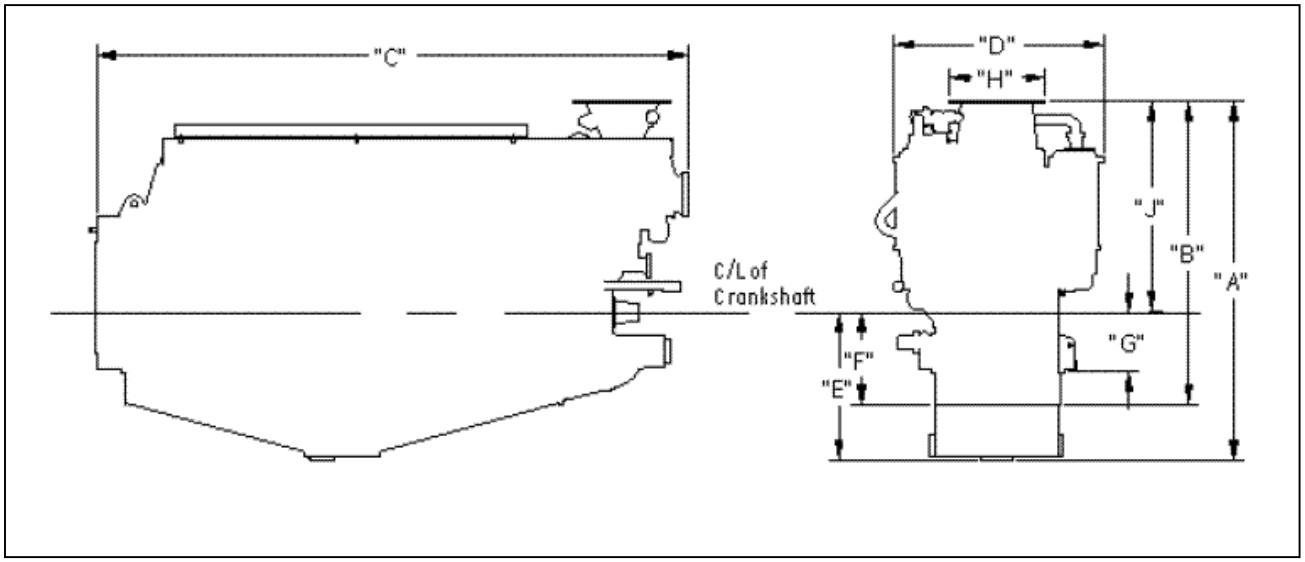


Figure 2-2. Engine Dimensions.

TABLE 2-1. ENGINE DIMENSIONS

Engine Dimensions		12V228
"A"	Height with deep sump	2762 mm (109 in.)
"B"	Height with shallow sump	2255 mm (101 in.)
"C"	Length	4136 mm (163 in.)
"D"	Width	1734 mm (68 in.)
"E"	Crank centerline to marine sump	968 mm (38 in.)
"F"	Crank centerline to shallow sump	771 mm (31 in.)
"G"	Crank centerline to mounting feet	480 mm (19 in.)*
"H"	Exhaust diameter	508 mm (20 in.)
"J"	Crank centerline to exhaust flange	1778 mm (70 in.)

**At Drive End; 489 mm (19.25 in.) at Free End.*

2.6. GE 12V228 ENGINE DATA AND OUTLINE DRAWINGS

Refer to **Table 2-2, GE 12V228 Engine Data** for specific engine data and refer to Figure 2-3 for 12V228 diesel engine outline drawing (foldout drawing at the end of this section).

Refer also to Figure 2-4, Flexible Connections Outline Drawing at the end of this section.

NOTE: Specifications subject to change without notification.

TABLE 2-2. GE 12V228 ENGINE DATA

Engine: GE 12V228 (84A221659 Rev. E)		**Type: 4 Stroke, Electronic Fuel Injection (EFI) Aspiration: Turbocharged and Intercooled Fuel Type: No. 2 Diesel: ASTM D-975 Emission Standard: MARPOL Annex VI Reference Conditions: per ISO 3046, Raw water temperature: 27°C (81°F)**
Specification	**Unit**	**Rated Engine Speed – 1000 RPM**
General Engine Data		
Maximum Continuous Rating (MCR)	kW (hp)	2179 (2922)
Overload rating (1 hr per 12 hr period)	kW (hp)	2397 (3214)
Bore	mm (in.)	228.6 (9)
Stroke	mm (in.)	266.7 (10.5)
Arrangement and number of cylinders	--	V–12
Cylinder volume	L (in^3)	10.95 (668)
BMEP (at maximum rating)	bar (psi)	21.9 (318)
Mean piston speed	m/s (ft/min)	8.89 (1750)
Compression ratio	--	15.7:1
Weight (dry)[1]	kg (lbs)	18942 (41760)
Weight (wet)[1]	kg (lbs)	19954 (43990)
Idle speed[2]	rpm	440
Heat Balance at Rated Load[3]		
Radiated heat	kW (BTU/min)	192 (10917)
Low-temperature intercoolers	kW (BTU/min)	629 (35787)
High-temperature jacket water	kW (BTU/min)	476 (27055)
High-temperature lubricating oil cooler	kW (BTU/min)	272 (15466)
Heat Balance at 110%[3]		
Radiated Heat	kW (BTU/min)	211 (12009)
Low-temperature intercoolers	kW (BTU/min)	692 (39364)
High-temperature jacket water	kW (BTU/min)	535 (30406)
High-temperature lubricating oil cooler	kW (BTU/min)	288 (16366)
High-Temperature (HT) Cooling Water System		
HT circuit pump flow rate	m^3/hr (gpm)	114 (500)
Water volume in engine	L (gal.)	189 (50)
Temperature before engine, nominal	°C (°F)	79 (175)
Temperature before engine, alarm	°C (°F)	104 (220)
Temperature after engine, nominal	°C (°F)	83 (182)
Temperature after engine, 110%	°C (°F)	84 (183.2)
HT maximum allowable external pressure drop[4]	bar (psi)	1.4 (20)
Low-Temperature (LT) Cooling Water System (Intercoolers)		
LT circuit pump flow rate	m^3/hr (gpm)	34 (150)
Water volume in engine	L (gal.)	322 (85)
Water temperature before intercooler, nominal	°C (°F)	41 (105)
Water temperature after intercooler, approx.	°C (°F)	57 (134)
Water temperature after intercooler, approx. (110%)	°C (°F)	58 (137)
LT maximum allowable external pressure drop[4]	bar (psi)	1 (14.5)

TABLE 2-2. GE 12V228 ENGINE DATA (CONT'D)

Engine: GE 12V228 (84A221659 Rev. E)		
Specification	**Unit**	**Rated Engine Speed – 1000 RPM**
Lubrication System		
Lube oil pump flow rate	m^3/hr (gpm)	55 (243)
Engine and sump capacity, deep oil pan[5]	L (gal)	908 (240)
Temperature before engine, nominal	°C (°F)	83 (182)
Temperature after engine, approximate	°C (°F)	93 (200)
Temperature after engine, alarm	°C (°F)	104 (220)
Fuel System		
Pump flow	m^3/hr (gpm)	2.7 (11.8)
Header pressure	kPa (psi)	414 (60)
Maximum suction lift	mm (in.)	1830 (72)
Fuel temperature at inlet, minimum	°C (°F)	4 (40)
Fuel temperature at inlet, maximum	°C (°F)	53 (127)
Intake Air System		
Combustion air at rated load	m^3/m (cfm)	252 (8912)
Combustion air at 110%	m^3/m (cfm)	278 (9803)
Intake air temperature, minimum[6]	°C (°F)	7 (45)
Intake air temperature, maximum[6]	°C (°F)	46 (115)
Manifold air temperature, alarm	°C (°F)	104 (220)
Maximum intake vacuum (dirty filter)	mbar (in. H_2O)	32 (13)
Exhaust System		
Exhaust flow at rated load	m^3/m (cfm)	549 (19285)
Exhaust flow at 110%	m^3/m (cfm)	601 (21212)
Exhaust temperature	°C (°F)	427 (800)
Maximum back pressure	mbar (in. H_2O)	24.9 (10)
Starting System		
Pressure at starter with engine cranking	kPa (psi)	621 (90)
Maximum system pressure	bar (psi)	30 (435)
Nominal cranking time (warm engine)	seconds	5
Nominal cranking flow	m^3/m (cfm)	48 (1700)
Maximum Allowable Engine Inclinations (deep pan)		
Static (permanent) conditions	Degrees[7] Degrees[8]	±5 ±30
Dynamic conditions	Degrees pitch Degrees roll	±13 ±48

[1] Marine configuration including deep sump oil pan and marine flywheel.
[2] Idle speed is configurable based on project requirements and TVA results. Minimum idle spped is 335 RPM.
[3] Does not include fouling.
[4] Sum of all components external to engine.
[5] Shallow sump oil pan configuration is available based on dynamic conditions requirements of the project.
[6] Fore and aft direction (based on engine, not vessel).
[7] Left and right direction (based on engine, not vessel).
[8] Values quoted at compressor inlet, any temperature rise from ambient to inlet must be taken into consideration; Temperature range is only valid for elevations less than 1000 ft.

NOTE: If the static (permanent) installation angles of the engine (fore/aft and left/right) are not equal to zero, then those values must be subtracted from the maximum dynamic angles (pitch and roll), respectively. Those calculated numbers would then become the new maximum dynamic angles allowable.

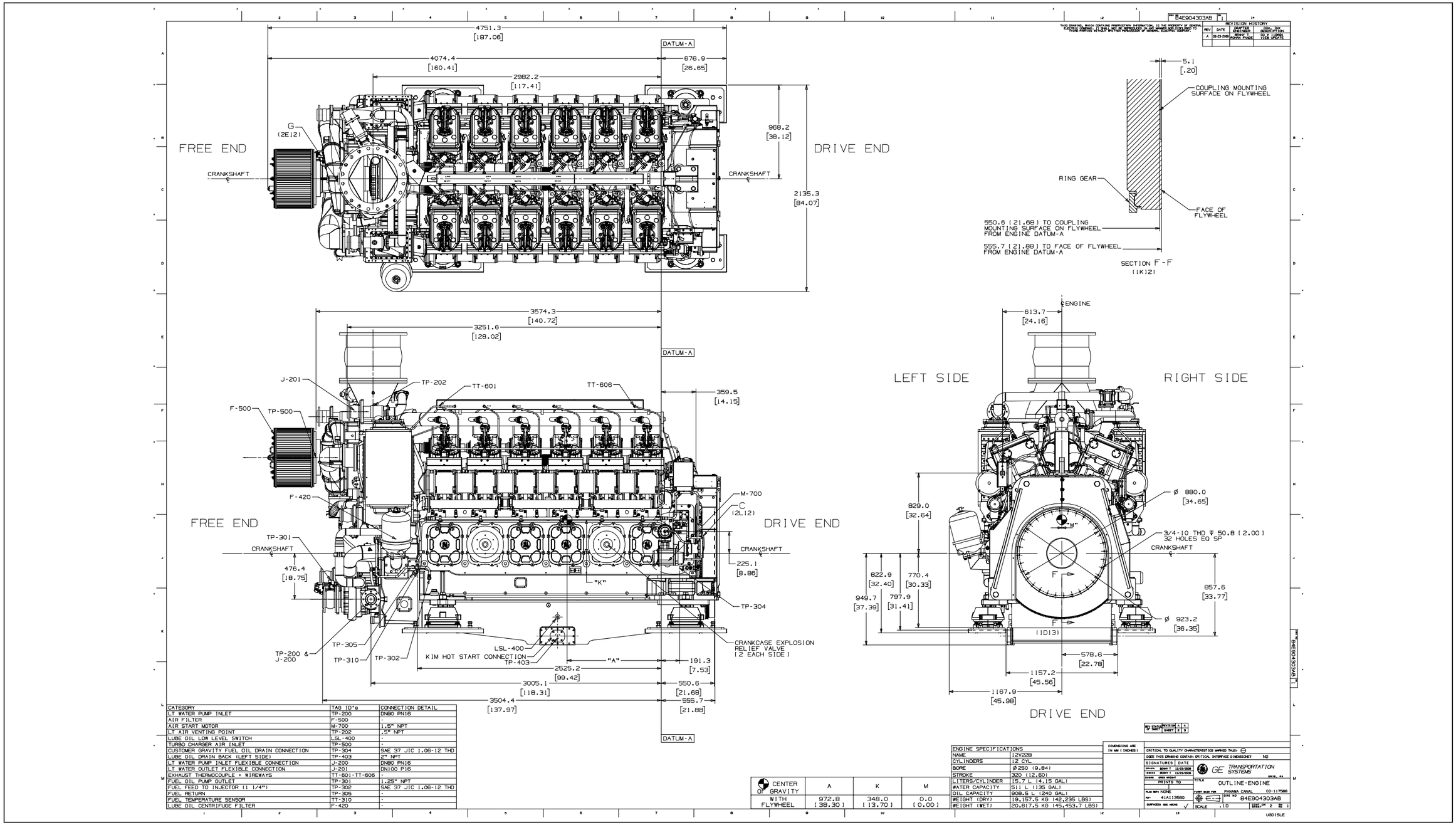
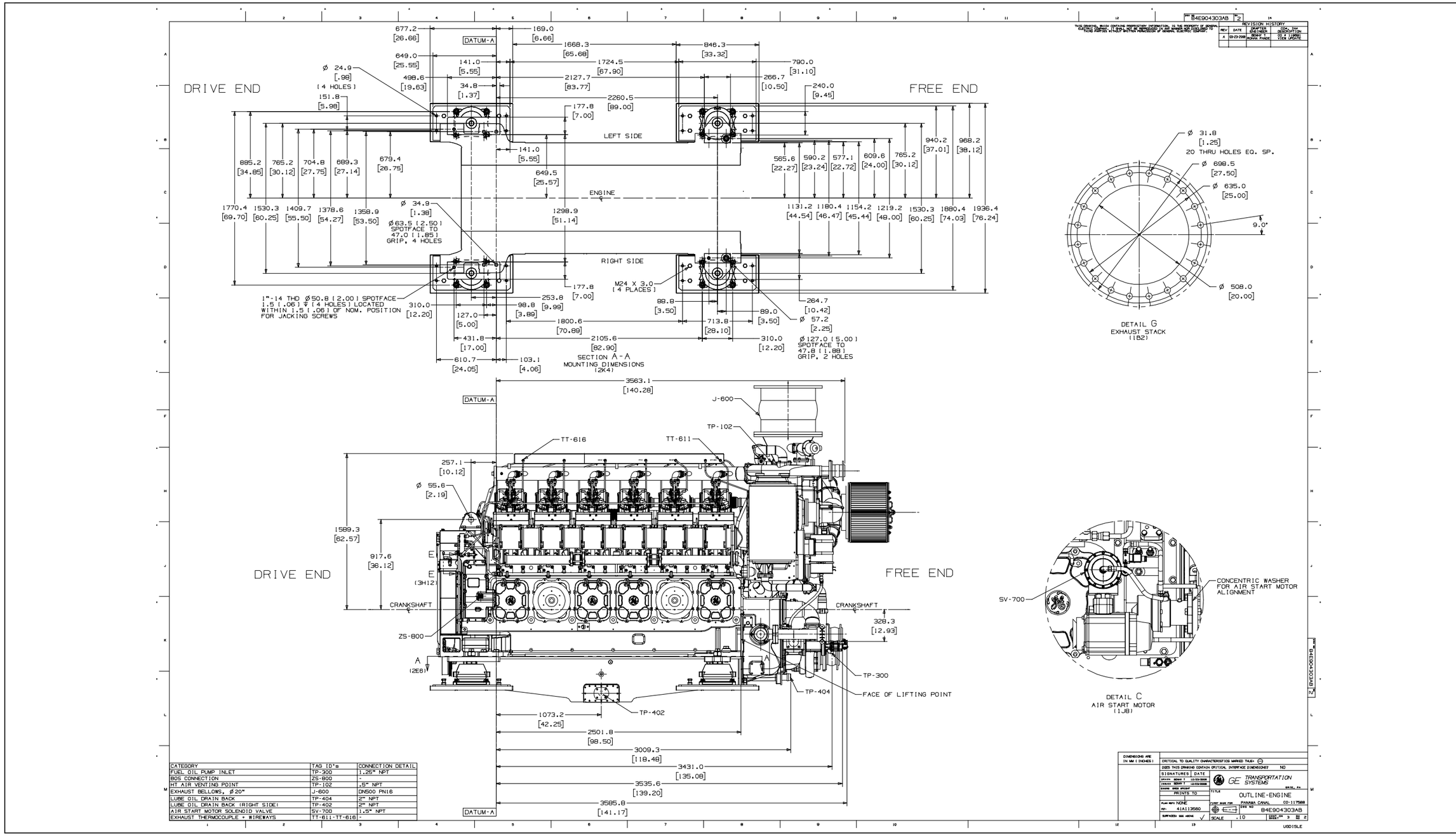
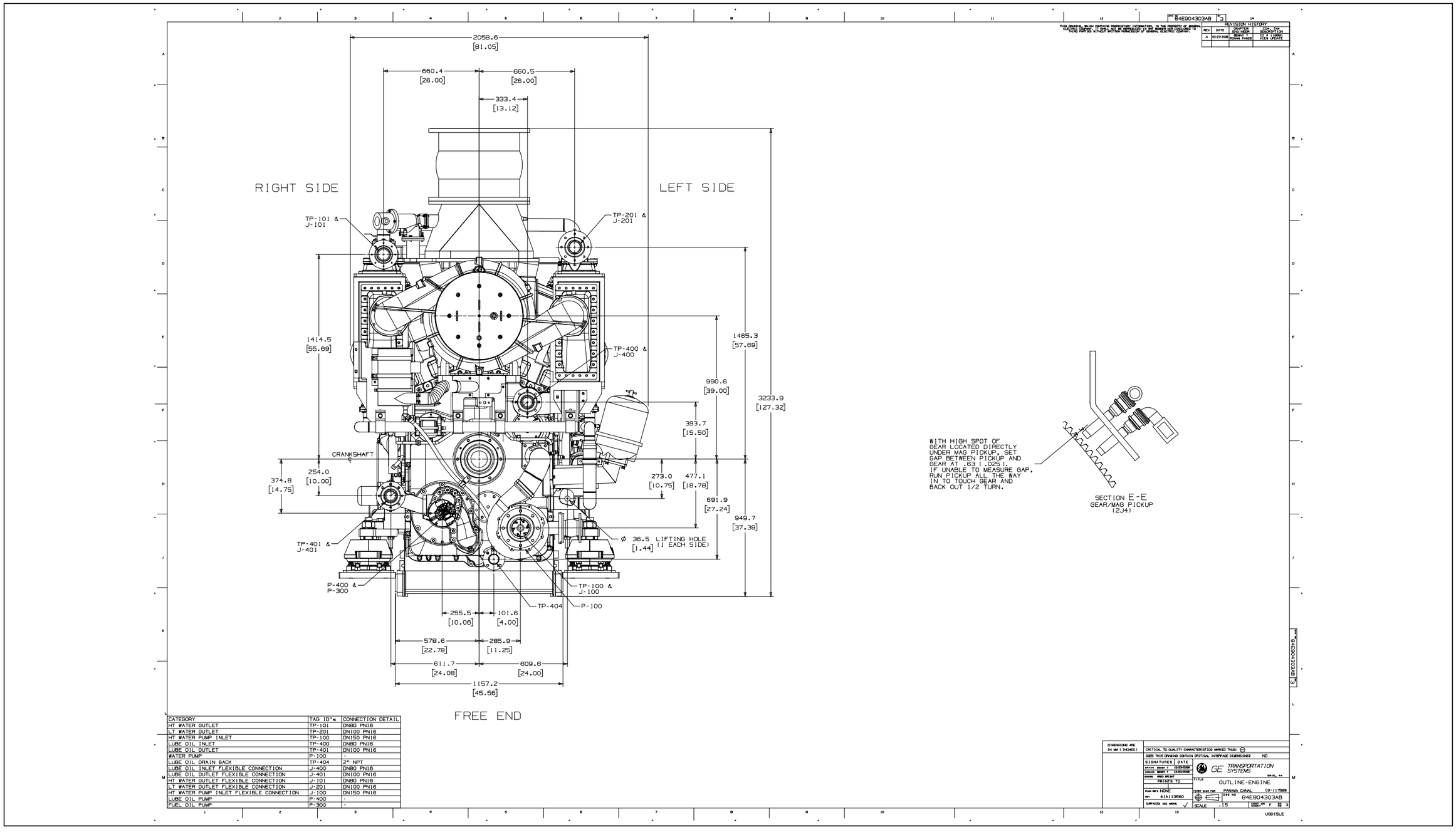


Figure 2-3. GE 12V228 Engine Outline Drawing, Sheet 1 of 3. (84E904303AB)



CATEGORY	TAG ID's	CONNECTION DETAIL
FUEL OIL PUMP INLET	TP-300	1.25" NPT
BOS CONNECTION	ZS-800	-
HT AIR VENTING POINT	TP-102	.5" NPT
EXHAUST BELLOWS, Ø 20"	J-600	DN500 PN16
LUBE OIL DRAIN BACK	TP-404	2" NPT
LUBE OIL DRAIN BACK (RIGHT SIDE)	TP-402	2" NPT
AIR START MOTOR SOLENOID VALVE	SV-700	1.5" NPT
EXHAUST THERMOCOUPLE + WIREWAYS	TT-611-TT-616	-

Figure 2-3. GE 12V228 Engine Outline Drawing, Sheet 2 of 3. (84E904303AB)



CATEGORY	TAG ID's	CONNECTION DETAIL
HT WATER OUTLET	TP-101	DN80 PN16
LT WATER OUTLET	TP-201	DN100 PN16
HT WATER PUMP INLET	TP-100	DN150 PN16
LUBE OIL INLET	TP-400	DN80 PN16
LUBE OIL OUTLET	TP-401	DN100 PN16
WATER PUMP	P-100	-
LUBE OIL DRAIN BACK	TP-404	2" NPT
LUBE OIL INLET FLEXIBLE CONNECTION	J-400	DN80 PN16
LUBE OIL OUTLET FLEXIBLE CONNECTION	J-401	DN100 PN16
HT WATER OUTLET FLEXIBLE CONNECTION	J-101	DN80 PN16
LT WATER OUTLET FLEXIBLE CONNECTION	J-201	DN100 PN16
HT WATER PUMP INLET FLEXIBLE CONNECTION	J-100	DN150 PN16
LUBE OIL PUMP	P-400	-
FUEL OIL PUMP	P-300	-

Figure 2-3. GE 12V228 Engine Outline Drawing, Sheet 3 of 3. (84E904303AB)

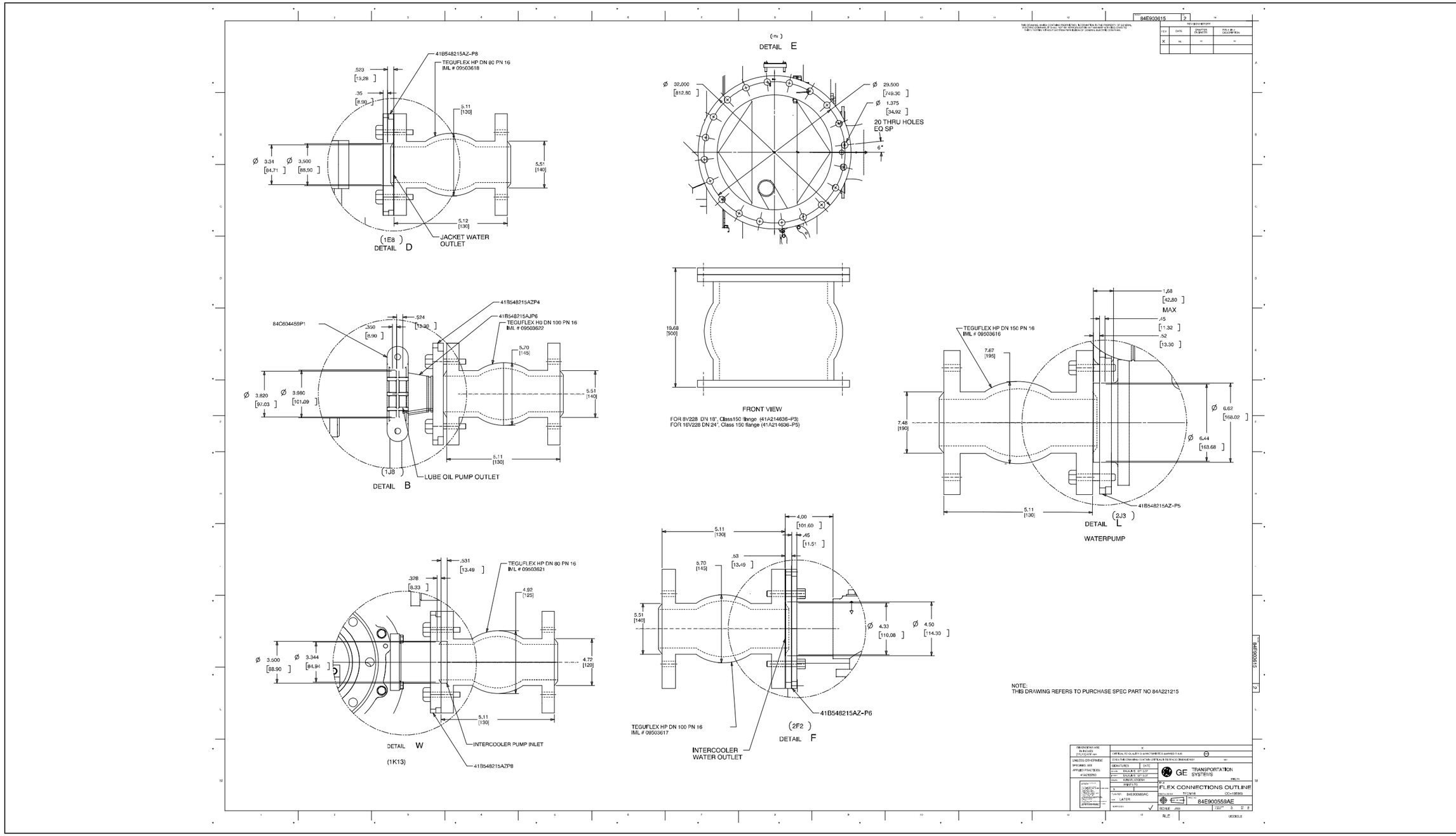


Figure 2-4. Flexible Connections Outline Drawing, Part 1 of 2. (84E903615, Sheet 2)

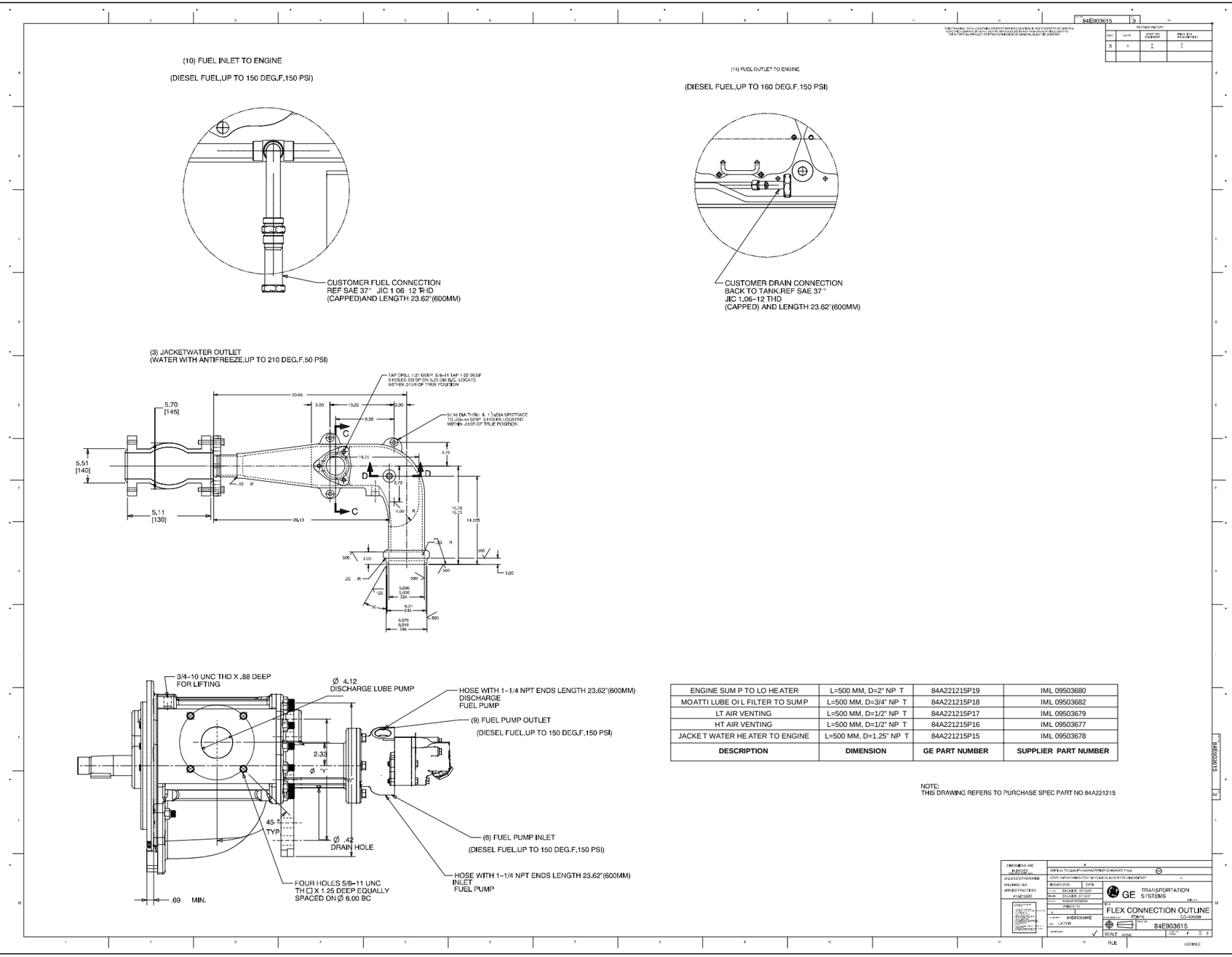


Figure 2-4. Flexible Connections Outline Drawing, Part 2 of 2. (84E903615, Sheet 3)

3. SCOPE OF SUPPLY

This section contains the Scope of Supply for GE and the purchaser for this project. This information is specific to each project.

TABLE 3-1. SCOPE OF SUPPLY GE 12V228 STATIONARY DIESEL ENGINES

Reference #	Item		Qty Per System
1	**General Equipment Description**		
1.1.1	**Engine Rating and General Description**		
	Engine model Engine continuous rating Bore Stroke Arrangement and number of cylinders Approximate dry weight	GE 12V228 Marine Diesel Engine 1962 kW (2630 hp) at 900 rpm 228.6 mm (9 in.) 266.7 mm (10.5 in.) V-12 17778 kg (39200 lb)	1
	Segmented camshafts Unitized power assemblies Flywheel and ring gear assembly Integral flywheel guard		
	Rotation	CCW when viewing the flywheel	1
1.1.2	**Class Certification**		
	Classification Society: LR with UMS notation		1
1.1.3	**Emissions Certification**		
	EIAPP emissions certificate – MARPOL 73/78 Annex VI		1
1.2	**Engine Systems**		
1.2.1	**Lube Oil System**		
	Deep sump oil pan with left and right side drain connections and provisions for lube oil level sensor – 12V228		1
	Engine-driven lube oil pump Pressure relief valve		1 1
	Automatic lube oil filter with integral centrifuge, includes bypass, safety net, counter-flanges, and pressure drop indicator (class certified) – ship loose		1
	Plate-type oil cooler for 12V228 (class certified) – ship loose		1
	Installation kit for plate-type oil cooler		1
1.2.2	**Fuel Oil System**		
	MDO – DMA – 12V228 (Marine Gas Oil) • Flash point 60°C (140°F) minimum • Kinematic Viscosity cSt at 40°C (104°F); minimum 1.5, maximum 6.0 • ***Sulfur, % mass, maximum 1.5*** • Cetane Index, minimum 40 • Ash, % mass, maximum 0.01 • Water, % (v/v), 0.0		1
	Engine-driven fuel transfer pump On-engine high-pressure, double walled, seamless steel fuel lines On-engine leak detection system Pressure relief and regulating valve		1 1 set 1 set 1
	Duplex fuel filter – automatic with manual backup		1
	Hand-operated fuel priming pump – ship loose		1
	Fuel filter, temporary for commissioning		1
	Fuel filter cartridge, temporary for commissioning		1

TABLE 3-1. SCOPE OF SUPPLY GE 12V228 STATIONARY DIESEL ENGINES

Reference #	Item	Qty Per System
1.2.3	**Cooling Water System**	
1.2.3.1	**High-Temperature (HT) Cooling Water System**	
	Engine-driven jacket water pump	1
	Marine high-temperature cooling circuit thermostatic valve – ship loose	1
1.2.3.2	**Low-Temperature (LT) Cooling Water System**	
	Engine-driven intercooler water pump	1
	Marine low-temperature cooling circuit thermostatic valve – ship loose	1
1.2.5	**Pre-Heater**	
	Lube oil and jacket water pre-heat and circulation system, 60 Hz, 3 PH – ship loose	1
1.2.6	**Intake Air System**	
	Combustion air filtration system – on engine, 12V228	1
1.2.7	**Exhaust System**	
	Sectional exhaust manifold	1
	Exhaust manifold heat shielding	1
	Four pipe exhaust manifold for 12V228	1
	Exhaust stack transition section for 12V228 (rectangular to 20-in. diameter round)	1
	Exhaust stack installation kit for 8/12 V228	1
	Exhaust bellows, 20-in. diameter, for resiliently mounted engine – ship loose	1
1.2.8	**Air Start System**	
	Air start motor – turbine-type Air start solenoid, 24 VDC On-engine piping	1 1 1 set
1.2.9	**Control System**	
	V228 marine engine controller in NEMA enclosure – ship loose	1
	One set of interconnect cables, engine-controller-to-engine, length = 18.3 m (60 ft) – ship loose	1
	Lube oil level sensor	1
	AMSC panel – ship loose - Includes monitoring, alarms and shutdowns per Class requirements - Parameters displayed (minimum): • Engine RPM • Jacket water pressure • Lube oil temperature • Exhaust stack temperature • Lube oil pressure • Fuel oil pressure • Starting air pressure • Individual cylinder exhaust temperatures • Operating hours meter - Alarms (minimum): • High jacket water temperature • High lube oil temperature • Low lube oil pressure • High crankcase pressure • Low lube oil level • Low water level • Overspeed tripped	1

TABLE 3-1. SCOPE OF SUPPLY GE 12V228 STATIONARY DIESEL ENGINES

Reference #	Item	Qty Per System
1.2.10	**Engine Mounting**	
	Engine mounting kit for resilient mounting	1
	One set of flexible engine connections for resiliently mounted engine – ship loose	1
	One set of Victaulic to DN adaptors	1
	TVA analysis ***NOTE: Couplings will be delivered 31 weeks after receipt of vessel drive train information required for the TVA analysis***	1
1.2.12	**Miscellaneous**	
	Exhaust thermocouples and wire-way	1 set
	Exhaust thermocouple wire harness	1
	Explosion-relief crankcase doors	1 set
	Flexible drive coupling with mounting hardware, 12V228, resilient mount, twin screw, Class certified – ship loose	1
2	**Factory Engine Test**	
	No customer witness of engine testing	1
3	**Documentation**	
	Maintenance manual on CD (provided at time of engine shipment) Renewal Parts manual on CD (provided at time of engine shipment) Initial installation information will be provided after contract signing and a complete Installation Guide will be provided approximately three months after contract signing ***NOTE: All documentation is provided in English***	3 3 1
4	**Technical Support**	
	- One week (5 days) on-site technical support in Panama per vessel - Three trips of two weeks (10 days per trip) on-site in China for the project	1
5	**Warranty**	
	12V228 - 24 months from date of shipment or 16 months from commissioning in China, whichever ends first	1
6	**Packing and Shipment**	
	Packaging 12-cylinder engine and loose ship items, wooden crate suitable for ocean shipment to China	1
	EXW (INCOTERMS 2000) Erie, PA, USA	1
7	**Specialized Tooling**	
	Not included	
8	**Spares**	
8.2	**Consumable Spares**	
	Priced separately (may be included with engines at a later date)	
8.2	**Recommended Spares**	
	Not included	

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4. DIESEL ENGINE

This section provides information on the GE V228 diesel engine connections, service, and emissions.

4.1. ENGINE PIPING SYSTEM AND CONNECTIONS

NOTE: The engine piping system and connections recommendations included for General Electric diesel engine installations are not intended to replace applicable regulatory agency requirements. Their requirements should be reviewed prior to initiating piping system design or evaluation.

CAUTION: All customer supplied piping interface is to be supported and aligned in accordance with IACS rules (UR P, part 2) and regulations at a minimum. IACS rules and regulations are only to be superseded when a specific class society or the country of vessel flag rules and regulations are more stringent.

This section describes engine piping system and connection parameters to be followed for installation of the GE diesel engine.

4.1.1. Pipe Routing

Piping should be routed as directly as possible with minimum bends, but with sufficient joints for ready accessibility and removal. Piping design must not disrupt the integrity of watertight and oil-tight areas in the structure.

- Piping must not interfere with walkways or doors and must permit unrestricted access in walkway areas and designated workspaces.
- Piping must clear areas required for machinery operation and control.
- Piping must be routed around machinery or tank access openings and access openings used for shipping or receiving machinery and equipment.
- Keep piping close to walls, behind framing, and along the underside of floors.
- Leave sufficient space between pipes and spool all pipes from floors and walls to permit easy maintenance and painting.
- Minimize piping in control rooms or over electrical equipment. When this is not possible, install the pipe in one length with all flanges or screwed connections kept away from electrical switchgear or cabinets.
- Avoid high and low points in the pipe routing if possible. Use plugs or valves for draining in unavoidable low points. Fit piping high points with vent valves.

NOTE: Use removable piping sections when routing obstructs equipment that requires dismantling for periodic overhaul. Provide isolating valves to minimize system disruption.

4.1.2. Piping Support And Protection

The piping must be supported to prevent vibration damage. Design the number of supports provided, the type selected, and the location to eliminate excessive vibration of piping under all normal operating conditions.

- When piping is subject to movement from expansion or other causes, specially designed hangers or supports must be provided.
- Spring-type hangers should be provided when required for engine exhaust gas pipes.
- Heavy items such as valves and fittings must be supported to prevent overloading the attached piping.
- Provide pipe support on the plant side of the system piping to minimize pipe movement and flex connection loading.

If piping is subject to mechanical damage, it should be adequately protected by removable metal guards. The guards must be designed and positioned to allow for inspection and painting.

4.1.3. Piping Connections

NOTE: Flexible connections installed in piping systems for fuel oil, flammable liquids, and high pressure containment may require approval by the classification society and/or other applicable regulatory bodies.

All piping connections at the engine are to be strain-free. Use flexible connections for all piping connected to the engine or other reciprocating machinery. The length and weight of piping mounted on the engine must be kept to a minimum, and the flexible connection should be placed right at the engine connection flange whenever possible.

Avoid piping arrangements with excessive turbulence, such as tee connections.

Expansion joints must be used at walls and floors to prevent piping damage from any structure movement. Use flange-type welded connections on either side of walls to permit pipe dismantling for service.

4.1.4. Pipe Venting

Vent any tanks containing flammable fluids to the atmosphere using a gooseneck ventilator and flame screens and closures. Position air vent discharges from tanks or valves so that discharge air does not:

- Enter any other ventilation air inlets
- Enter openings to accommodations or work spaces
- Discharge onto machinery or electrical equipment
- Discharge onto personnel

4.1.5. Pipe Cleaning

Thoroughly clean all piping and equipment after fabrication and prior to installation. Visually inspect combustion air and exhaust gas piping systems to ensure weld slag and debris is removed prior to installation.

After installation, each piping system must be cleaned and flushed with the applicable system's medium, or an approved substitute.

NOTE: The cleaning/flushing process should be reviewed by the owner, regulatory agency's inspector, and GE.

Conduct each flushing at the system's maximum operating pressure and temperature, and above normal line velocity. Remove, bypass, or blank-off heat exchangers, control valves, and other in-line components that could trap debris during the flushing process.

4.1.5.1. Inhibited Sulfuric Acid Pickling

The following method of cleaning is to be applied to all ferrous pipe used in the lubricating oil and fuel oil systems. Refer to **Table 4-1, Cleaning Concentrations**, for cleaning solution concentrations.

TABLE 4-1. CLEANING CONCENTRATIONS

Item	Concentration
Sulfuric Acid 60° Be	1-2 parts by volume
Water	8-9 parts by volume
Rodine No. 81 Inhibitor	Per manufacturer's recommendations
Alkaline or Emulsion Type Degreaser	Per manufacturer's recommendations
Soluble Oil (Kutwell No. 50)	1 part by volume
Water	50 parts by volume
Univis	P-48 Oil

NOTE: After the pipe has been immersed for two minutes, it should be raised and lowered vertically in the tank to create some agitation and facilitate the removal of the scale.

1. Immerse the pipe in the degreasing tank maintained at 82° to 93°C (180° to 200°F) for approximately five minutes.
2. Rinse the pipe with hot water followed by a rinse with cold water.
3. Immerse the pipe in the hot acid pickle solution with temperature at 79° to 93°C (175° to 200°F) for at least three minutes and up to a maximum time of 10 minutes.
4. Remove the pipe from the hot acid pickle solution and rinse in hot water.
5. Wire brush the entire internal bore of the pipe with a flexible circular brush to remove loosened scale and smut.
6. Immerse the pipe in the hot acid pickle solution again for 5 to 10 seconds, then rinse with hot water.
7. Immerse the pipe in the alkaline cleaning tank to neutralize and remove traces of residual acid.
8. Immerse the pipe in the cold-water tank, then immediately immerse in the soluble oil tank.
9. Remove the pipe from the soluble oil tank and place in a position to allow it to drain freely and thoroughly.
10. Inspect the pipe's internal bore and verify that it is free of mill scale and weld splatter and has a steel gray appearance.
    - If inspection is satisfactory, proceed to the following steps.
    - If inspection is unsatisfactory, repeat the above cleaning process.
11. Coat the interior of the pipe with Univis P-48 oil by flushing, dipping or spraying.
12. Protect the pipe openings with gauze secured with masking tape to allow free circulation of air after the application of Univis P-48 oil. Do not seal the pipe openings.

CAUTION: If the pipes are to be stored before final assembly, they must be stored inside, protected from the weather and in such a position so that the gauze on the open end is not damaged.

4.1.6. Piping Valves And Monitoring Gauges

CAUTION: Pay special attention to the selection of valve seat, stem, and trim materials. Improper material application may result in the accelerated corrosion and failure of service valves and deterioration of seat materials in ball and butterfly valves used in fuel oil and lubricating oil transfer systems.

NOTE: Valves attached to oil tanks should be selected and arranged based on classification society requirements.

The valves are in no way to restrict system flow. Valve handles are to be capable of being positively retained in their normally open position to prevent accidental closure. Hand wheels or operating levers of valves should be easily operated from a walkway or deck. Unless obvious, provide valves with nameplates clearly stating their purpose.

Safety or relief valve inlet piping should be as short as possible. Discharge oil system relief valves to the low-pressure side of the system.

Valves should normally be gate or globe type, except for throttling purposes where globe type valves should be used. The substitution of butterfly or ball valves can be made where permitted by regulating agencies. Do not use butterfly or ball valves where close, controllable throttling is mandatory.

System monitoring gauges, thermometers, etc. should be visible from operating areas. Thermometers should have separate wells. Pressure gauges should have test tees. Locate isolating valves close to the main piping run.

4.1.7. Piping Fluid Velocities

Table 4-2, Fluid Design Velocities, is a pipe selection guide for suggested fluid velocities. To avoid erosion, water hammer, or the possibility of noise, the upper velocity limits should not be exceeded. The final pipe sizes should be selected based on considerations of piping layout, number of fittings, valves, viscosity of fluid passing through the pipe and pressure drop.

Head loss on the suction side of pumps should be carefully analyzed. Compare the losses in the suction piping to the net positive suction head available with the specific pump selected.

TABLE 4-2. FLUID DESIGN VELOCITIES

Service	Nominal		Maximum	
	m/sec	(ft/sec)	m/sec	(ft/sec)
Fresh water suction	0.18√d	(3√d)	4.6	(15)
Fresh water discharge	0.30√d	(5√d)	6.1	(20)
Lubricating oil service pump suction	0.06√d	(1√d)	1.2	(4)
Lubricating oil discharge	0.12√d	(2√d)	1.8	(6)
Fuel oil service suction	0.06√d	(1√d)	1.2	(4)
Fuel oil service discharge	0.09√d	(1.5√d)	1.8	(6)
Fuel oil transfer suction	0.06√d	(1√d)	1.8	(6)
Fuel oil transfer discharge	0.12√d	(2√d)	4.6	(15)
Diesel oil suction	0.12√d	(2√d)	2.1	(7)
Diesel oil discharge	0.30√d	(5√d)	3.7	(12)
Hydraulic oil suction	0.09√d	(1.5√d)	2.4	(8)
Hydraulic oil discharge	0.48√d	(8√d)	6.1	(20)
Sea water suction	0.18√d	(3√d)	4.6	(15)
Sea water discharge	0.30√d	(5√d)	4.6	(15)

4.1.8. Piping Materials

Do not use galvanized piping or galvanized fittings in the fuel oil and lubricating oil piping systems. Galvanizing of ferrous piping should be done only after fabrication. Refer to **Table 4-3, Piping Schedule**, for piping system material recommendations.

TABLE 4-3. PIPING SCHEDULE

System		Piping		Take Down Joints	
#	**Service**	**Size**	**Type**	**Size**	**Type**
1	Cooling Fresh Water	Above 10 mm (1/2 in.)	Seamless, ASTM A106, Sch. 40, Grade A or B	Above 10 mm (1/2 in.)	Steel Slip-on Welded Flanges, Butt Welded or Sleeve
		10 mm (1/2 in.) and Below	Seamless Copper, ASTM B88, Type K or L	10 mm (1/2 in.) and Below	Brass Unions, Bite Joint or Sleeve
2	Any Service not otherwise specified	Above 10 mm (1/2 in.)	Seamless, ASTM A106, Sch. 80, Grade A or B, Galvanized	Above 10 mm (1/2 in.)	Steel Slip-on Welded Flanges, Butt Welded or Sleeve
		10 mm (1/2 in.) and Below	Seamless Copper, ASTM B88, Type K or L	10 mm (1/2 in.) and Below	Brass Unions, Bite Joint or Sleeve
3	Oil & Fuel – Filling, Transfer, and Service	Above 10 mm (1/2 in.)	Seamless, ASTM A106, Sch. 40, Grade A or B	Above 10 mm (1/2 in.)	Steel Slip-on Welded Flanges, Butt Welded or Sleeve
		10 mm (1/2 in.) and Below	Seamless Copper, ASTM B88, Type K or L	10 mm (1/2 in.) and Below	Brass Unions, Bite Joint or Sleeve
4	Exhaust Gas*	All	Steel Resistance Welded, ASTM A53*	All	Steel Plate Flanges
5	Exhaust Gas-Open Drains	All	Steel Resistance Welded, ASTM A53 Sch. 40	--	--
6	Starting Air and Control Air	Above 10 mm (1/2 in.)	Seamless, ASTM A106, Sch. 40, Grade A or B	Above 10 mm (1/2 in.)	Steel Slip-on Welded Flanges, Butt Welded or Sleeve
		10 mm (1/2 in.) and Below	Seamless Copper, ASTM B88, Type K or L	10 mm (1/2 in.) and Below	Brass Unions, Bite Joint or Sleeve

**Pipe is to be at least ¼ inch thick.*

TABLE 4-3. PIPING SCHEDULE (CONT'D)

System		Valves			Fittings		
#	**Service**	**Size**	**Press. Bar (psi)**	**Material**	**Trim**	**Size**	**Type**
1	Cooling Fresh Water	50 mm (2 in.) and Above	8.6 (125)	Cast Iron or Forged Steel Flanged	Brass	50 mm (2 in.) and Above	Forged Steel Std. Wt., Butt Welded ends, ASTM A-234
		40 mm (1.5 in.) and Below	13.8 (200)	Bronze	Brass	40 mm (1.5 in.) and Below	Ductile Iron, Forged Steel, or Bronze, Screwed
2	Any Service not otherwise specified	50 mm (2 in.) and Above	10.3 (150)	Cast Steel, Flanged	Brass or Monel	50 mm (2 in.) and Above	Butt Welded Galvanized
		40 mm (1.5 in.) and Below	13.8 (200)	Bronze, Flanged	Brass or Monel	40 mm (1.5 in.) and Below	Ductile Iron or Forged Steel, Galvanized, Screwed
34	Oil & Fuel - Filling, Transfer, and Service*	50 mm (2 in.) and Above	8.6 (125)	Cast Iron or Forged Steel Flanged	Brass	50 mm (2 in.) and Above	Forged Steel Std. Wt., Butt Welded ends, ASTM A-234
			10.3 (150)	Cast Steel, Flanged			
		40 mm (1.5 in.) and Below	13.8 (200)	Bronze, Flanged or Screwed	Brass	40 mm (1.5 in.) and Below	Ductile Iron or Forged Steel, Screwed or Socket Weld
4	Exhaust Gas	--	--	--	--	All	Forged Steel, Butt Welded Flanged. (Flex connections To be Stainless Steel)
5	Exhaust Gas-Open Drains	50 mm (2 in.) and Above	13.8 (200)	Bronze, Flanged	Brass or Monel	50 mm (2 in.) and Above	Forged Steel, Butt Welded
		40 mm (1.5 in.) and Below	13.8 (200)	Bronze, Flanged or Screwed	Brass or Monel	40 mm (1.5 in.) and Below	Ductile Iron or Forged Steel, Screwed or Socket Weld
6	Starting Air and Control Air	50 mm (2 in.) and Above	10.3 (150)	Cast Iron or Forged Steel Flanged	Brass	50 mm (2 in.) and Above	Forged Steel, Flanged or Butt Welded
		40 mm (1.5 in.) and Below	13.8 (200)	Bronze, Flanged or Screwed	Brass	40 mm (1.5 in.) and Below	Forged Steel, Screwed or Socket Weld

**Valves on oil and fuel tanks will be cast steel flanged type.*

TABLE 4-3. PIPING SCHEDULE (CONT'D)

System		Bolts And Nuts	Gaskets
#	Service		
1	Cooling Fresh Water	ASTM A307, Grade B	Inserted Rubber Sheet
2	Any Service not otherwise specified	ASTM A307, Galvanized	Inserted Rubber Sheet
3	Oil and Fuel -Filling, Transfer, and Service	ASTM A307, Galvanized	Nitrile
4	Exhaust Gas	ASTM A307, Galvanized	Hi-Temp, Asbestos Free
5	Exhaust Gas - Open Drains	--	--
6	Starting Air and Control Air	ASTM A307, Galvanized	Nitrile

4.2. ENGINE MAINTENANCE CLEARANCE

The following clearances are required in order to perform maintenance operations and component removal when necessary:

- C Overhead Clearance 2324 mm (91.5 in.)
- S Minimum Separation 2499 mm (98.4 in.)
- W Wall Clearance 1524 mm (60 in.)

Refer to Figure 4-1 for clearance required for cylinder removal.

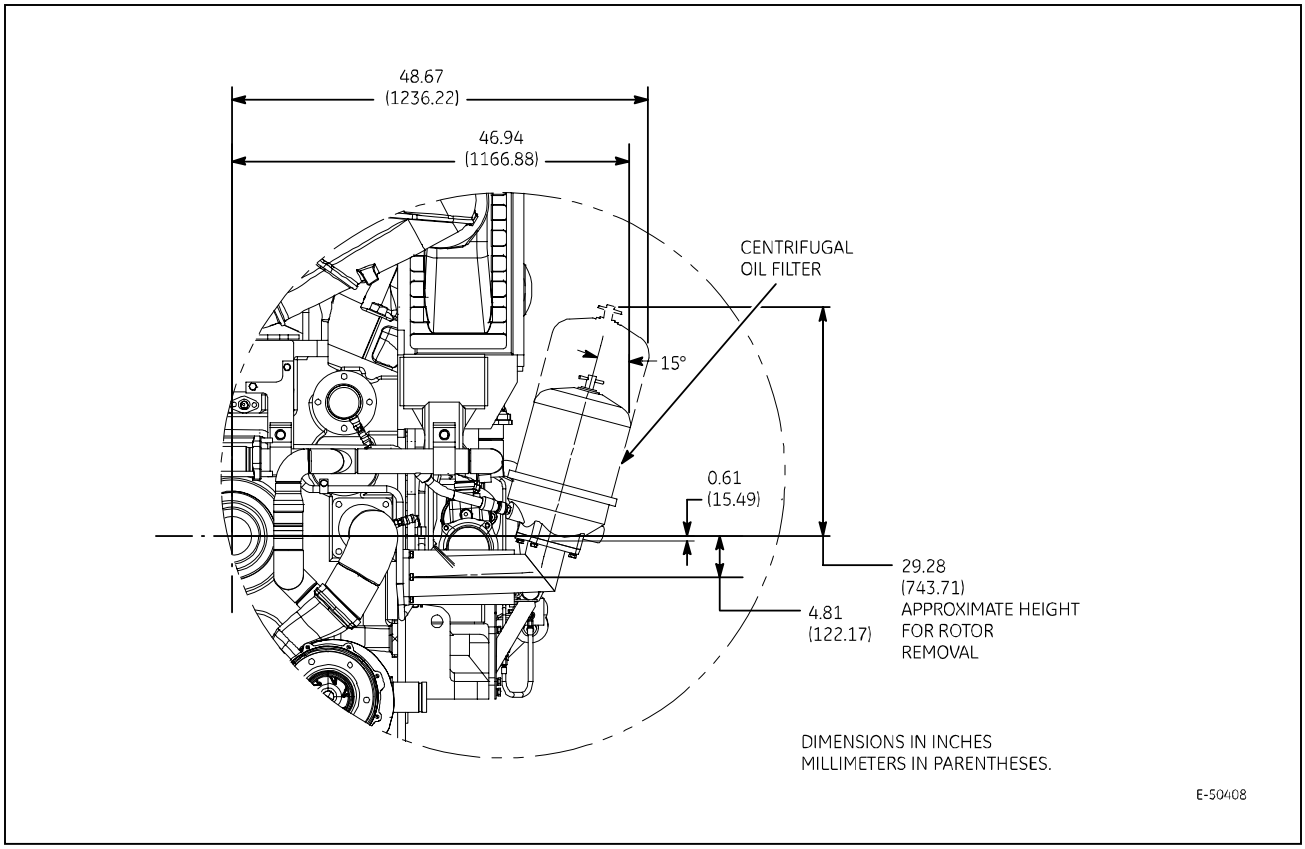

Figure 4-1. Clearance Required for Cylinder Removal. (E-50408)

4.3. ENGINE ALIGNMENT AND THERMAL DYNAMICS

NOTE: Alignment procedures must be submitted to GE for review and approval prior to the alignment taking place.

4.3.1. Engine Growth

When the diesel engine transitions from ambient conditions to normal operating temperatures, the engine will grow. This growth must be taken into consideration during the alignment procedure.

The engine will grow:

- Axially, from the drive end engine mount bolt hole centerline to the free end mount bolt hole centerline - typically 1.5 mm (0.061 in.) for the 12V228 engine.
- Vertically, from the bottom of the drive end mounting foot to the crankshaft centerline – typically 0.43 to 0.48 mm (0.017 to 0.019 in.).

The crankshaft will grow:

- Axially, toward the reduction gear, from the torsional coupling register surface on the flywheel – typically 0.46 to 0.71 mm (0.018 to 0.028 in.).

4.3.2. Crankshaft Deflection

Crankshaft deflection is measured with the engine and driven equipment in a "Cold Iron Condition," with the engine and driven machinery at ambient temperatures. Maximum crankshaft deflection is +0.10 mm (+0.004 in.), total, and is measured between the #6 and #7 main bearings on the 12V228 engine.

NOTE: GE must review the engine-to-generator alignment procedure. It may be possible that due to the driven machinery design, the "Cold Iron Condition" crankshaft deflection will exceed the 0.10 mm (0.004 in.) maximum deflection tolerance. If so, this condition will require GE approval.

4.4. ENGINE EMISSIONS

GE high-compression EFI engines enable reduced fuel consumption, improved reliability, and decreased emissions. The V228 engines comply with MARPOL Annex VI, U.S. EPA, and EPA Marine Tier 1 and Tier 2 requirements.

The level of calculated emissions is determined from a weighted load schedule where emissions levels are recorded at each of the expected load points for the particular service type, then multiplied by weighting factors and summed. The sum of the weighting factors equals 1.0.

The U.S. Environmental Protection Agency (EPA) recognizes that engines can operate on a variety of loads for any given speed, especially when diesel electric drive systems are involved.

To maintain compliance when operating off the duty cycle curve, the engine must stay below 1.25 x Family Emissions Limits (FEL) at every point within a defined band, above and below the nominal power curve. CFR Part 94, Section 94.106 defines different Not-To-Exceed zones for various duty cycles.

4.4.1. Visible Emissions – Smoke

There are no specific federal regulations for steady state or transient smoke on stationary engines, but there may be specific customer or local requirements that need to be reviewed before committing to any compliance. GE V228 engines shall not produce visible smoke in excess of 20% opacity for more than three minutes in any hour of operation. Opacity shall be evaluated in accordance with the Ringlemann chart as published by the U.S. Bureau of Mines.

4.5. FUEL CONSUMPTION

Refer to Figure 4-2 and to **Tables 4-4** and **4-5** for fuel consumption data for the GE 12V228 diesel engine running at 1000 rpm.

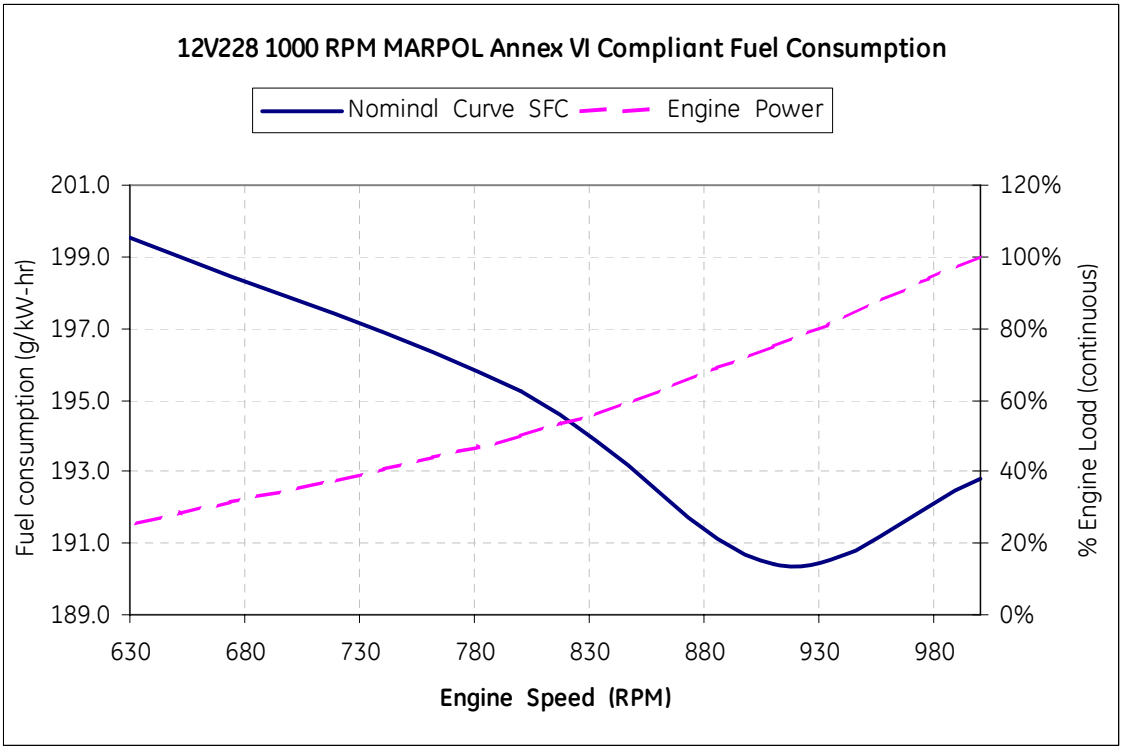

Figure 4-2. 12V228 MARPOL Annex VI Fuel Consumption Curve, 1000 RPM. (84A220581, Rev.C)

TABLE 4-4. 12V228 MARPOL ANNEX VI FUEL CONSUMPTION DATA – 1000 RPM

Fuel Consumption*							
RPM	% Engine Load	Power (kW)	Power (HP)	BSFC (g/kW-hr)	BSFC (lbs/hp-hr)	Fuel Burn (l/hr)	Fuel Burn (gal/hr)
1000	100%	2179	2922	0.317	192.8	490.4	129.5
910	75%	1634	2192	0.313	190.4	363.2	95.9
800	50%	1089	1461	0.321	195.3	248.3	65.6
630	25%	545	731	0.328	199.5	126.9	33.5

TABLE 4-5. 12V228 MARPOL ANNEX VI FUEL CONSUMPTION AT CONSTANT SPEED DATA – 1000 RPM

Constant Speed Fuel Consumption*							
RPM	% Engine Load	Power (kW)	Power (HP)	BSFC (g/kW-hr)	BSFC (lbs/hp-hr)	Fuel Burn (l/hr)	Fuel Burn (gal/hr)
1000	100%	2179	2922	0.317	193.1	491.0	129.7
1000	75%	1634	2192	0.315	191.5	365.4	96.5
1000	50%	1089	1461	0.328	199.7	253.9	67.1
1000	25%	545	731	0.376	228.7	145.4	38.4

Data shown in **Tables 4-4 and **4-5** are representative of a typical engine with all engine-driven pumps attached.*

- *All values are ISO 3046-1 Standard Corrected (reference value for fuel lower heating value of 42700 kJ/kg).*
- *Fuel corresponding to ASTM D975 S5000 and DMX value corresponding to ISO 8217.*
- *Tolerance +5%.*

4.6. POWER POTENTIAL CURVES

Refer to Figures 4-3 and 4-4 and **Tables 4-6** and **4-7** in this section for the power curves and data for the GE 6L250 diesel engine running at 1000 rpm. Power curves show maximum power, continuous power, and nominal propeller power ratings. Power Output Curves and Full Load Torque Curves are shown for 1000 rpm engines.

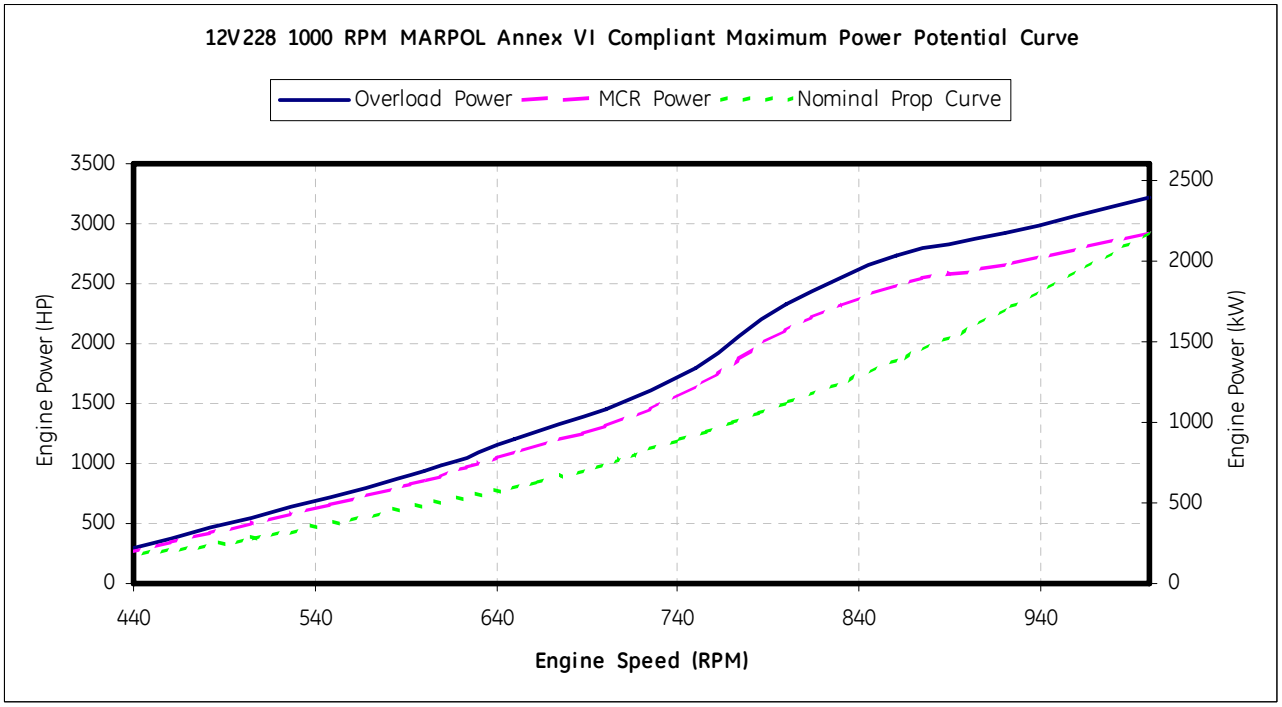

Figure 4-3. 12V228 MARPOL Annex VI Maximum Power Potential Curve, 1000RPM (84A220581, Rev. C)

TABLE 4-6. 12V228 MARPOL ANNEX VI POWER POTENTIAL DATA, 1000RPM

Power Output Curve				
RPM	Maximum Continuous Rating (MCR) Power		Overload Power*	
	kW	bhp	kW	bhp
1000	2179	2922	2397	3214
920	1985	2661	2183	2927
860	1855	2488	2041	2736
800	1577	2115	1735	2326
750	1221	1638	1344	1802
700	980	1314	1078	1445
650	812	1089	893	1198
600	638	855	701	941
440	201	270	221	297

**One hour per 12-hour period*

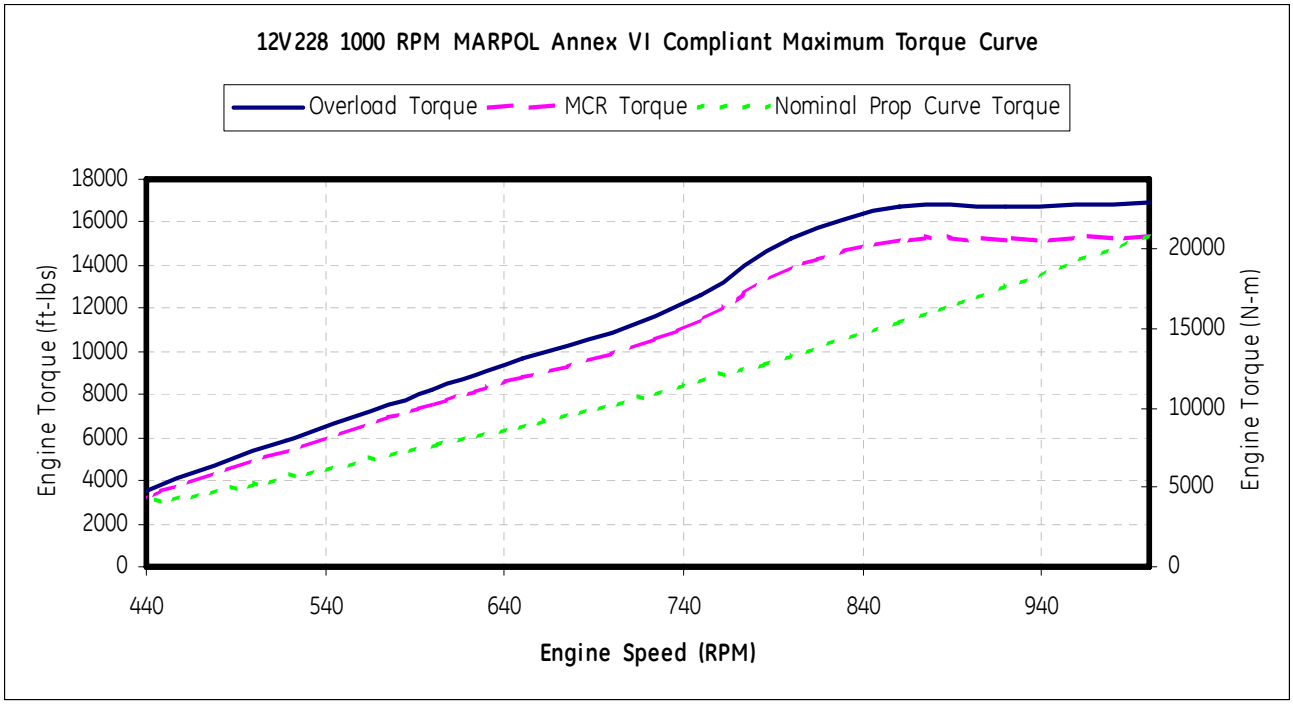

Figure 4-4. 12V228 MARPOL Annex VI Full Load Torque Curve, 1000RPM (84A220581, Rev. C)

TABLE 4-7. 12V228 MARPOL ANNEX VI FULL LOAD TORQUE DATA, 1000RPM

Full Load Torque Curve				
RPM	Maximum Continuous Rating (MCR) Torque		Overload Torque*	
	Nm	lb.-ft.	Nm	lb.-ft.
1000	20807	15346	22886	16880
920	20599	15193	22658	16712
860	20598	15192	22657	16711
800	18826	13885	20707	15273
750	15551	11470	17106	12617
700	13367	9859	14704	10845
650	11930	8799	13123	9679
600	10147	7484	11162	8233
440	4370	3223	4806	3545

**One hour per 12-hour period*

4.7. LUBRICATING OIL CONSUMPTION

GE 12V228 diesel engine lubricating oil consumption for a new engine running at 1000 RPM after a 500-hour break-in period is 1.4 LPH (0.370 GPH). Engine oil consumption may be higher for applications operating at reduced or frequent transient loads. Engines operating above the maximum limit should be inspected.

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5. ENGINE SYSTEMS

This section provides information on GE 12V228 diesel engine systems: Cooling Water, Fuel, Lubricating Oil, Combustion Air, Exhaust Gas, Starting Air, and Crankcase and Speed Detection systems. Refer to *SECTION 15, FLUID SPECIFICATIONS*, for cooling water, fuel oil, and lubricating oil requirements.

5.1. SPLIT COOLING SYSTEM

For cooling circuit flow and system components, refer to Figure 5-20, HT and LT Coolant Flow schematic, foldout drawing at the end of this section. Refer to Figures 5-1 and 5-2 for the HT and LT coolant circuit pump curves.

GE diesel engines use a split cooling system for maximum fuel efficiency and low emissions. The two circuits are separate and utilize fresh water treated with rust inhibitors. Flow is provided through the high-temperature (HT) and low-temperature (LT) loops by a dual-impeller, engine-driven water pump.

5.1.1. High-Temperature (HT) Circuit

The HT circuit provides cooling for the engine water jacket and lube oil. The HT heat exchanger is customer provided and must be sized correctly for the specific application. To assist with sizing, GE includes heat balance data and HT system data on the Technical Data sheets. Refer to the tables in *SECTION 2*.

5.1.2. Low-Temperature (LT) Circuit

The LT circuit provides cooling for the intercoolers. The LT heat exchanger is also customer provided and must be sized correctly for the specific application. To assist with sizing, GE includes heat balance data and LT system data on the Technical Data sheets. Refer to the tables in *SECTION 2*.

5.1.3. Expansion Tanks

GE uses a combination-type expansion tank for both the HT and LT cooling circuits. The expansion tank must be installed at a minimum height above the highest point of the cooling water piping system and/or the engine, whichever is higher.

NOTE: If the expansion tank is to be installed at a height greater than 6096 mm (20 ft), GE must review the installation.

For combination-type expansion tanks, the two chambers must be interconnected externally with 51 mm (2 in.) diameter pipe that has an isolation valve. If separate tanks are used for HT and LT systems, the tanks must be mounted at the same height with similar interconnection.

5.1.4. External Piping Requirements for HT and LT System

GE uses a dual impeller water pump for the HT and LT systems. The radiator piping and radiators can adversely affect the performance of this pump. The maximum allowable pressure drop across the external system must not exceed 1.36 bar (20 psi) for the HT system and 0.95 bar (14 psi) for the LT system.

External piping must be designed so that the system curve will be within the working range of the pump curves. Flow regulation orifices must be provided in the HT and LT systems as shown in the coolant flow schematic. Flow rates will be observed during commissioning and, if required, the service engineer will calibrate the flow by changing the orifice diameter appropriately.

GE uses thermostatic valves of 74°C (165°F) in the HT system, and 54°C (130°F) in the LT system.

Refer to Figure 5-3, Jacket Water Thermostatic Valve; Figure 5-4, Intercooler Thermostatic Valve; and Figure 5-5, Flange Adapter.

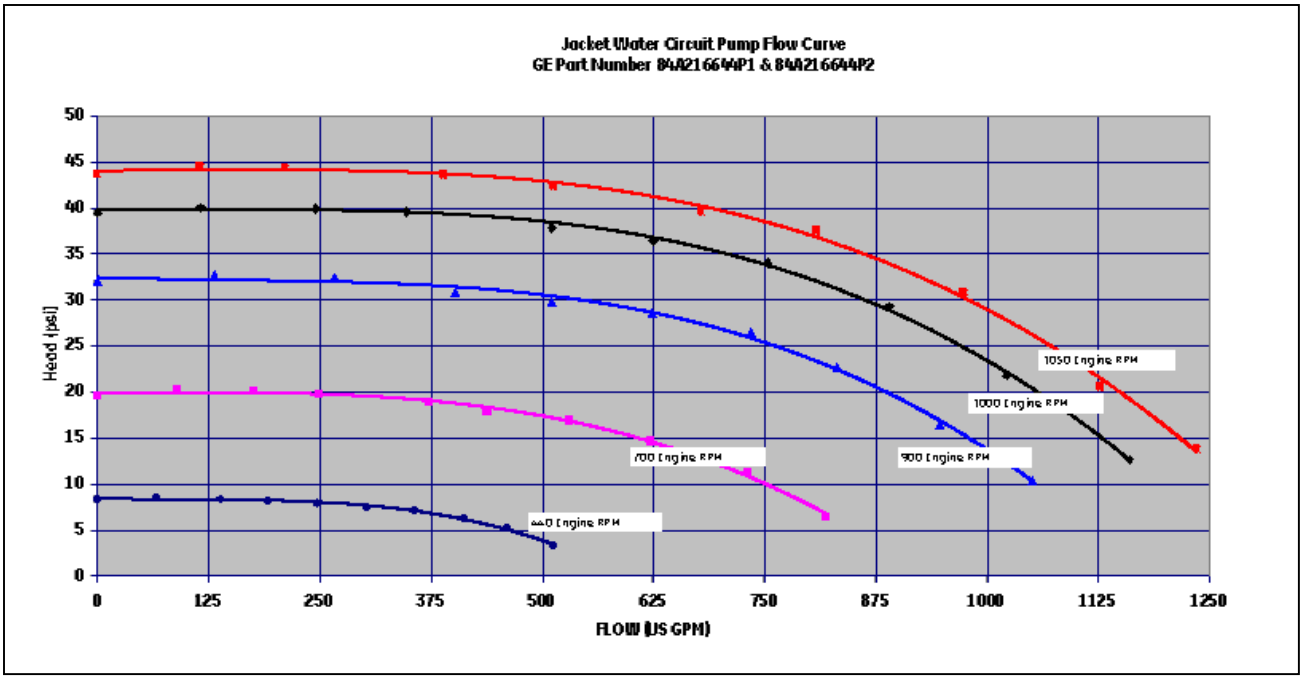


Figure 5-1. HT Circuit Coolant Pump Curve. (84A216644P1, P2)

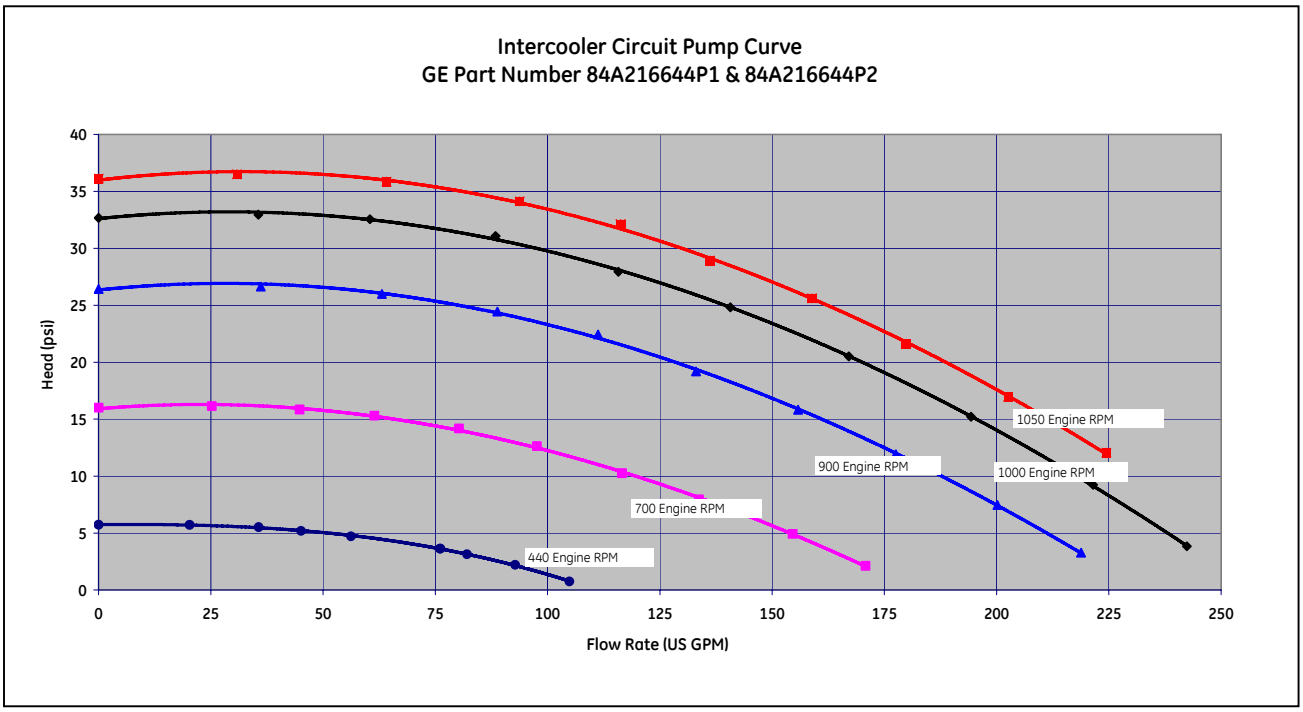
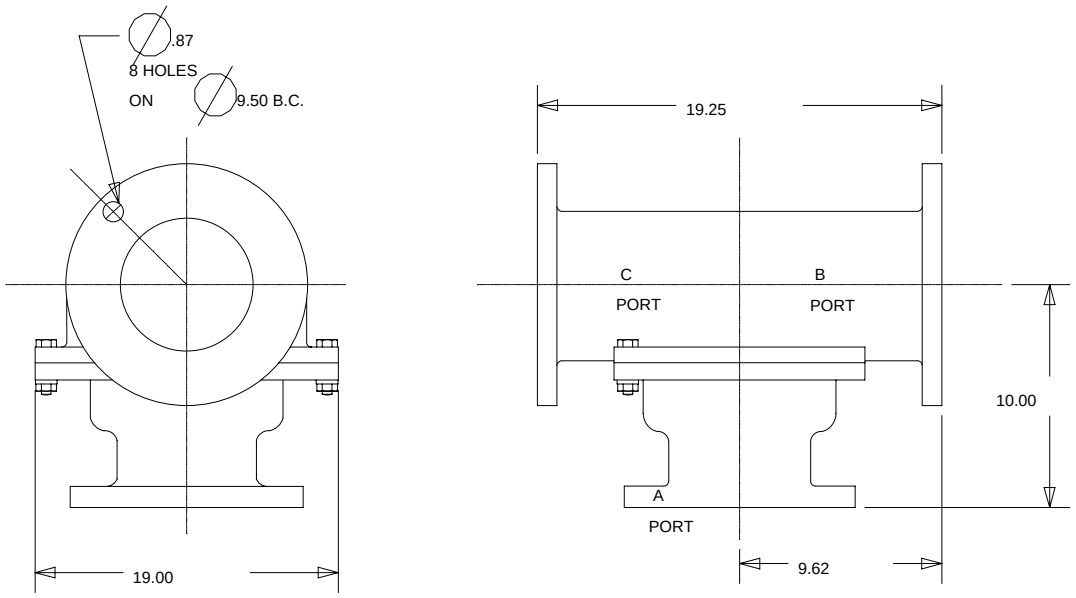
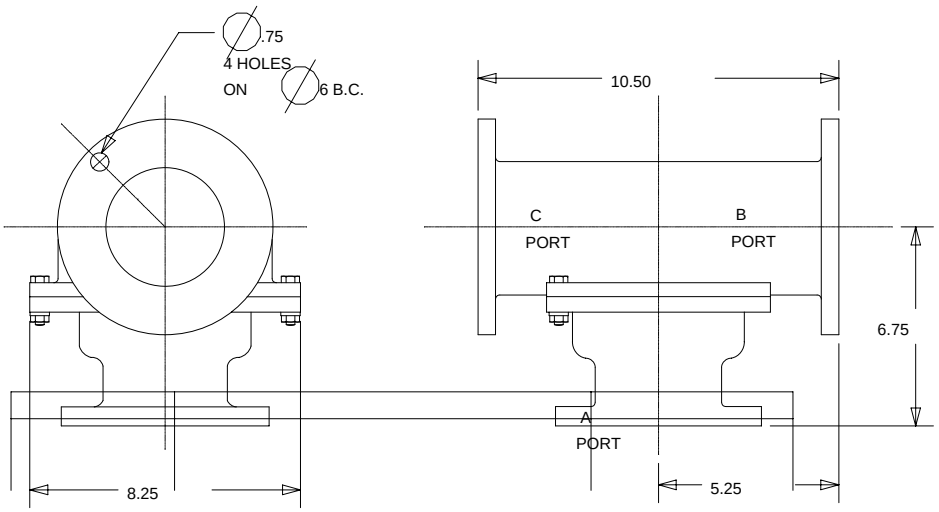


Figure 5-2. LT Circuit Coolant Pump Curve. (84A216644P1, P2)



PART NO	DESCRIPTION	AMOT PART NO
84A216003P1	JACKET WATER TC VALVE (165F) PRESET VALVE	6BOCF16503
84A216003P4	JACKET WATER TC VALVE (175F) PRESET VALVE FOR HIGH TEMPERATURE APPLICATIONS	6BOCF17503
84A216003P5	JACKET WATER TC VALVE (185F) PRESET VALVE FOR HIGH TEMPERATURE APPLICATIONS	6BOCF18503

Figure 5-3. Jacket Water Thermostatic Valve, 84A216003P5. (84A216007)



PART NO.	DESCRIPTION	AMOT PART NO.
84A216003P2	INTERCOOLER WATER TC VALVE (130F) PRESET VALVE FOR STATIONARY APPLICATIONS.	3BOCF13003
84A216003P3	INTERCOOLER WATER TC VALVE (105F) PRESET VALVE FOR MARINE APPLICATIONS.	3BOCF10503

Figure 5-4. Intercooler Thermostatic Valve, 84A216003P3. (84A216007AB)

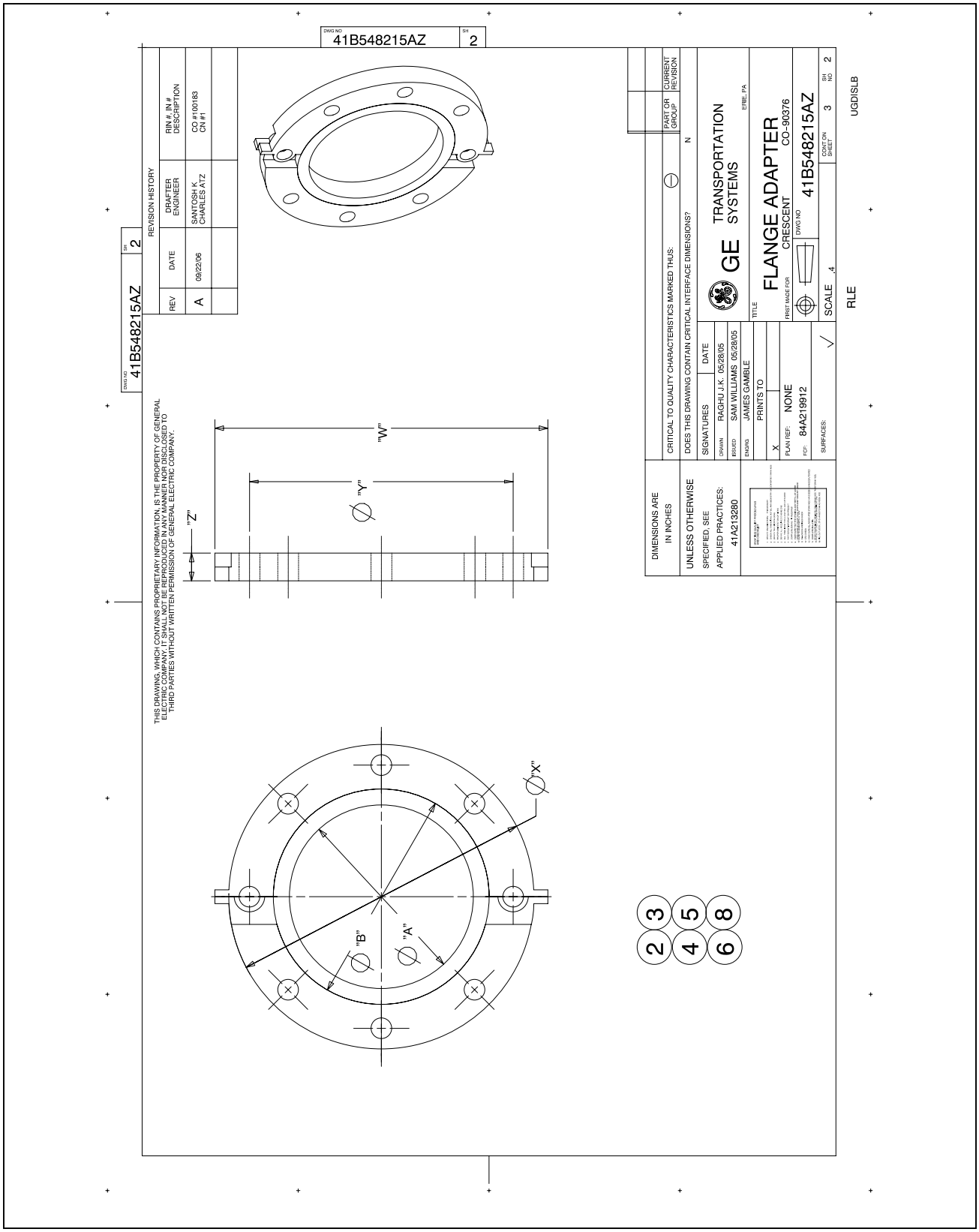


Figure 5-5. Flange Adapter. (41B548215AZP4,P5,P6,P8, Sheet 2)

5.2. FUEL SYSTEM

Refer to Figure 5-21 (foldout drawing at the end of this section) for a fuel oil system schematic.

The fuel system consists of a low-pressure and a high-pressure system. The low-pressure system takes fuel from the day tank, through the fuel oil filter and to the high-pressure fuel pumps on each power assembly. The high-pressure pumps then increase the pressure of the fuel for injection into the combustion chamber.

Refer to Figure 5-6, Hand Priming Fuel Oil Pump; **Table 5-1, Parts List for Hand Priming Pump**; and Figure 5-7, Temporary Fuel Filter for Commissioning. Refer also to Figure 5-8, Fuel Filter.

5.2.1. Fuel/Water Separator

Fuel must be run through a fuel/water separator before going to the fuel oil transfer pump and the engine's fuel oil filter. The flow capacity of the fuel/water separator must exceed the maximum flow of the fuel oil transfer pump and must allow for continuous engine running during service of separator.

NOTE: The fuel/water separator can be supplied by GE or be customer supplied.

5.2.2. Engine-Driven Fuel Transfer Pump and Fuel Day Tank

The GE 12V228 diesel engine uses an on-engine, engine-driven fuel transfer pump to supply fuel from the engine day tank to the high-pressure engine fuel pumps. The fuel transfer pump has a nominal flow capacity of 45.4 liters per minute (12 gallons per minute) and a maximum suction head limit of 0.655 bar (9.5 psig).

The fuel oil day tank must be located within the capabilities of the engine-driven fuel oil transfer pump and the engine's fuel system relief valve, which is set at 4.137 bar (60 psig) for 12V228 engines.

5.2.3. Low-Pressure Fuel Pipes and Fuel Drain Pipes

NOTE: The fuel drain tank and all piping, valves, fittings, and controls are customer supplied. The flow from the fuel drain tank back to the fuel day tank must be unrestricted.

The low-pressure fuel pipes carry fuel from the fuel transfer pump to the high-pressure pump and are designed to meet requirements of classification societies requested by the customer. The GE V228 diesel engine also includes a gravity-drain system to remove fuel that bleeds off from the fuel injector before and after needle lift. This fuel runs down the fuel pump pushrod (where it serves as a lubricant) and then drains through the mainframe into a collection manifold (commonly called a "candy cane") bolted to the side of the mainframe. The collection manifold is connected to the fuel drain tank by flexible fuel hoses. The leak-off fuel is collected in the fuel drain tank and then transferred to the fuel day tank. The GE 12V228 engine has a leak-off flow rate of 54.5 liters per hour (14.4 gallons per hour) when the engine is running at full load.

NOTE: Leak-off flow rates provided above are for high-pressure fuel pumps that are due for overhaul; therefore, these are a worst-case condition.

5.2.4. Fuel Heating/Cooling Requirements

The fuel temperature at the engine's fuel inlet connections must be between 15.6°C and 48.9°C (60°F and 120°F). If the normal operating fuel temperatures are expected to be outside of this range, consult GE for fuel heating or cooling guidance.

5.2.5. High-Pressure Fuel Lines and Leakage Detection System

The high-pressure fuel lines that carry fuel from the high-pressure pump to the injector are single walled or double walled (double walled are optional, mainly for marine applications). The high-pressure fuel line is the primary fluid carrier from the high-pressure pump to the injector. In double-walled fuel lines the secondary (outer) wall is intended to seal leaking fuel from a failure or poor seal at either end from escaping into the engine compartment. The secondary wall and leak-collection system contains the fuel in the event of a high-pressure fuel line failure.

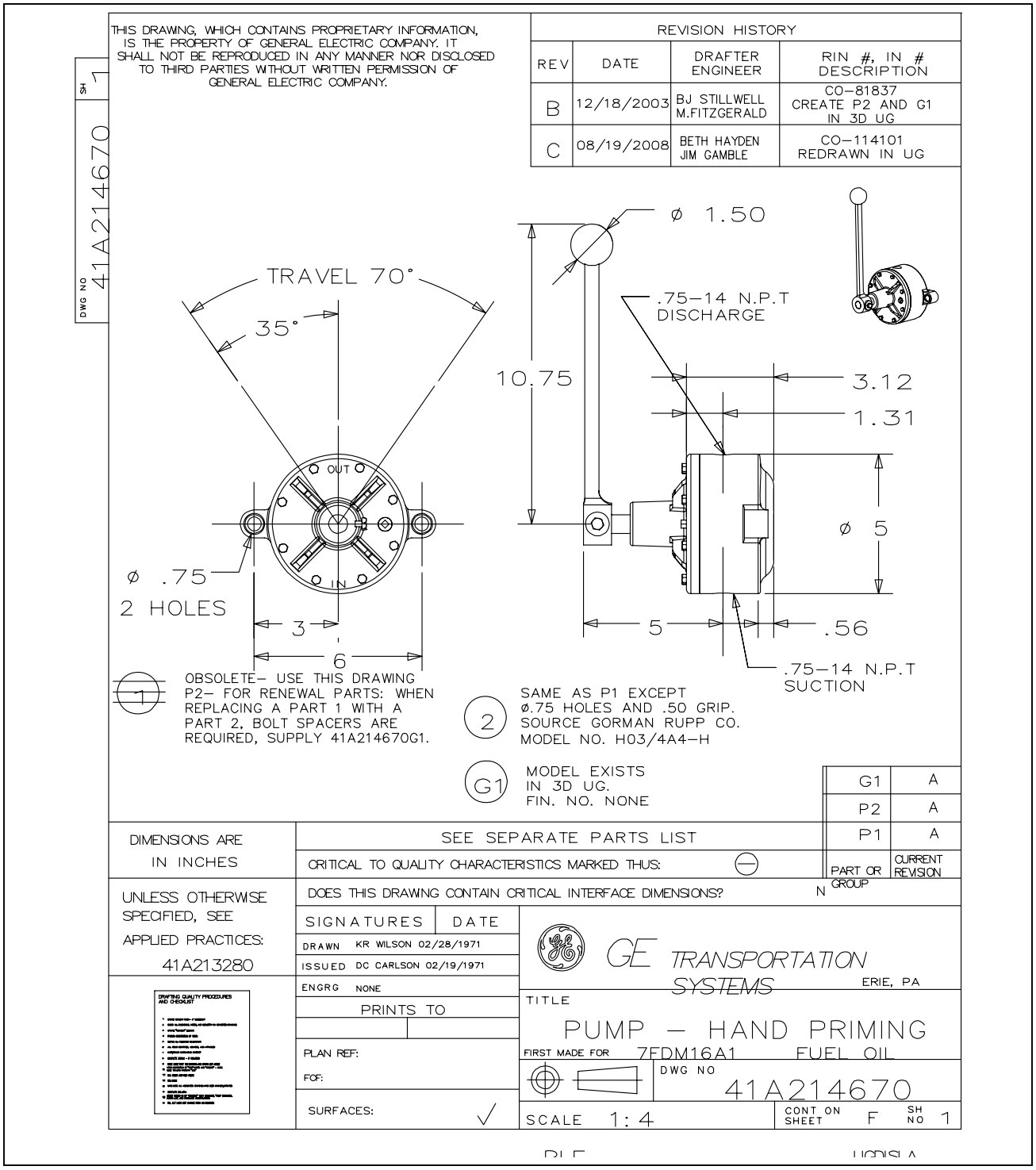


Figure 5-6. Hand Priming Fuel Oil Pump. (41A214670G1)

TABLE 5-1. PARTS LIST FOR HAND PRIMING PUMP (41A214670G1)

Item	Identification	Description	G1
2	41A214670P2	Prime Pump - Fuel	1
3	155B9002ACP4	Spacer	2

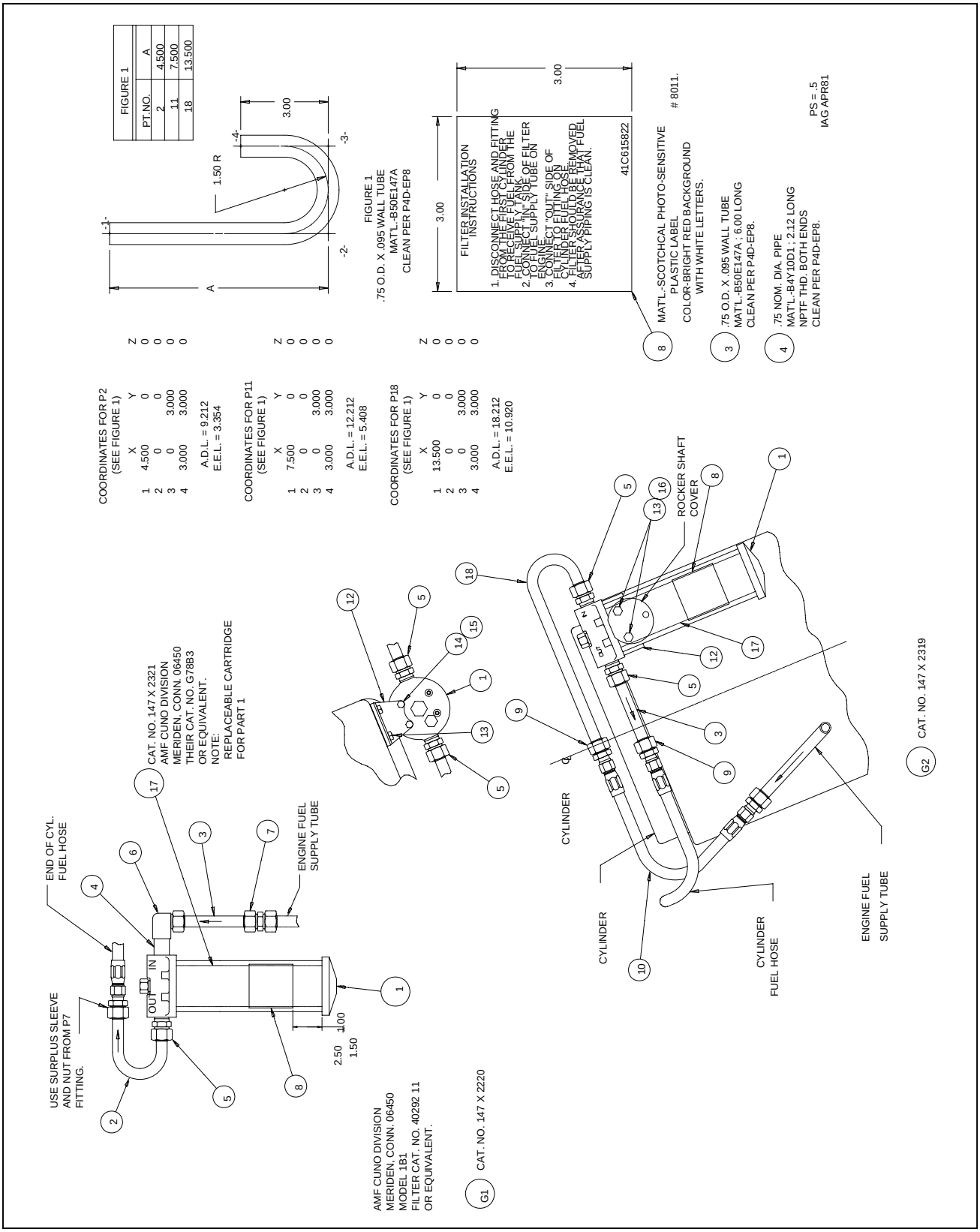
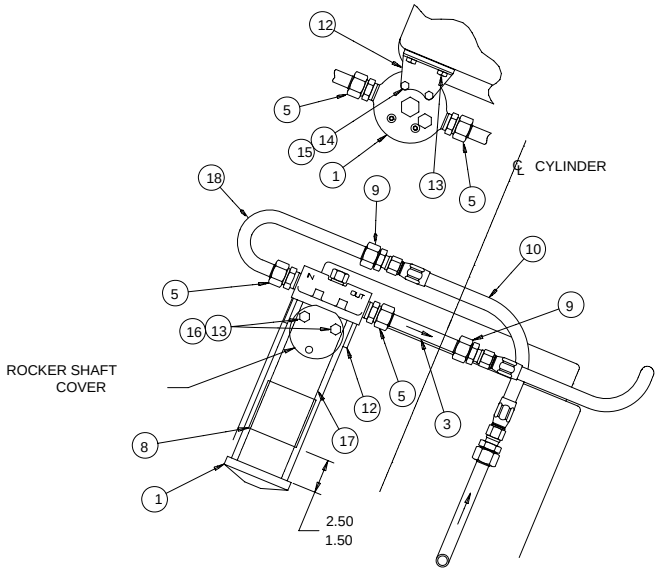
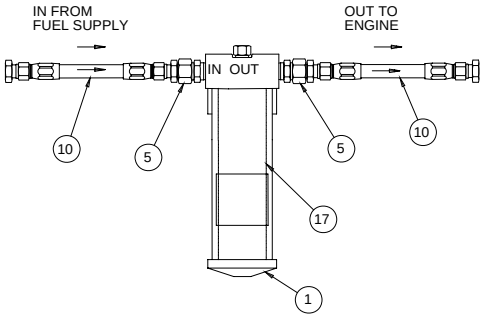


Figure 5-7. Temporary Fuel Filter For Commissioning, Part 1 of 2. (41C615822P1)



G3 CAT. NO. 147X2568



MOUNT AT FUEL INLET OF ENGINE

G4 CAT. NO. 147X2569

Figure 5-7. Temporary Fuel Filter For Commissioning, Part 2 of 2. (41C615822P17)

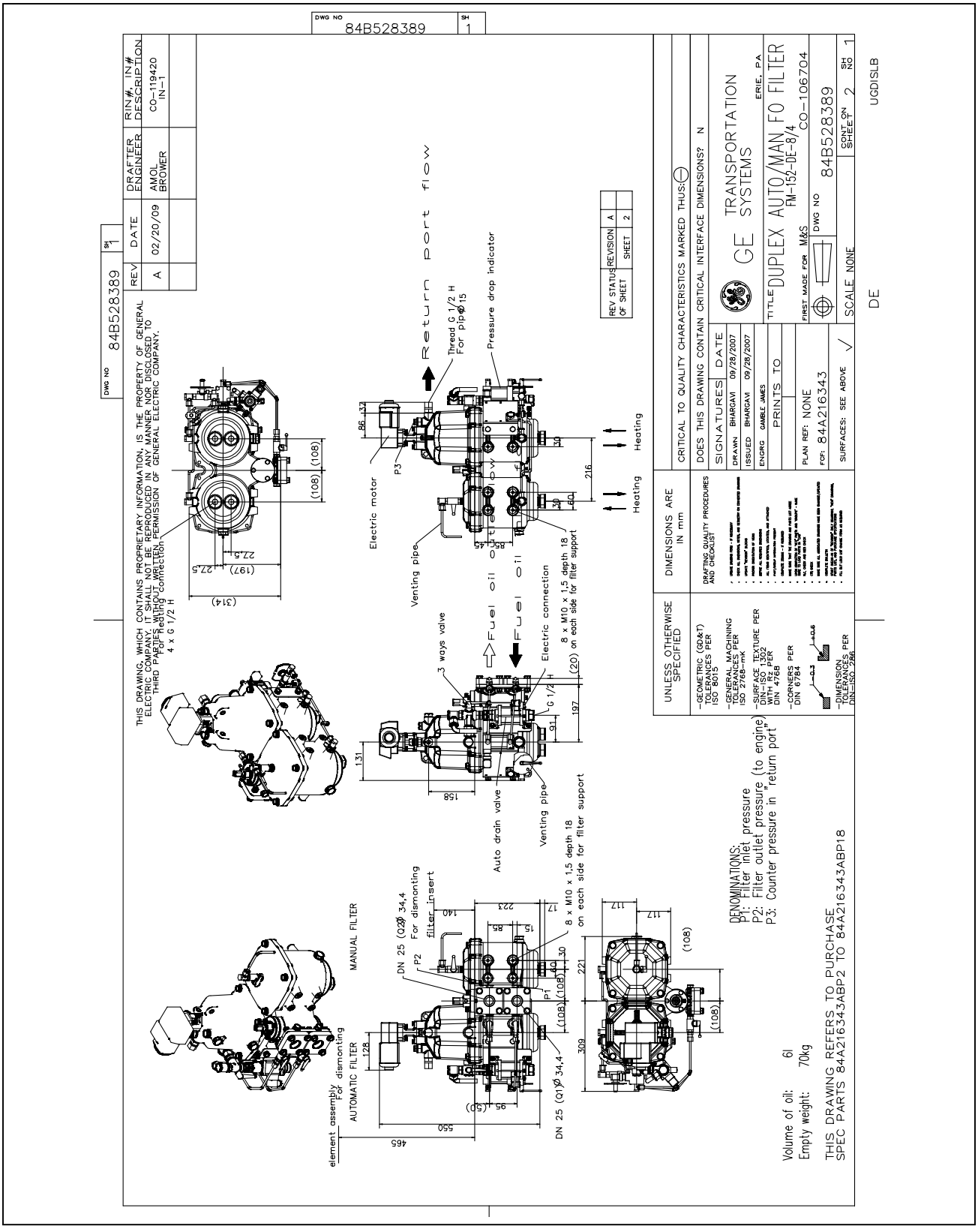


Figure 5-8. Fuel Filter, 84A216343ABP16. (84B528389, Sheet 1 of 2)

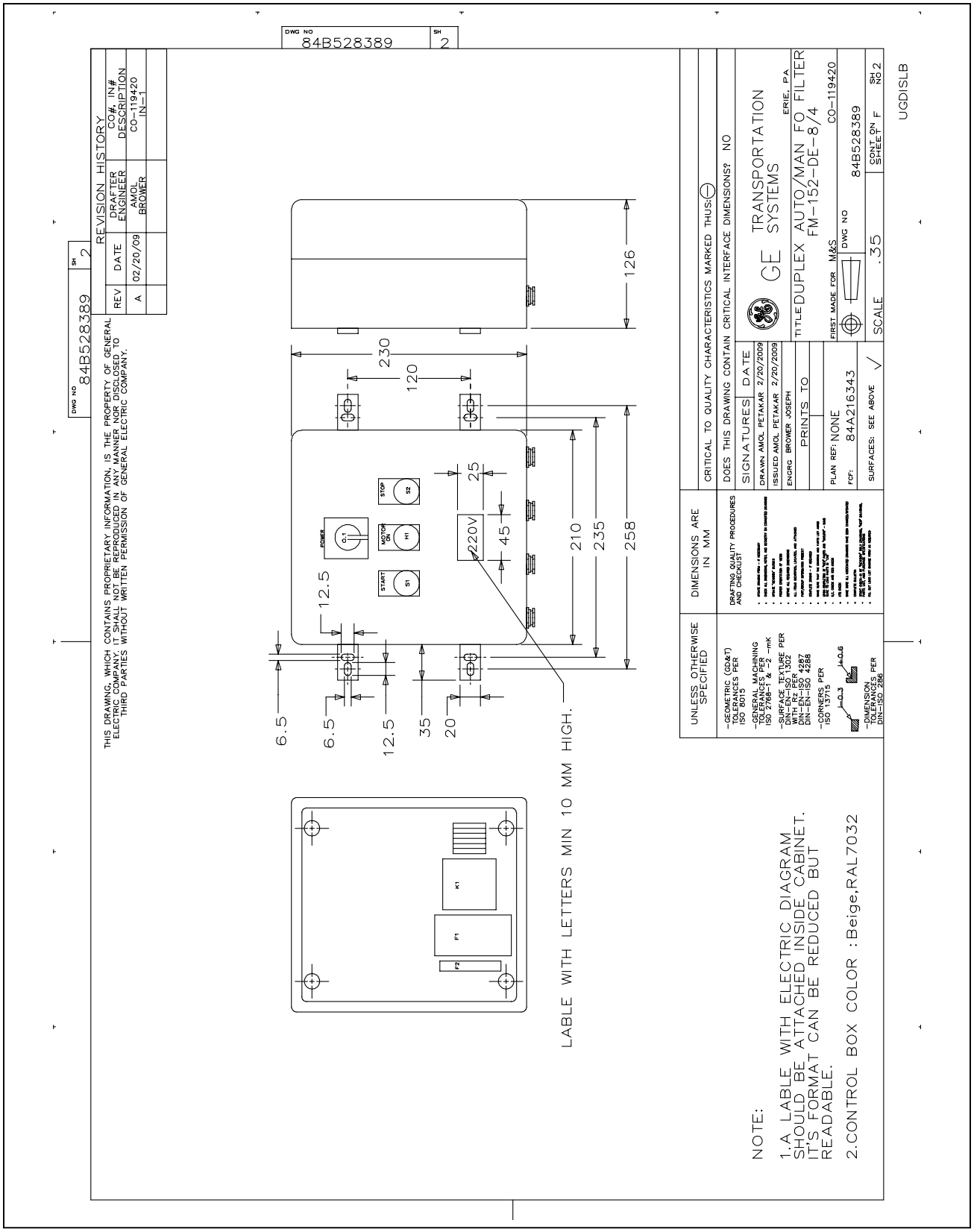


Figure 5-8. Fuel Filter, 84A216343ABP16. (84B528389, Sheet 2 of 2)

5.3. LUBRICATING OIL SYSTEM

A mechanically driven combination lubricating oil fuel transfer pump is mounted on the engine as one assembly. Two separate, but similar, pump designs are used for standard and reverse-rotation engines.

Refer to Figure 5-9, HT Oil Cooler; Figures 5-10 and 5-11, Heater Oil and Coolant Hot Start System, and to **Table 5-2, Parts List for Oil Cooler Install Kit**. Also refer to Figure 5-12, Self-Cleaning Oil Filter; Figure 5-13, Reducer; and Figure 5-14, Coupling. Refer to Figure 5-22 (foldout drawing at the end of this section) for a lubricating oil system schematic.

NOTE: GE includes spare engine-driven lubricating oil pumps in their list of recommended spare parts in order to comply with regulatory agency standby pump requirements.

5.3.1. Oil Temperature and Pressure

Oil temperature is maintained between 90.6°C and 85.0°C (195°F and 185°F). Oil temperature is monitored at both high and low limits. Based on engine warm up strategy, full load cannot be obtained until lube oil temperature is greater than 60°C (140°F), but can be over-ridden if necessary.

Lube oil temperature exceeding 104.4°C (220°F) is an alarm condition. Lube oil temperature exceeding 115.6°C (240°F) is a shutdown event.

5.3.2. Centrifugal Oil Filter

A single centrifugal oil filter is provided on these engines. This filter can either be mounted on the engine's accessory rack or on the forward end of the engine, in place of one of the oil fill assemblies. The nominal flow removed for centrifugal filtering is 5% of the normal operating flow.

Refer to Figure 5-15, Centrifuge Installation, and **Table 5-3, Parts List for Centrifuge Installation**.

5.3.3. Lubricating Oil Quality

The General Electric V228 diesel engine requires a heavy-duty, high-dispersant SAE 40 or multigrade (typical SAE 20W-40) lubricating oil. Single-grade lubricating oil is preferred.

Lubricating oils used in the General Electric diesel engine must meet General Electric's approval criteria, which is based on demonstrated performance. When a specific oil is approved for diesel engine use, GE sends a letter to the oil supplier indicating that approval. Oil suppliers must provide a copy of this letter to verify approval prior to use of the oil. Lubricating oils specifications for oil to be used in the General Electric V228 diesel engine is given in *SECTION 15, FLUID SPECIFICATIONS*, of this publication. For specific information about approved oils not listed, contact General Electric or the engine oil suppliers.

TABLE 5-2. PARTS LIST FOR OIL COOLER INSTALL KIT (84A216971G1)

Item	Identification	Description	G1
20	84C602463ACG1	Pipe ASM PHE Flange	2
30	84B518360ABG1	Pipe ASM PHE Flange	2
50	84C603361ACG1	Cover Asm PHE	1
70	84C604459P1	Coupling, 3.5" Vic-Style 77	2
80	41B548215ACP7	Coupling, 3.0" Vic-Style 75	2
90	41A219499ABP246	O-Ring	4
100	N402AP15B13	Washer, 0.50 Narrow	20
110	N405P45B13	Lockwasher, 1/2 Reg	20
120	N22P29024B13	Bolt, 1/2-13 x 1-1/2	16
130	N22P29016B13	Bolt, 1/2-13 x 1.00	4

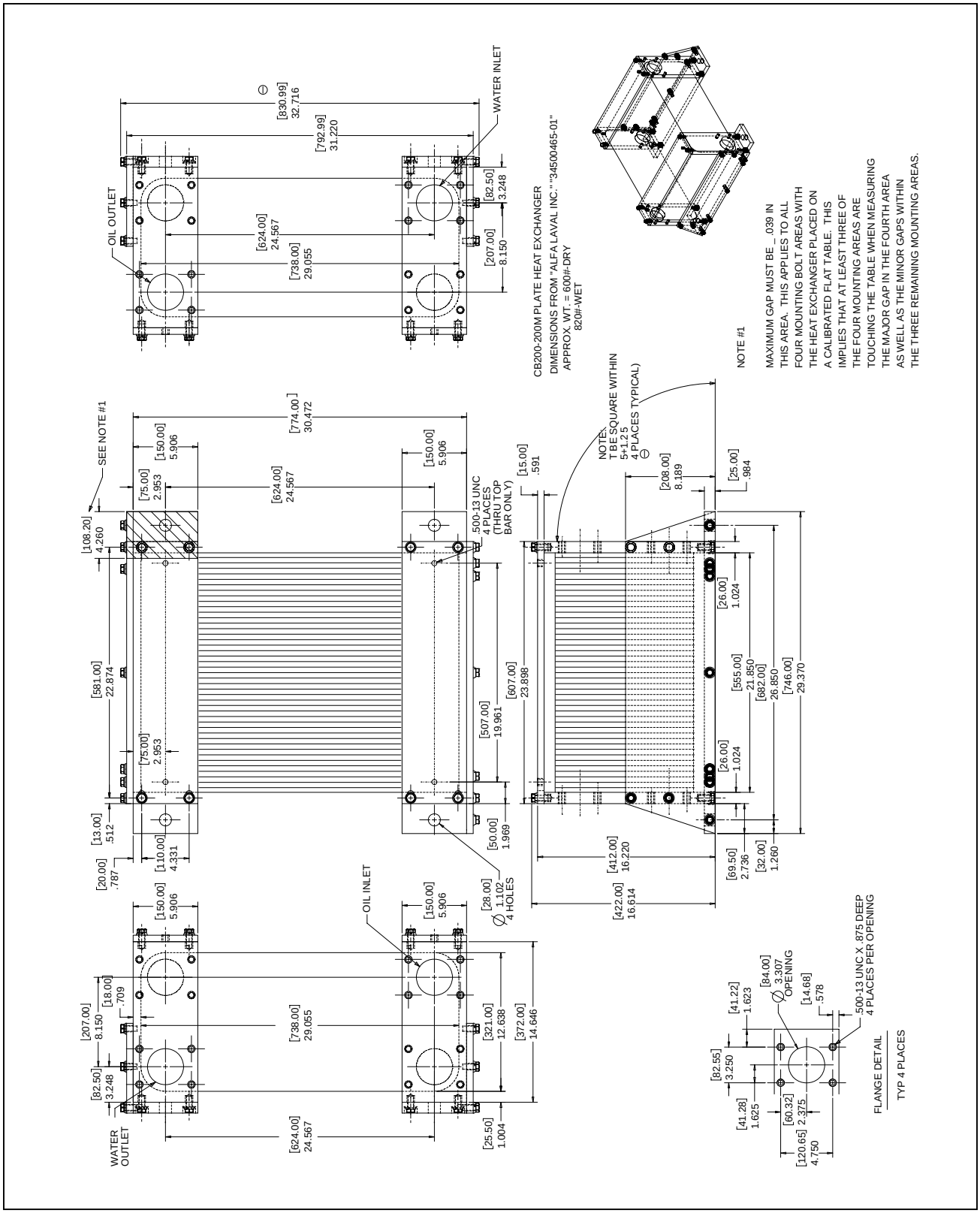


Figure 5-9. HT Oil Cooler, 84A213197AGP7. (84D712673, Sheet 1)

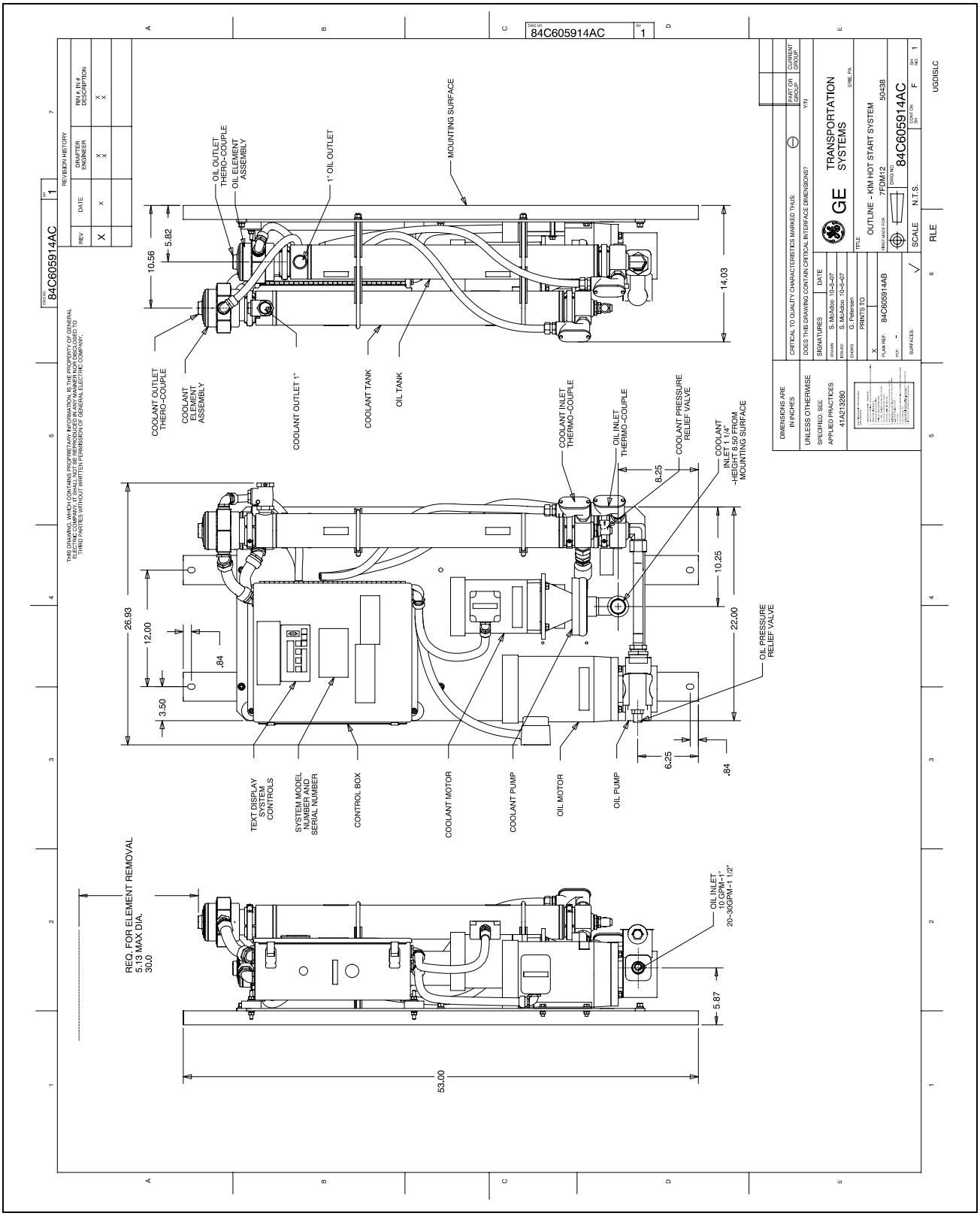


Figure 5-10. Heater Oil and Coolant Hot Start System Outline, 84A200858ABP7. (84C605914AC, Sheet 1)

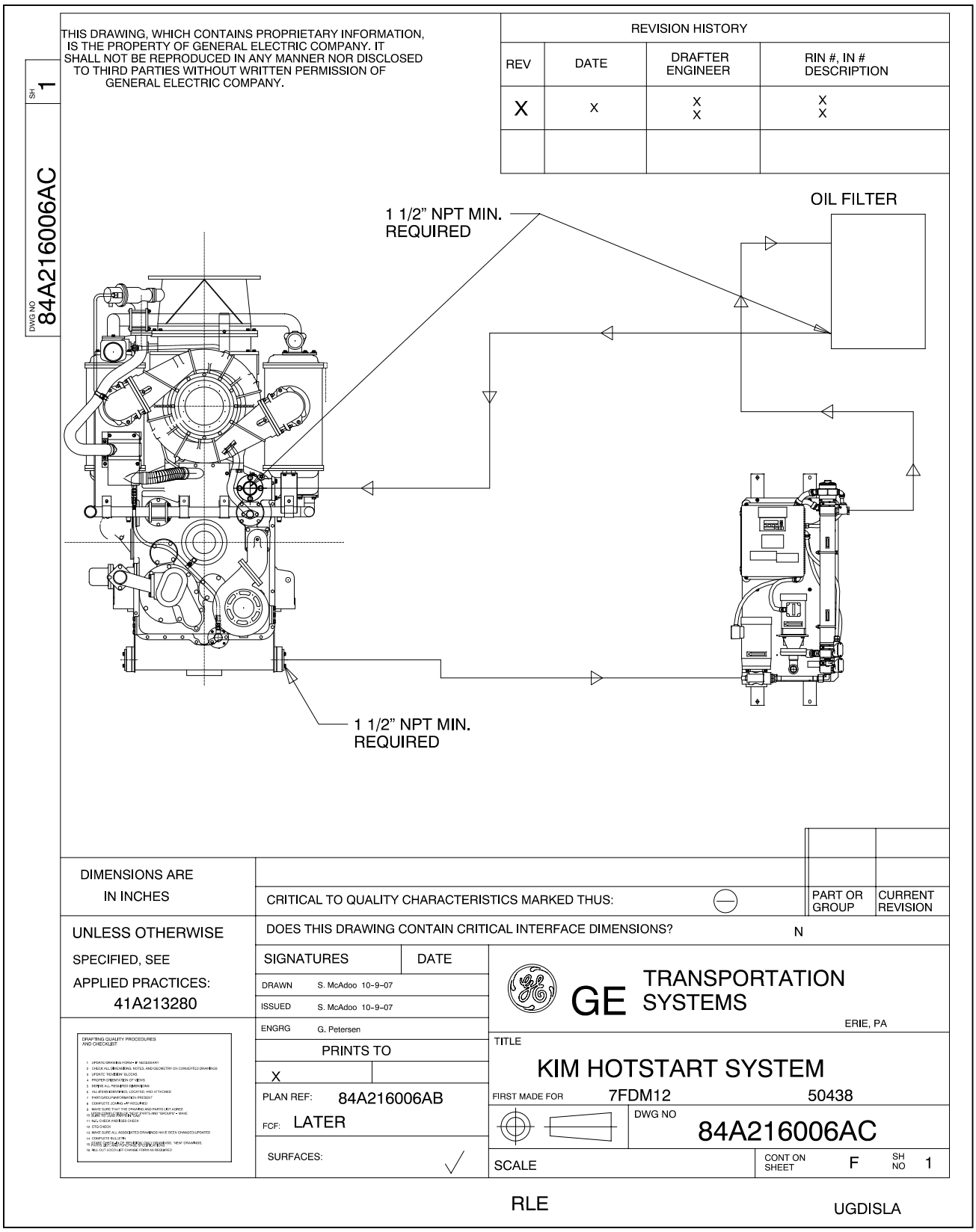


Figure 5-11. Heater Oil and Coolant Hot Start System, 84A200858ABP7. (84C216006AC, Sheet 1)

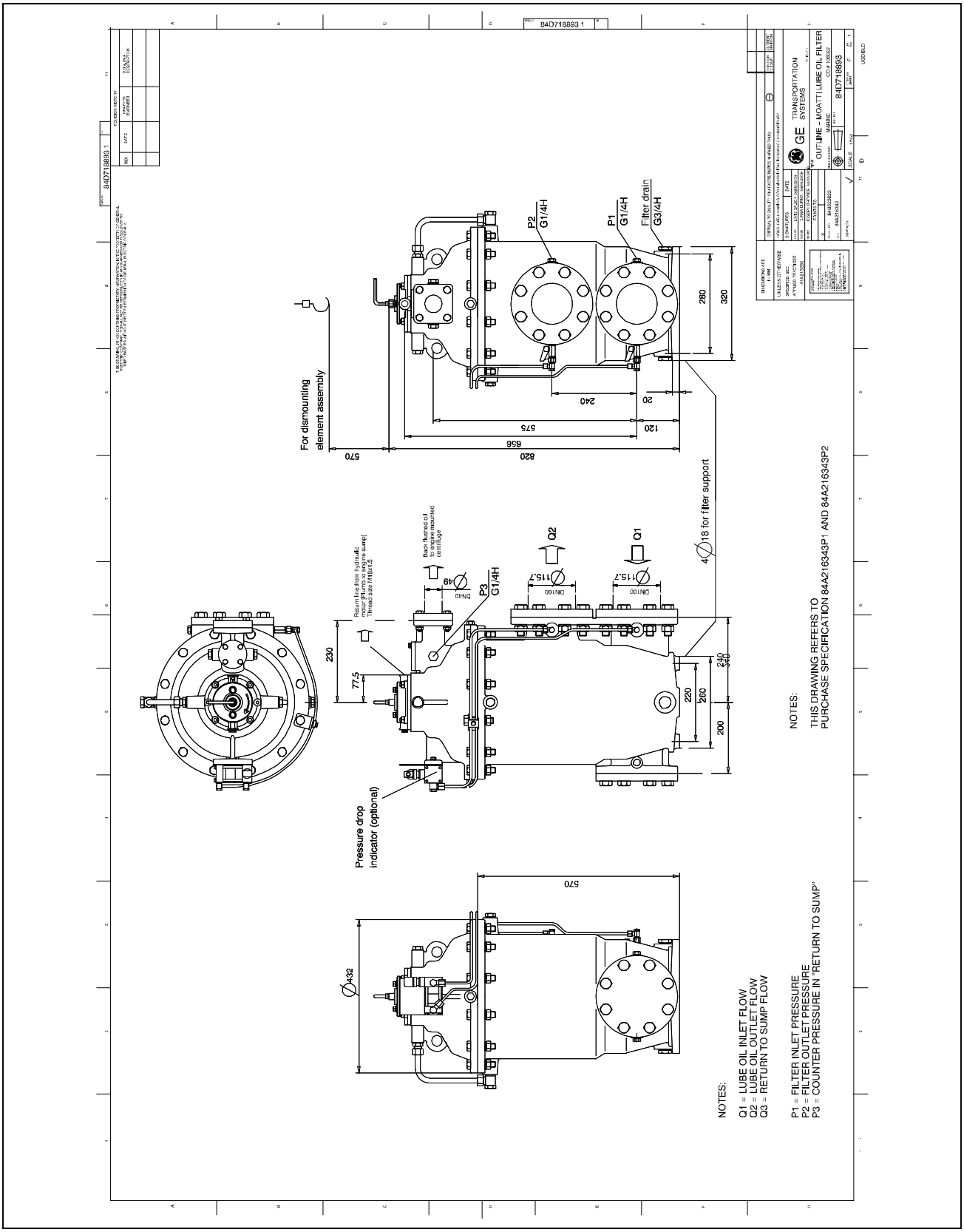


Figure 5-12. Self-Cleaning Oil Filter, 84A216343P8. (84D718893)

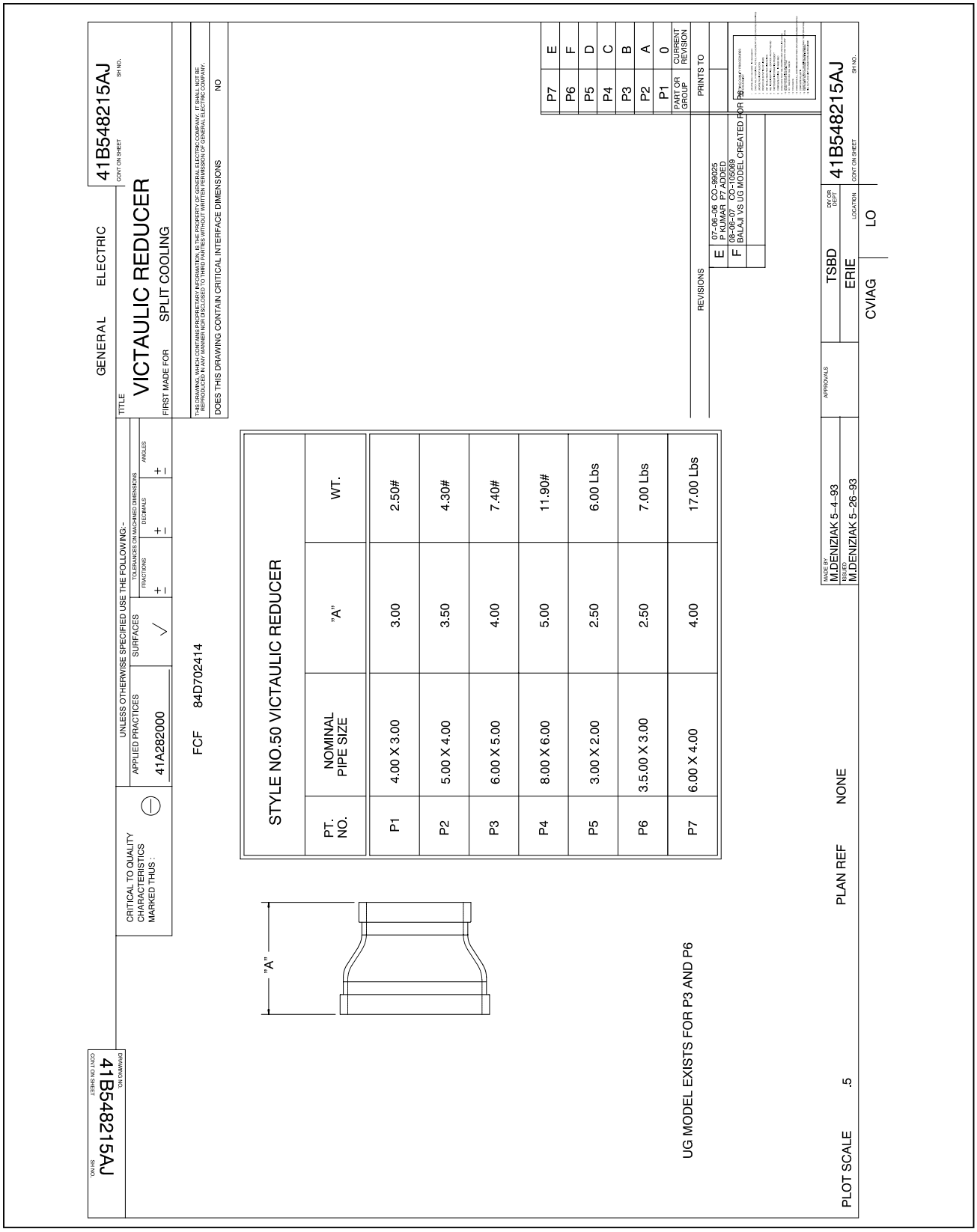


Figure 5-13. Reducer, 3.5x3, Victaulic. (41B548215AJP6)

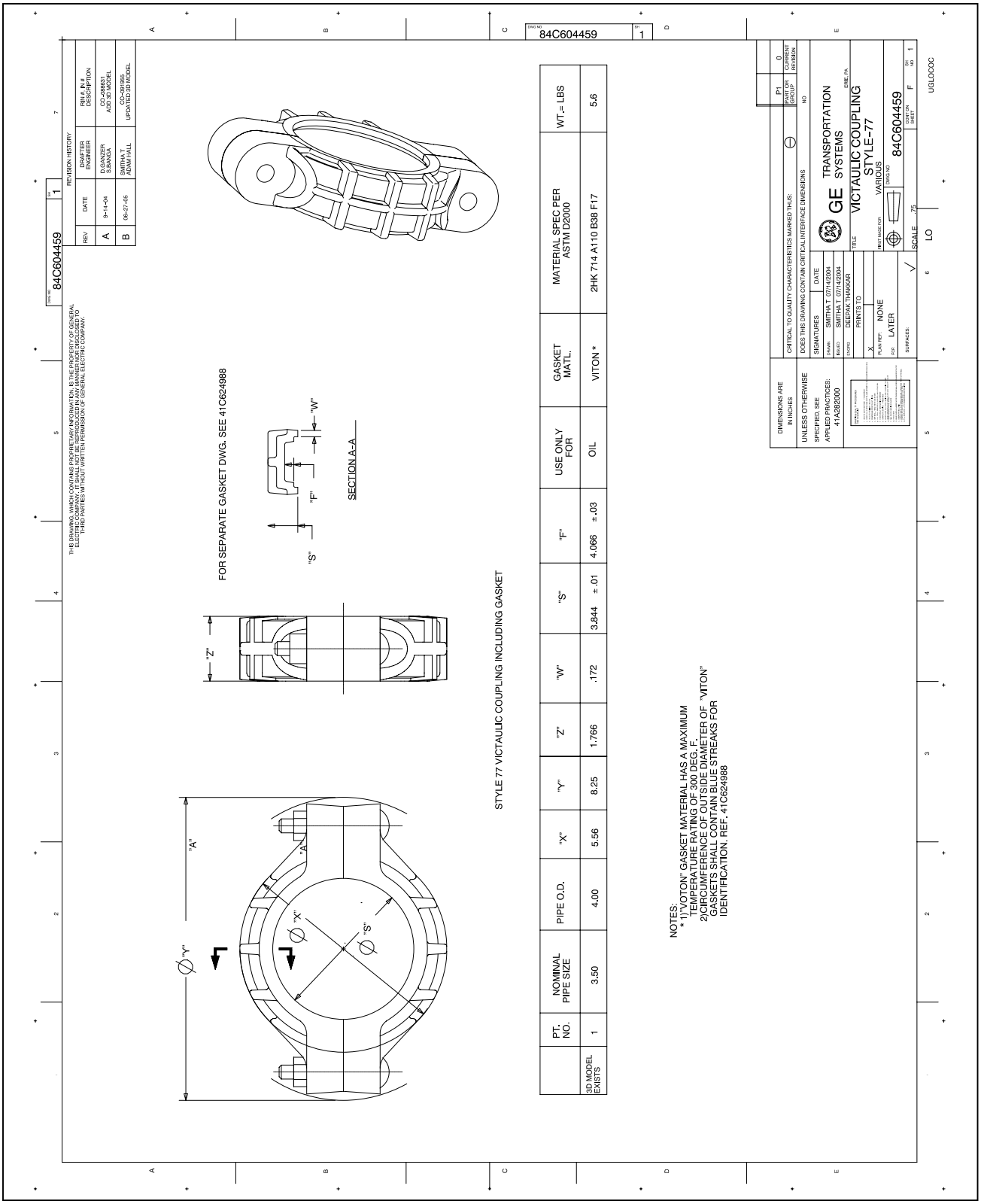


Figure 5-14. Coupling, 3.5"VIC-STYLE77. (84C604459P1)

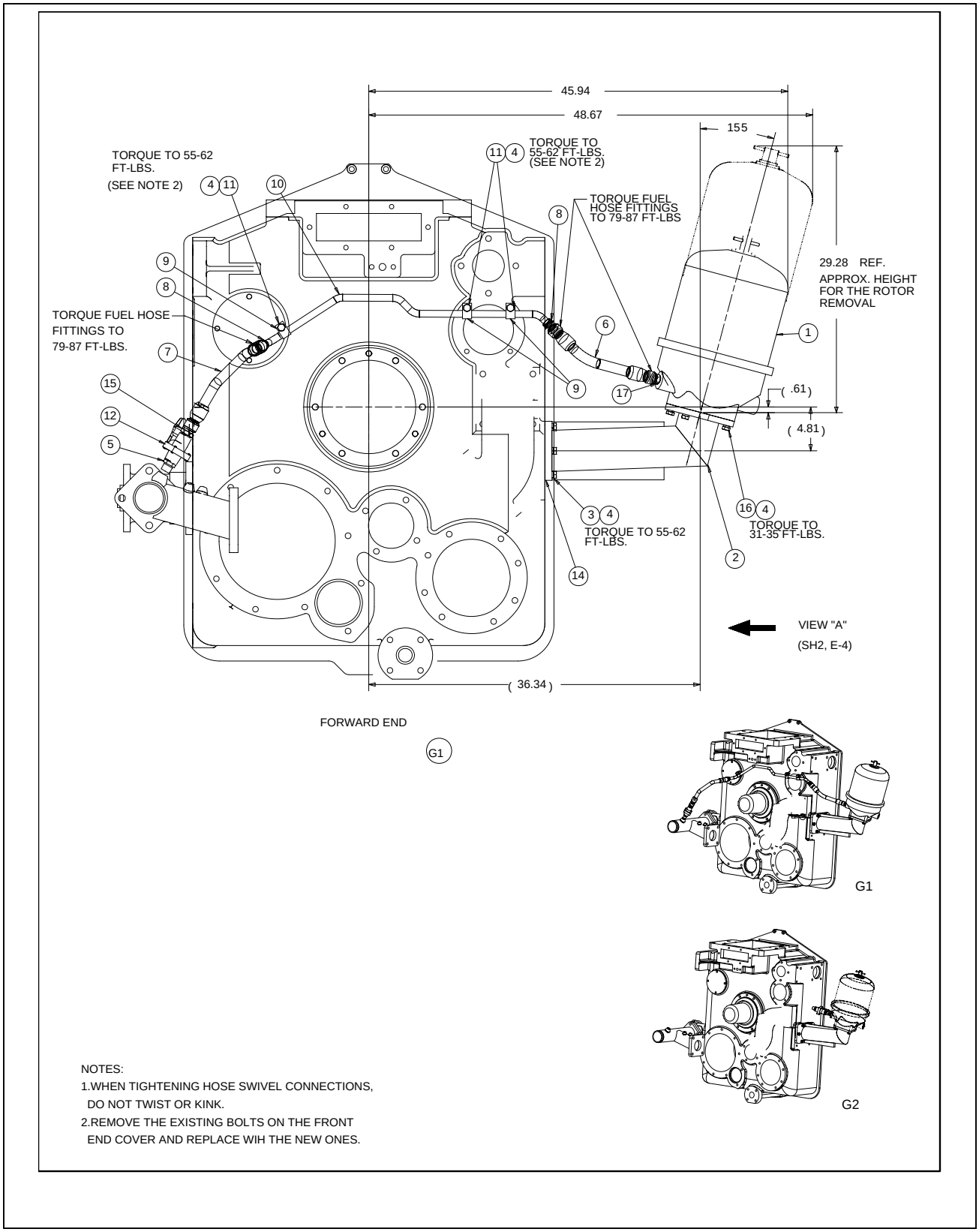


Figure 5-15. Centrifuge Installation. (84C604566G2, Sheet 1)

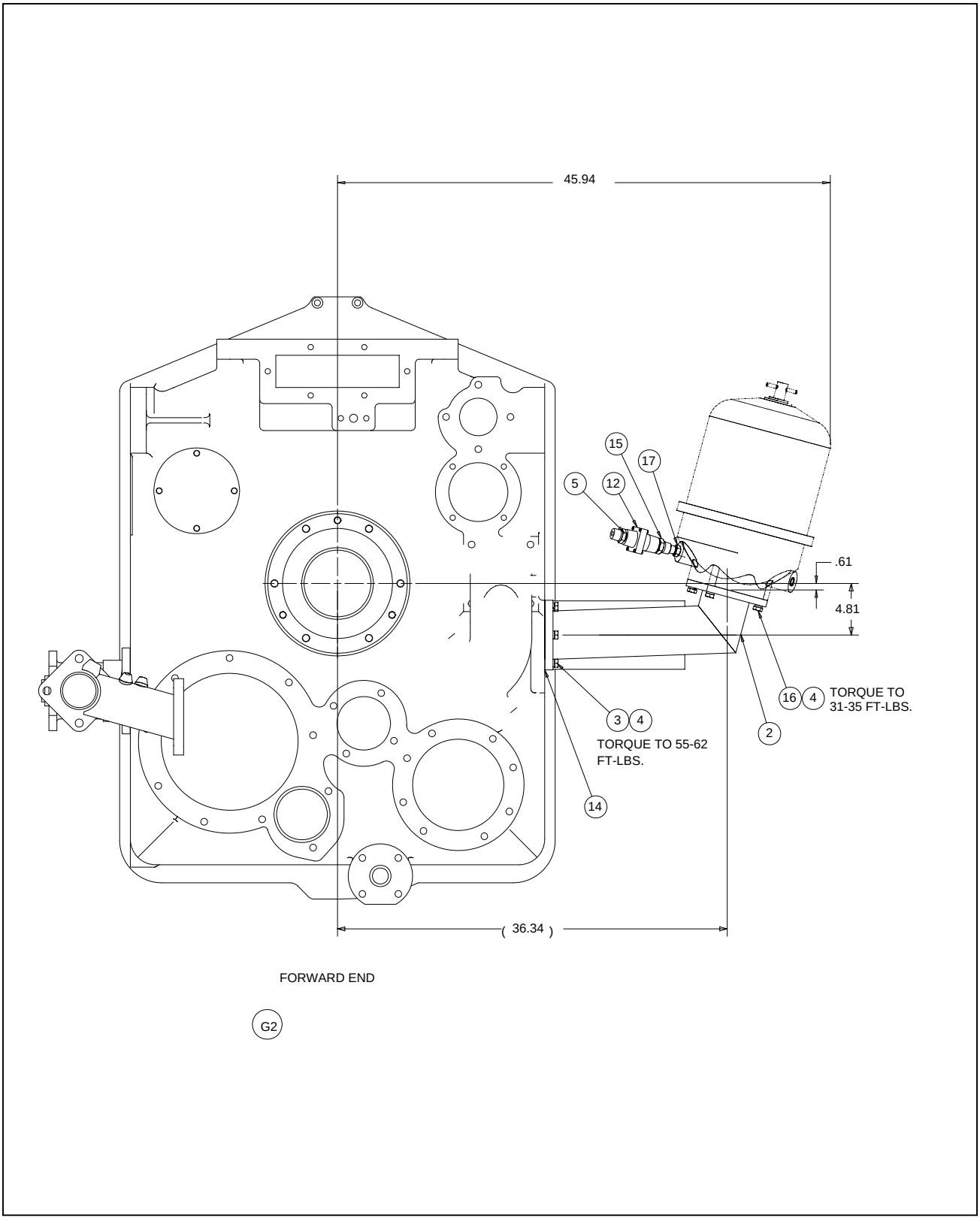


Figure 5-15. Centrifuge Installation. (84C604566G2, Sheet 3)

TABLE 5-3. PARTS LIST FOR CENTRIFUGE INSTALLATION (84C604566G2)

Item	Identification	Description	G2
2	84C604850G1	Support Pipe	1
3	N22P29024	Bolt 1/2-13 X 1.5	6
4	N405P75	Lockwasher 0.50 Heavy	13
5	41B541600AZP5	Fitting Nipple	1
12	84A212752P11	Cutout Cock Valve	1
14	41A222121P1	Gasket	1
15	41B541600ACP22	Adapter, 0.75MP X 1.06-12MT	1
16	N22P29028	Bolt, Hex 0.50-13 X 1.75	4
17	41B541600FHP1	Adapter	1
18	84A215918P1	O-Ring, Green, Viton	1

5.4. COMBUSTION AIR

Refer to Figure 5-16, Air Filter Installation; Figure 5-17, On-Engine Air Intake Filter; and **Table 5-4, Parts List for On-Engine Air Filter Installation**. Refer also to Figure 5-23 (foldout drawing at the end of this section) for a combustion air and exhaust system schematic.

The quality of the combustion air has a large impact on engine performance, filter life, and engine wear. The engine-mounted air filter package is only to be used in engine compartments supplied with clean ventilation air.

The engine-mounted air intake filter is attached directly to the face of the turbocharger. Engine intake air filtration removes particles from the combustion air that might damage the engine and is done in two stages.

1. The first stage is the replaceable coarse filter wrap that removes the larger particles from the engine intake air and extends the service life of the secondary filter.
2. The second stage is the round pleated filter element that removes the remaining small particles from the combustion air. The engine air filters should be replaced on a planned schedule or when the pressure drop across the filter becomes too high.

The ventilation air supplied to the engine compartment must be of sufficient quantity to provide both combustion air to the diesel and (if necessary) remove excess heat from the engine compartment. The ventilation air system and engine compartment sealing must be designed so that water, foam, oil mist, sand, dust, exhaust fumes, and etc. cannot enter.

Calculations and provisions for supplying the required ventilation air are the customer's responsibility. Perform calculations and provisions with the following requirements:

- The quantity of combustion air required is 0.116m^3/(kW-min.) (3.05 cfm/ghp).
- The quantity of ventilation air required is dependent on the desired engine compartment temperature and the temperature of the ventilation air, and engine load. A general guide for heat rejection to the engine compartment is 6% of operating power.
- A slight positive pressure in the engine compartment is desirable with a positive pressure of no more than 12.7 mm (0.5 in.) of water.

NOTE: The amount of vacuum pressure in front of the turbocharger can be monitored to indicate a clogged air filter condition. An alarm can be generated to notify operators of clogged air filters.

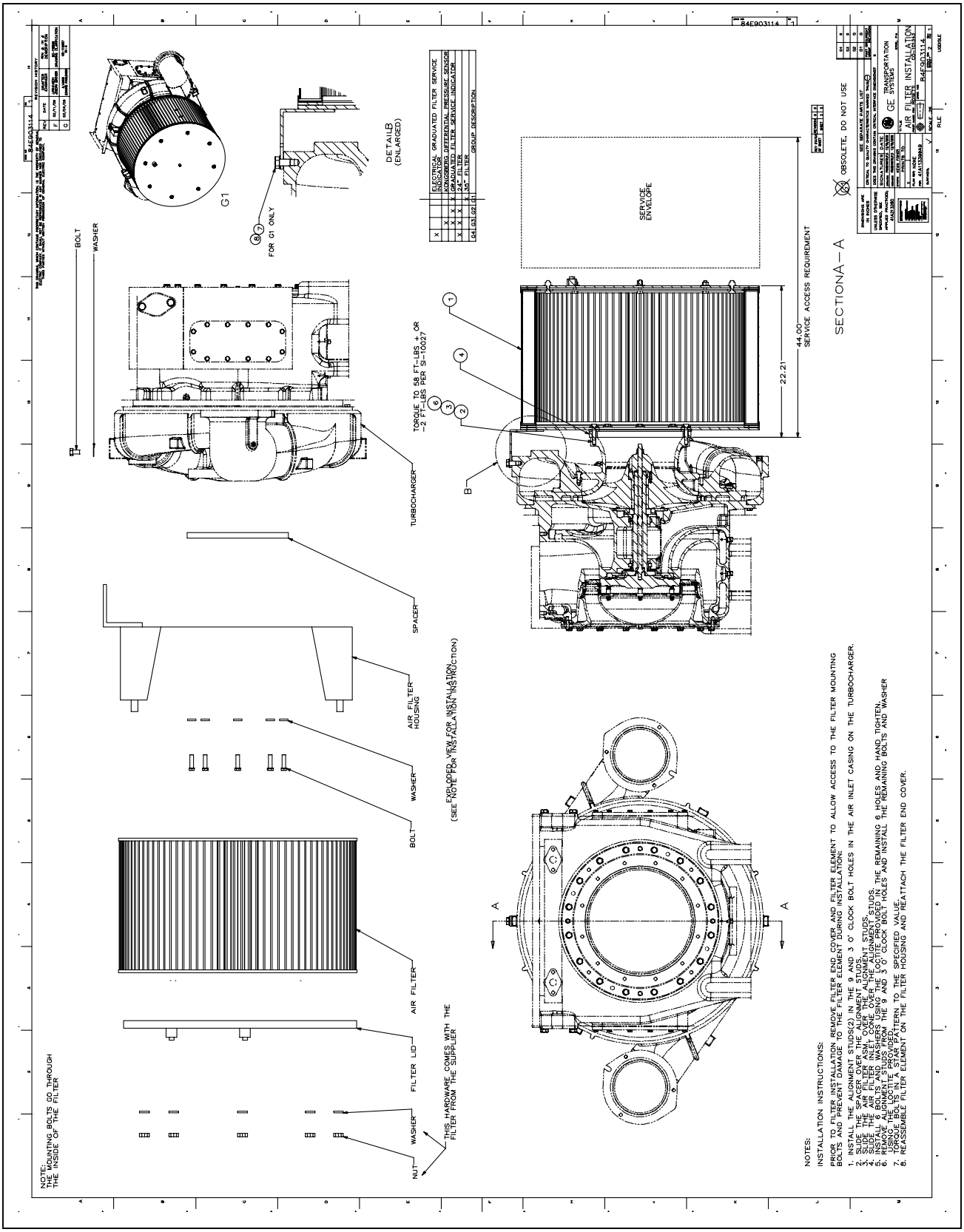


Figure 5-16. Air Filter Installation. (84E903114G2)

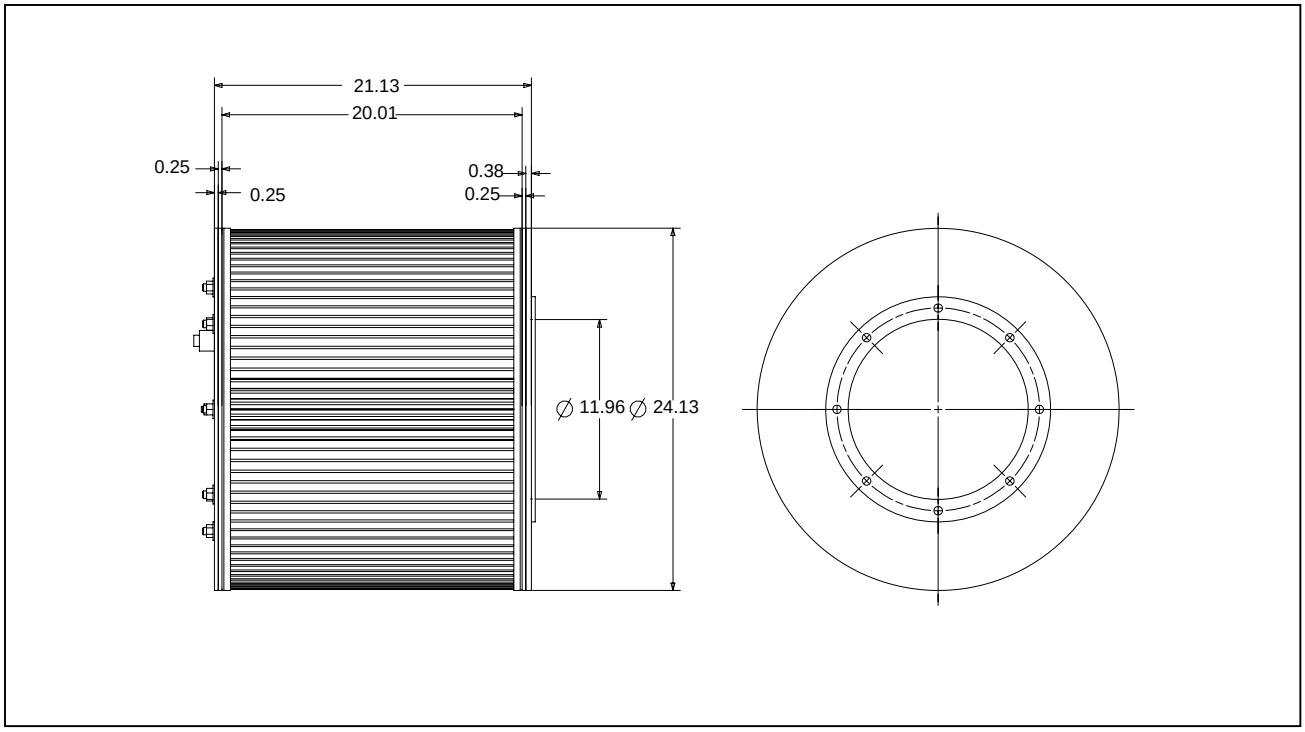


Figure 5-17. On-Engine Air Intake Filter. (84C608446, Sheet 2)

TABLE 5-4. PARTS LIST FOR ON-ENGINE AIR FILTER INSTALLATION (84E903114G2)

Item	Identification	Description	G2
1	84A219939P5	Air Filter Assembly	1
2	N22P29040B13	Bolt, 1/2-13 x 2.5	8
3	N402AP15	Flat Washer	8
4	84B526249P1	Spacer	1
5	41A279870P54	Stud, 1/2-13 x 8.5	2
6	84A218083P1	Locktite 222 Thread Lock	A/R

5.5. EXHAUST SYSTEM

5.5.1. Exhaust System Design

Refer to Figure 5-23 (foldout drawing at the end of this section) for a combustion air and exhaust system schematic.

Refer to Figure 5-18, Exhaust Stack; and **Table 5-5, Parts List for Exhaust Stack**; Figure 5-19, Exhaust Stack Installation; and **Table 5-6, Parts List for Exhaust Stack Installation**.

Each engine should have its own exhaust pipe from the turbocharger outlet transition. Flexible bellows must be mounted directly to the transition piece at the turbocharger outlet to compensate for thermal expansion and prevent damage to the turbocharger. The exhaust piping that connects to these bellows must be properly secured.

Bends should be made with the largest possible bending radius; the minimum bending radius used should be (1.5 x Pipe Diameter). The exhaust pipe should be insulated all the way from the turbocharger, and the insulation should be protected by a covering plate or similar device to keep the insulation intact.

CAUTION: It is especially important to prevent the turbocharger from sucking the insulation away. Insulation ingestion into the turbocharger may cause severe engine damage.

The exhaust gas pipes and/or silencers should be provided with water separating pockets and drainage. Absolute maximum exhaust gas backpressure is 254 mm (10 in.) of water at full load, which should be calculated by the customer and verified during commissioning.
Recommended maximum flow velocity in the exhaust pipe is 40 m/s (131.34 ft/s) at full load. If the pipe is long, or an exhaust gas boiler is installed, the velocity needs to be lower. The recommended pipe size (inner diameter) for the GE 12V228 diesel engine is 508.0 mm (20 in.).

NOTE: Refer to SECTION 2, ENGINE SPECIFICATIONS, for exhaust gas quantities and temperatures.

5.5.2. Silencer

When included in the scope of supply, the standard silencer is a sound-absorption type, equipped with a spark arrester, soot collector, and water drain. It is provided without mounting brackets and insulation.

5.5.3. Crankcase Ventilation System

The crankcase is ventilated to keep cylinder blow-by gasses from building up in the crankcase. The ventilation system maintains a crankcase vacuum in high speeds (880–1050 rpm), and cannot go above +2.54 mm (0.1 in.) of water at lower speeds (440-880 rpm). The crankcase ventilation system flow path is through an eductor tube that connects the free end cover under the turbocharger to the exhaust stack.

Engines operating over 2,237 kW (3,000 BHP) must include a mist detection system to sense when excessive vapor mist is being evacuated from the crankcase if the engines are class certified.

TABLE 5-5. PARTS LIST FOR EXHAUST STACK (41B520212G3)

Item	Identification	Description	G3
3	41C613983P7	Ejector	1
4	41A221204P2	Gasket	1
5	N405P113	L Washer 3/8	8
6	N22P25020B13	Bolt 3/8-16 X 1 1/4	8
7	41A221205P2	Gasket	1
8	41C640245G1	Exhaust Stack, 20" ID	1

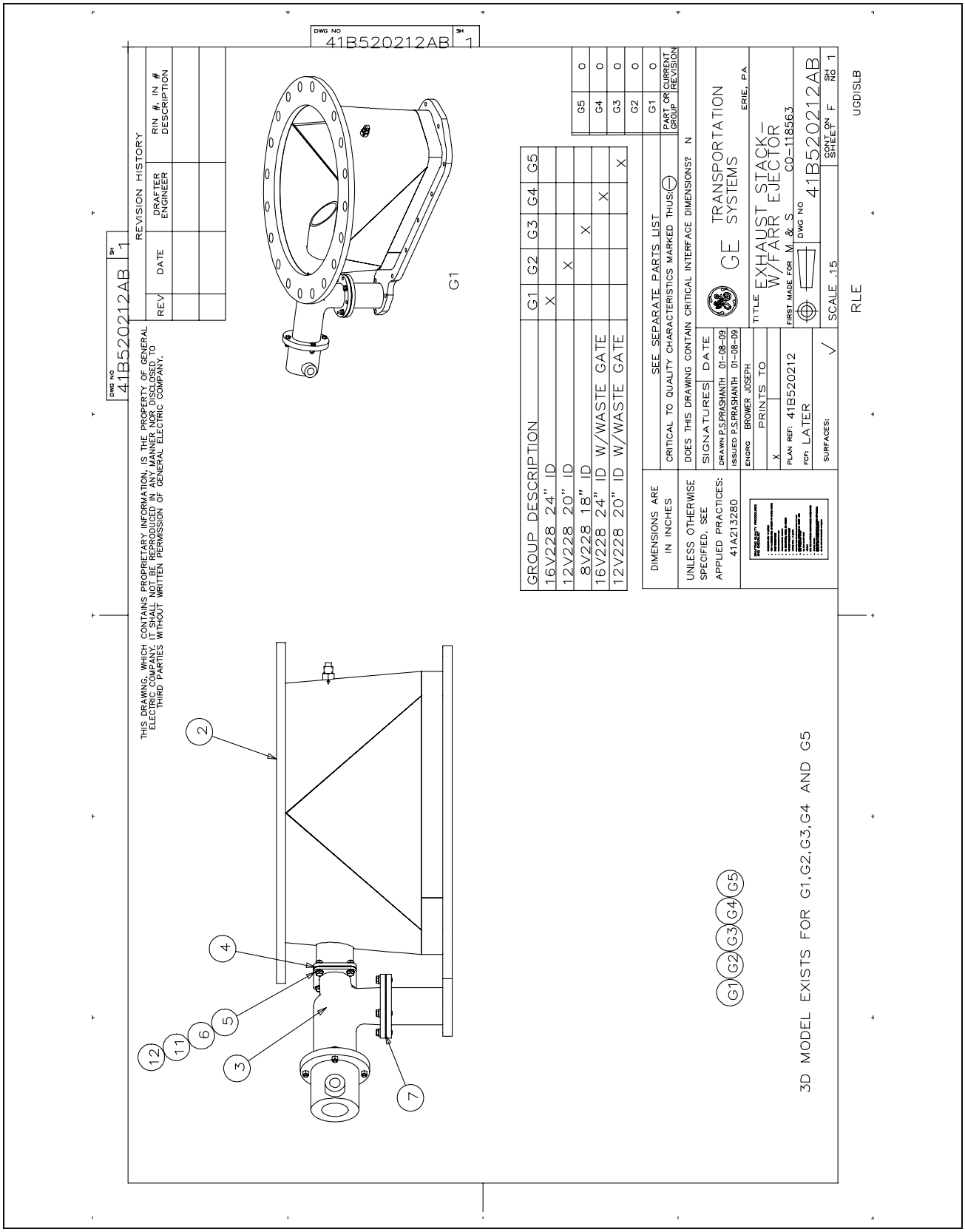
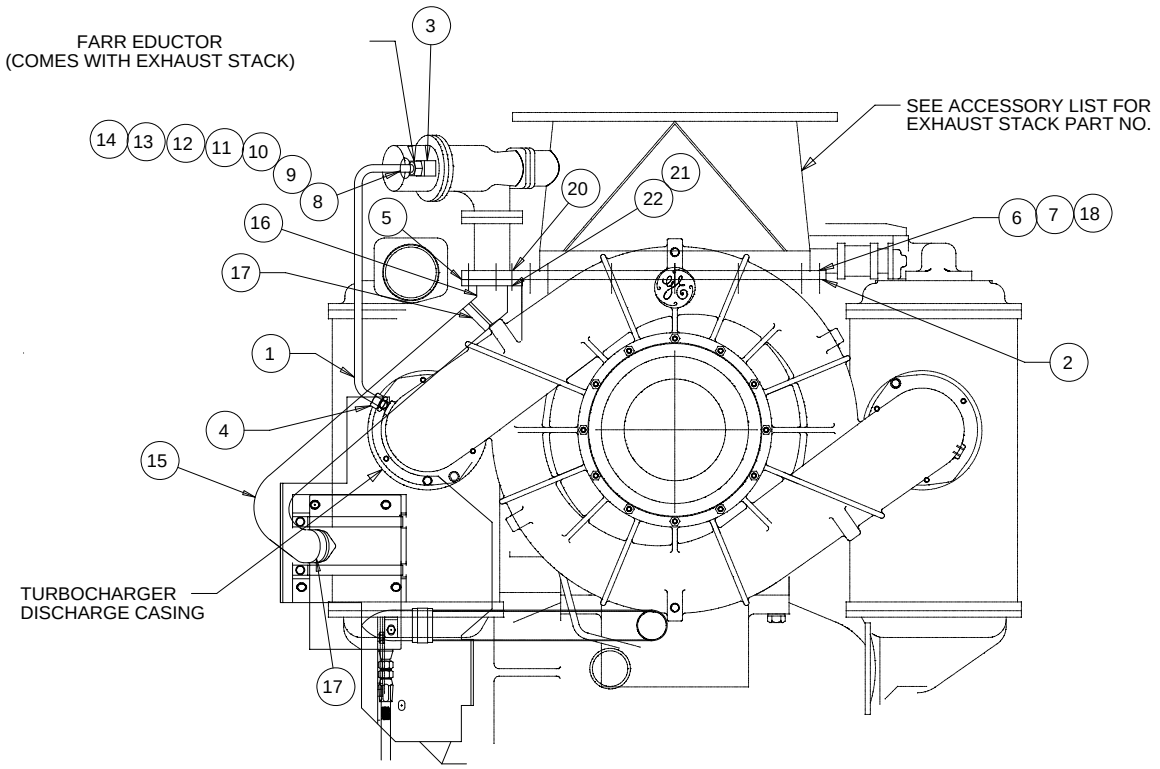


Figure 5-18. Exhaust Stack. (41B520212ABG2)



NOTE:

ORIFICES (P8,9,10,11,12,13) ALONG WITH A LOCKWASHER (P14) TO BE USED INSIDE EDUCTOR TO ADJUST THE CRANKCASE VACUUM TO BETWEEN 1" & 2" WATER AT FULL POWER. THE CORRECT ORIFICE SIZE IS DEPENDENT ON THE INDIVIDUAL EXHAUST SYSTEM. (THE LARGER THE ORIFICE DIA THE MORE THE VACUUM)

Figure 5-19. Exhaust Stack Installation. (84B520892ABG2)

TABLE 5-6. PARTS LIST FOR EXHAUST STACK INSTALLATION (84B520892ABG2)

Item	Identification	Description	G2
1	41B520699ACG2	Tube ASM	1
2	41A213308P2	Gasket, Graphite	2
3	41A213062P19	Fitting	1
4	41A213061P9	Fitting .75 X .50	1
5	41A213399P3	Gasket	1
6	41A221631P2	Bolt	10
7	41A214356P1	Washer	10
8	41C613983P3	Orifice .25 DIA	1
9	41C613983P4	Orifice .18 DIA	1
10	41C613983P5	Orifice .12 DIA	1
11	41C613983P8	Orifice .44 DIA	1
12	41C613983P9	Orifice .50 DIA	1
13	41C613983P10	Orifice .56 DIA	1
14	N403P100	L Washer	6
15	84A203700P11	Hose 3.00 ID X 4.0 Ft	1
16	41C642127G1	Flange	1
17	41A222727P1	Hose Clamp	2
18	41A213226P1	Compound FELPRO C5-A	A/R
20	N22P29040	Bolt-Hex 1/2-13 X 2.50	3
21	N405P75	Lockwasher .50 Heavy	3
22	N258P29	Nut 1/2-13 No Fin.	3

5.6. STARTING AIR SYSTEM

Refer to Figure 5-24 (foldout drawing at the end of this section) for a schematic of the starting air system. The air motor starter receives compressed air from the compressed air system. GE V228 engines use a turbine-type, pre-engaged air motor starter.

5.6.1. Required Starting Air Pressure

The air motor starter requires 6.2 bar (90 psi) air pressure while cranking the engine. GE includes an air motor starter pressure-regulating valve that can handle a maximum inlet air pressure of 30 bar (435 psi). Refer to **Table 5-7, Air Motor Starter Specifications**, for additional starter information.

TABLE 5-7. AIR MOTOR STARTER SPECIFICATIONS

Pressure bar (psi)	Breakaway Torque Nm (ft./lb.)	Speed at Maximum HP RPM	Maximum Power KW (HP)	Flow at Maximum HP L/sec. (SCFM)	Weight kg (lbs.)
6.2 (90)	485 (360)	1935	49 (66)	802 (1700)	28.6 (63)

Table 5-8, V228 Air Receiver Volume Requirements, provides air receiver volumes that meet typical regulatory agency requirements for 4, 6, 8, 10 and 12 consecutive warm engine starting attempts.

TABLE 5-8. V228 AIR RECEIVER VOLUME REQUIREMENTS

Air Receiver Pressure	14 bar (200 psi)	17 bar (250 psi)	30 bar (435 psi)
Engine Start Attempts	**Air Receiver Volume Requirements, Liters (gallons)**		
4	2139 (566)	1470 (389)	680 (180)
6	3209 (849)	2206 (584)	1021 (270)
8	4279 (1132)	2941 (778)	1361 (360)
10	5349 (1415)	3676 (973)	1701 (450)
12	6418 (1698)	4411 (1167)	2041 (540)

5.6.2. Installation Guidelines

Ensure that all piping, hoses and valves are clean prior to installation. Also make sure that the starter inlet is free of dirt and foreign material during installation. Improper hook-up impairs the efficiency of the air starter. Follow these guidelines for supply line installation:

- Keep the number of tees and elbows and the length of the supply line to a minimum.
- Use 76.2 mm (3.0 in.) hose or pipe for supply lines.
- Always run the supply line from the side or top of the air receiver, never at or near the bottom where moisture in the air could collect.
- Use a recommended sealant on all connection to prevent leaks that may drain the air supply system.

5.7. CRANKCASE AND SPEED DETECTION

A sensor located at the left side cam gear cover senses crankcase pressure. The crankcase is ventilated to keep cylinder blow-by gasses from building up (refer to *SECTION 5.5, EXHAUST SYSTEM*). If crankcase pressure of more than 51 mm (2 in.) of water for more than 10 seconds or 254 mm (10 in.) of water for more than 0.5 seconds, a shutdown alarm is sent to the local control display panel.

In case of a crankcase explosion, the crankcase doors act as explosion-relief valves. Per IACS requirements, the crankcase doors are flame arrested and close quickly after any such explosion.

Two engine speed sensors are located next to the left side camshaft drive gear. The engine is provided with overspeed protection, with overspeed defined as an engine speed greater than 10% over rated speed for longer than 0.2 seconds. The engine will shut down if an overspeed incident occurs.

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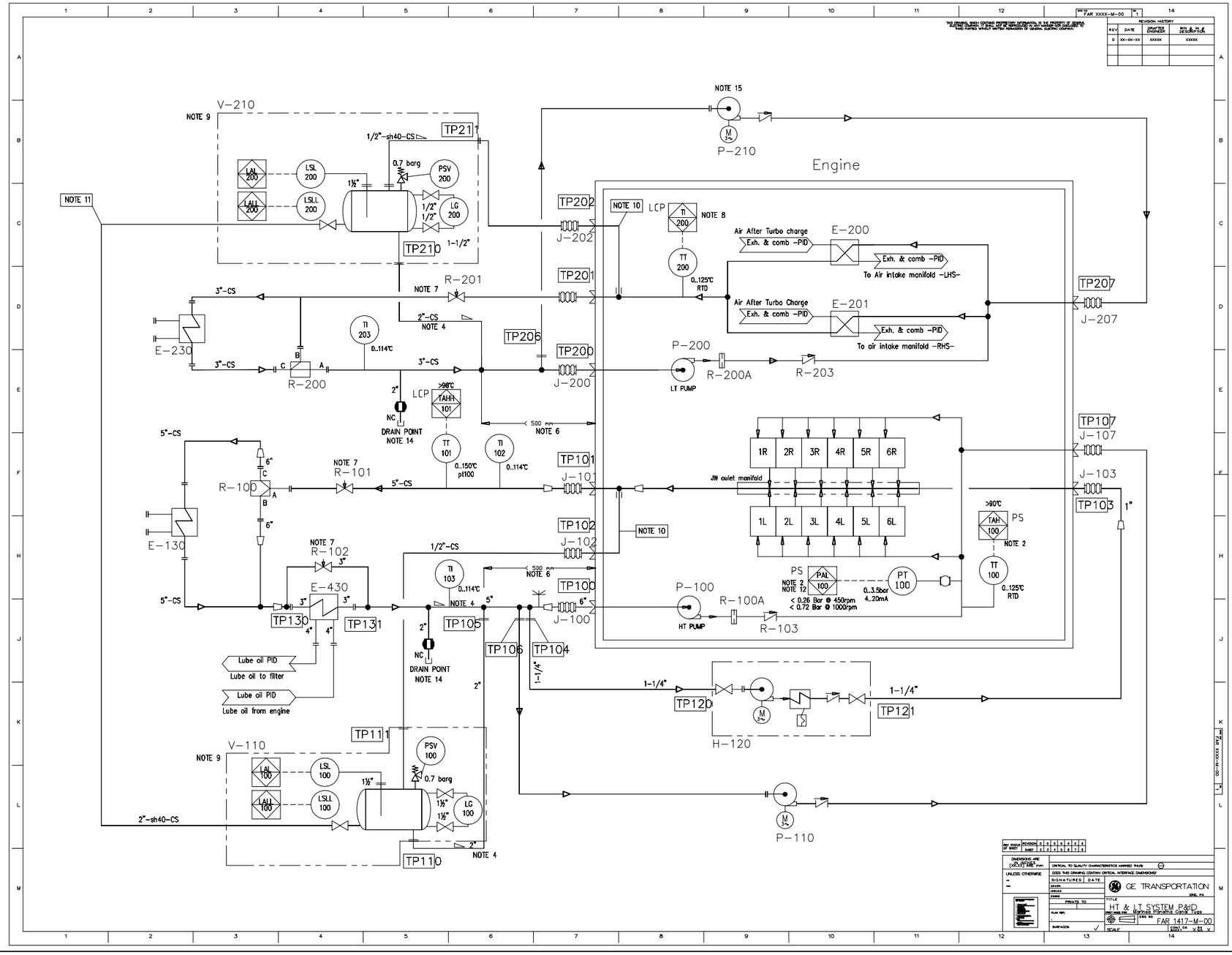
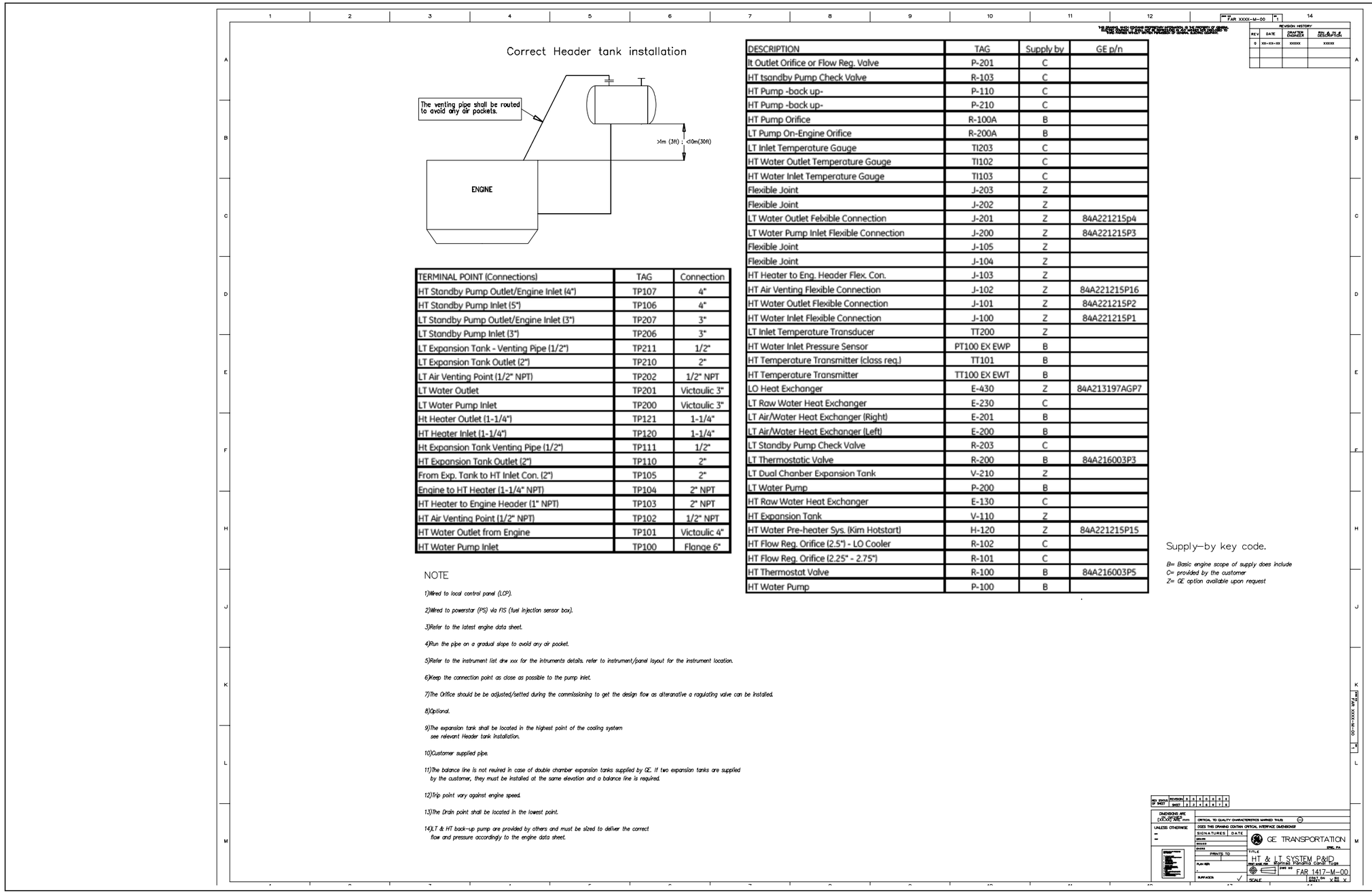


Figure 5-20. HT and LT Coolant Flow, Part 1 of 2. (AutoCAD)



TERMINAL POINT (Connections)	TAG	Connection
HT Standby Pump Outlet/Engine Inlet (4")	TP107	4"
HT Standby Pump Inlet (5")	TP106	4"
LT Standby Pump Outlet/Engine Inlet (3")	TP207	3"
LT Standby Pump Inlet (3")	TP206	3"
LT Expansion Tank - Venting Pipe (1/2")	TP211	1/2"
LT Expansion Tank Outlet (2")	TP210	2"
LT Air Venting Point (1/2" NPT)	TP202	1/2" NPT
LT Water Outlet	TP201	Victaulic 3"
LT Water Pump Inlet	TP200	Victaulic 3"
Ht Heater Outlet (1-1/4")	TP121	1-1/4"
HT Heater Inlet (1-1/4")	TP120	1-1/4"
Ht Expansion Tank Venting Pipe (1/2")	TP111	1/2"
HT Expansion Tank Outlet (2")	TP110	2"
From Exp. Tank to HT Inlet Con. (2")	TP105	2"
Engine to HT Heater (1-1/4" NPT)	TP104	2" NPT
HT Heater to Engine Header (1" NPT)	TP103	2" NPT
HT Air Venting Point (1/2" NPT)	TP102	1/2" NPT
HT Water Outlet from Engine	TP101	Victaulic 4"
HT Water Pump Inlet	TP100	Flange 6"

NOTE

1)Wired to local control panel (LOP).

2)Wired to powerstar (PS) via FIS (fuel injection sensor box).

3)Refer to the latest engine data sheet.

4)Run the pipe on a gradual slope to avoid any air pocket.

5)Refer to the instrument list drw xxx for the intruments details. refer to instrument/panel layout for the instrument location.

6)Keep the connection point as close as possible to the pump inlet.

7)The Orifice should be be adjusted/setted during the commissioning to get the design flow as alteranative a ragulating valve can be installed.

8)Optional.

9)The expansion tank shall be located in the highest point of the cooling system see relevant Header tank installation.

10)Customer supplied pipe.

11)The balance line is not reuired in case of double chamber expansion tanks supplied by GE. If two expansion tanks are supplied by the customer, they must be installed at the same elevation and a balance line is required.

12)Trip point vary against engine speed.

13)The Drain point shall be located in the lowest point.

14)LT & HT back-up pump are provided by others and must be sized to deliver the correct flow and pressure accordingly to the engine data sheet.

DESCRIPTION	TAG	Supply by	GE p/n
lt Outlet Orifice or Flow Reg. Valve	P-201	C	
HT tsandby Pump Check Valve	R-103	C	
HT Pump -back up-	P-110	C	
HT Pump -back up-	P-210	C	
HT Pump Orifice	R-100A	B	
LT Pump On-Engine Orifice	R-200A	B	
LT Inlet Temperature Gauge	TI203	C	
HT Water Outlet Temperature Gauge	TI102	C	
HT Water Inlet Temperature Gauge	TI103	C	
Flexible Joint	J-203	Z	
Flexible Joint	J-202	Z	
LT Water Outlet Felxible Connection	J-201	Z	84A221215p4
LT Water Pump Inlet Flexible Connection	J-200	Z	84A221215P3
Flexible Joint	J-105	Z	
Flexible Joint	J-104	Z	
HT Heater to Eng. Header Flex. Con.	J-103	Z	
HT Air Venting Flexible Connection	J-102	Z	84A221215P16
HT Water Outlet Flexible Connection	J-101	Z	84A221215P2
HT Water Inlet Flexible Connection	J-100	Z	84A221215P1
LT Inlet Temperature Transducer	TT200	Z	
HT Water Inlet Pressure Sensor	PT100 EX EWP	B	
HT Temperature Transmitter (class req.)	TT101	B	
HT Temperature Transmitter	TT100 EX EWT	B	
LO Heat Exchanger	E-430	Z	84A213197AGP7
LT Raw Water Heat Exchanger	E-230	C	
LT Air/Water Heat Exchanger (Right)	E-201	B	
LT Air/Water Heat Exchanger (Left)	E-200	B	
LT Standby Pump Check Valve	R-203	C	
LT Thermostatic Valve	R-200	B	84A216003P3
LT Dual Chanber Expansion Tank	V-210	Z	
LT Water Pump	P-200	B	
HT Raw Water Heat Exchanger	E-130	C	
HT Expansion Tank	V-110	Z	
HT Water Pre-heater Sys. (Kim Hotstart)	H-120	Z	84A221215P15
HT Flow Reg. Orifice (2.5") - LO Cooler	R-102	C	
HT Flow Reg. Orifice (2.25" - 2.75")	R-101	C	
HT Thermostat Valve	R-100	B	84A216003P5
HT Water Pump	P-100	B	

Supply–by key code.

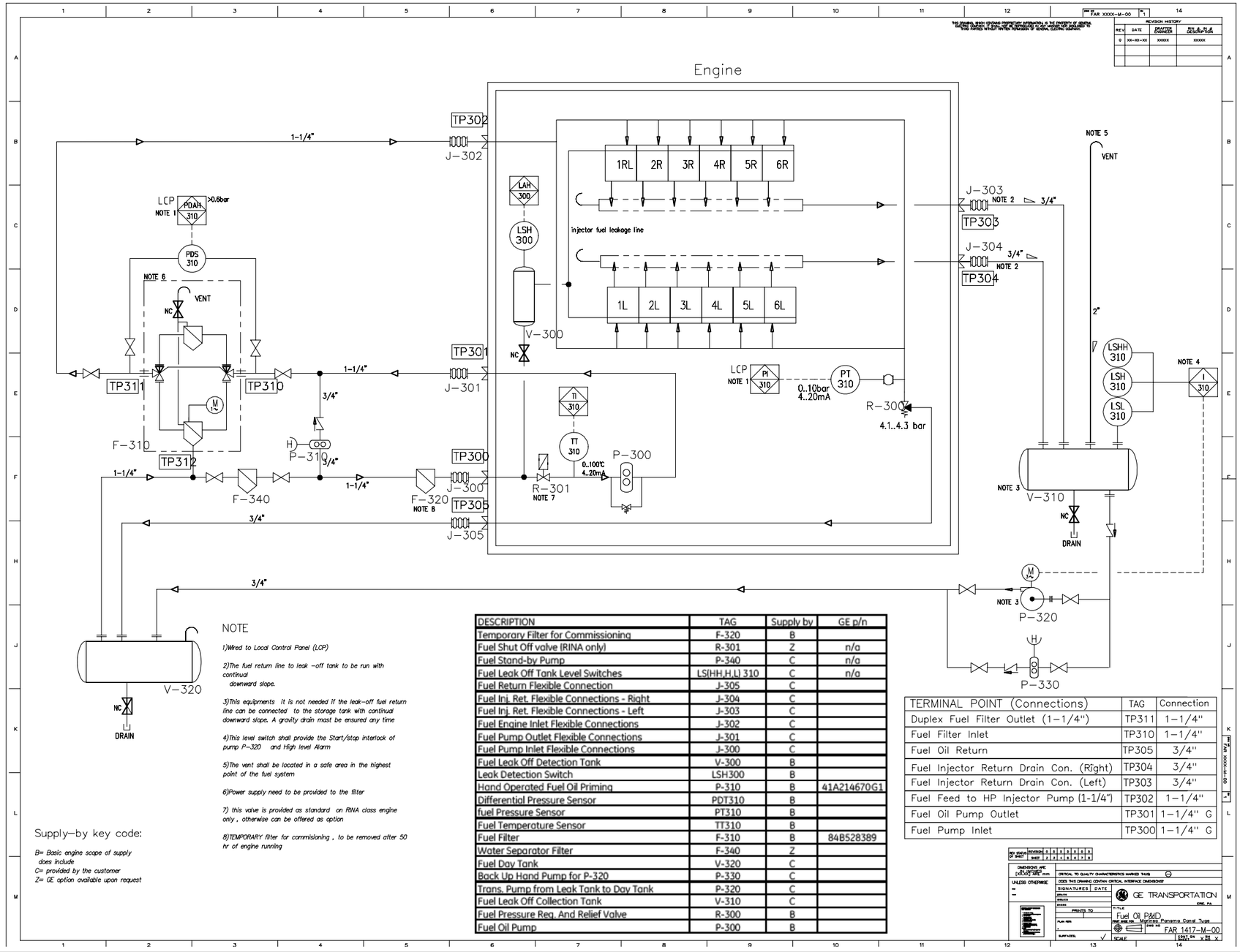
B= Basic engine scope of supply does include
C= provided by the customer
Z= GE option available upon request

GE TRANSPORTATION

HT & LT SYSTEM P&ID

FAR 1417-M-00

Figure 5-20. HT and LT Coolant Flow, Part 2 of 2. (AutoCAD)



NOTE

1)Wired to Local Control Panel (LCP)

2)The fuel return line to leak –off tank to be run with continual downward slope.

3)This equipments It is not needed If the leak–off fuel return line can be connected to the storage tank with continual downward slope. A gravity drain mast be ensured any time

4)This level switch shall provide the Start/stop interlock of pump P–320 and High level Alarm

5)The vent shall be located in a safe area in the highest point of the fuel system

6)Power supply need to be provided to the filter

7) this valve is provided as standard on RINA class engine only , otherwise can be offered as option

8)TEMPORARY filter for commisioning , to be removed after 50 hr of engine running

Supply–by key code:

B= Basic engine scope of supply does include
C= provided by the customer
Z= GE option available upon request

DESCRIPTION	TAG	Supply by	GE p/n
Temporary Filter for Commissioning	F-320	B	
Fuel Shut Off valve (RINA only)	R-301	Z	n/a
Fuel Stand-by Pump	P-340	C	n/a
Fuel Leak Off Tank Level Switches	LS(HH,H,L) 310	C	n/a
Fuel Return Flexible Connection	J-305	C	
Fuel Inj. Ret. Flexible Connections - Right	J-304	C	
Fuel Inj. Ret. Flexible Connections - Left	J-303	C	
Fuel Engine Inlet Flexible Connections	J-302	C	
Fuel Pump Outlet Flexible Connections	J-301	C	
Fuel Pump Inlet Flexible Connections	J-300	C	
Fuel Leak Off Detection Tank	V-300	B	
Leak Detection Switch	LSH300	B	
Hand Operated Fuel Oil Priming	P-310	B	41A214670G1
Differential Pressure Sensor	PDT310	B	
fuel Pressure Sensor	PT310	B	
Fuel Temperature Sensor	TT310	B	
Fuel Filter	F-310	B	84B528389
Water Separator Filter	F-340	Z	
Fuel Day Tank	V-320	C	
Back Up Hand Pump for P-320	P-330	C	
Trans. Pump from Leak Tank to Day Tank	P-320	C	
Fuel Leak Off Collection Tank	V-310	C	
Fuel Pressure Reg. And Relief Valve	R-300	B	
Fuel Oil Pump	P-300	B	

TERMINAL POINT (Connections)	TAG	Connection
Duplex Fuel Filter Outlet (1–1/4")	TP311	1–1/4"
Fuel Filter Inlet	TP310	1–1/4"
Fuel Oil Return	TP305	3/4"
Fuel Injector Return Drain Con. (Right)	TP304	3/4"
Fuel Injector Return Drain Con. (Left)	TP303	3/4"
Fuel Feed to HP Injector Pump (1-1/4")	TP302	1–1/4"
Fuel Oil Pump Outlet	TP301	1–1/4" G
Fuel Pump Inlet	TP300	1–1/4" G

GE TRANSPORTATION

Fuel Oil P&ID
Marinsa Panama Canal Tugs
FAR 1417–M–00

Figure 5-21. Fuel Oil System Schematic. (AutoCAD)

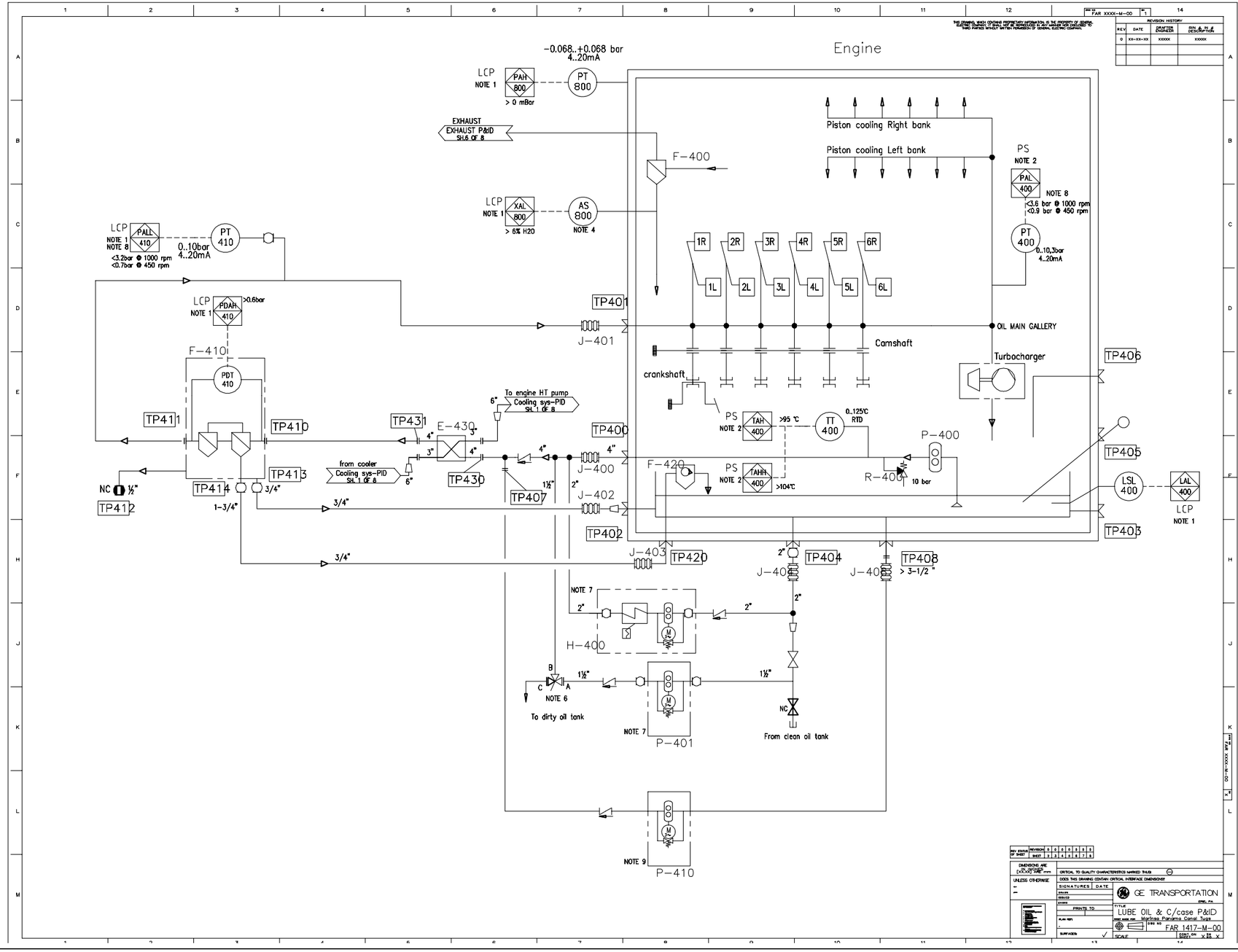


Figure 5-22. Lubricating Oil System Schematic, Part 1 of 2. (AutoCAD)

TERMINAL POINT (Connections)	TAG	Connection
LO Emerhency Stand-By Pump Inlet	TP408	3-1/2"
LO Engine to LO Htr Con./LO Prime Pump	TP407	3-1/2"
Oil Heat Exchanger OUTLET	TP431	1" NPT
Oil Heat Exchanger INLET	TP430	1" NPT
Centrifuge LO Inlet	TP420	1" NPT
LO Filter to LO Centrifuge Connection	TP414	FLANGE 1-3/4"
LO Filter to Lo Sump Connection	TP413	M18 x1.5
LO Heater Outlet Connection	TP412	1" NPT
LO Filter Outlet Connection	TP411	FLANGE 4"-150RF
LO Filter Inlet Connection	TP410	FLANGE 4"-150RF
Lo Filler Neck	TP406	2/1/2002
LO Dip Stick	TP405	n.a.
LO Drain Back/LO Htr. Inlet Con./LO PP	TP404	2" NPT
LO Drain Back (Left)	TP403	2" NPT
LO Drain Back (Right)	TP402	2" NPT
LO Pump Outlet	TP401	Victaulic 4"
Lo Inlet	TP400	Victaulic 4"

DESCRIPTION	TAG	Supply by	GE p/n
Lube Oil Back-Up Pump	P-410	C	
LO Level Switch	LSL400	C	
Flexible Joint	J-404	C	
Flexible Joint	J-403	C	
Flexible Joint	J-402	C	
LO Outlet Flexible Connection	J-401	C	
LO Inlet Flexible Connection	J-400	C	
High Crankcase Pressure	PT800	B	
Oil Mist Detector	AS800	B	
LO Pressure Sensor (class reg.)	PT410	B	
Lube Oil Differential Pressure Transm.	PDT410	B	
LO Low Level Pressure Transmitter	PT400 (LOP)	B	
LO Temperature Sensor	TT400 (LOT)	B	
Coalescent Filter	F-400	B	
LO Priming Pump	P-401	C	
LO Heater and Circulating Pump	H-400	B	84A221215P19
LO Heat Exchanger	E-430	B	84A213197AGP7
LO Centrifuge Filter	F-420	B	84C604566G2
LO Filter	F-410	B	84B523623
LO Relief Valve	R-400	B	
LO Pump	P-400	B	

Supply–by key code:

B= Basic engine scope of supply does include
C= provided by the customer
Z= GE option available upon request

NOTE

1)Wired to Local Control Panel (LCP).

2)Wired to PowerStar (PS) via FIS (Fuel Injection Sensor box).

3)Refer to the latest Engine data sheet.

4)The Crank Case mist detector is fitted on the engine.

5)Refer to the instrument list drawing for the instrument details. Refer to the instrument/panel layout for the instrument locations.

6)Priming/Lube Oil discharge valve.

7)Alternative (Oil heater or priming pump only).

8)Trip point varies against engine speed (ref. 84A213165AD pg.68).

9) Lube oil back-up pump is provided by others and must be sized to deliver the correct flow and pressure according to the engine data sheet.

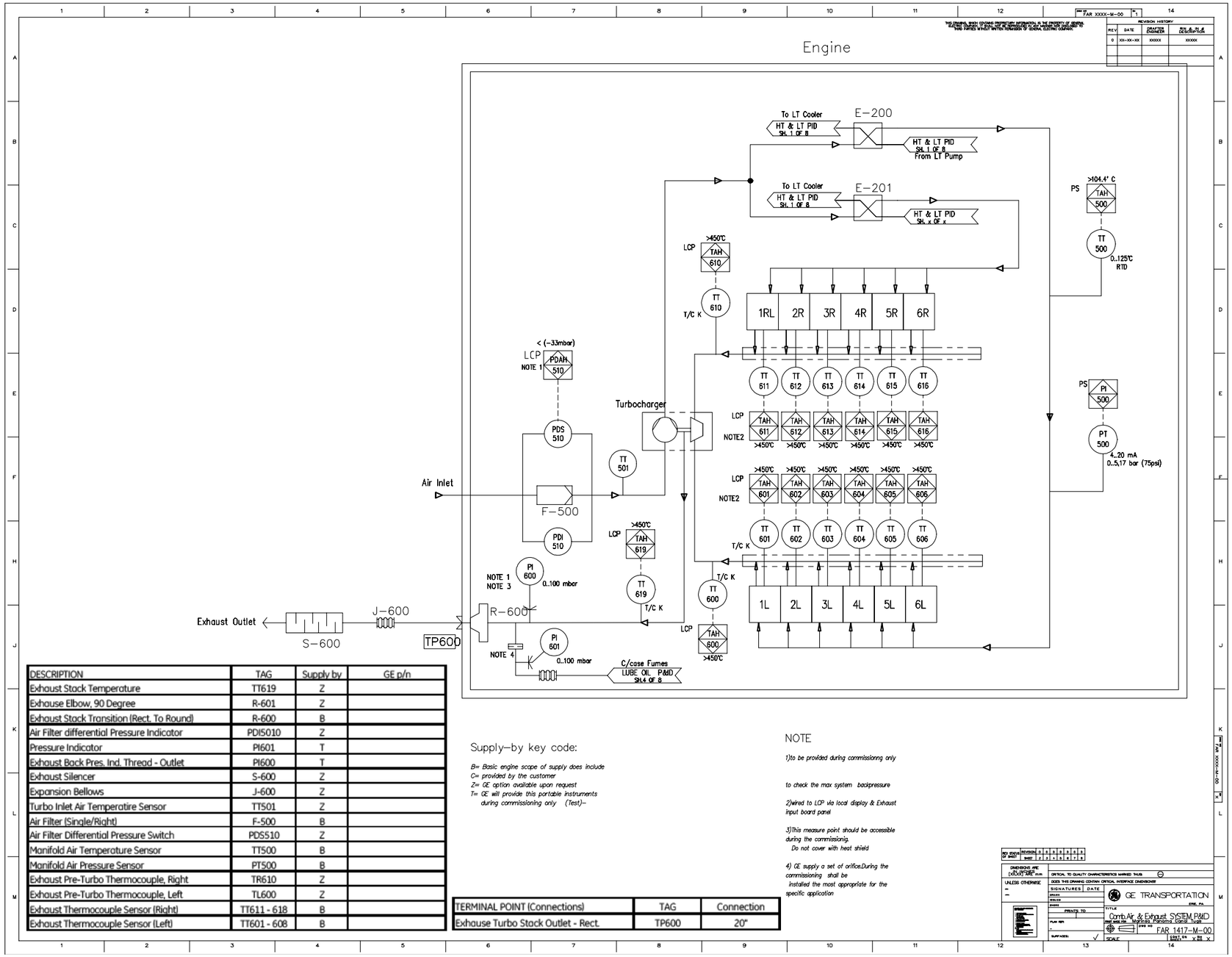
GE TRANSPORTATION

LUBE OIL & C/case P&ID

Marinsa Panama Canal Tugs

FAR 1417-M-00

Figure 5-22. Lubricating Oil System Schematic, Part 2 of 2. (AutoCAD)



DESCRIPTION	TAG	Supply by	GE p/n
Exhaust Stack Temperature	TT619	Z	
Exhause Elbow, 90 Degree	R-601	Z	
Exhaust Stack Transition (Rect. To Round)	R-600	B	
Air Filter differential Pressure Indicator	PDI5010	Z	
Pressure Indicator	PI601	T	
Exhaust Back Pres. Ind. Thread - Outlet	PI600	T	
Exhaust Silencer	S-600	Z	
Expansion Bellows	J-600	Z	
Turbo Inlet Air Temperatire Sensor	TT501	Z	
Air Filter (Single/Right)	F-500	B	
Air Filter Differential Pressure Switch	PDS510	Z	
Manifold Air Temperature Sensor	TT500	B	
Manifold Air Pressure Sensor	PT500	B	
Exhaust Pre-Turbo Thermocouple, Right	TR610	Z	
Exhaust Pre-Turbo Thermocouple, Left	TL600	Z	
Exhaust Thermocouple Sensor (Right)	TT611 - 618	B	
Exhaust Thermocouple Sensor (Left)	TT601 - 608	B	

Supply—by key code:

B= Basic engine scope of supply does include
C= provided by the customer
Z= GE option available upon request
T= GE will provide this portable instruments during commissioning only (Test)—

TERMINAL POINT (Connections)	TAG	Connection
Exhause Turbo Stack Outlet - Rect.	TP600	20"

NOTE

1)to be provided during commissionng only

to check the max system backpressure

2)wired to LCP via local display & Exhaust input board panel

3)This measure point should be accessible during the commissionig.
Do not cover with heat shield

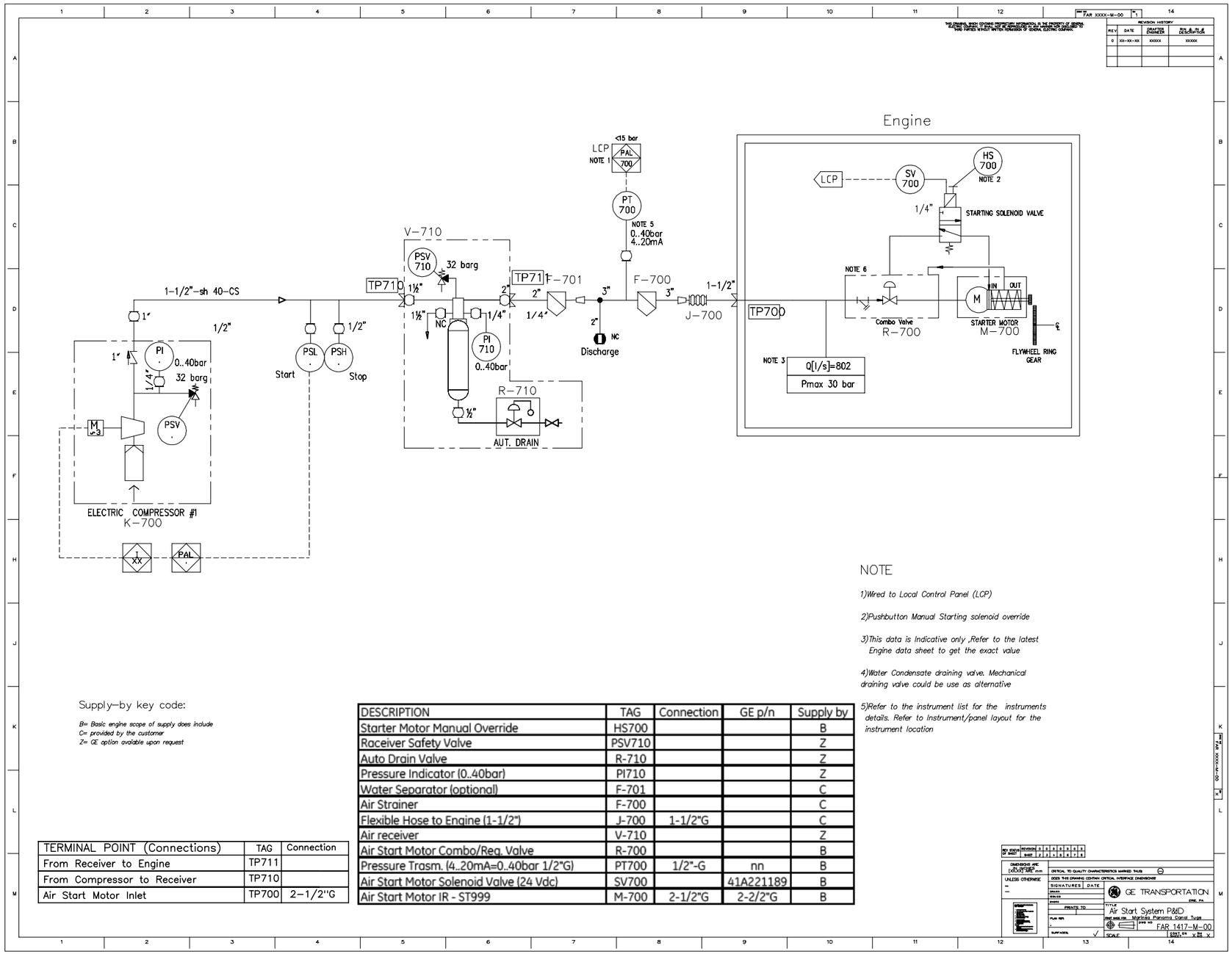
4) GE supply a set of orifice.During the commissioning shall be installed the most appropriate for the specific application

GE TRANSPORTATION

Comb.Air & Exhaust SYSTEM P&ID

FAR 1417-M-00

Figure 5-23. Combustion Air and Exhaust System. (AutoCAD)



DESCRIPTION	TAG	Connection	GE p/n	Supply by
Starter Motor Manual Override	HS700			B
Raceiver Safety Valve	PSV710			Z
Auto Drain Valve	R-710			Z
Pressure Indicator (0..40bar)	PI710			Z
Water Separator (optional)	F-701			C
Air Strainer	F-700			C
Flexible Hose to Engine (1-1/2")	J-700	1-1/2"G		C
Air receiver	V-710			Z
Air Start Motor Combo/Reg. Valve	R-700			B
Pressure Trasm. (4..20mA=0..40bar 1/2"G)	PT700	1/2"-G	nn	B
Air Start Motor Solenoid Valve (24 Vdc)	SV700		41A221189	B
Air Start Motor IR - ST999	M-700	2-1/2"G	2-2/2"G	B

TERMINAL POINT (Connections)	TAG	Connection
From Receiver to Engine	TP711	
From Compressor to Receiver	TP710	
Air Start Motor Inlet	TP700	2-1/2"G

Figure 5-24. Starting Air System Schematic. (AutoCAD)

6. ELECTRICAL SYSTEMS

This section provides information on diesel engine electrical system components and installation. The installation of electrical components depends upon the nature of the application and Scope of Supply. In general, the following items comprise the electrical components that accompany a GE V228 diesel engine installation:

- GE V228 Engine Controller
- Pre-Lube Pump
- Air Motor Starter
- Leak Detection System
- Engine Control Panel
- Engine Gauge Panel
- Alarm and Monitoring Panel
- Exhaust Thermocouples

Refer to **Table 6-15, Instrument List,** foldout table at the end of this section, for a listing of sensors and alarms.

6.1. GE V228 ENGINE CONTROLLER WIRING

GE V228 Engine Controller is the key interface between the engine and the power plant's electrical system. The V228 Engine Controller provides engine speed control by interfacing between the genset control system and the engine's electronic fuel injection system. It provides control signals to the motor starters that start the fuel pump, intercooler pump, and pre-lube pump. It provides control signals to the contactor for the air motor starter solenoid. The V228 Engine Controller interfaces with the engines control panel for start/stop functionality. The V228 Engine Controller does not interface with the exhaust thermocouples.

Refer to Figures 6-6 through 6-11, at the end of this section, for harness drawings. There are five harnesses that run between the engine and the V228 Engine Controller as follows:

- Fuel Injector Sensor (FIS) Harness
- Fuel Injection pump (FIP) Harness
- Bar Over Switch (BOS) Harness
- Engine Position Sensor (EPS) Harness
- Engine Crank Angle (ECA) Harness

Some engines may also have a Fuel Oil Temperature (FOT) Harness. GE provides a standard cable length of 18288 mm (60 ft.) to be run between the engine sensor box and the V228 Engine Controller. There are also interfaces between the V228 Engine Controller and the various pumps and panels.

6.1.1. GE V228 Engine Controller Electrical Requirements

The GE V228 Engine Controller requires the following electrical power:

- Maximum amps at full load: 9 Amps
- Operating voltage range: 18 – 34 VDC
- Nominal voltage: 24 VDC
- Power consumption at full load: 216 Watts

6.1.2. GE V228 Engine Controller Protection Configuration

The GE V228 Engine Controller provides protection to the engine by monitoring several engine performance parameters. It also monitors the health of its internal components.

When engine parameters or internal engine controller checks fall out of accepted values, a warning or fault is logged, and depending on the situation, the engine does one of the following:

- Keeps operating as before the warning alarm
- Goes to idle rpm and stays there
- Goes to idle rpm and begins to increase speed
- Shuts down

The GE V228 Engine Controller has default conditions for all warnings/alarms; however, different gensets respond to events in different ways. Therefore, the genset operator must either accept the default values or specify how events will be handled. This must be done as early in the project as possible, and no later than six weeks before the first engine start-up. The parameters are shown in the **Table 6-1, Warnings And Alarms**.

NOTE: The V228 Engine Controller is not an engine alarm and monitoring system as recognized by regulating agencies. The protection it provides the engine is part of the engine control scheme. To meet classification society requirements, an independent system must be installed to provide the protection required by the regulating agency being used.

TABLE 6-1. WARNINGS AND ALARMS

Event	Default Action
Overspeed	Engine shutdown
Lubricating Oil Temperature (LOT) > 104.4°C (220°F)	Warning
Lubricating Oil Temperature (LOT) > 115.6°C (240°F)	Engine shutdown
Low Engine Water Pressure (EWP)	Warning
Low Lubricating Oil Pressure (LOP)	Warning
Crankcase Over Pressure (COP) Fault	Warning
Check Engine*	Engine shutdown

**Check engine is a combination of faults including power supplies, built in tests, and intercooler high water temperature.*

6.1.3. Power Supply to the GE V228 Engine Controller

Customer-supplied materials for power supply installation include:

- 15A breaker
- Dedicated 20A, 2-pole contact switch on the Engine Control Panel (ECP)
- Wiring between 15A breaker and contact supply switch on the ECP
- Wiring between the dedicated 20A, 2-pole contact switch on the ECP and The GE V228 Engine Controller terminal board.

6.1.3.1. Power Supply Wiring Installation Procedure

NOTE: Install the V228 Engine Controller near the engine so that the harness length from the engine mounted sensor box and the engine controller is 18288 mm (60 ft.) or less. If this is not possible, contact your GE representative for instructions.

1. Install a 15A breaker in the appropriate location.
2. Run the wiring from the 15A breaker to the power supply switch on the ECP.
3. Run the wiring between the dedicated 20A, 2 pole contact switch on the ECP and The GE V228 Engine Controller Terminal Board 1 (TB1). Refer to Figure 6-1, Terminal Board #1 Connections for details.

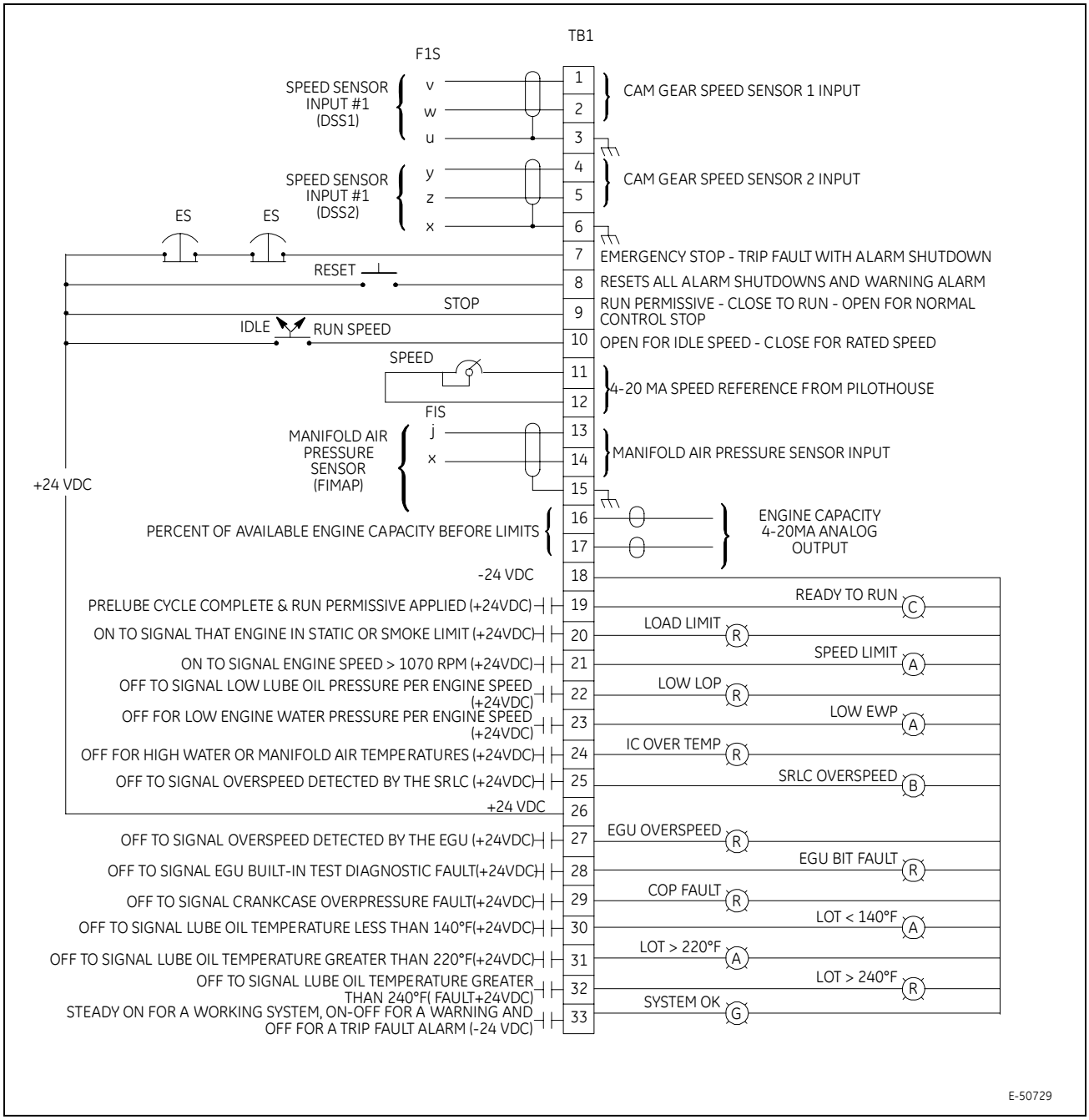


Figure 6-1. Terminal Board #1 (TB1) Connections.

6.1.4. Fuel Injector Sensor Harness to the V228 Engine Controller

The Fuel Injector Sensor (FIS) harness runs from the engine sensors to the V228 Engine Controller Terminal Board 2 (TB2). One end of the harness has a circular threaded style connector and the other end has ring terminals. The side of the harness with the circular connector terminates at the engine mounted sensor box on the left side at the rear of the engine. Refer to Figure 6-2, Terminal Board #2 Connections for details.

NOTE: No customer materials are required if distance from the V228 Engine Controller to the engine sensor box is less than 18288 mm (60 ft.).

6.1.4.1. FIS Harness Installation Procedure

1. Connect the threaded connector end of the FIS harness to FIS plug located on the engine sensor box.
2. Bring ring terminal end of harness into the bottom of the V228 Engine Controller box using the connector that is on the end of the conduit.
3. Terminate the ring terminals on the terminal board as shown in **Table 6-2, FIS Harness Wire Schedule**.

TABLE 6-2. FIS HARNESS WIRE SCHEDULE

From (Soc)	Insulation Color	To (Terminal Block)	Wires/Pairs
FIS-A	White	TB2-49	1 pair non-shielded
FIS-B	Orange	TB2-50	
Fold Back	Drain (White/Orange)	Fold Back	- - - - - -
FIS-C	White	TB2-51	1 pair non-shielded
FIS-D	Blue	TB2-52	
Fold Back	Drain (White/Blue)	Fold Back	- - - - - -
FIS-E	Red-Black	TB2-38	1 pair shielded terminate shield
FIS-F	White	TB2-39	
Fold Back	Drain (White/Red-Black)	TB2-40	
FIS-G	Black-White	TB2-41	1 pair shielded terminate shield
FIS-H	White	TB2-42	
Fold Back	Drain (White/Black-White)	TB2-40	
FIS-J	Black	TB1-13	1 pair shielded terminate shield
FIS-K	White	TB1-14	
Fold Back	Drain (White/Black)	TB1-15	
FIS-L	Blue-Black	TB2-55	2 single wires
FIS-M	White	TB2-53	
Fold Back	Drain (White/Blue-Black)	Fold Back	- - - - - -
FIS-N	Orange-Black	TB2-24	1 pair non-shielded
FIS-P	White	TB2-25	
Fold Back	Drain (White/Orange-Black)	Fold Back	- - - - - -
FIS-Q	Green-Black	TB4-1	2 single wires (LCP, see KM wire plan)
FIS-R	White	TB4-2	
Fold Back	Drain (White/Green-Black)	Fold Back	- - - - - -
FIS-S	Red	TB2-35	1 pair shielded terminate shield
FIS-T	White	TB2-36	
Fold Back	Drain (White/Red)	TB2-37	
FIS-U	Drain (White/Red-White)	TB1-3	

TABLE 6-2. FIS HARNESS WIRE SCHEDULE (CONT'D)

From (Soc)	Insulation Color	To (Terminal Block)	Wires/Pairs
FIS-V	Red-White	TB1-1	1 pair shielded terminate shield
FIS-W	White	TB1-2	
FIS-X	Drain (White/Blue-White)	TB1-6	
FIS-Y	White	TB1-4	1 pair shielded terminate shield
FIS-Z	Blue-White	TB1-5	

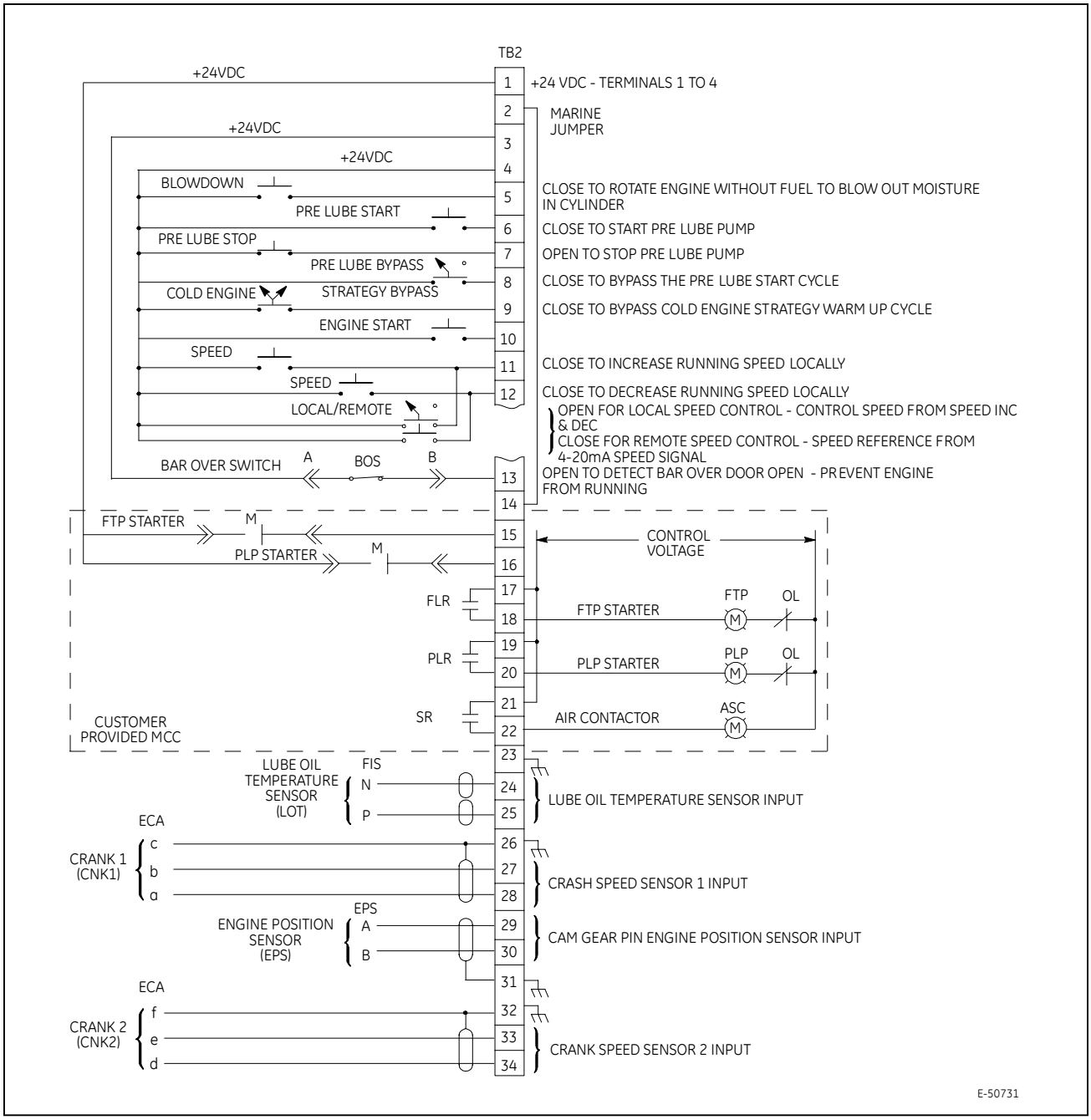


Figure 6-2. Terminal Board #2 (TB2) Connections, Part 1 of 2.

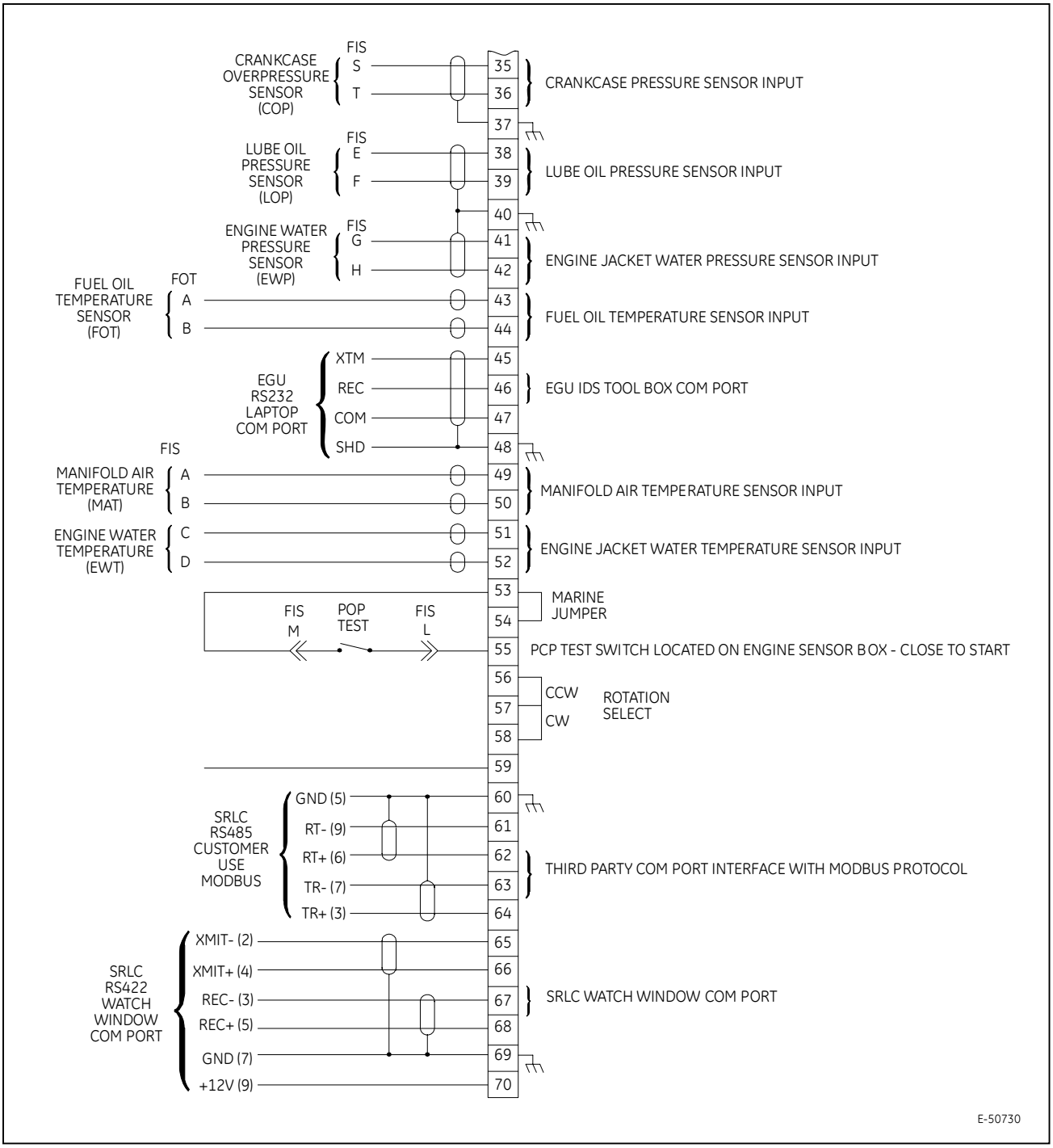


Figure 6-2. Terminal Board #2 (TB2) Connections, Part 2 of 2.

6.1.5. Fuel Injection Pump Harness to the V228 Engine Controller

The Fuel Injection Pump (FIP) harness runs from the high-pressure fuel pumps on the engine to the V228 Engine Controller Terminal Board B (TBB). One end of the harness has a circular threaded style connector and the other end has ring terminals. The end of the harness with the circular connector terminates at the engine mounted sensor box on the left rear of the engine. Refer to Figure 6-3, Terminal Board B Connections for terminal connection details.

NOTE: No customer materials are required if distance from the V228 Engine Controller to the engine sensor box is less than 18288 mm (60 ft.).

6.1.5.1. FIP Harness Installation Procedure

1. Connect the threaded connector end of the FIP harness to the FIP plug located on the engine sensor box.
2. Bring the ring terminal end of the harness into the bottom of the V228 Engine Controller box using the connector that is on the end of the conduit.
3. Terminate the ring terminals on the terminal board as shown in **Table 6-3, FIP Harness Wire Schedule**.

TABLE 6-3. FIP HARNESS WIRE SCHEDULE

From (Soc)	Insulation Color	To (Terminal Block)	Wires/Pairs
FIP-A	Brown	TBB-13	Single Wire
FIP-B	Black-White	TBB-19	Single Wire
FIP-C	Purple-White	TBB-14	Single Wire
FIP-D	Orange-White	TBB-16	Single Wire
FIP-E	Yellow	TBB-20	Single Wire
FIP-F	Grey-White	TBB-18	Single Wire
FIP-G	N/A	TBB-15	Single Wire
FIP-H	N/A	TBB-17	Single Wire
FIP-J	Red-White	TBB-1	Single Wire
FIP-K	White-Black	TBB-5	Single Wire
FIP-L	Orange	TBB-11	Single Wire
FIP-M	Grey	TBB-6	Single Wire
FIP-N	Yellow-White	TBB-8	Single Wire
FIP-P	Blue-White	TBB-12	Single Wire
FIP-Q	Violet	TBB-10	Single Wire
FIP-R	N/A	TBB-7	Single Wire
FIP-S	N/A	TBB-9	Single Wire
FIP-T	Blue	TBB-2	Single Wire
FIP-U	Green-White	GND BAR	Single Wire
FIP-V	Brown-White	TBB-4	Single Wire
FIP-W	White	TBB-3	Single Wire
FIP-X	Green	GND BAR	Single Wire

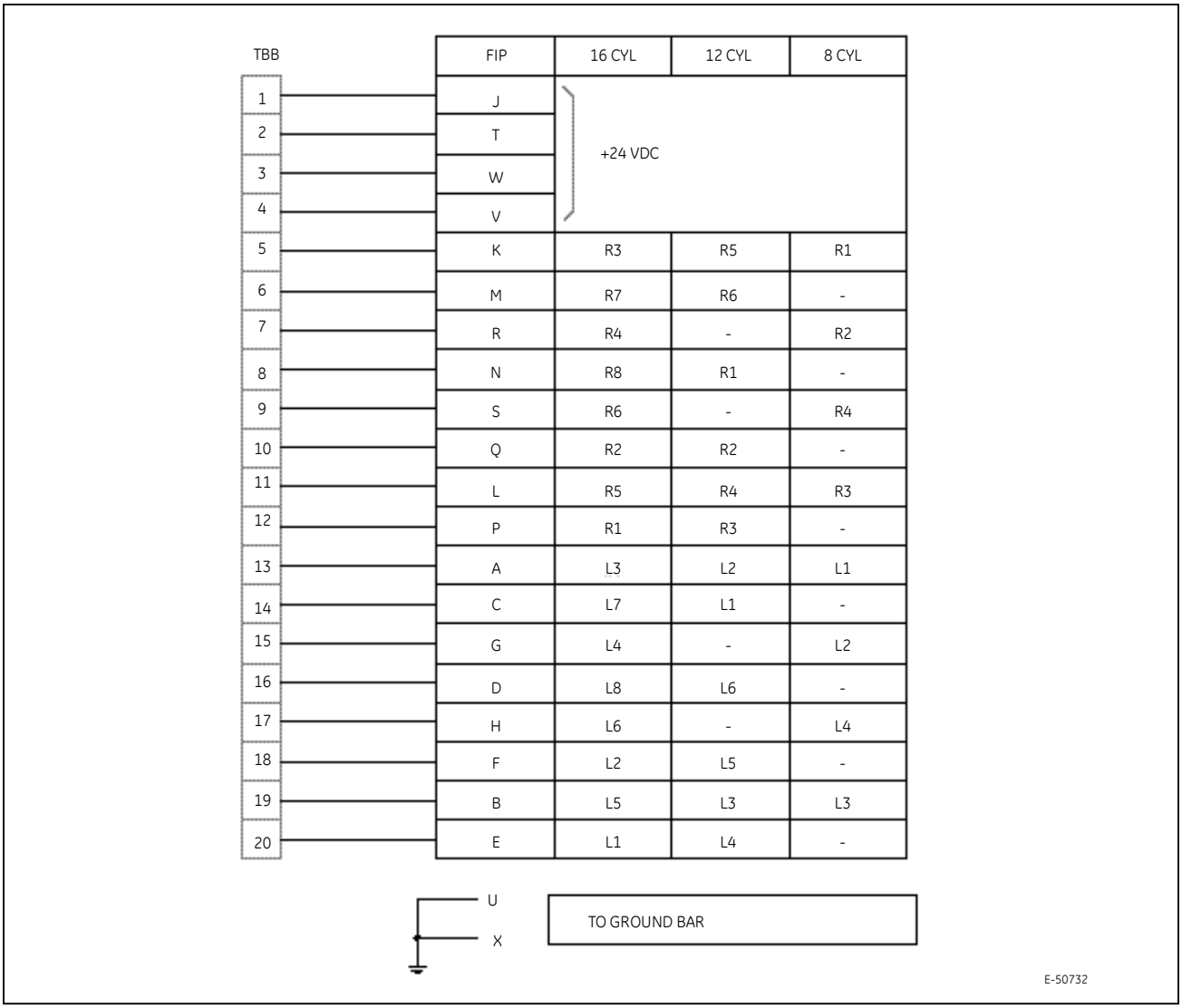


Figure 6-3. Terminal Board B (TBB) Connections.

6.1.6. Bar Over Switch Harness to The GE V228 Engine Controller

The Bar Over Switch (BOS) harness runs from the bar over switch mounted on the cam gear cover on the right side at the rear of the engine to the V228 Engine Controller Terminal Board #2 (TB2). One end of the harness has a circular threaded style connector and the other end has ring terminals. The end of the harness with the circular connector terminates on the cam gear cover. Refer to Figure 6-2, Terminal Board #2 Connections for terminal connection details.

NOTE: No customer materials are required if distance from the V228 Engine Controller to the engine sensor box is less than 18288 mm (60 ft.).

6.1.6.1. BOS Harness Installation Procedure

1. Connect the threaded connector end of the BOS harness to the BOS plug located on the cam gear cover.
2. Bring the ring terminal end of the harness into the bottom of the V228 Engine Controller box using the connector that is on the end of the conduit.
3. Terminate the ring terminals on the terminal board as shown in **Table 6-4, BOS Harness Wire Schedule**.

TABLE 6-4. BOS HARNESS WIRE SCHEDULE

From (Soc)	Insulation Color	To (Terminal Block)	Wires/Pairs
BOS-A	Black	TB2-3	2 single wires
BOS-B	White	TB2-13	
BOS-C	N/A	None - Blue Filler	Blue Filler

6.1.7. EPS Harness to the V228 Engine Controller

The Engine Position Sensor (EPS) harness runs from the engine position sensor mounted on the cam gear cover above the air motor starter to the V228 Engine Controller Terminal Board #2 (TB2). One end of the harness has a circular threaded style connector and the other end has ring terminals. The end of the harness with the circular connector terminates on the cam gear cover. Refer to Figure 6-2, Terminal Board #2 Connections for terminal connection details.

NOTE: No customer materials are required if distance from the V228 Engine Controller to the engine sensor box is less than 18288 mm (60 ft.).

6.1.7.1. EPS Harness Installation Procedure

1. Connect the threaded connector end of the EPS harness to the EPS plug located on the cam gear cover located above the air motor starter of the diesel engine.
2. Bring the ring terminal end of the harness into the bottom of the V228 Engine Controller box using the connector that is on the end of the conduit.
3. Terminate the ring terminals on the terminal board as shown in **Table 6-5, EPS Harness Wire Schedule**.

TABLE 6-5. EPS HARNESS WIRE SCHEDULE

From (Soc)	Insulation Color	To (Terminal Block)	Wires/Pairs
EPS-A	Black	TB2-29	1 pair shielded
EPS-B	White	TB2-30	
Shield	Drain	TB2-31	

6.1.8. ECA Harness to the V228 Engine Controller

The Engine Crank Angle Sensor (ECA) harness runs from the engine position sensor mounted on the cam gear cover above the air motor starter to the V228 Engine Controller Terminal Board #2 (TB2). One end of the harness has a circular threaded style connector and the other end has ring terminals. The end of the harness with the circular connector terminates on the cam gear cover. Refer to Figure 6-2, Terminal Board #2 Connections for terminal connection details.

NOTE: No customer materials are required if distance from the V228 Engine Controller to the engine sensor box is less than 18288 mm (60 ft.).

6.1.8.1. ECA Harness Installation Procedure

1. Connect the threaded connector end of the ECA harness to the ECA plug located on the cam gear cover located above the air motor starter of the diesel engine.
2. Bring the ring terminal end of the harness into the bottom of the V228 Engine Controller box using the connector that is on the end of the conduit.
3. Terminate the ring terminals on the terminal board as shown in **Table 6-6, ECA Harness Wire Schedule**.
4. Add the appropriate jumper to Terminal Board #2 (TB2) to define the rotation of the engine:
   - For standard (counterclockwise) rotation, place jumper between TB2 terminals 56 and 57.
   - For reverse (clockwise) rotation, place jumper between TB2 terminals 57 and 58.

TABLE 6-6. ECA HARNESS WIRE SCHEDULE

From (Soc)	Insulation Color	To (Terminal Block)	Wires/Pairs
EPS-A	Black	TB2-28	1 pair shielded
EPS-B	White	TB2-27	
EPS-C	Drain	TB2-26	
EPS-D	White-Black	TB2-34	1 pair shielded
EPS-E	White	TB2-33	
EPS-F	Drain	TB2-32	

6.2. MONITOR SPEED REFERENCE LOAD CONTROL (SRLC) PARAMETERS

The Electronic Fuel Injection (EFI) control's primary function is engine speed control under varying loads. Additional functions include engine protection and start-stop control. The EFI control resides in two controllers: the Speed Reference and Load Control (SRLC) and the Engine Governor Unit (EGU). The SRLC manages speed and load functions as well as start-stop control. These functions are software-driven within the SRLC microprocessor. The EGU is also a microprocessor-based controller with embedded software that determines the amount of fuel injected into each cylinder. Both the SRLC and EGU share engine protection functions.

6.2.1. V228 AMSC Third Party MODBUS Specification

This section references the V228 AMSC software purchase specification (84A223030CA), and defines AMSC serial MODBUS communication to third party systems.

6.2.1.1. Communication Protocol

Refer to **Table 6-7** for details on the communication protocol of the AMSC system to the third party interface.

TABLE 6-7. THIRD PARTY COMMUNICATION PROTOCOL

Communication Type	MODBUS Master
Electrical Interface	RS422 (four wire, half duplex), RS485 (two wire)
Transmission Mode	RTU
Error Detection	CRC
Baud Rate	19200
Data Bits	8
Parity	None
Stop Bits	1
Slave ID	1

6.2.1.2. MODBUS Address List

Refer to **Table 6-8** for details on the third party MODBUS address list for V228 AMSC systems. Serial analog addresses begin at 40001. Digital input addresses begin at 10001.

TABLE 6-8. THIRD PARTY MODBUS ADDRESS LIST

Tag name	Tag Description	Modbus Address
AI-001	WARNING NUMBER	40001
AI-002	ALARM NUMBER	40002
AI-010	AI1-DSLC PWR REF INPUT (UA)	40003
AI-011	AI2-DSLC SPEED BIAS INPUT(MILLIV	40004
AI-012	AI3-REMOTE SPEED REF INPUT (UA)	40005
AI-013	AI4-MANIFOLD AIR PRESS INPUT (UA	40006
AI-020	AO1-CONFIGURABLE ANALOG OUTP.(UA	40007
AI-021	AO2-DSLC LOAD REF OUTPUT(UA)	40008
AI-022	AO3-CNFGBL ANAL.OUTP.(UA,MAX100)	40009
AI-023	AO4-EGU OUTPUT (MA)	40010
AI-030	SPEED INPUT #1 (RPM)	40011
AI-031	SPEED INPUT #2 (RPM)	40012
AI-032	ENGINE SPEED (RPM)	40013
AI-040	BIASED SPEED REFERENCE (RPM)	40014
AI-041	SPEED REFERENCE (RPM)	40015
AI-042	DSLC BIAS(RPM)	40016
AI-050	TORQUE (FTLB)	40017
AI-051	HORSEPOWER	40018
AI-052	PERCENT LOAD	40019
AI-053	ENGINE CAPACITY	40020
AI-054	TORQUE CAPACITY	40021
AI-055	MANIFOLD AIR DENSITY	40022
PT500	MANIFOLD AIR PRESSURE (PSIA)	40023
TT500	MANIFOLD AIR TEMPERATURE, EGU	40024
TT400	LUBE OIL TEMPERATURE, EGU	40025
PT400	LUBE OIL PRESSURE, EGU (WARNING)	40026

TABLE 6-8. THIRD PARTY MODBUS ADDRESS LIST (CONT'D)

Tag name	Tag Description	Modbus Address
AI-063	FILTERED SPEED, EGU	40027
TT100	COOLANT TEMPERATURE, EGU	40028
PT100	COOLANT PRESSURE, EGU	40029
PT800	CRANKCASE AIR PRESSURE, EGU	40030
AI-067	MAX SPEED LIMIT, EGU	40031
AI-068	MAX FUEL LIMIT, EGU	40032
AI-069	ADVANCE ANGLE, EGU	40033
AI-070	TYPE OF FUEL, EGU	40034
QT800	FUEL DEMAND A/D VALUE, EGU	40035
TT310	FUEL TEMPERATURE (DEGF), EGU	40036
AI-073	SOFTWARE VERSION, EGU	40037
AI-080	FUEL DEMAND	40038
AI-081	START FUEL LIMIT	40039
AI-082	TORQUE FUEL LIMIT(%FD)	40040
AI-083	SMOKE FUEL LIMIT LEVEL (% FD)	40041
AI-084	MAX FUEL LIMIT	40042
AI-085	EGU TORQUE FUEL LIMIT	40043
ST800	AI3-REMOTE SPEED INPUT (RPM)	40044
AI-093	AI4-MAP FUEL LIMIT INPUT (PSIA)	40045
AI-100	AO1-CONFIGURED ANALOG OUTP.(ENGR	40046
AI-101	AO2-CONFIGURED ANALOG OUTP.(ENGR	40047
AI-102	AO3-VIRTUAL RACK POSITION (%)	40048
AI-103	AO4-OUTPUT TO EGU (%)	40049
AI-110	DSLC LOAD REFERENCE IN (%)	40050
AI-111	DSLC LOAD REFERENCE OUT (%)	40051
AI-112	DSLC HOT OIL DERATE LIMIT (%)	40052
AI-113	DSLC OTHER DERATE LIMIT (%)	40053
TT601	EXH GAS TEMP CYLINDER 1L	40054
TT602	EXH GAS TEMP CYLINDER 2L	40055
TT603	EXH GAS TEMP CYLINDER 3L	40056
TT604	EXH GAS TEMP CYLINDER 4L	40057
TT605	EXH GAS TEMP CYLINDER 5L	40058
TT606	EXH GAS TEMP CYLINDER 6L	40059
TT607	EXH GAS TEMP CYLINDER 7L	40060
TT608	EXH GAS TEMP CYLINDER 8L	40061
TT600	PRE-TURBINE LEFT BANK	40062
TT611	EXH GAS TEMP CYLINDER 1R	40063
TT612	EXH GAS TEMP CYLINDER 2R	40064
TT613	EXH GAS TEMP CYLINDER 3R	40065
TT614	EXH GAS TEMP CYLINDER 4R	40066
TT615	EXH GAS TEMP CYLINDER 5R	40067
TT616	EXH GAS TEMP CYLINDER 6R	40068
TT617	EXH GAS TEMP CYLINDER 7R	40069
TT618	EXH GAS TEMP CYLINDER 8R	40070

TABLE 6-8. THIRD PARTY MODBUS ADDRESS LIST (CONT'D)

Tag name	Tag Description	Modbus Address
TT610	PRE-TURBINE RIGHT BANK	40071
SPARE1	SPARE1	40072
PT310	FUEL OIL PRESSURE	40073
PdT310	FUEL OIL FILTER DIFFERENTIAL PR.	40074
PdT510	AIR FILTER DIFFERENTIAL PR.	40075
PT700	START AIR PRESSURE	40076
TT101	HT WATER OUTLET	40077
PT411	LUBE OIL PRESSURE VERY LOW	40078
TT609	PRE-TURBINE LEFT BANK TOP	40079
TT619	PRE-TURBINE RIGHT BANK TOP	40080

		Description		Modbus
Tag Name	Tag Description	Open	Closed	Address
DI-001	WARNING ACTIVE	NORMAL	WARN	10001
DI-002	ALARM ACTIVE	NORMAL	ALARM	10002
DI-010	H-RUN PERMISSIVE	OPEN	CLOSED	10003
DI-011	G-CLOSE FOR RATED	OPEN	CLOSED	10004
DI-012	F-CHECK ENG FAULT CONTACT	NORMAL	ALARM	10005
DI-013	E-LOW WAT PRESS CONTACT	NORMAL	ALARM	10006
DI-014	D-LOW OIL PRESS CONTACT	NORMAL	ALARM	10007
DI-015	C-IC OVERTEMP CONTACT	NORMAL	ALARM	10008
DI-016	B-ALARM RESET	OPEN	CLOSED	10009
DI-017	A-EMERGENCY STOP	NORMAL	ALARM	10010
DI-020	DO1-EGU ALARM RELAY	OPEN	CLOSED	10011
DI-021	DO2-SRLC ALARM RELAY	OPEN	CLOSED	10012
DI-022	DO3-FUEL LIMIT DETECT RELAY	OPEN	CLOSED	10013
DI-030	DISCRETE IN MOD 1 CHANNEL 1	OPEN	CLOSED	10014
DI-031	DISCRETE IN MOD 1 CHANNEL 2	OPEN	CLOSED	10015
DI-032	DISCRETE IN MOD 1 CHANNEL 3	OPEN	CLOSED	10016
DI-033	DISCRETE IN MOD 1 CHANNEL 4	OPEN	CLOSED	10017
DI-034	DISCRETE IN MOD 1 CHANNEL 5	OPEN	CLOSED	10018
DI-035	DISCRETE IN MOD 1 CHANNEL 6	OPEN	CLOSED	10019
DI-036	DISCRETE IN MOD 1 CHANNEL 7	OPEN	CLOSED	10020
DI-037	DISCRETE IN MOD 1 CHANNEL 8	OPEN	CLOSED	10021
DI-038	DISCRETE IN MOD 1 CHANNEL 9	OPEN	CLOSED	10022
DI-039	DISCRETE IN MOD 1 CHANNEL 10	OPEN	CLOSED	10023
DI-040	DISCRETE IN MOD 1 CHANNEL 11	OPEN	CLOSED	10024
DI-041	DISCRETE IN MOD 1 CHANNEL 12	OPEN	CLOSED	10025
DI-042	DISCRETE IN MOD 1 CHANNEL 13	OPEN	CLOSED	10026
DI-043	DISCRETE IN MOD 1 CHANNEL 14	OPEN	CLOSED	10027
DI-044	DISCRETE IN MOD 1 CHANNEL 15	OPEN	CLOSED	10028
DI-045	DISCRETE IN MOD 1 CHANNEL 16	OPEN	CLOSED	10029
DI-070	SPEED IN CONTROL (LSS)	OPEN	CLOSED	10030
DI-071	ON START LIMIT (LSS)	OPEN	CLOSED	10031

TABLE 6-8. THIRD PARTY MODBUS ADDRESS LIST (CONT'D)

		Description		Modbus
Tag Name	Tag Description	Open	Closed	Address
DI-072	ON MAX LIMIT (LSS)	OPEN	CLOSED	10032
DI-073	ACTUATOR SHUTDOWN	NORMAL	ALARM	10033
DI-074	ON TORQUE LIMIT (LSS)	NORMAL	ALARM	10034
DI-075	ON SMOKE LIMIT	NORMAL	ALARM	10035
DI-076	ON ACTUATOR BUMP	NORMAL	ALARM	10036
DI-077	ON EGU TORQUE LIMIT	NORMAL	ALARM	10037
DI-090	SPEED SWITCH #1 ACTIVE	OPEN	CLOSED	10038
DI-091	SPEED SWITCH #2 ACTIVE	OPEN	CLOSED	10039
DI-101	TCU1 (RIGHT) SOLENOID 8 FAULT	NORMAL	ALARM	10040
DI-102	TCU1 (RIGHT) SOLENOID 7 FAULT	NORMAL	ALARM	10041
DI-103	TCU1 (RIGHT) SOLENOID 6 FAULT	NORMAL	ALARM	10042
DI-104	TCU1 (RIGHT) SOLENOID 5 FAULT	NORMAL	ALARM	10043
DI-105	TCU1 (RIGHT) SOLENOID 4 FAULT	NORMAL	ALARM	10044
DI-106	TCU1 (RIGHT) SOLENOID 3 FAULT	NORMAL	ALARM	10045
DI-107	TCU1 (RIGHT) SOLENOID 2 FAULT	NORMAL	ALARM	10046
DI-108	TCU1 (RIGHT) SOLENOID 1 FAULT	NORMAL	ALARM	10047
DI-109	TCU2 (LEFT) SOLENOID 8 FAULT	NORMAL	ALARM	10048
DI-110	TCU2 (LEFT) SOLENOID 7 FAULT	NORMAL	ALARM	10049
DI-111	TCU2 (LEFT) SOLENOID 6 FAULT	NORMAL	ALARM	10050
DI-112	TCU2 (LEFT) SOLENOID 5 FAULT	NORMAL	ALARM	10051
DI-113	TCU2 (LEFT) SOLENOID 4 FAULT	NORMAL	ALARM	10052
DI-114	TCU2 (LEFT) SOLENOID 3 FAULT	NORMAL	ALARM	10053
DI-115	TCU2 (LEFT) SOLENOID 2 FAULT	NORMAL	ALARM	10054
DI-116	TCU2 (LEFT) SOLENOID 1 FAULT	NORMAL	ALARM	10055
DI-117	ATOD 7 FAIL(PRESS.PSU MONITOR#2)	NORMAL	ALARM	10056
DI-118	ATOD 6 FAIL(PRESS.PSU MONITOR#1)	NORMAL	ALARM	10057
DI-119	ATOD 5 FAIL(LVDT SENSOR)	NORMAL	ALARM	10058
DI-120	ATOD 4 FAIL(COOLANT_PRESSURE)	NORMAL	ALARM	10059
DI-121	ATOD 3 FAIL(LUBE_OIL_PRESSURE)	NORMAL	ALARM	10060
DI-122	ATOD 2 FAIL(CRANK_CASE_PRESSURE)	NORMAL	ALARM	10061
DI-123	ATOD 1 FAIL(COOLANT_TEMPERATURE)	NORMAL	ALARM	10062
DI-124	ATOD 0 FAIL(MANIFOLD_AIR_TEMP.)	NORMAL	ALARM	10063
DI-125	ATOD 15 FAIL(GROUND)	NORMAL	ALARM	10064
DI-126	ATOD 14 FAIL(-10 VREF MONITOR)	NORMAL	ALARM	10065
DI-127	ATOD 13 FAIL(+10 VREF MONITOR)	NORMAL	ALARM	10066
DI-128	ATOD 12 FAIL(+24 PSU MONITOR)	NORMAL	ALARM	10067
DI-129	ATOD 11 FAIL(-15 PSU MONITOR)	NORMAL	ALARM	10068
DI-130	ATOD 10 FAIL(+15 PSU MONITOR)	NORMAL	ALARM	10069
DI-131	ATOD 9 FAIL(+5 PSU MONITOR)	NORMAL	ALARM	10070
DI-132	ATOD 8 FAIL(PRESS.PSU MONITOR#3)	NORMAL	ALARM	10071
DI-133	FAILURE SHUTDOWN FAULT	NORMAL	ALARM	10072
DI-134	OVERSPEED FAULT	NORMAL	ALARM	10073
DI-135	CHECK ENGINE FAULT	NORMAL	ALARM	10074
DI-136	ATOD 20 FAIL(PRESS.PSU MONITOR#4	NORMAL	ALARM	10075

TABLE 6-8. THIRD PARTY MODBUS ADDRESS LIST (CONT'D)

		Description		Modbus
Tag Name	Tag Description	Open	Closed	Address
DI-137	ATOD 19 FAIL(MANIFOLD_AIR_PRESS.	NORMAL	ALARM	10076
DI-138	ATOD 18 FAIL(CPTMON)	NORMAL	ALARM	10077
DI-139	ATOD 17 FAIL(TEMPERATURE 4)	NORMAL	ALARM	10078
DI-140	ATOD 16 FAIL(LUBE OIL TEMP.)	NORMAL	ALARM	10079
DI-141	ATOD 31 FAIL(GNDA2)	NORMAL	ALARM	10080
DI-142	ATOD 30 (DGND)	NORMAL	ALARM	10081
DI-143	ATOD 29 (PGND)	NORMAL	ALARM	10082
DI-144	CRANK SENSOR 2 OUT OF PHASE	NORMAL	ALARM	10083
DI-145	CRANK SENSOR 1 OUT OF PHASE	NORMAL	ALARM	10084
DI-146	HIGH TEMPERATURE FAULT	NORMAL	ALARM	10085
DI-147	LOW COOLANT PRESSURE FAULT	NORMAL	ALARM	10086
DI-148	LOW OIL PRESSURE FAULT	NORMAL	ALARM	10087
DI-149	SPEED LIMIT CLAMP FAULT	NORMAL	ALARM	10088
DI-150	TORQUE LIMIT CLAMP FAULT	NORMAL	ALARM	10089
DI-151	INVALID ROTATION REQUEST FAULT	NORMAL	ALARM	10090
PAH800	CRANKCASE OVER PRESSURE	NORMAL	ALARM	10091
DI-153	BIT FAULT	NORMAL	ALARM	10092
DI-154	CAM FAIL	NORMAL	ALARM	10093
DI-155	CRANK2 FAIL	NORMAL	ALARM	10094
DI-156	CRANK1 FAIL	NORMAL	ALARM	10095
DI-157	BIT TEST7 FAIL(PROGRAM PROM)	NORMAL	ALARM	10096
DI-158	BIT TEST6 FAIL(BOOT PROM)	NORMAL	ALARM	10097
DI-159	BIT TEST5 FAIL(INTERNAL RAM)	NORMAL	ALARM	10098
DI-160	BIT TEST4 FAIL(HIGH RAM)	NORMAL	ALARM	10099
DI-161	BIT TEST3 FAIL(LOW RAM)	NORMAL	ALARM	10100
DI-162	BIT TEST2 FAIL(CPU)	NORMAL	ALARM	10101
DI-163	BIT TEST1 FAIL(WATCHDOG MONITOR)	NORMAL	ALARM	10102
DI-164	SPARE	NORMAL	ALARM	10103
DI-165	SPARE	NORMAL	ALARM	10104
DI-166	MAP SURGE FAULT(SPARE GENSAT APP	NORMAL	ALARM	10105
DI-167	DISCRETE WRAP4 FAIL(HIGH TEMP)	NORMAL	ALARM	10106
DI-168	DISCRETE WRAP3 FAIL(LOW OIL)	NORMAL	ALARM	10107
DI-169	DISCRETE WRAP2 FAIL(LOW COOLANT)	NORMAL	ALARM	10108
DI-170	DISCRETE WRAP1 FAIL(CHECK_ENGIN)	NORMAL	ALARM	10109
DI-171	BIT TEST 9 FAIL (NVM ADJUSTMENT)	NORMAL	ALARM	10110
DI-172	BIT TEST 8 FAIL (DATA PROM)	NORMAL	ALARM	10111
DI-173	CHECK ENGINE	NORMAL	ALARM	10112
DI-174	BOTH SPEED SENSORS FAILED	NORMAL	ALARM	10113
DI-175	MPU1 FAILED	NORMAL	ALARM	10114
DI-176	MPU2 FAILED	NORMAL	ALARM	10115
DI-177	EMERGENCY STOP	NORMAL	ALARM	10116
DI-178	REMOTE POWER REFERENCE FAILED	NORMAL	ALARM	10117
DI-179	REMOTE SPEED REFERENCE FAILED	NORMAL	ALARM	10118
DI-180	LINKNET COMM ERROR	NORMAL	ALARM	10119

TABLE 6-8. THIRD PARTY MODBUS ADDRESS LIST (CONT'D)

		Description		Modbus
Tag Name	Tag Description	Open	Closed	Address
SS811	EGU OVERSPEED	NORMAL	ALARM	10120
SS812	SRLC OVERSPEED	NORMAL	ALARM	10121
DI-183	PRELUBE INTERLOCK FAIL	NORMAL	ALARM	10122
DI-184	FUEL PUMP INTERLOCK FAILED	NORMAL	ALARM	10123
DI-185	EGU/SRLC SPEED MISMATCH	NORMAL	ALARM	10124
ZS800	BAROVER DOOR OPEN	NORMAL	ALARM	10125
DI-187	MAP INPUT FAILED	NORMAL	ALARM	10126
DI-188	MODBUS PORT 3 COMM ERROR	NORMAL	ALARM	10127
DI-189	MODBUS PORT 2 COMM ERROR	NORMAL	ALARM	10128
DI-190	HIGH INTERCOOLER TEMP	NORMAL	ALARM	10129
DI-191	HIGH OIL TEMP	NORMAL	ALARM	10130
DI-192	S/W VERSION MISMATCH	NORMAL	ALARM	10131
DI-193	WASTE GATE CONTROL FAILURE	NORMAL	ALARM	10132
DI-194	SPARE	NORMAL	ALARM	10133
DI-195	SPARE	NORMAL	ALARM	10134
DI-196	SPARE	NORMAL	ALARM	10135
DI-201	TCU1 (RIGHT) SOLENOID 8 FAULT	NORMAL	ALARM	10136
DI-202	TCU1 (RIGHT) SOLENOID 7 FAULT	NORMAL	ALARM	10137
DI-203	TCU1 (RIGHT) SOLENOID 6 FAULT	NORMAL	ALARM	10138
DI-204	TCU1 (RIGHT) SOLENOID 5 FAULT	NORMAL	ALARM	10139
DI-205	TCU1 (RIGHT) SOLENOID 4 FAULT	NORMAL	ALARM	10140
DI-206	TCU1 (RIGHT) SOLENOID 3 FAULT	NORMAL	ALARM	10141
DI-207	TCU1 (RIGHT) SOLENOID 2 FAULT	NORMAL	ALARM	10142
DI-208	TCU1 (RIGHT) SOLENOID 1 FAULT	NORMAL	ALARM	10143
DI-209	TCU2 (LEFT) SOLENOID 8 FAULT	NORMAL	ALARM	10144
DI-210	TCU2 (LEFT) SOLENOID 7 FAULT	NORMAL	ALARM	10145
DI-211	TCU2 (LEFT) SOLENOID 6 FAULT	NORMAL	ALARM	10146
DI-212	TCU2 (LEFT) SOLENOID 5 FAULT	NORMAL	ALARM	10147
DI-213	TCU2 (LEFT) SOLENOID 4 FAULT	NORMAL	ALARM	10148
DI-214	TCU2 (LEFT) SOLENOID 3 FAULT	NORMAL	ALARM	10149
DI-215	TCU2 (LEFT) SOLENOID 2 FAULT	NORMAL	ALARM	10150
DI-216	TCU2 (LEFT) SOLENOID 1 FAULT	NORMAL	ALARM	10151
DI-217	ATOD 7 FAIL(PRESS.PSU MONITOR#2)	NORMAL	ALARM	10152
DI-218	ATOD 6 FAIL(PRESS.PSU MONITOR#1)	NORMAL	ALARM	10153
DI-219	ATOD 5 FAIL(LVDT SENSOR)	NORMAL	ALARM	10154
DI-220	ATOD 4 FAIL(COOLANT_PRESSURE)	NORMAL	ALARM	10155
DI-221	ATOD 3 FAIL(LUBE_OIL_PRESSURE)	NORMAL	ALARM	10156
DI-222	ATOD 2 FAIL(CRANK_CASE_PRESSURE)	NORMAL	ALARM	10157
DI-223	ATOD 1 FAIL(COOLANT_TEMPERATURE)	NORMAL	ALARM	10158
DI-224	ATOD 0 FAIL(MANIFOLD_AIR_TEMP.)	NORMAL	ALARM	10159
DI-225	ATOD 15 FAIL (GROUND)	NORMAL	ALARM	10160
DI-226	ATOD 14 FAIL (-10 VREF MONITOR)	NORMAL	ALARM	10161
DI-227	ATOD 13 FAIL (+10 VREF MONITOR)	NORMAL	ALARM	10162

TABLE 6-8. THIRD PARTY MODBUS ADDRESS LIST (CONT'D)

		Description		Modbus
Tag Name	Tag Description	Open	Closed	Address
DI-228	ATOD 12 FAIL (+24 PSU MONITOR)	NORMAL	ALARM	10163
DI-229	ATOD 11 FAIL (-15 PSU MONITOR)	NORMAL	ALARM	10164
DI-230	ATOD 10 FAIL (+15 PSU MONITOR)	NORMAL	ALARM	10165
DI-231	ATOD 9 FAIL (+5 PSU MONITOR)	NORMAL	ALARM	10166
DI-232	ATOD 8 FAIL(PRESS.PSU MONITOR#3)	NORMAL	ALARM	10167
DI-233	FAILURE SHUTDOWN FAULT	NORMAL	ALARM	10168
DI-234	OVERSPEED FAULT	NORMAL	ALARM	10169
DI-235	CHECK ENGINE FAULT	NORMAL	ALARM	10170
DI-236	ATOD 20 FAIL(PRESS.PSU MONITOR#4	NORMAL	ALARM	10171
DI-237	ATOD 19 FAIL(MANIFOLD_AIR_PRESS)	NORMAL	ALARM	10172
DI-238	ATOD 18 FAIL(CPTMON)	NORMAL	ALARM	10173
DI-239	ATOD 17 FAIL(TEMPERATURE 4)	NORMAL	ALARM	10174
DI-240	ATOD 16 FAIL(LUBE OIL TEMP.)	NORMAL	ALARM	10175
DI-241	ATOD 31 FAIL(GNDA2)	NORMAL	ALARM	10176
DI-242	ATOD 30 (DGND)	NORMAL	ALARM	10177
DI-243	ATOD 29 (PGND)	NORMAL	ALARM	10178
DI-244	CRANK SENSOR 2 OUT OF PHASE	NORMAL	ALARM	10179
DI-245	CRANK SENSOR 1 OUT OF PHASE	NORMAL	ALARM	10180
DI-246	HIGH TEMPERATURE FAULT	NORMAL	ALARM	10181
DI-247	LOW COOLANT PRESSURE FAULT	NORMAL	ALARM	10182
DI-248	LOW OIL PRESSURE FAULT	NORMAL	ALARM	10183
DI-249	SPEED LIMIT CLAMP FAULT	NORMAL	ALARM	10184
DI-250	TORQUE LIMIT CLAMP FAULT	NORMAL	ALARM	10185
DI-251	INVALID ROTATION REQUEST FAULT	NORMAL	ALARM	10186
PAHH800	CRANKCASE OVER PRESSURE	NORMAL	ALARM	10187
DI-253	BIT FAULT	NORMAL	ALARM	10188
DI-254	CAM FAIL	NORMAL	ALARM	10189
DI-255	CRANK2 FAIL	NORMAL	ALARM	10190
DI-256	CRANK1 FAIL	NORMAL	ALARM	10191
DI-257	BIT TEST7 FAIL (PROGRAM PROM)	NORMAL	ALARM	10192
DI-258	BIT TEST6 FAIL (BOOT PROM)	NORMAL	ALARM	10193
DI-259	BIT TEST5 FAIL (INTERNAL RAM)	NORMAL	ALARM	10194
DI-260	BIT TEST4 FAIL (HIGH RAM)	NORMAL	ALARM	10195
DI-261	BIT TEST3 FAIL (LOW RAM)	NORMAL	ALARM	10196
DI-262	BIT TEST2 FAIL (CPU)	NORMAL	ALARM	10197
DI-263	BIT TEST1 FAIL(WATCHDOG MONITOR)	NORMAL	ALARM	10198
DI-264	SPARE	NORMAL	ALARM	10199
DI-265	SPARE	NORMAL	ALARM	10200
DI-266	MAP SURGE FAULT(SPARE GENSAT APP	NORMAL	ALARM	10201
DI-267	DISCRETE WRAP4 FAIL(HIGH TEMP)	NORMAL	ALARM	10202
DI-268	DISCRETE WRAP3 FAIL(LOW OIL)	NORMAL	ALARM	10203
DI-269	DISCRETE WRAP2 FAIL(LOW COOLANT)	NORMAL	ALARM	10204
DI-270	DISCRETE WRAP1 FAIL(CHECK_ENGIN)	NORMAL	ALARM	10205
DI-271	BIT TEST 9 FAIL(NVM ADJUSTMENTS)	NORMAL	ALARM	10206

TABLE 6-8. THIRD PARTY MODBUS ADDRESS LIST (CONT'D)

		Description		Modbus
Tag Name	Tag Description	Open	Closed	Address
DI-272	BIT TEST 8 FAIL(DATA PROM)	NORMAL	ALARM	10207
DI-273	CHECK ENGINE	NORMAL	ALARM	10208
DI-274	BOTH SPEED SENSORS FAILED	NORMAL	ALARM	10209
DI-275	MPU1 FAILED	NORMAL	ALARM	10210
DI-276	MPU2 FAILED	NORMAL	ALARM	10211
DI-277	EMERGENCY STOP	NORMAL	ALARM	10212
DI-278	REMOTE POWER REFERENCE FAILED	NORMAL	ALARM	10213
DI-279	REMOTE SPEED REFERENCE FAILED	NORMAL	ALARM	10214
DI-280	LINKNET COMM ERROR	NORMAL	ALARM	10215
DI-281	EGU OVERSPEED	NORMAL	ALARM	10216
DI-282	SRLC OVERSPEED	NORMAL	ALARM	10217
DI-283	PRELUBE INTERLOCK FAIL	NORMAL	ALARM	10218
DI-284	FUEL PUMP INTERLOCK FAIL	NORMAL	ALARM	10219
DI-285	EGU/SRLC SPEED MISMATCH	NORMAL	ALARM	10220
DI-286	BAROVER DOOR OPEN	NORMAL	ALARM	10221
DI-287	MAP INPUT FAILED	NORMAL	ALARM	10222
DI-288	MODBUS PORT 3 COMM ERROR	NORMAL	ALARM	10223
DI-289	MODBUS PORT 2 COMM ERROR	NORMAL	ALARM	10224
DI-290	HIGH INTERCOOLER TEMP	NORMAL	ALARM	10225
DI-291	HIGH OIL TEMP	NORMAL	ALARM	10226
DI-292	S/W VERSION MISMATCH	NORMAL	ALARM	10227
DI-293	SPARE	NORMAL	ALARM	10228
DI-294	SPARE	NORMAL	ALARM	10229
DI-295	SPARE	NORMAL	ALARM	10230
DI-296	SPARE	NORMAL	ALARM	10231
PdT410	LUB. OIL FILTER DIFFERENTIAL PR.	NORMAL	ALARM	10232
PS INTERLOCK	START INTERLOCK	NORMAL	INTERL	10233
LSH300	FUEL OIL LEAKAGE	ALARM	NORMAL	10234
SHUTDOWN	SHUTDOWN ACTIVE	NORMAL	SHUTDN	10235
XH800	OIL MIS IN CRANCASE	NORMAL	SHUTDN	10236
TAH100	COOLANT TEMPERATURE, EGU, AH	NORMAL	ALARM	10237
PAL100	COOLANT PRESSURE, EGU, AL	NORMAL	ALARM	10238
TAH400	LUBE OIL TEMPERATURE, EGU, AH	NORMAL	ALARM	10239
TAHH400	LUBE OIL TEMPERATURE, EGU, AHH	NORMAL	ALARM	10240
PAL400	LUBE OIL PRESSURE, EGU, AL	NORMAL	ALARM	10241
TAH500	MANIFOLD AIR TEMP., EGU, AH	NORMAL	ALARM	10242
PdAH310	FUEL OIL FILTER DIFF. PR., AH	NORMAL	ALARM	10243
PdAH310 IFL	FUEL OIL FILTER DIFF. PR., IFL	NORMAL	ALARM	10244
PdAH510	AIRFILTER DIFF. PR., AH	NORMAL	ALARM	10245
PdAH510 IFL	AIRFILTER DIFFERENTIAL PR., IFL	NORMAL	ALARM	10246
PAL700	START AIR PRESSURE, AL	NORMAL	ALARM	10247
PAL700 IFL	START AIR PRESSURE, IFL	NORMAL	ALARM	10248
TAHH101	HT WATER OUTLET, AHH	NORMAL	ALARM	10249
TAHH101 IFL	HT WATER OUTLET, IFL	NORMAL	ALARM	10250

TABLE 6-8. THIRD PARTY MODBUS ADDRESS LIST (CONT'D)

		Description		Modbus
Tag Name	Tag Description	Open	Closed	Address
PALL411	LUBE OIL PRESSURE, ALL	NORMAL	ALARM	10251
PALL411 IFL	LUBE OIL PR., IFL	NORMAL	ALARM	10252
TAH600	PRE-TURBINE LEFT BANK, AH	NORMAL	ALARM	10253
TAH601	EXH GAS TEMP CYLINDER 1L, AH	NORMAL	ALARM	10254
TAH602	EXH GAS TEMP CYLINDER 2L, AH	NORMAL	ALARM	10255
TAH603	EXH GAS TEMP CYLINDER 3L, AH	NORMAL	ALARM	10256
TAH604	EXH GAS TEMP CYLINDER 4L, AH	NORMAL	ALARM	10257
TAH605	EXH GAS TEMP CYLINDER 5L, AH	NORMAL	ALARM	10258
TAH606	EXH GAS TEMP CYLINDER 6L, AH	NORMAL	ALARM	10259
TAH607	EXH GAS TEMP CYLINDER 7L, AH	NORMAL	ALARM	10260
TAH608	EXH GAS TEMP CYLINDER 8L, AH	NORMAL	ALARM	10261
TAH610	PRE-TURBINE RIGHT BANK, AH	NORMAL	ALARM	10262
TAH611	EXH GAS TEMP CYLINDER 1R, AH	NORMAL	ALARM	10263
TAH612	EXH GAS TEMP CYLINDER 2R, AH	NORMAL	ALARM	10264
TAH613	EXH GAS TEMP CYLINDER 3R, AH	NORMAL	ALARM	10265
TAH614	EXH GAS TEMP CYLINDER 4R, AH	NORMAL	ALARM	10266
TAH615	EXH GAS TEMP CYLINDER 5R, AH	NORMAL	ALARM	10267
TAH616	EXH GAS TEMP CYLINDER 6R, AH	NORMAL	ALARM	10268
TAH617	EXH GAS TEMP CYLINDER 7R, AH	NORMAL	ALARM	10269
TAH618	EXH GAS TEMP CYLINDER 8R, AH	NORMAL	ALARM	10270
PSLL001	GEAR OIL PRESSURE LOW	NORMAL	SHUTDN	10271
EM STOP	EMERGENCY STOP	NORMAL	SHUTDN	10272
OVERSPEED EG	OVERSPEED FROM EGU	NORMAL	SHUTDN	10273
OVERSPEED W	OVERSPEED FROM WOODWARD	NORMAL	SHUTDN	10274
SHD 04	SPARE	NORMAL	SHUTDN	10275
LSL400	LUBE OIL SUMP LOW LEVEL	ALARM	NORMAL	10276
YI002	ENGINE IS RUNNING	STOP	RUN	10277
ZSL001	CLUTCH ENGAGED	ENGAGE	NOT	10278
HS005	SHUTDOWN OVERRIDE	NORMAL	ACTIVE	10279
OIL HT SYS	OIL PRESENCE INTO HT SYSTEM	ALARM	NORMAL	10280
LSL100	HT LEVEL LOW SWITCH	ALARM	NORMAL	10281
LSL200	LT LEVEL LOW SWITCH	ALARM	NORMAL	10282
TAH609	PRE-TURBINE RIGHT BANK BOTTO, AH	NORMAL	ALARM	10283
TAH619	PRE-TURBINE RIGHT BANK TOP, AH	NORMAL	ALARM	10284

6.3. PRE-LUBRICATING OIL PUMP WIRING

The Pre-Lubricating Oil Pump is available in various voltages as shown in **Table 6-9, Pre-Lubricating Oil Pump Power Requirements**.

TABLE 6-9. PRE-LUBRICATING OIL PUMP POWER REQUIREMENTS

Voltage	Power - HP	Full Load Amps	Service Factor
230	5.0	15.4	1.15
380	5.0	14.2	1.15
460	5.0	7.1	1.15

Customer-supplied materials for pre-lube pump wiring include:

- Control wiring from the V228 Engine Controller Terminal Board #2 (TB2) to the Motor Control Center (MCC)
- Wiring from the service power to the pre-lube pump terminal board
- Motor Control Center (MCC) including motor starter

6.3.1. Pre-Lubricating Oil Pump Wiring Installation Procedure

1. Install motor control center (MCC) wiring per Figure 6-2, Terminal Board #2 Connections.
2. Wire the pre-lubricating oil pump as shown in Figure 6-4, Pre-Lubricating Oil Pump Connections, to match the service power.
3. Run control wire from the V228 Engine Controller Terminal Board 2 (TB2) to the motor control center (MCC). Refer to Figure 6-2, Terminal Board #2 Connections for details.

6.4. AIR MOTOR STARTER WIRING

The GE V228 diesel engine uses an air starter to both start the engine and provide blow-down functionality. The engine ships from the factory with the air starter and air starter solenoid installed. A customer-supplied 30A contactor must be installed between the V228 Engine Controller and the engine-mounted solenoid.

Customer-supplied materials for air motor starter wiring include:

- 30-Amp Contactor
- Control wiring from the V228 Engine Controller Terminal Board #2 (TB2) to the contactor
- Wiring from the contactor to the air motor starter solenoid

6.4.1. Air Motor Starter Wiring Installation Procedure

1. Install the 30 Amp contactor.
2. Run control wiring from the V228 Engine Controller Terminal Board 2 (TB2) to the 30 Amp contactor. Refer to Figure 6-2, Terminal Board #2 Connections for details.
3. Run appropriate wiring between the 30 Amp contactor and the engine-mounted air motor starter solenoid. Solenoid is available in 24 VDC, 115 VDC and 240 VAC power versions.

6.5. LEAK DETECTION SYSTEM WIRING

GE V228 diesel engines include a leak detection system for the double walled fuel lines. This system provides a signal to the alarm system in the event of a high-pressure fuel line failure.

The customer is responsible for material and installation of wiring from the V228 Engine Controller Terminal Board 4 (TB4) to the alarm panel. Refer to Figure 6-5, Terminal Board #4 (TB4) Connections for details.

6.6. ENGINE SPEED CONTROL WIRING

The speed of the engine is determined by an incoming signal from the customer's genset control system. The signal is a +/-3V analog bias control (provided by the customer) to adjust the engine speed.

Customer-supplied materials for engine speed control wiring include:

- Appropriate length twisted pair control wire
- Genset control system

Installation Procedure:

Run the twisted pair control wire from genset control system to the V228 Engine Controller Terminal Board #1 (TB1) terminals 11 and 12. Refer to Figure 6-1, Terminal Board #1 Connections for details.

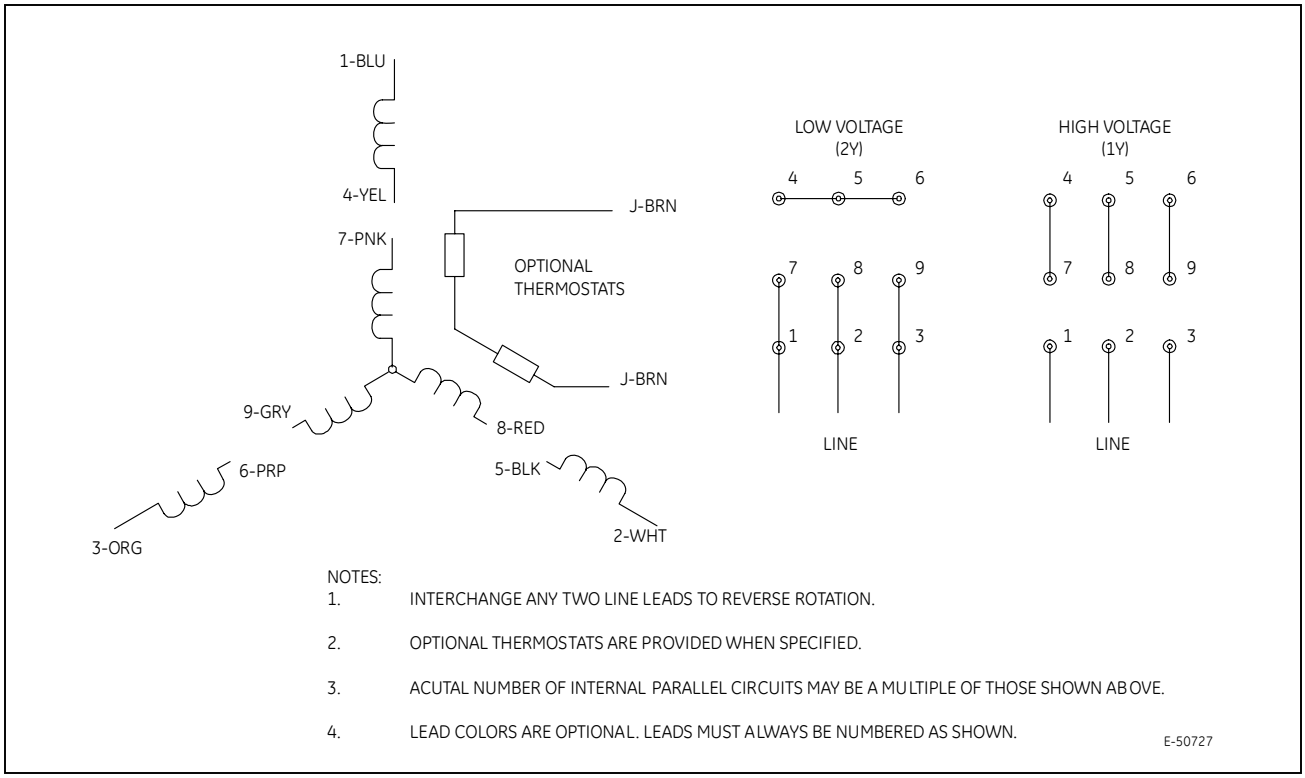


Figure 6-4. Pre-Lubricating Pump Connections.

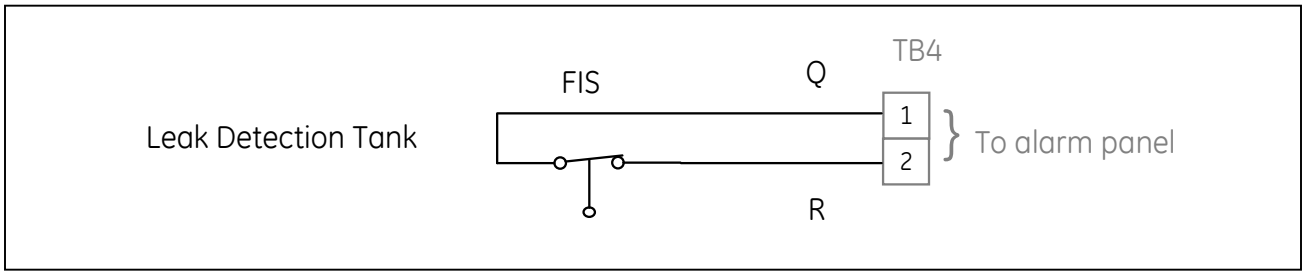


Figure 6-5. Terminal Board #4 (TB4) Connections.

6.7. ENGINE CONTROL PANEL INTERFACE WIRING

Control functionality is provided through the interface wiring between the Engine Control Panel (ECP) and the V228 Engine Controller. The Engine Control Panel and Gauge Panel may or may not be included in the GE scope of supply depending on the nature of the installation.

To maintain the electrical integrity of the Engine Control Panel and Gauge Panel, it is imperative that control voltage feeds as shown on Figures 6-1 and 6-2 are followed.

- 24 VDC control voltage for TB1 is provided from terminal 26 for inputs on TB1 terminals 7, 8, 9 and 10. The negative return for TB1 is provided on terminal 18.

- 24 VDC control voltage for TB2 is provided on terminals 1, 2, 3 and 4 for inputs on TB2 terminals 5 through 16.

Customer-supplied materials for engine control panel interface wiring include:

- Engine Control Panel and Gauge Panel (depending on scope of supply)
- All 24 VDC wiring, conduit and connectors from the Engine Control Panel and Gauge Panel to the V228 Engine Controller

Installation Procedure:

- Run 24 VDC wiring from engine control panel to the V228 Engine Controller TB1 and TB2. Refer to Figure 6-1, Terminal Board #1 Connections and Figure 6-2, Terminal Board #2 Connections for details. Refer to **Table 6-10, Engine Control Panel Functionality** for the type of signal required for each function.

TABLE 6-10. ENGINE CONTROL PANEL FUNCTIONALITY

Function	To	Comments
Emergency Stop	TB1-7, 26	Normally closed, open for emergency stop
Alarm Reset	TB1-8, 26	Normally open, close to reset
Stop	TB1-9, 26	Normally closed, open for normal stop
Blowdown	TB2-5, 4	Normally open, close to blow down engine
Pre-lube start	TB2-6, 4	Normally open, close to start pre-lube
Pre-lube stop	TB2-7, 4	Normally closed, open to stop pre-lube
Pre-lube by-pass	TB2-8, 4	Normally open, close to bypass pre-lube start cycle. Switch should be a timer.
Cold engine bypass	TB2-9, 4	Normally open, close to by-pass cold engine protection. Switch should be a timer.
Start	TB2-10, 4	Normally open, close to start
Speed increase	TB2-11, 4	Normally open, close to increase speed locally
Speed decrease	TB2-12, 4	Normally open, close to decrease speed locally
Local/remote	TB2-11, 12, 4	Open for local speed control – Control speed from speed increase & decrease. Close for remote speed control – Speed reference from 4 - 20 ma sensor.

6.8. ALARM AND MONITORING PANEL INTERFACE WIRING

Alarm and monitoring functionality is provided through the interface wiring between the Alarm and Monitoring Panel and the GE V228 Engine Controller. The Alarm and Monitoring Panel may or may not be included in the GE scope of supply, depending on the nature of the installation.

NOTE: The features listed in Table 6-11, Alarm and Monitoring Panel Functionality, are part of the V228 Engine Controller and may need to be duplicated as part of the AMS System for certain regulating agency requirements.

To maintain the electrical integrity of the Alarm and Monitoring Panel, it is imperative that control voltage feeds as shown on Figure 6-1 are followed.

- 24 VDC control voltage for TB1 is provided from terminal 26 for inputs on TB1 terminals 7, 8, 9 and 10. The negative return for TB1 is provided on terminal 18.

Customer-supplied materials for Alarm and Monitoring Panel interface wiring include:

- Alarm and Monitoring Panel (depending on scope of supply)

- All 24 VDC wiring, conduit and connectors from the Alarm and Monitoring Panel to the V228 Engine Controller

Installation Procedure:

- Run 24 VDC wiring from the alarm and monitoring panel to the V228 Engine Controller TB1. Refer to Figure 6-1, Terminal Board #1 Connections for details. Refer to **Table 6-11, Alarm and Monitoring Panel Functionality** for a description of signal required for each function.

TABLE 6-11. ALARM AND MONITORING PANEL FUNCTIONALITY

Function	To	Comments
24 VDC	TB1-18	Output to lamps.
% of engine capacity available before limits	TB1-16, 17	4 - 20 ma output.
Ready to run	TB1-19	24 VDC on when pre-lube cycle is complete and run permissive is applied.
Load limit	TB1-20	24 VDC on when engine has reached an internally set limit such as smoke. Returns to 0 VDC when engine loading goes below threshold.
Speed limit	TB1-21	24 VDC on when engine speed is greater than 1070 rpm. Returns to 0 VDC when engine loading goes below threshold.
Low lube oil pressure	TB1-22	0 VDC when lube oil pressure is below preset value as a function of speed. Returns to 24 VDC when lube oil pressure goes back above preset value as a function of speed.
Low engine water pressure	TB1-23	0 VDC when engine water pressure is below preset value as a function of speed. Returns to 24 VDC when engine water pressure goes back above preset value as a function of speed.
Intercooler over temperature	TB1-24	0 VDC when either engine water temperature or manifold air temperature is high. Returns to 24 VDC when either engine water temperature or manifold air temperature go back below preset threshold.
Overspeed	TB1-25	0 VDC when The V228 Engine Controller has detected an over-speed. Returns to 24 VDC only after 24 VDC is put on alarm reset on TB1-8.
Overspeed II	TB1-27	0 VDC when The V228 Engine Controller has detected an over-speed. Returns to 24 VDC only after 24 VDC is put on alarm reset on TB1-8.
Built-In test fault	TB1-28	0 VDC when the EGU has failed a built in test. Returns to 24 VDC only after 24 VDC is put on alarm reset on TB1-8.
Crankcase over pressure	TB1-29	0 VDC when crankcase pressure has exceeded the predetermined limit. Returns to 24 VDC only after 24 VDC is put on alarm reset on TB1-8.
Low lube oil temperature	TB1-30	0 VDC when LOT is below 60°C (140°F).
Lube oil temperature warning	TB1-31	0 VDC when LOT is above 104°C (220°F).
Lube oil temperature alarm0 VDC when LOT is above 104°C (220°F).	TB1-32	0 VDC when LOT goes above 116°C (240°F). Signal stays at 0 VDC until 24 VDC is put on alarm reset on TB1-8.
System OK	TB1-33	24 VDC steady on when no trip faults have occurred. 24 VDC on flashing when any of the following warnings has been occurred: low lube oil pressure, low engine water pressure, intercooler over temperature, lube oil temperature warning, LOT > 104°C (220°F) 24 VDC steady off when a trip fault has occurred. Trip faults are defaulted as SRLC overspeed, EGU overspeed, EGU BIT fault, Crankcase overpressure, lube oil temperature > 116°C (240°F).
Engine Speed	NA	Two additional sensors are provided on the engine to enable local display of speed. The sensor is magnetic type and pulses for each tooth on the ring gear. There are 318 pulses per revolution of the crankshaft.
Engine Hours	NA	Engine hours can be counted by beginning the count as soon as there is oil pressure, and stopping when there is no oil pressure.

6.9. OIL AND COOLANT PRE-HEATING SYSTEM REQUIREMENTS

The oil and coolant heating system heats the engine coolant and lubrication oil while the engine is shut down to prevent freezing and enhance the engine's cold starting ability. This oil and coolant heating system consists of all the necessary components required to heat the engine while it is shut down. The system components are mounted in the engine room or accessory rack (if supplied) and should be appropriately piped by the customer upon installation in the application. The system should have the proper flow switches and thermostats to permit automatic operation. **Refer to Table 6-12, Standard Oil and Coolant Heating System Data** and **Table 6-13, Standard Lubrication Oil Only Heating System Data** for information on these systems.

TABLE 6-12. STANDARD OIL AND COOLANT HEATING SYSTEM DATA

Model Number	Coolant kW	Oil kW	Volts	Hertz	Amps	Phase	Coolant HP/m^3/hr (GPM)	Oil HP/ m^3/hr (GPM)
COL1110/0902	11	9	240	60	95.2	1	0.75 / 9.1 (40)	2 / 3.6 (16)
COL1110/0902-5	11	9	240	50	95.2	1	0.75 / 7.5 (33)	2 / 3.0 (13)
COL3240/0903-5	24	9	380	50	58.7	3	0.75 / 7.5 (33)	2 / 3.0 (13)
COL3240/0904	24	9	480	60	47.8	3	0.75 / 9.1 (40)	2 / 3.6 (16)
COL3180/0908	18	9	208	60	74.9	3	0.75 / 9.1 (40)	2 / 2.6 (16)

TABLE 6-13. STANDARD LUBRICATION OIL ONLY HEATING SYSTEM DATA

Model Number	Oil kW	Volts	Hertz	Amps	Phase	Oil HP/ m^3/hr (GPM)
OWT30903-5	9	380	50	19.6	3	2 / 3.0 (13)
OWT30904	9	480	60	16.6	3	2 / 3.6 (16)

6.10. EXHAUST THERMOCOUPLE WIRING

Conduit tray-connected exhaust temperature thermocouples are installed on the engine and wired to terminal boards in the conduit tray on top of the engine. There is one sensor per cylinder and one sensor for the overall pre-turbine temperature. The thermocouples are type K. This system is independent of the V228 Engine Controller and is available for local display of temperatures. To read the temperatures, wiring must be run from the terminal boards in the conduit tray to a thermocouple reader.

Customer-supplied materials:

- Thermocouple wiring (AlumEL or CHRomEL type) from terminal boards on engine to thermocouple readout
- Ring terminals for #8-32 studs
- Thermocouple readout

6.10.1. Exhaust Thermocouple Wiring Installation Procedure (Early Production Only)

1. Run type K thermocouple wire, using ring terminals for #8-32 studs, to the thermocouple readout according to **Table 6-14, Thermocouple Wire Schedule**.
2. Connect the red wire from the thermocouple readout to the terminal that has the red wire from the respective cylinder thermocouple.
3. Connect the yellow wire from the thermocouple readout to the terminal that has the yellow wire from the respective cylinder thermocouple.

TABLE 6-14. THERMOCOUPLE WIRE SCHEDULE

Wire-way Terminal Board	Wire Color	Cylinder
TBB1 1	Red	
TBB1 4	Yellow	Pre-turbine left
TBB1 6	Yellow	
TBB1 7	Red	Pre-turbine right
TTB1 2	Red	
TTB1 3	Yellow	1 left
TTB1 5	Yellow	
TTB1 8	Red	1 right
TTB8 2	Red	
TTB8 3	Yellow	2 left
TTB8 5	Yellow	
TTB8 8	Red	2 right
TTB8 2	Red	
TTB8 3	Yellow	3 left
TTB8 5	Yellow	
TTB8 8	Red	3 right
TTB8 2	Red	
TTB8 3	Yellow	4 left
TTB8 5	Yellow	
TTB8 8	Red	4 right
TTB8 2	Red	
TTB8 3	Yellow	5 left
TTB8 5	Yellow	
TTB8 8	Red	5 right
TTB8 2	Red	
TTB8 3	Yellow	6 left
TTB8 5	Yellow	
TTB8 8	Red	6 right
TTB8 2	Red	
TTB8 3	Yellow	7 left
TTB8 5	Yellow	
TTB8 8	Red	7 right
TTB8 2	Red	
TTB8 3	Yellow	8 left
TTB8 5	Yellow	
TTB8 8	Red	8 right

6.10.2. Exhaust Thermocouple Wireway Assembly (Late Production Only)

An anodized aluminized wireway assembly is used in late production. This assembly is prewired with connectors and thermocouple sensors that mate to the wireway.

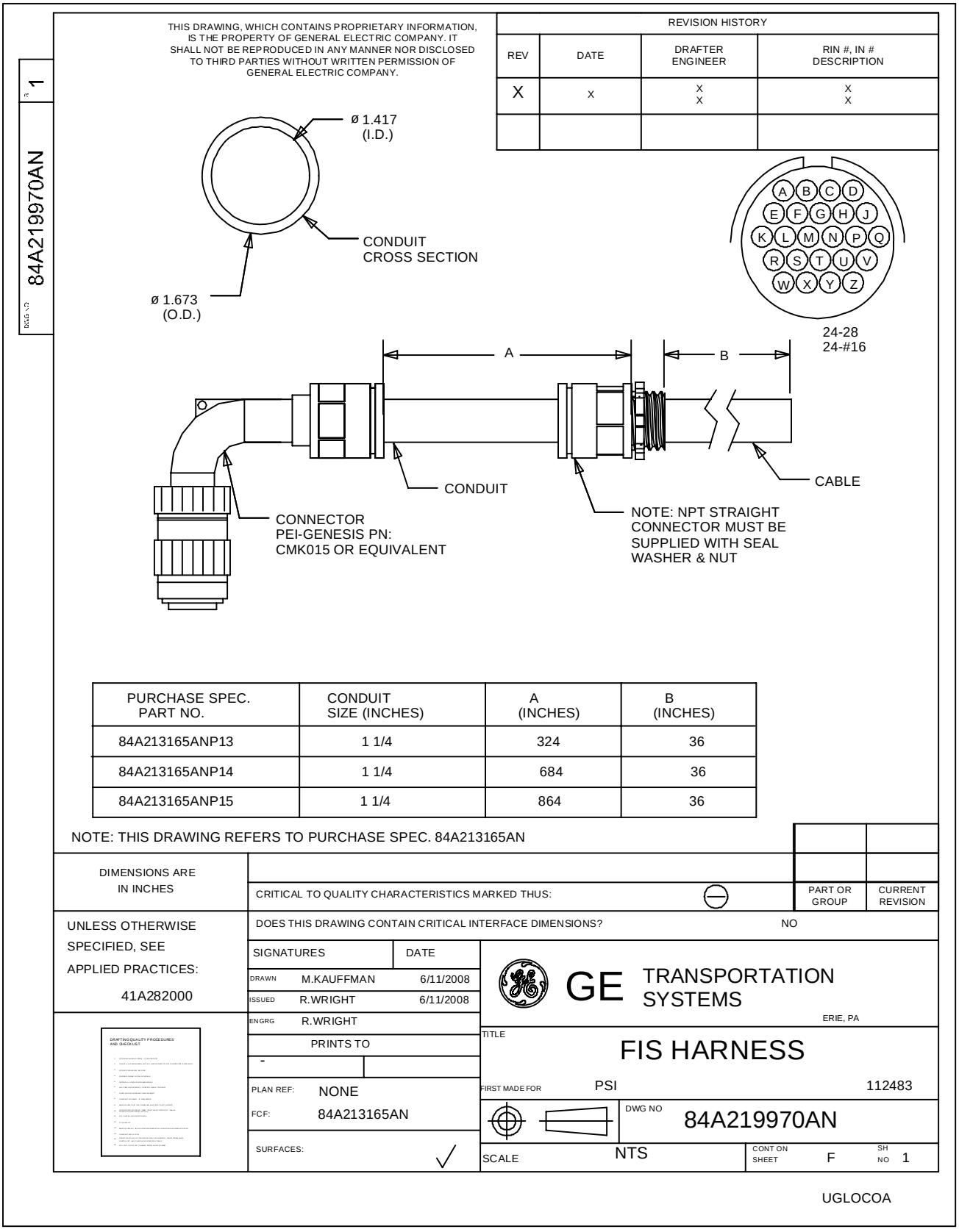


Figure 6-6. FIS Harness, 84A213165ANP14. (84A219970AN)

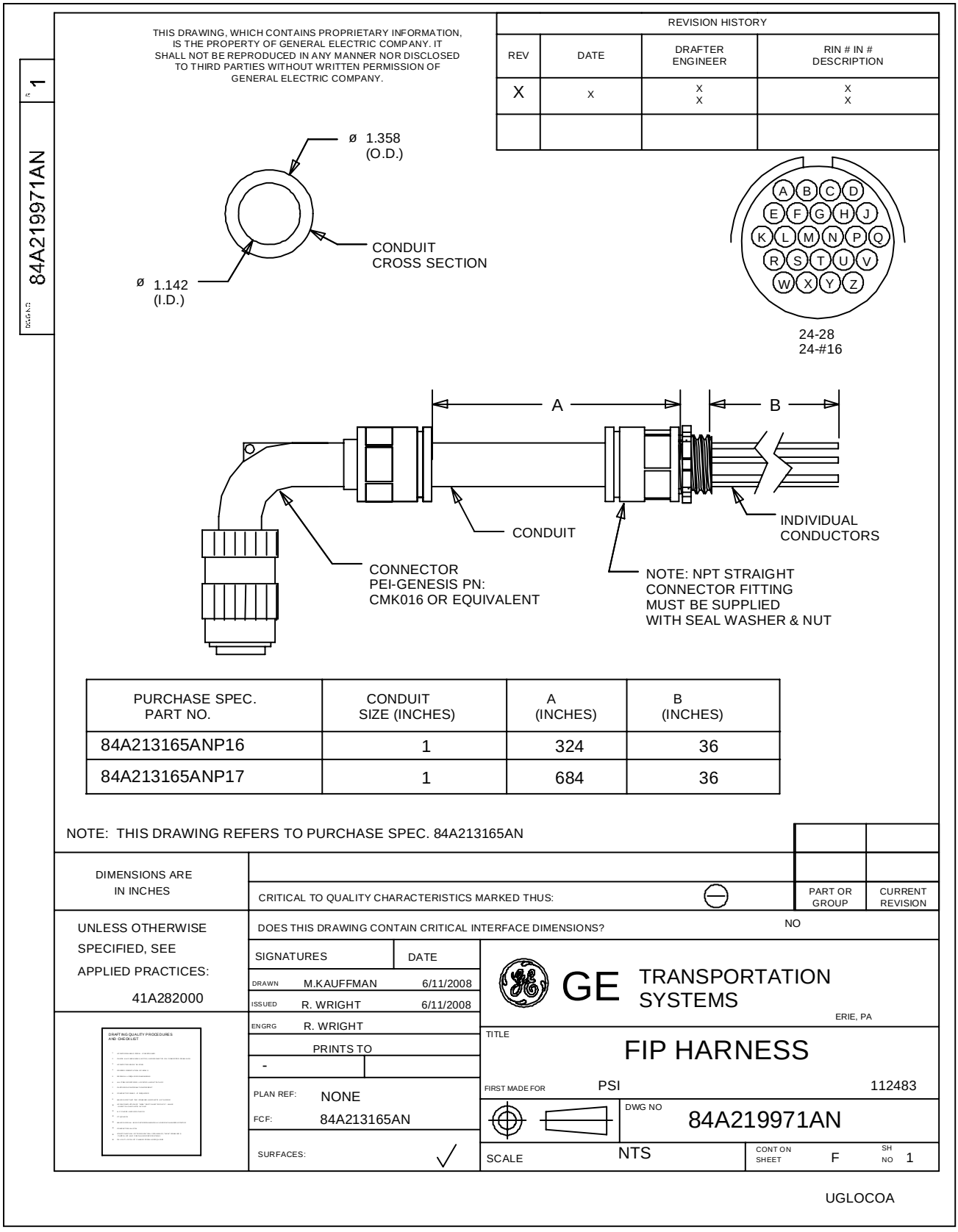


Figure 6-7. FIP Harness, 84A213165ANP17. (84A219971AN)

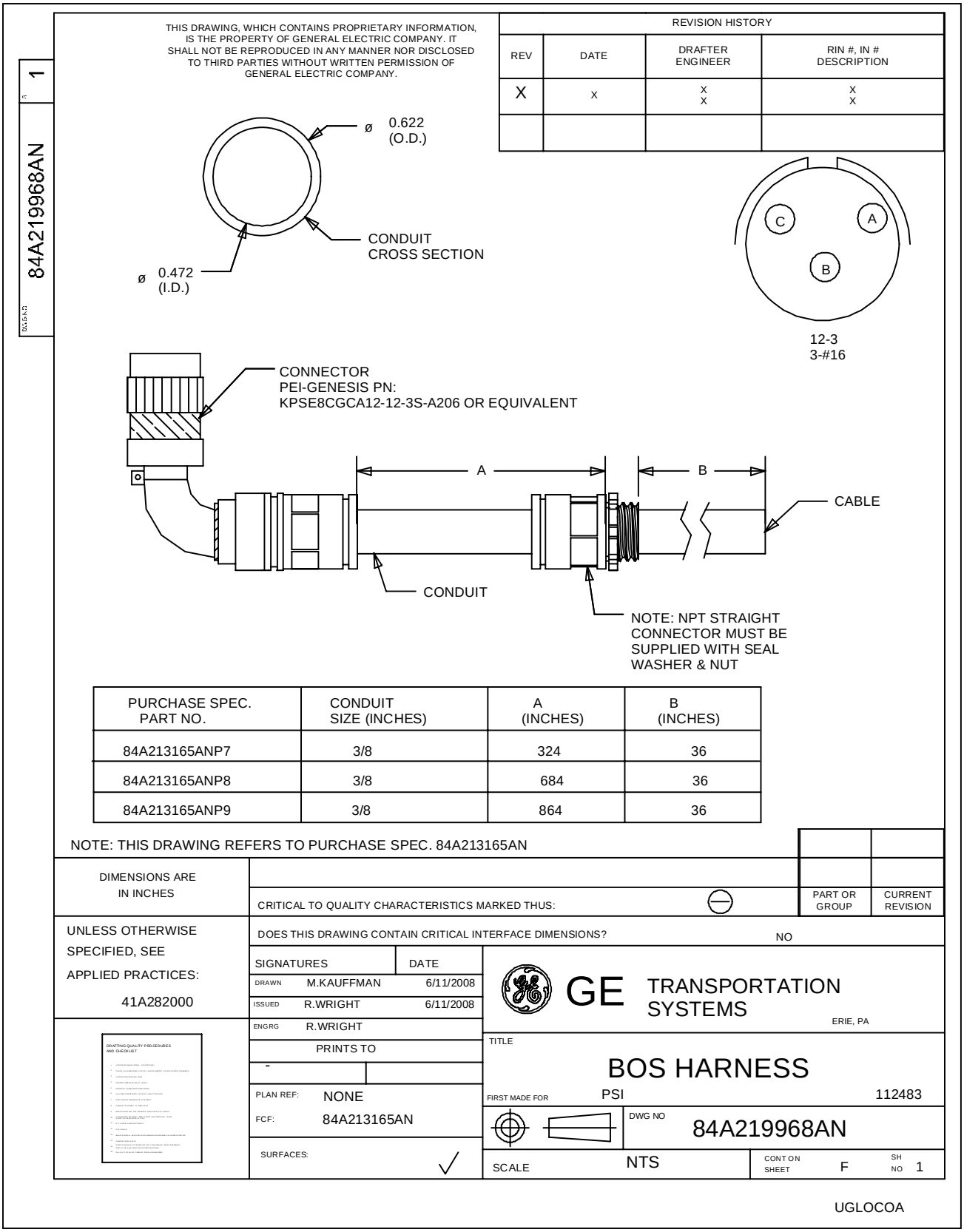


Figure 6-8. BOS Harness, 84A213165ANP8. (84A219968AN)

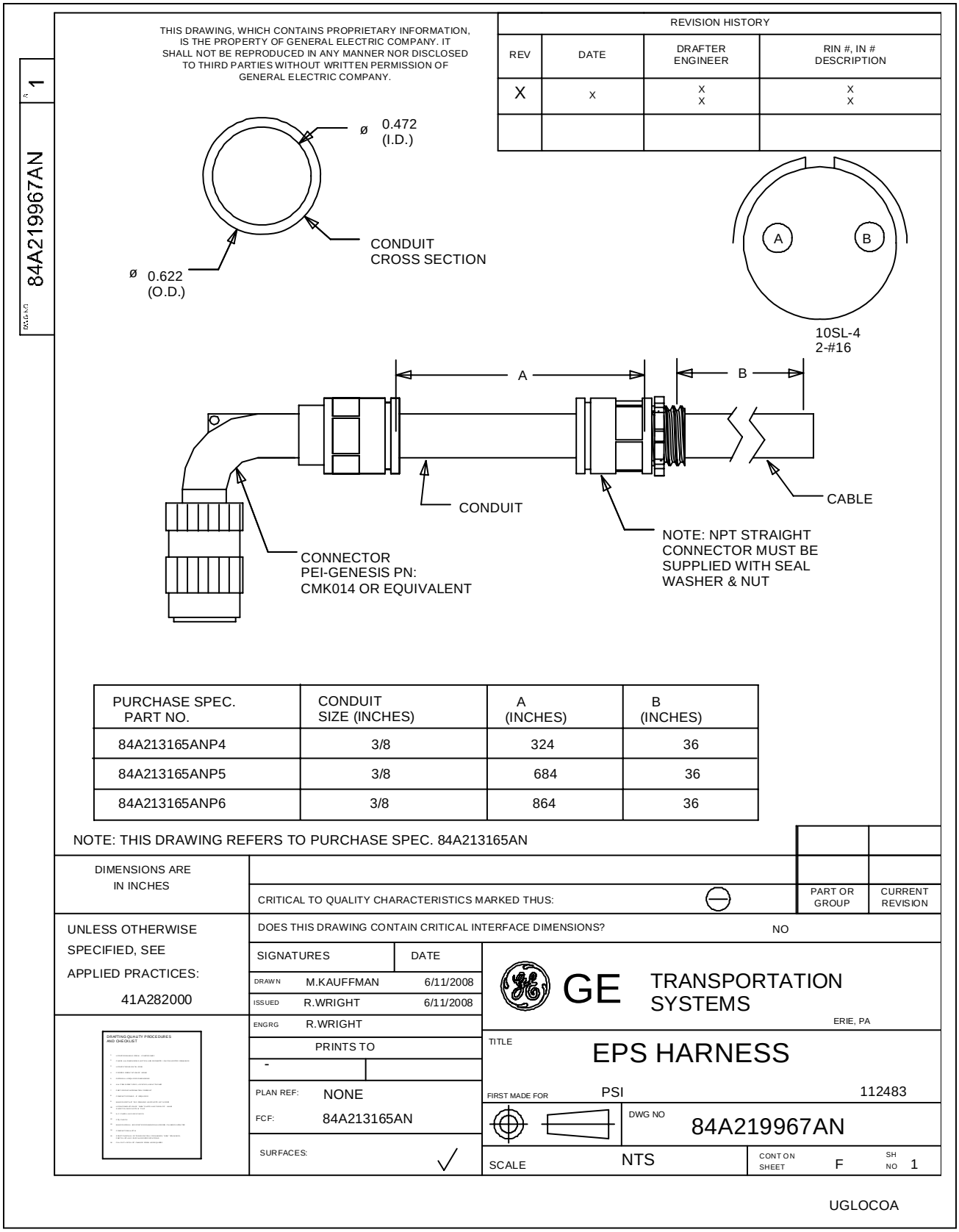


Figure 6-9. EPS Harness, 84A213165ANP5. (84A219967AN)

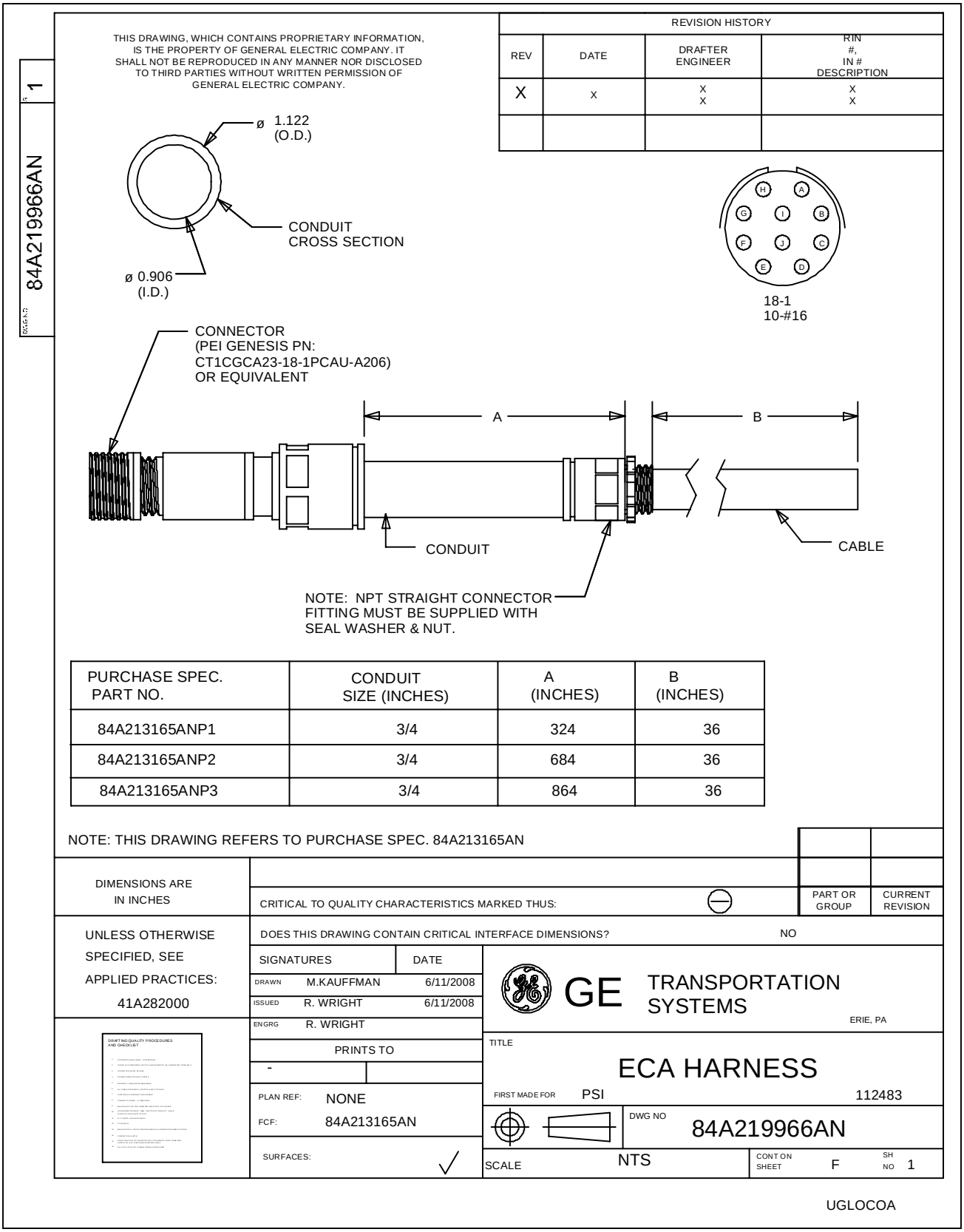


Figure 6-10. ECA Harness, 84A213165ANP2. (84A219966AN)

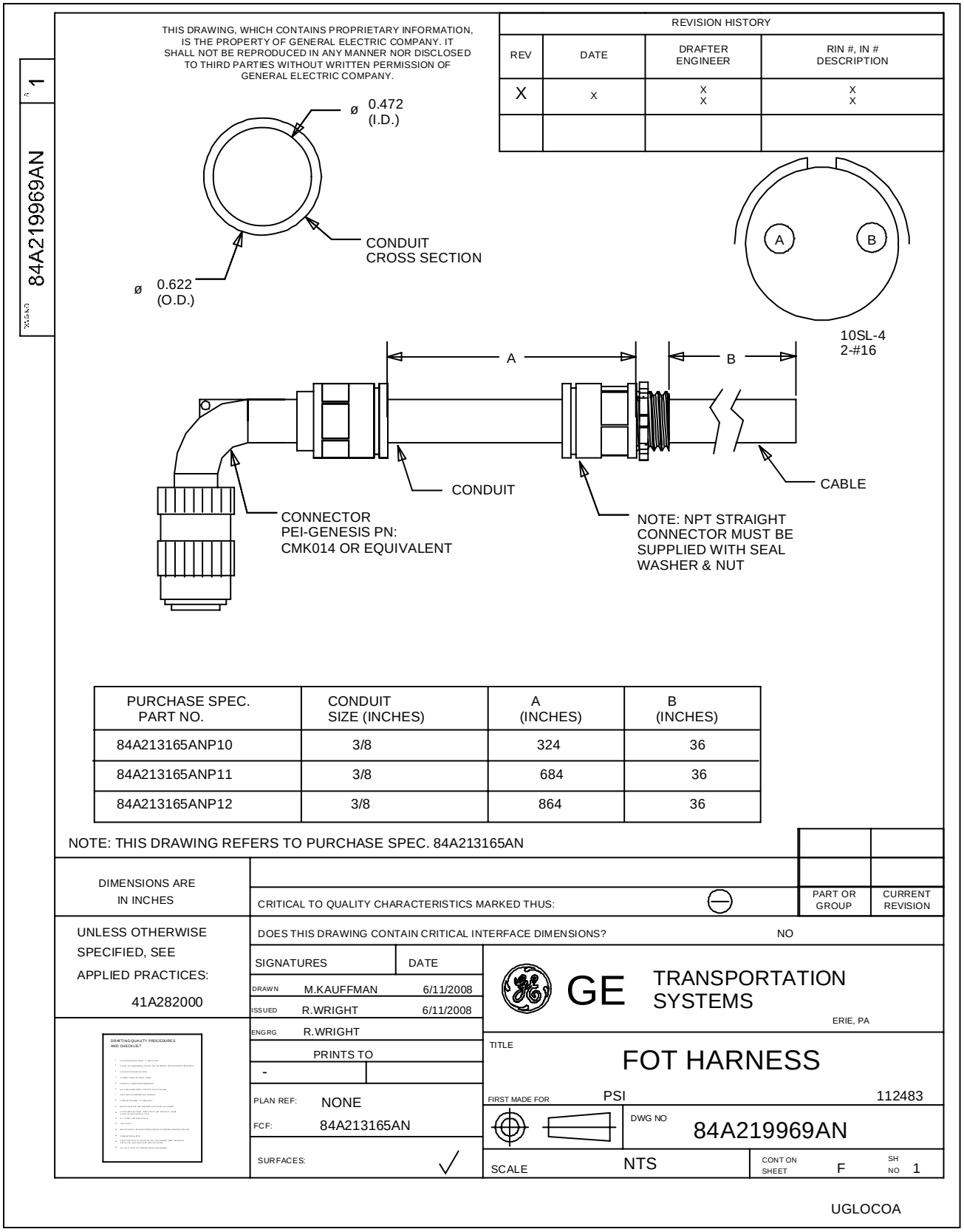


Figure 6-11. FOT Harness, 84A213165ANP11. (84A219969AN)

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TABLE 6-15. INSTRUMENT LIST FOR MARINSA/CHEOY LEE/PANAMA CANAL (FAR 1417, GE 12V228)

Project	**FAR 1417**
Hull	**Panama Canal Tugs**
Classification	**Lloyd's Register of Shipping (LRS)**
Customer SDIS Name	**Marinsa Miami Corp.**

GE Transportation Systems

Sensor Tag	Alarm Tag	Description of the Measured Process	Measure Range Min.	Measure Range Max.	Output (Input)	Trip Set Point	Function	MOS Display	Termination Point	Port Engine	Stbd. Engine
1xx - HT Jacket Water (JW) COOLING SYSTEM											
TT100 (ex EWT)	TAH100	Engine water inlet temperature	-40°C	125°C	Thermistor	> 93°C	Warning	Yes	PS-TB2 (51/52)	OK	OK
TT101	TAHH101	Engine water outlet temperature (TT100 back up sensor to suit Class requirements, e.g. RINA/ABS etc.)	0°C	100°C	PT 100 = 0..100°C	> 100°C	**Slow down** request	Yes	KM – DP4 (92/93/94)	OK	OK
PT100 (ex EWP)	PAL100	Engine water pressure	0	3.4 bar 50 psi	4..20 mA = 0..3,4 bar (50 psig)	Dynamic, from PS dataset	Warning	Yes	PS-TB2 (41/42)	OK	OK
2xx - LT Aftercooler (AC) COOLING SYSTEM											
TT200	--	Intercooler water temperature	Not used							N/A	
3xx - FUEL OIL											
LSH300	LAH300	Fuel oil leak detection	OFF	ON	Digital switch	0V =Leak detect, 24V = OK	Warning	Yes	KM – DPU 4 (82/84)	OK	OK
dPT310	dPAH310	Fuel oil differential pressure across the filter	0	2 barg, 30 psi	4..20 mA (0..2 barg)	> 0.6 barg	Warning	Yes	KM – DPU 4 (31/32)	OK	OK
PT310	N/A	Fuel oil pressure	0	10 barg, 150 psi	4..20 mA (0..10 barg)	N/A	Monitor, pressure	Yes	KM – DPU 4 (11/12)	OK	OK
TT310	N/A	Fuel oil temperature	-40°C	125°C	Thermistor	N/A	Monitor, temperature	Yes	PS-TB2 (43/44)	--	--
SV300	N/A	Fuel oil shut-off valve (N.O.)	OFF	ON	24VDC	N/A	**Shutdown**, redundant	Yes	KM – DPU 1 (51/52)	--	--
4xx - LUBE OIL											
TT400 (ex LOT)	TAH400	Engine lube oil inlet temperature	-40°C	125°C	Thermistor	> 104°C (220°F)	Warning	Yes	PS-TB2 (24/25)	OK	OK
	TAHH400					> 115°C (230°F)	**Slow down** request	Yes		OK	OK
PT400 (ex LOP)	PAL400	Lube oil pressure	0	10 bar 150 psi	4..20 mA = 0..3,4 bar (50 psig)	Dynamic, from PS dataset	Warning	Yes	PS-TB2 (38/39)	OK	OK
dPT410	dPAH410	Lube oil differential pressure across the filter	OFF	ON	Digital switch	24V = Leak detect 0V = OK	Warning, filter restriction	Yes	KM – DPU 4 (22/24)	OK	OK
PT411	PALL411	Lube oil pressure (PT400 backup sensor to suit Class requirements; e.g., RINA/ABS, etc.	N/A	N/A	4..20 mA -> 0..10 barg	Dynamic, from PS dataset	**Shutdown**, low lube pressure	Yes	KM – DPU 4 (101/102)	--	--
LSL400	--	Lube oil sump low level	Not used						--	N/A	N/A
5xx - COMBUSTION AIR											
TT500 (ex MAT)	TAH500	Manifold air temperature	-40°C	125°C	Thermistor	>104°C (220°F)	Warning	Yes	PS-TB2 (49/50)	OK	OK
PT500 (ex MAP)	N/A	Manifold air pressure	0	5 barg 75 psig	4..20 mA -> 0..5 bar (75 psi)	N/A	Monitor, pressure	Yes	PS-TB2 (13/14)	--	--
dPT510	dPAH510	Air filter differential pressure across the filter	0	100 mbarg 1.4 psi	4..20 mA -> 0..100 mbar	> 33 mbar (vacuum)	Warning, filter restriction	Yes	KM – DPU 4 (41/42)	OK	OK

TABLE 6-15. INSTRUMENT LIST FOR MARINSA/CHEOY LEE/PANAMA CANAL (FAR 1417, GE 12V228) (CONT'D)

6xx - EXHAUST SYSTEM											
TT600	TAH600	**Exhaust gas – left pre-turbine**	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 2 (43/44)	OK	OK
TT601	TAH601	Exhaust gas temperature cyl. 1L	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 2 (25/26)	OK	OK
TT602	TAH602	Exhaust gas temperature cyl. 2L	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 2 (27/28)	OK	OK
TT603	TAH603	Exhaust gas temperature cyl. 3L	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 2 (29/30)	OK	OK
TT604	TAH604	Exhaust gas temperature cyl. 4L	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 2 (31/32)	OK	OK
TT605	TAH605	Exhaust gas temperature cyl. 5L	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 2 (35/36)	OK	OK
TT606	TAH606	Exhaust gas temperature cyl. 6L	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 2 (37/38)	OK	OK
TT610	TAH610	**Exhaust gas – right pre-turbine**	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 3 (23/24)	OK	OK
TT611	TAH611	Exhaust gas temperature cyl. 1R	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 3 (2/3)	OK	OK
TT612	TAH612	Exhaust gas temperature cyl. 2R	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 3 (7/8)	OK	OK
TT613	TAH613	Exhaust gas temperature cyl. 3R	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 3 (9/10)	OK	OK
TT614	TAH614	Exhaust gas temperature cyl. 4R	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 3 (11/12)	OK	OK
TT615	TAH615	Exhaust gas temperature cyl. 5R	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 3 (13/14)	OK	OK
TT616	TAH616	Exhaust gas temperature cyl. 6R	0	800°C	T/C type K	>640°C (1184°F)	Warning	Yes	KM – DPU 3 (15/16)	OK	OK
7xx - STARTING AIR											
PT700	PAL700	Starting pressure indicator	0	30 bar	4..20 mA -> 0..30 barg	< 5 barg	Warning	Yes	KM – DPU 4 (51/52)	OK	OK
SV700	N/A	Starting solenoid valve (NC)	N/A	N/A	24 VDC	N/A	Engine starting	No	KM relay K2	OK	OK
8xx - CRANKCASE and SPEED DETECTION											
SS800 (ex CNK1)	N/A	Crankshaft speed #1	N/A	N/A	MPU	> 1150 rpm	**Shutdown**, EGU overspeed	Yes	PS-TB2 (26/27/28 shld)	OK	OK
SS801 (ex CNK2)	N/A	Crankshaft speed #2	N/A	N/A	MPU	> 1150 rpm	**Shutdown**, EGU overspeed	Yes	PS-TB2 (32/33/34 shld)	OK	OK
SS810 (ex EPS)	N/A	Cam gear pin speed pickup	N/A	N/A	MPU	N/A	Monitor, engine position	No	PS-TB2 (29/30/31 shld)	OK	OK
SS811 (ex DSS1)	SH811	Cam gear speed sensor #1	N/A	N/A	MPU	> 1150 RPM	**Shutdown**, SLRC overspeed	Yes	PS-TB1 (1/2/3 shld)	OK	OK
SS812 (ex DSS2)	SH812	Cam gear speed sensor #2	N/A	N/A	MPU	> 1150 RPM	**Shutdown**, SLRC overspeed	Yes	PS-TB1 (4/5/6 shld)	OK	OK
ZS800 (BOS)	N/A	Limit switch, barring over engaged	OFF	ON	Digital switch	0V = Cranking is not allowed	Warning during run, disallow an engine start	No	PS-TB2 (3/13 shld)	OK	OK
PT800 (ex COP)	PAH800	Crankcase overpressure	-68 mbar - 1 psi	68 mbar 1 psi	4 mA = -68 mbar 20 mA = +68 mbar	> 0 mbar, Warning	**Shutdown** +2 in 10 sec, +10 in 0.5 sec	Yes	PS-TB2 (35/36/37 shld)	OK	OK
XH800	XA800	Oil mist detector	OFF	ON	Digital switch	0V = Mist detect, 24V = OK	**Shutdown**	Yes	KM – DPU 1 (5/6)	OK	OK

NOTES:

A *Refer to the Kongberg local control panel Connection Arrangement Document.*
B *For the sensor location, refer to project drawing.*
C *For full PowerStar description, refer to GEJ-6849 (GE PowerStar EFI control system).*
D *Refer to PowerStar wiring diagram 84A213165AJ.*

KM	*Kongsberg Maritime panel*
PS	*PowerStar panel*
DPU	*Distributed processing unit – from KM*

7. ACCESSORY RACK

NOTE: Marinsa Miami Corp./Cheoy Lee/Panama Canal (ACP) does not use the GE Accessory Rack. For information on GE Accessory Racks, contact your GE representative.

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8. FOUNDATION INSTALLATION AND ENGINE MOUNTING

The GE V228 diesel engine can be flexibly mounted on rubber elements, or rigidly mounted on the foundation. Contact a GE representative for information pertaining to mounting the engine on rubber elements or with steel chocks.

The foundation must be as stiff as possible in all directions to absorb the dynamic forces caused by the engine, among others. The foundation for the propeller thrust bearing (reduction gear) especially, must be designed so that harmful deformations are avoided.

NOTE: All marine applications require that a Torsional Vibration Analysis (TVA) of the propulsion system be performed. This is best performed during the design stage, prior to purchase of equipment, in order to allow for design modifications if the TVA shows any potential problems and to facilitate timely selection/approval of primary drive and couplings. The TVA can be performed by GE or by the customer, however, customer performed analyses must be submitted to GE for review and approval.

Use the information in this section along with GE drawing **84E903167G1** (included as Figure 8-1, foldout drawing at the end of this section) to mount the engine in the vessel.

8.1. MOUNT AND BASE PREPARATION

The foundation will ultimately be required to accept boltholes per Figure 8-1 (foldout at the end of this section).

1. Back the center studs on the mounts out by hand until they stop against the upper clearance limit inside the mount.
2. Remove the nut and washer from the top of the center stud.
3. Tighten the height adjuster all the way down and rotate back approximately two full turns.

NOTE: The tapped holes in the foundation may also use the metric equivalent thread (M27 x 3.0 x 80 mm). Grade 12.9 hardware should be selected. The foundation may also use thru holes with nuts rather than tapped holes.

Lateral adjustments to the engine position should be made by shifting the mount base. Elastomer (rubber) sections should not be painted. Solvent, oil, and fuel exposure should be limited to splash contact only. Continuous exposure should be avoided. Mount type approval (certification number): LRS [04/00001 (E1)], ABS (GE 615383), BV (14664/AO), DNV (M-10427).

NOTE: All item references in parentheses refer to Figure 8-1 (foldout at the end of this section) unless otherwise noted.

8.2. FREE-END PLATE INSTALLATION

1. Using an appropriate lifting device, install the plate (Item 2) to one side of the free-end. Install the bolt, washer and Loctite (Items 4, 5, and 13) to the plate from the bottom up and torque to 124 Nm (100 lb.-ft.)
2. At the same position, install a 1-1/4 bolt (Item 12) from the top with a washer, spacer, and Loctite (Items 8, 9, and 13). Torque bolt to 610-680 Nm (450-500 lb.-ft.).
3. Apply a final torque of 610-680 Nm (450-500 lb.-ft.) to the upward facing bolt (Item 4).
4. Repeat steps 1 thru 3 for the opposite side of the free-end.

8.3. DRIVE-END PLATE INSTALLATION

1. Using an appropriate lifting device, install a plate (Item 3) to one side of the drive-end. Install a bolt, washer and Loctite (Items 4, 5, and 13) to the plate from the bottom up and torque to 125 Nm (100 lb.-ft.).
2. At the same position, install two bolts, washers and Loctite (Items 7,8, and 13). Torque these bolts to 610-680 Nm (450-500 lb.-ft.)
3. Apply a final torque of 610-680 Nm (450-500 lb.-ft.) to the upward facing bolt (Item 4).
4. Repeat steps 1 thru 3 for the opposite side of the drive-end.

8.4. ENGINE MOUNTING

1. With the full engine weight on the mounts and initial settling accounted for, align the driven equipment with the rear of the engine.
   - Use the height adjustments to position the engine vertically.
   - There should be less than 2 mm difference in height between the two mounts on either side, at the same location. If not, the weight may be unevenly distributed.
2. Mark the location of the conical mount base holes on the foundation for drilling and tapping of the 1"-8 threaded holes as shown in Figure 8-1.
3. Drill and tap holes in the foundation, or apply nuts and washers with thread locking compound.
4. Reset the engine over the drilled and tapped hole, and install the bolts (Item 10) and washers (Item 11), then torque them to 1000-1060 Nm (738-782 lb.-ft.).
4. Tighten the center stud in the mount down until it bottoms out, then back off two complete turns.
5. Install the nuts and washers to the top of the mounting studs and, while holding the center stud, tighten the nut to 2970-3010 Nm (2192-2221 lb.-ft.).
6. After initial running in up to engine temperature and cool down, loosen the top nut on each stud and repeat steps 4 and 5.
7. Recheck the engine alignment to the drive system after completing the above steps.

NOTE: Shipyard alignment procedures must be submitted to GE for review and approval prior to the alignment taking place. Refer to SECTION 4.3, ENGINE ALIGNMENT AND THERMAL DYNAMICS for additional information.

8.5. ENGINE MOUNTING DRAWING AND PARTS LIST

Refer to Figure 8-1 (GE drawing 84E903167G1, foldout at the end of this section) for reference when performing engine mounting. **Table 8-1, 84E903167G1 Parts List,** provides identification for parts called out on the drawing.

TABLE 8-1. 84E903167G1 PARTS LIST*

Item	Identification	Description	Quantity
1	84C608852P1	Mounting Block Resilient (45)	2
2	84A220503P1	Mounting Plate Rear	2
3	84A220502P1	Mounting Plate Front	2
4	41A214127P6	Bolt	4
5	41B537660P21	Hardened Washer, 1”-24 x 2” PLT	4
7	N14P45064	Bolt, Hex 1.25 – 7 x 4.00	4
8	41B537660P22	Hardened Washer, 1-1/4	6
9	84A218666P1	Spacer	2
10	N733P39056	Bolt 1 – 8 x 3.50	16
11	41B537660P21	Hardened Washer, 1”-24 x 2” PLT	16
12	N14P45088	Bolt, Hex Grade 8, 1.25 –7 x 5.50	2
13	497A806P122	Loctite #243 Treadlock	As Required
14	84C608852P3	Mounting Block Resilient (65)	2

**All dimensions given in inches.*

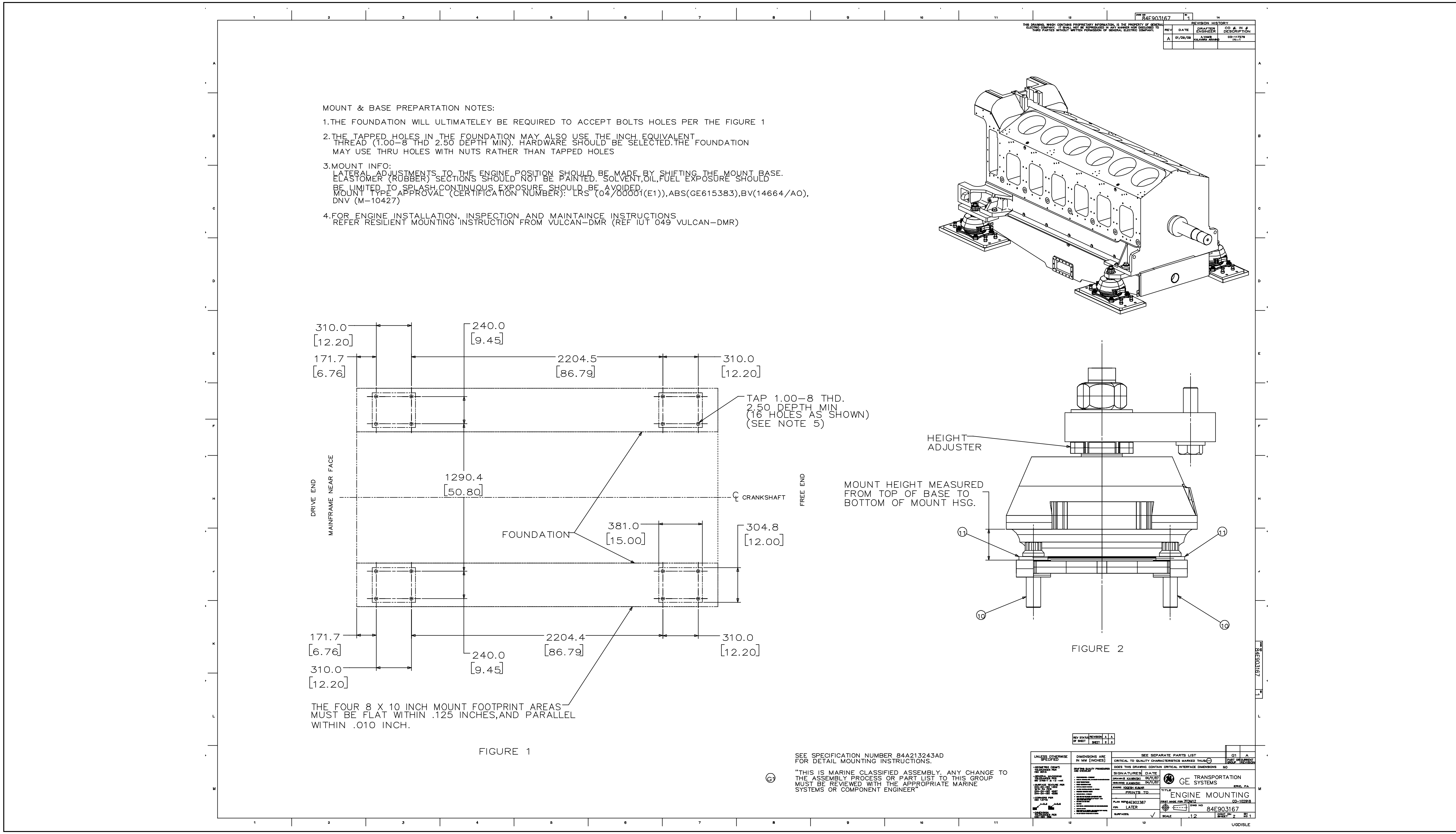


Figure 8-1. Engine Mounting Drawing, Part 1 of 3. (84E903167G1, Sheet 1)

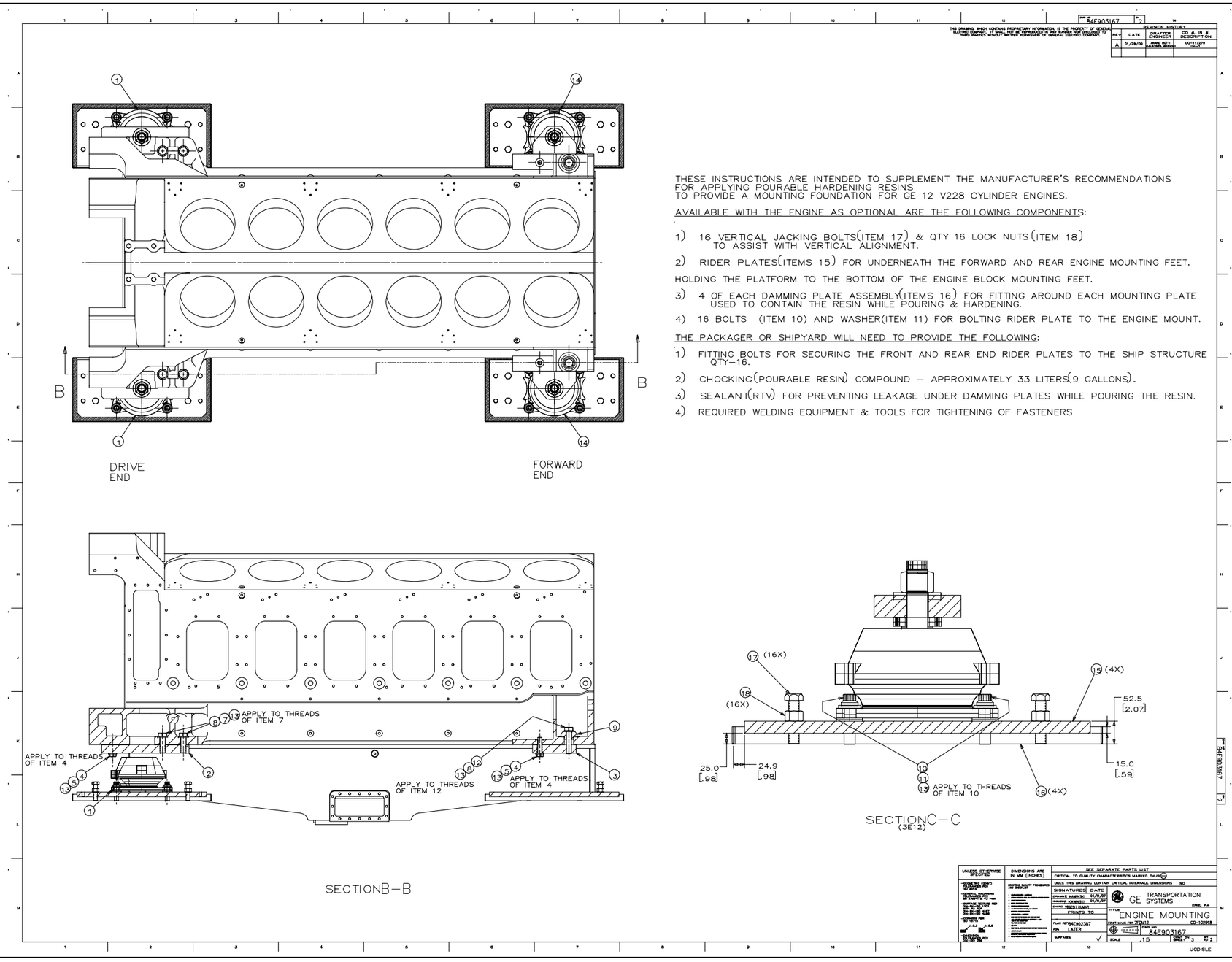


Figure 8-1. Engine Mounting Drawing, Part 2 of 3. (84E903167G1, Sheet 2)

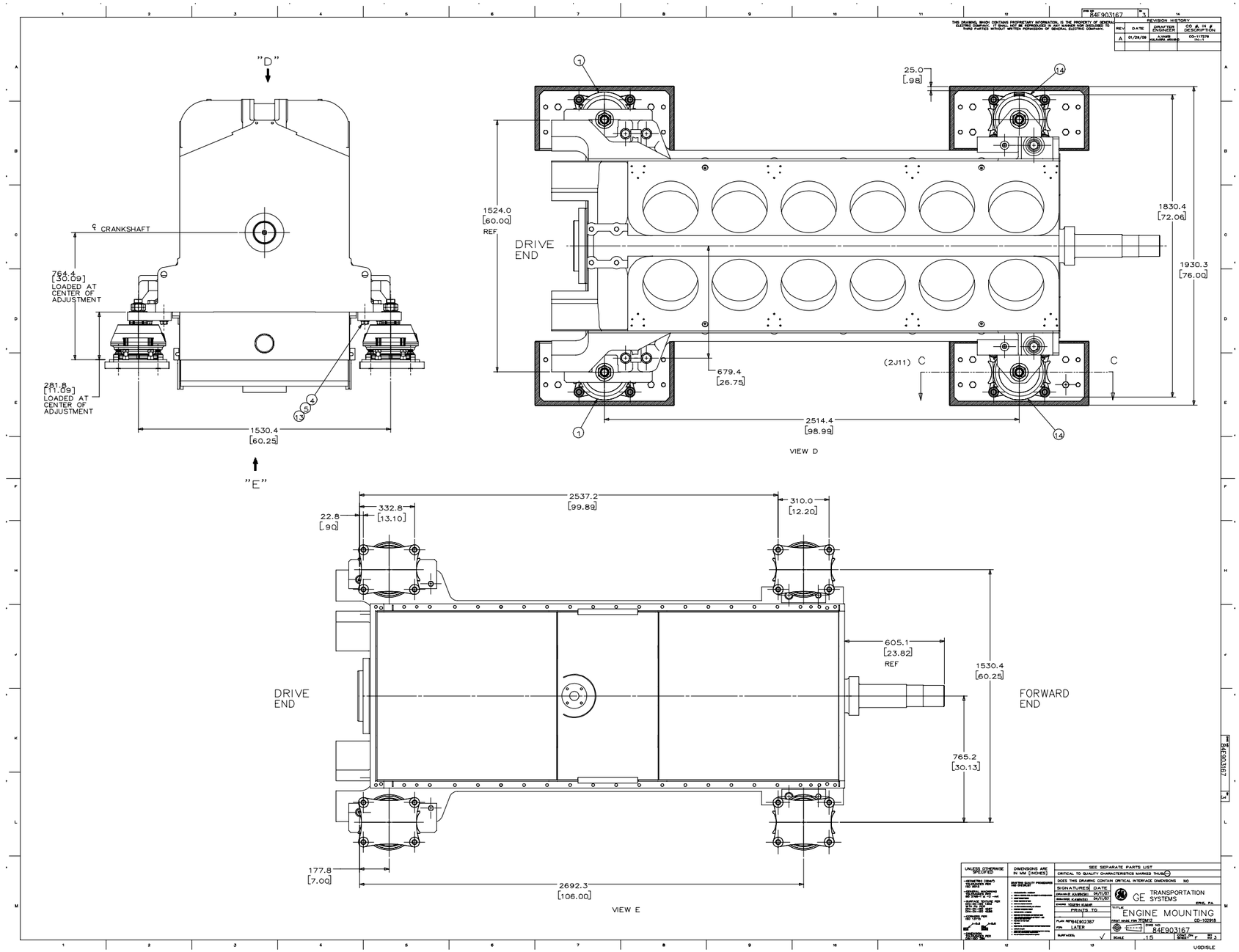


Figure 8-1. Engine Mounting Drawing, Part 3 of 3. (84E903167G1, Sheet 3)

9. ENGINE LIFTING PROCEDURES

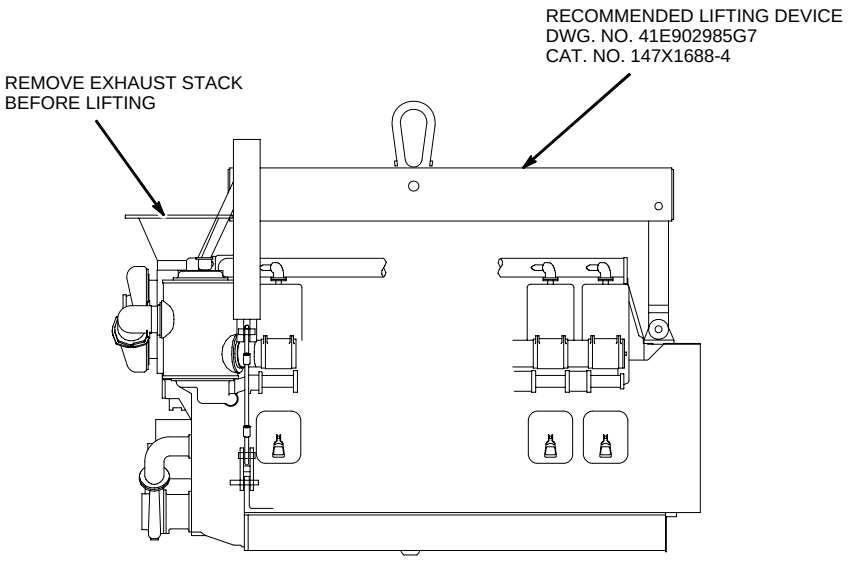
This section provides information on recommended lifting procedures for the diesel engine. Refer to the outline drawing in *SECTION 2* of this manual for the GE 12V228 diesel engine weight.

CAUTION: When lifting the engine, attachments should be made only at those points provided on the engine. Lifting at other points may cause damage to the engine.

The engine has one lifting eye on each side of the main frame above the free-end engine mount. The third point is at the large eye on top of the main frame at the flywheel end. The recommended lifting arrangement and fixture is shown in Figures 9-1 and 9-2.

With this lifting fixture, the entire weight of the engine may be lifted by a single crane hook. The customer should use a similar 3-point arrangement and lifting fixture.

WARNING: Verify that the lifting device and rigging (crane, cables, hooks, etc.) are of sufficient capacity for the engine being lifted. Failure to do so may cause serious personal injury or death.



RECOMMENDED LIFTING ARRANGEMENT (FOR COMPLETE ENGINE)

NOTE: This recommended lifting arrangement is for reference only. Designated lifting points must be observed. Selection of cable, spreader bar, hooks and rigging practices are the responsibility of the customer.

Figure 9-1. Recommended Lifting Arrangement. (E-49170)

Figure 9-2. GE V228 Diesel Engine Lifting Fixture. (E-49171)

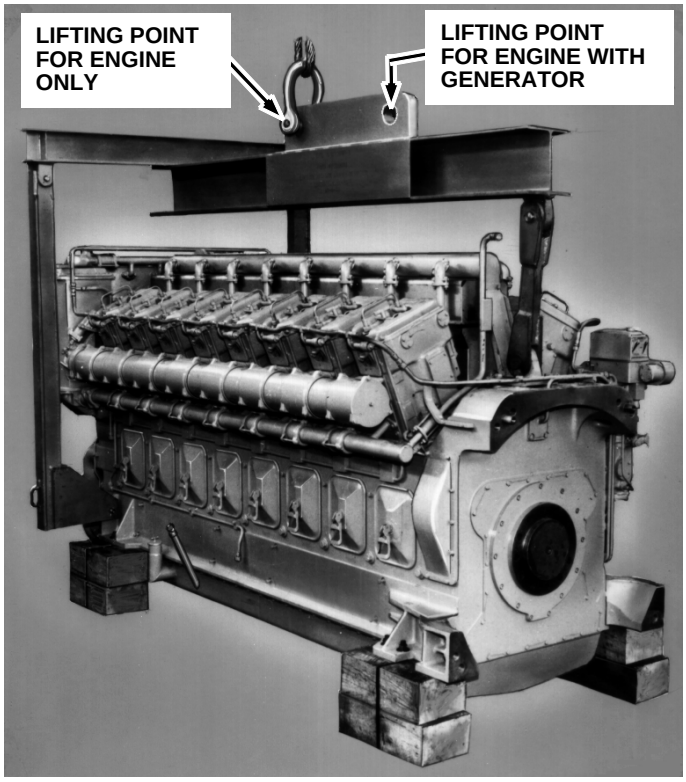


Figure 9-3. GE V228 Diesel Engine Lifting Fixture Assembled to Engine. (E-10034)

10. POWER TRANSMISSION

GE V228 diesel engine power transmission is accomplished through a flexible coupling mounted on the flywheel.

10.1. FLYWHEEL AND RING GEAR

Refer to Figure 10-2, Flywheel Assembly; **Table 10-1, Parts List for Flywheel Assembly;** and Figure 10-3, Flywheel, at the end of this section. GE V228 engines include a flywheel bolted directly to the drive flange end of the crankshaft. The ring gear is bolted to the flywheel and these bolts are lock-wired to avoid self-loosening as well as for safety. The starter motor gear pinion automatically engages the ring gear when the starter solenoid is energized and automatically disengages when the solenoid is de-energized. Different ring gears and starter motors are used for standard (CCW rotation) and reverse (CW rotation) engines.

WARNING: The GE-provided guard or shroud must always be installed around the flywheel to protect personnel and equipment from contact with the flywheel. Failure to provide such protection may result in serious personal injury or death.

10.2. DRIVE COUPLINGS

The diesel engine must be installed so that thrust loads on the crankshaft will be nominally at zero at engine operating temperatures, and no axial loads are transmitted into the crankshaft thrust bearings during engine operation.

NOTE: Depending on the purchase agreement, the coupling may be included in the GE Scope of Supply.

10.3. ENGINE VIBRATIONS

10.3.1. Axial/Transverse Vibrations

Axial or transverse vibrations transmitted through the base of the engine must comply with the limits set forth by the classification society under which the engine is being sold. ISO 2372/3945 defines the vibration for the engines on rigid support as follows (vibration measured on foundations and bearings):

- Unacceptable > 26 mm/second (> 1.024 inches/second)
- Acceptable 11.2 – 26 mm/second (0.441 – 1.024 inches/second)
- Satisfactory 3.6 – 11.2 mm/second (0.142 – 0.441 inches/second)
- Good < 3.6 mm/second (< 0.142 inches/second)

The frequency range covered by this standard is from 2 – 1000 Hz.

Rules from the IACS divide the vibration limits into three areas: A, B, and C. These areas are enclosed by the boundary curves shown in Figure 10-1.

- Area A < 14 mm/second (< 0.551 inches/second)
- Area B 14 – 25 mm/second (0.551 – 0.984 inches/second)
- Area C 25 – 45 mm/second (0.984 – 1.772 inches/second)

The limits are for the range from 10 – 100 Hz, RMS values in mm/second:

- Within Area A No additional consideration needed.
- Within Area B Measurement needed on connected equipment to prove that the vibrations are below Area B limits.
- Within Area C Measurement needed on connected equipment to prove that the vibrations are below Area C limits.

The following limits are for the diesel engine and turbocharger:

- Diesel Engine Veff = 10.6 RMS for 4.9 – 100 Hz to be measured in the transverse direction front and rear on the engine top.
- Turbocharger Veff = 21.2 RMS for 4.8 – 26.5 Hz to be measured in any direction on the bearings.

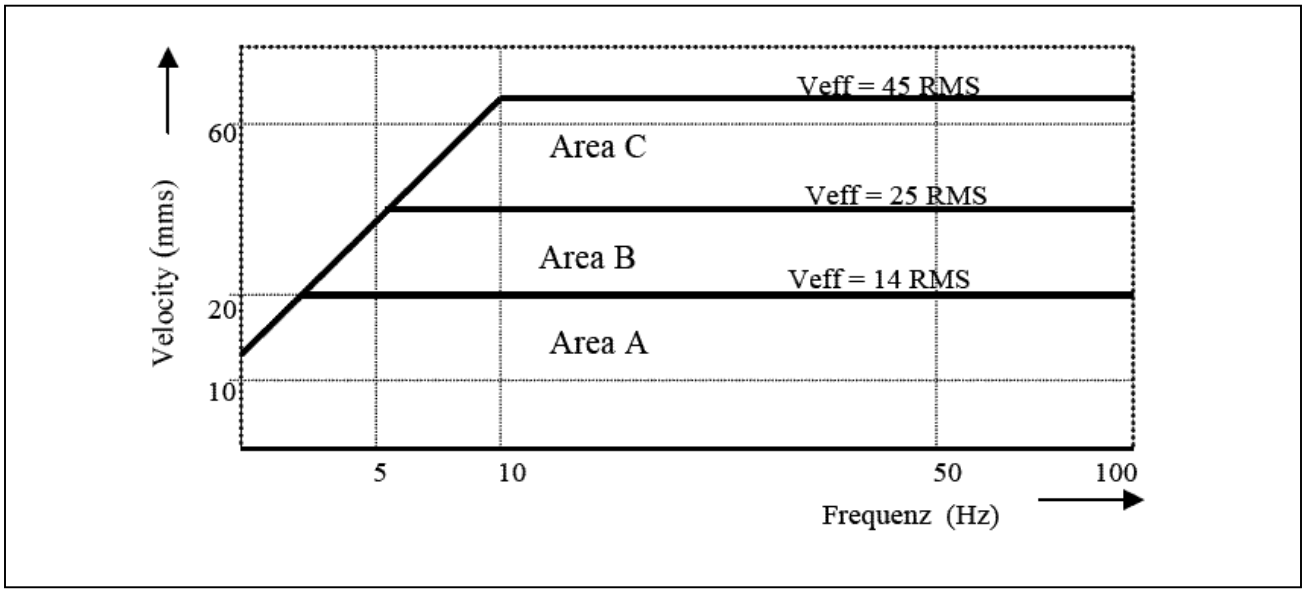


Figure 10-1. Assessment Areas of Vibration Loads.

10.3.2. Torsional Vibrations

Torsional vibrations are controlled by a viscous damper assembled to the free end of the engine crankshaft within the forward end cover (FEC).

- The maximum torsional stress allowance for the crankshaft from the main drive end of the crankshaft is 207 bar (3,000 psi) at speeds above 90% rated speed.
- The maximum load applied to the end of the engine crankshaft from coupling and shafting weight is 136 kg (300 lbs.).
- The crankshaft can bear no axial load from the driven equipment including that, which might be caused by thermal expansion of the engine crankshaft, or any driven shafting.

TABLE 10-1. PARTS LIST FOR FLYWHEEL ASSEMBLY (84E902130ACG1)

Item	Identification	Description	Qty
1	N14P43096	Bolt, 1.25-12 X 6	12
2	41B537660P22	Hardened Washer, 1-1/4	12
3	41D713860P1	Ring Gear	1
4	41A213277P19	Bolt	33
	M/F	N22P33020	33
5	41A221276AAP11	Lock wire, 0.063 X 12 Ft	1
6	41C615895P12	Flywheel	1
7	41A214915P1	Bushing	3
8	41A244104MSP7	Paint, Gray Alkyd	AR

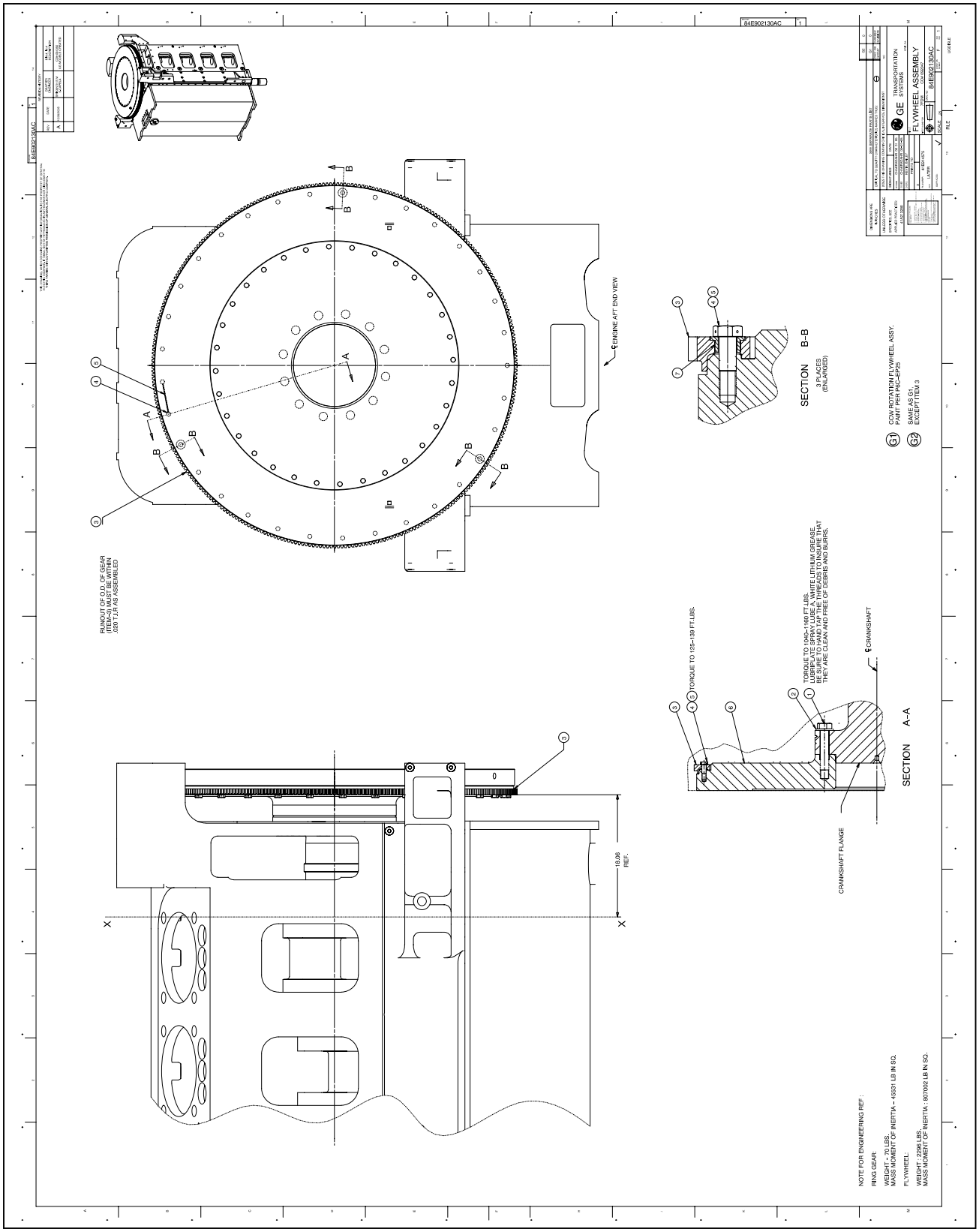


Figure 10-2. Flywheel Assembly. (84E902130ACG1, Sheet 1)

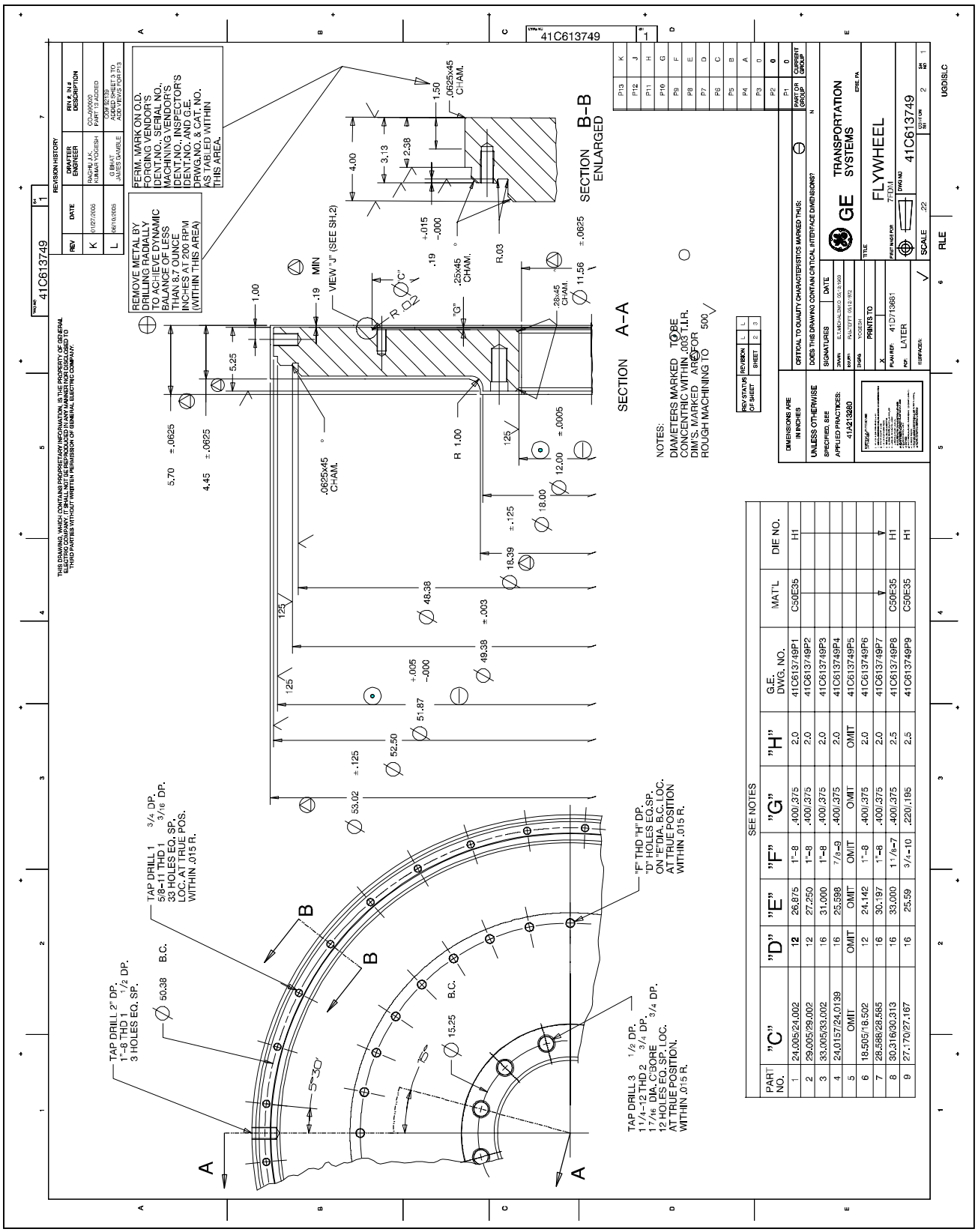


Figure 10-3. Flywheel. (41C613749P13, Sheet 1 of 3)

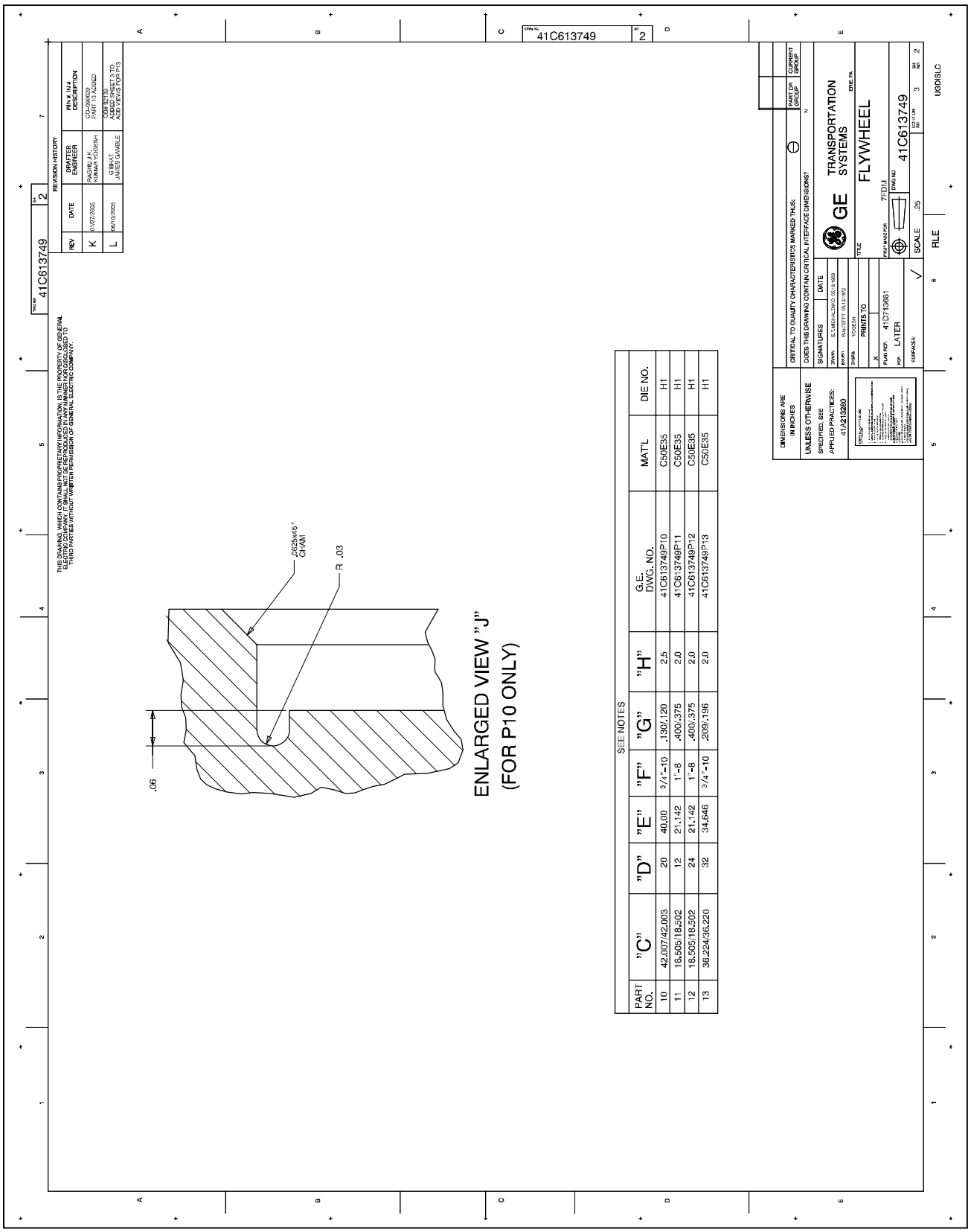


Figure 10-3. Flywheel. (41C613749P13, Sheet 2 of 3)

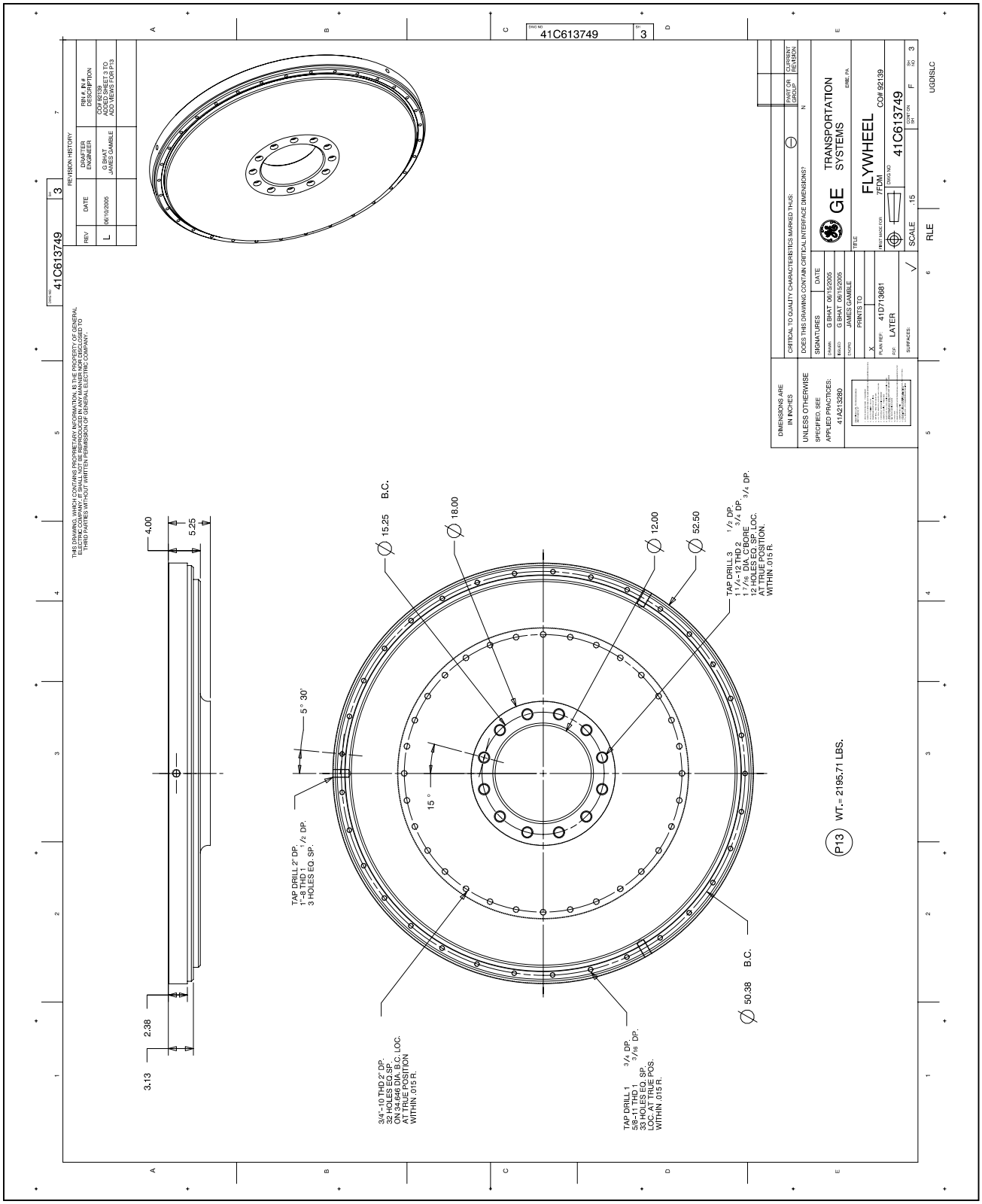


Figure 10-3. Flywheel. (41C613749P13, Sheet 3 of 3)

11. SPARE PARTS

This section provides information on recommended spare parts to be kept in inventory for the GE 12V228 diesel engine. Note that additional spares may be required per the applicable regulatory society.

NOTE: Do not order parts from this manual. Refer to the appropriate renewal parts bulletin when ordering parts.

TABLE 11-1. RECOMMENDED SPARE PARTS FOR GE 12V228, STANDARD ROTATION (CCW)

Part Number	Description	Quantity
114X1103-1	Main Bearing Shell, Upper	1
114X1150	Main Bearing Shell, Lower	1
115X1905	O-Ring, M/B Cross Bolt	2
147X1143-1	Moly-Cote Lubricant	1
147X1614	Spray Lube A	1
114X1111-4	Thrust Bearing, Crankshaft	2
121X1290	Power Assembly	1
150X1264	P/A Installation Gasket Kit	2
121X1186-1	Bolt, P/A To Main Frame	4
121X1187	Washer, P/A To Main Frame Bolt	4
123X1160-1	Fuel Injector	6
150X1270	Fuel Injector Installation Kit	6
115X2460	Seal Washer, Fuel Injector Stud	12
140X2906	J/W Inlet Header Section	1
140X1492-1	J/W Outlet Pipe Section	1
140X1095-5	J/W Outlet Pipe Coupling	1
117X1070	Bearing, Connecting Rod, Upper	1
117X1045-2	Bearing, Connecting Rod, Lower	1
142X1068	Piston	1
150X1250	Piston Ring Set	2
142X1052	Piston Pin	1
117X1040	Piston Pin Bolts	2
117X1041-1	Spacer	4
117X1038	Articulating Rod Pin Bolts	2
117X1029-5	Articulating Rod Pin	1
117X1063	Master Connecting Rod	1
117X1012-7	Articulating Connecting Rod	1
132X1869	Fuel Injection Pump	1
150X1272-1	Fuel Injection Pump Installation Kit	1
140X3040	High Pressure Fuel Line	1
131X1255	Air Start Motor	1
84A213165ACP1	Governor, SRLC For P/S I	1
84A213165ADP1	Governor, EGU For P/S I	1
84A216551P1	Lube Oil/Fuel Pump, Mechanical, CCW	1
150X1139-1	Lube Oil/Fuel Oil Pump Installation Gasket Kit	2
84A216644P1	Dual Impeller Water Pump, CCW	1
190X1200	Water Pump Installation Gasket Kit	2

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12. TOOLING

This section provides information on specific tooling/fixtures required to work on the GE V228 diesel engine. These tools/fixtures are in addition to the normal hand tools (sockets, ratchets, torque wrenches, etc.) that should normally be kept for maintenance.

12.1. RECOMMENDED TOOLING

TABLE 12-1. RECOMMENDED TOOLING FOR GE V228 DIESEL ENGINES

Item	Part Number	Description	Quantity
1	147X2361	Manual Cylinder Hold Down Bolt Torque Kit	1
2	147X1040-1	Rocker Arm Depressor	1
3	147X1089-1	Piston Ring Compressor	1
4	147X1367	Cylinder Installation Guide Pin	2
5	147X1406-2	Piston Retainer	2
6	147X2322-1	Piston Retainer	2
7	147X1841-1	Piston Pin Bolt Torque Kit	1
8	147X1090	Piston Support Bar	1
9	147X1458-2	Articulating Rod and Piston Pin Bolt Wrench, 3/4 in. Square Drive With 1-1/8 in. 12-Point Socket	1
10	147X1517-1	Adapter, 1-1/8 in. Shank	1
11	147X1511	3/4 in. Square Drive With 15/16 in. Double Hex Output	1
12	147X1510	3/4 in. Square Drive With 1-1/16 in. Double Hex Output	1
13	147X1606-1	Cylinder Lifter	1
14	147X1592-5	High Pressure Fuel Line Kit, EFI and MFI	1
15	147X2362	Valve Feeler Gage	1
16	147X2571	EFI Barring Arbor	1
17	T55971	Pushrod Height Adjustment Gage	1
18	147X2517	Exhaust Manifold Wrench Set	1
19	T56051	Tappet Nut Torque Wrench Kit	1
20	147X1982	1 in. Ratcheting Head Wrench	1
21	147X1856	Nozzle Knocker	1
22	147x2457	Torque Adapter, Front HP Fuel Pump Bolts/Cam Section Bolt	2
23	147x2460	Fuel Pump Bolt Torque Wrench	1
24	147X1122	Art Rod Guide Pin	1
25	147X1492-1	Connecting Rod Bearing Retainers	1
26	147X1823	3/4 in. Torque Wrench, 100 - 600 lb.-ft.	1
27	147X1458-2	Art Rod and Piston Pin Bolt Wrench	1
28	147X1517-1	Adapter	1
29	147X1511	15/16 in. Socket, 3/4 in. square drive	1
30	147X1298-1	Main Bearing Wrench, Left Hand	1
31	147X1299-1	Main Bearing Wrench, Right Hand	1
32	147X2309-4	Main Bearing Stud Stretch Gage	1
33	147X1742	Hydraulic Frame Spreader	1
34	147X1368-1	Individual Compression Tester	1

12.2. TOOLING UPGRADES

The following items are recommended tooling upgrades for more efficiently working on the engine:

- 147X2106 230 VAC Main Bearing Wrench (Replaces: 147X1298-1 and147X1299-1)
- T24101-LC Pneumatic Torque Wrench For Cylinder Hold Down Bolts (Replaces 147X2361)

The following two meters are also recommended for more efficiently analyzing cooling water samples:

- 147X2261 Dissolved Solids Meter
- 147X2262 Dissolved Solids Meter Test Solution, 3000 PPM

13. ENGINE STORAGE AND PROTECTION

This section provides information on recommended storage and protection procedures for the GE V228 diesel engines. Engines that are to be stored for a period of one month or more, or are to be prepared for foreign shipment, must be treated with corrosion preventatives according to the following instructions.

Refer to Figures 13-1 and 13-2 for areas of engine protection.

13.1. MATERIALS

The following materials are recommended for their respective areas of engine protection:

- Engine Fuel Oil System Treatment - Use Shell Clavus* Oil for the engine fuel oil system.
- Engine Interior Coating - Use Tectyl** 823EM on the interior surfaces of the engine. This corrosion preventive coating is completely soluble in, and completely compatible with, engine lubricating oil. This material dries leaving an oily and translucent film.
- Engine Exterior Coating - Use corrosion preventive compounds such as Tectyl** 890 that meet U.S. Government Specification MIL-C-16173D, Grade 1, on the exterior surfaces of the engine. This material dries leaving a firm, black asphalt type film.

13.2. ENGINE FUEL OIL SYSTEM PROTECTION

1. Connect the suction side of the booster fuel pump to a 19-liter (5 gallon) supply of the fuel oil system treatment.
2. Connect a drain from the fuel oil header return to the fuel oil system treatment container.
3. Run the engine for approximately 15 minutes on the fuel oil system treatment to fully distribute the treatment throughout the fuel system.
4. Disconnect the booster fuel pump from the fuel oil system treatment and disconnect the drain from the fuel oil header into the fuel oil system treatment container.

13.3. ENGINE INTERIOR PROTECTION

13.3.1. Lubricating Oil System and Bearings

1. Connect an independent pump to a container of engine interior coating on the suction side of the pump and to the lubricating oil header at the free-end cover.
2. Remove the crankcase inspection covers so that interior coating flow can be verified.
3. Pump the interior coating into the engine through the lubricating oil lines and bearings.
4. When the coating can be seen dripping from bearings and rods, the engine lubricating oil passages are sufficiently coated.
5. Disconnect the independent pump from the engine interior coating container and from the lubricating oil header on the free-end cover.
6. Reinstall the crankcase inspection covers.

**Product of Shell Oil Company.*
***Product of Ashland Oil.*

13.3.2. Crankcase

1. Remove the crankcase inspection covers.
2. Spray or brush the engine interior coating material on all finished surfaces within the crankcase.
3. Coat the inside of each crankcase inspection cover with engine interior coating material prior to reinstalling the cover on the engine.

CAUTION: Do not leave excess coating in the combustion chamber as it could cause hydraulic locking.

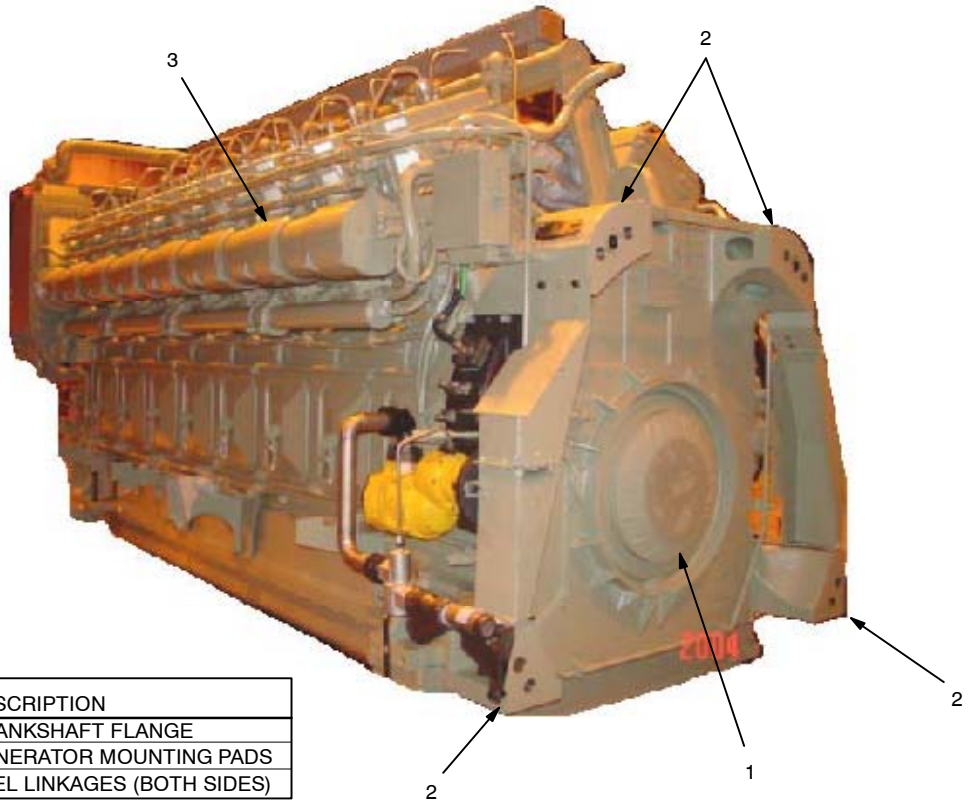
13.3.3. Cylinder Valve Train

NOTE: Use a 90° tip on the sprayer tool to coat the cylinder liner walls and a 175° tip to coat the cylinder head combustion face.

1. Remove the power assembly valve covers.
2. Remove the fuel injectors according to the procedure in **SMI-90033, Diesel Engine Maintenance**.
3. Connect the lubricant pump to the Tectyl engine interior protection container.
4. Ensure that the cylinder sprayer tool is clean and free of debris and attach it to the end of the Tectyl supply line.
5. Carefully insert cylinder sprayer tool (with 90° tip) into each cylinder through the fuel injector opening and lightly coat the inside of each cylinder with Tectyl lubricant. A 2- to 5-second spray should be sufficient, depending on the location of the piston relative to top-dead-center.
6. Change the sprayer tool to the 175° tip and carefully insert the cylinder sprayer tool into each cylinder through the fuel injector opening and lightly coat the cylinder head combustion face with Tectyl lubricant.
7. After all cylinders have been conditioned, switch to the lubricant sprayer gun and coat the rocker arms and valve springs with Tectyl lubricant.
8. Reinstall the fuel injectors according to the procedure in SMI-90033, Diesel Engine Maintenance.
3. Coat the inside of each power assembly valve cover with engine interior coating material prior to reinstalling the cover on the power assembly.
4. Re-install the power assembly valve covers.

CAUTION: Do not leave excess coating in the combustion chamber, as it could cause hydraulic locking.

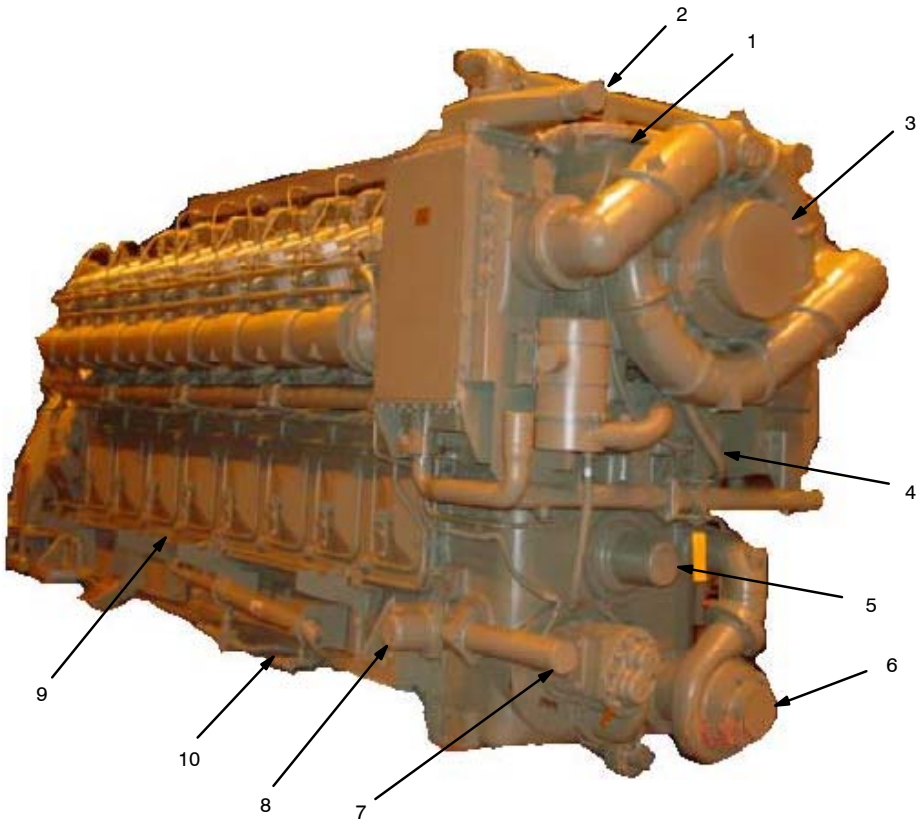
NOTE: After the engine protection procedures are completed, suitable precautions should be taken to prevent the engine from being barred over. In the event that the engine must be barred over, the engine protection procedures must be repeated immediately.



NOTE	REF	DESCRIPTION
A	1	CRANKSHAFT FLANGE
A	2	GENERATOR MOUNTING PADS
B	3	FUEL LINKAGES (BOTH SIDES)

NOTES:
A - COAT AND COVER WITH WAX PAPER
B - COAT

Figure 13-1. Protection Points For Engine Storage, Drive-End. (E-46394)



NOTE	REF	DESCRIPTION
A	1	EXHAUST STACK (NOT SHOWN)
A	2	WATER OUTLET
A	3	AIR INLET
B	4	LUBE OIL HEADER (NOT VISIBLE)
A	5	DRIVE FLANGE
B	6	WATER INLET
B	7	OIL OUTLET
B	8	FREE-END COVER DRAIN
A	9	FUEL LINES (BOTH SIDES)
B	10	OIL PAN DRAIN

NOTES:
A - COAT AND COVER WITH WAX PAPER
B - COAT AND COVER WITH MASONITE*
*MASONITE™ BY MASONITE CORP, CHICAGO, ILL.

Figure 13-2. Protection Points For Engine Storage, Free-End. (E-46393)

14. COMMISSIONING PROCEDURE

Commissioning procedures for the diesel engine must be conducted after engine installation and engine installation reviews are complete.

14.1. INSTALLATION REVIEWS

An installation review should be conducted at least twice; the first should occur at the time of engine installation and the second should occur just prior to engine/genset start. Additional reviews may be required.

14.2. PRE-COMMISSIONING

After completion of the engine installation, a pre-commissioning should be performed to confirm that the genset system is operating as expected and is ready for commissioning. The pre-commissioning also serves to validate the system design.

14.3. COMMISSIONING

Commissioning is the final test for the newly installed genset. The specific objectives of commissioning are as follows:

- To demonstrate satisfactory operation of the genset plant for a specified period of time at a specified power.
- To demonstrate satisfactory operation of the genset plant controls.
- To obtain genset plant data for future use in evaluating performance and service needs.

A sample commissioning form is shown on the next two pages.

GE Transportation
Stationary Power

Parameter	Unit	Range	Cold		Hot	Range
Crankshaft Thrust	in.	.008-.018				.20 - .45 mm
Web Deflection	in.	.003 max				.076 mm

Customer:
Date:
EGU Sft:
Woodward:
Engine SN:
Model No:

		Commanded Engine Load											
	Engine Load	Partial_____% Load			Partial_____% Load			100% Load			110% Load		
		Unit	Range	Actual	Unit	Range	Actual	Unit	Range	Actual	Unit	Range	Actual
Misc.	RPM (actual)	RPM	N/A		RPM	N/A		RPM	N/A		RPM	N/A	
	AA Timing (EGU)	TDC	-4-24		TDC	-4-24		TDC	-4-24		TDC	-4-24	
	Manifold Air Density	gm/m³	4100 Max		gm/m³	4100 Max		gm/m³	4100 Max		gm/m³	4100 Max	
	Engine Power (Approx.)	HP	N/A		HP	N/A		HP	N/A		HP	N/A	
	Fuel Demand	mm³	1-1900		mm³	1-1900		mm³	1-1900		mm³	1-1900	
Temperatures	Fuel Temp In	°F	N/A		°C	N/A		°F	N/A		°C	N/A	
	Fuel Return Temp	°F	N/A		°C	N/A		°F	N/A		°C	N/A	
	Engine Room Air Temp	°F	N/A		°C	N/A		°F	N/A		°C	N/A	
	J/W In - Engine	°F	170-185		°C	76-85		°F	170-185		°C	76-85	
	J/W Out - Engine	°F	175-190		°C	79-88		°F	175-190		°C	79-88	
	Delta J/W In-Out	°F	10		°C	5.5 Max		°F	10		°C	5.5 Max	
	Intercooler In	°F	90-128		°C	32-53		°F	90-128		°C	32-53	
	Intercooler Out	°F	200		°C	93 max		°F	200		°C	93 max	
	MAT (EGU)	°F	140.0		°C	60 max		°F	140.0		°C	60 max	
	L/O In - Engine	°F	170-190		°C	76-88		°F	170-190		°C	76-88	
	L/O Out - Engine	°F	180-200		°C	82-93		°F	180-200		°C	82-93	
	Delta - Lube Oil	°F	10 Max		°C	5.5 Max		°F	10 Max		°C	5.5 Max	
	Exhaust - R1	°F	1200		°C	640		°F	1200		°C	640	
	Exhaust - R2	°F			°C			°F			°C		
	Exhaust - R3	°F			°C			°F			°C		
	Exhaust - R4	°F			°C			°F			°C		
	Exhaust - R5	°F			°C			°F			°C		
	Exhaust - R6	°F			°C			°F			°C		
	Exhaust - R7	°F			°C			°F			°C		
	Exhaust - R8	°F			°C			°F			°C		

GE Transportation
Stationary Power

Parameter	Unit	Range	Cold		Hot	Range
Crankshaft Thrust	in.	.008-.018				.20 - .45 mm
Web Deflection	in.	.003 max				.076 mm

Customer:
Date:
EGU Sft:
Woodward:
Engine SN:
Model No:

Engine Load		Commanded Engine Load: Partial_____% Load			Partial_____% Load			100% Load			110% Load		
		Unit	Range	Actual	Unit	Range	Actual	Unit	Range	Actual	Unit	Range	Actual
	Pre-Turbine - RB	°F			°C			°F			°C		
	Exhaust - L1	°F			°C			°F			°C		
	Exhaust - L2	°F			°C			°F			°C		
	Exhaust - L3	°F			°C			°F			°C		
	Exhaust - L4	°F			°C			°F			°C		
	Exhaust - L5	°F	1200		°C	640		°F	1200		°C	640	
	Exhaust - L6	°F			°C			°F			°C		
	Exhaust - L7	°F			°C			°F			°C		
	Exhaust - L8	°F			°C			°F			°C		
	Pre-Turbine - LB	°F			°C			°F			°C		
Pressures	Oil Header (EGU)	psig	75-90		Bar	5 - 7		psig	75-90		Bar	5 - 7	
	Water Header (EGU)	psig	35-45		Bar	2.4-3.1		psig	35-45		Bar	2.4-3.1	
	Fuel Header	psig	55-65		Bar	3.7-4.5		psig	55-65		Bar	3.7-4.5	
	Intercooler Pump Out	psig	10 - 15		Bar	0.6-1.0		psig	10 - 15		Bar	0.6-1.0	
	Manifold Air (EGU)	psia	35-45		Bar	2.4-3.1		psia	35-45		Bar	2.4-3.1	
	Inlet Air Restriction	"H_2O	< 13"		mBar	< 33		"H_2O	< 13"		mBar	< 33	
	Exhaust Backpressure	"H_2O	< 10"		mBar	< 25		"H_2O	< 10"		mBar	< 25	
	Crankcase Pressure	"H_2O	< 0		mBar	< 0		"H_2O	< 0		mBar	< 0	

NOTE: Data for Rated Speed & Load used for validation purposes. Partial load points for reference only.

NOTE: Temperatures valid when at ISO standard conditions (77°F Air Inlet, 29.1 in.Hg Barometric Pressure, 77°F Ambient Water).

NOTE: Cylinder Exhaust temps should be < 300°F between cylinders; Pre-Turbine temps should be < 100°F Spread bank-to-bank.

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15. FLUID SPECIFICATIONS

This section provides specifications and information on the recommended fluids for GE V228 diesel engines.

15.1. FUEL OILS

GE V228 stationary diesel engines are capable of operating on the following fuel (refer to the published standard for the exact specifications for this fuel category):

- **ASTM D-975, No. 2 Diesel (2D) S15, S500, and S5000**: ASTM D-975 is the recommended fuel for GE diesel engines. It meets the requirements of the American Society for Testing and Materials (ASTM), Specification D-975 for No. 2 Diesel (N2D) fuel.

Other international or organizational fuel specifications (i.e., GOST, EN Australian fuel specifications) may be applicable to the extent that those specifications describe fuel that is the equivalent of ASTM D-975. Samples of such fuel must be evaluated and approved by GE prior to use in the GE V228 diesel engine.

15.2. LUBRICATING OILS

The General Electric diesel engine requires a heavy-duty, highly dispersant SAE 40 or multigrade (typical SAE 20W-40) lubricating oil. The minimum new oil kinematic viscosity for SAE 40 oils is 13.9 cSt at 100°C (75 SSU at 210°F) and the viscosity index range for straight weight oils is 65 to 105. The minimum absolute viscosity for multigrade oils is 10.8 centiPoise at 100°C (212°F) and the viscosity index range for these oils is 108 to 125.

Lubricating oils used in GE diesel engines must meet GE's approval criteria, which is based on demonstrated performance. Approval letters issued by General Electric are given to the companies who market engine oils to the users of GE diesel engines. Customers should contact General Electric for recommendations and a list of GE-approved Generation 4 Long Life Engine oils.

NOTE: GE diesel engine oils are typically categorized by using the Locomotive Maintenance Officers Association (LMOA) Generation Designations. These designations categorize lubricating oils by performance. Total Base Number (TBN) of the engine oils listed below is measured by the American Society for Testing and Materials (ASTM) test method D2896.

15.2.1. Generation 4 Engine Oils (13 TBN)

Generation 4 engine oils contain additive packages that have demonstrated improved oxidation stability, detergency, dispersion and alkalinity over the Generation 3 oils. Generation 4 oils are not currently marketed in the United States; however, Generation 4 oils are still available Internationally. General Electric does not recommend use of Generation 4 oils; GE recommends use of Generation 4 "Long Life" oils.

15.2.2. Generation 4 "Long Life" Engine Oils (13 TO 18 TBN)

Generation 4 Long Life oils (also referenced as Generation 5 oils) contain the most advanced additive technologies available today. Advances in lubricating oil technology have allowed for increased oil and oil filter life while preserving Generation 4 performance standards in wear control, engine cleanliness and deposit control. Field test data have documented substantial increases in oil life over conventional Generation 4 lubricating oils with no detrimental effect to the engine**.** Generation 4 Long Life oils are recommended for use in GE Stationary diesel engines.

15.2.3. Multigrade Engine Oils

Multigrade engine oils (typical SAE 20W-40) are currently approved and acceptable for use in the General Electric diesel engines. Recognizing the fuel efficiency benefits brought about by the special viscosity characteristics of multigrade oils, engine users have had an increasing demand for multigrade oil.

The unique viscosity characteristics of multigrade oils cannot be correctly measured through kinematic viscosity techniques. To qualify new multigrade oils, a minimum absolute viscosity of 10.8 CentiPoise at 100°C (212°F) is required. An absolute viscosity specification takes into account the permanent and temporary viscosity losses of multigrade oils. These viscosity losses are responses to the high shearing forces existing within the bearing clearances and on the cylinder walls, etc.

The minimum absolute viscosity measurement is found by running the new engine oil through ASTM test method D3945 Procedure B (FISST technique) to factor in permanent viscosity losses. After this test is complete, this same new oil is taken and processed through ASTM test method D6616 (Tapered Bearing Simulator), modified to 100°C (212°F), or ASTM test method D4741 (Tapered Plug Viscometer at 100°C [212°F]). The Tapered Bearing Simulator takes into account the temporary viscosity losses of the multigrade oil and measures the absolute viscosity of the engine oil in CentiPoise at 100°C (212°F).

15.2.4. Mixture Of Engine Oils

All engine oils on the General Electric Approved Lists for use in GE diesel engines are fully compatible, and may be mixed in any ratio without causing harm to the engine. However, for optimal performance and prevention of possible unforeseen incompatibility issues, GE recommends single source supply.

When lubricating oils listed in one category are mixed with those of another category, the resulting mixture belongs in the same category as that of the lowest ranking oil used. For example, when lubricating oils listed as "Generation 4" are mixed with oils listed as "Generation 4 Long Life," the resulting mixture is automatically ranked in the lower "Generation 4" category, and should be used only in situations where "Generation 4" oils are approved.

For all lubricants other than engine lubricating oil, the statement "never mix lubricants of different brands or grades" still applies. Since multiple brands and grades of these lubricants are available, thorough testing for compatibility is impossible. With engine lubricating oils, however, approval is made by brand and grade; therefore, compatibility is known. An oil is not approved until found to be compatible with all others on the approved list. Approval consists of both factory and field testing.

15.2.5. Engine Oil Condemning Limits And Measurements

General Electric recommends frequent testing of lubricating oil for pentane insolubles, metal, viscosity, water content, and alkalinity reserve. These tests should be performed every 150 - 250 hours of engine operation.

Frequent testing will help detect fuel dilution and water contamination and avoid excessive deposits, corrosion or oxidized oil, which could damage engine bearings and other components. Additional tests such as Infrared Spectra may be used to obtain other oil condition information (i.e., oxidation, sulfation, etc.). Elemental analysis may be used for trending any wear metals.

Engine oil condemning limits on viscosity and water contamination as well as alkalinity and insolubles are given in **Table 15-1**.

It is suggested that an advanced warning system (flagging technique) be used for monitoring oil analysis trend results. If the oil analysis trend indicates the oil is approaching an oil condemning limit(s), a warning should be made to ensure the diesel engine does not operate with such oil beyond the oil's useful life.

TABLE 15-1. CONDEMNING LIMITS OF ENGINE LUBRICATING OIL

Property	Condemning Limit	Test Method
PENTANE INSOLUBLES (Maximum)	4% (Generation 4 Long Life Oil With Class A Fuel)	ASTM D7317
KINEMATIC VISCOSITY (SAE 40)	Maximum 25% Increase (Above New Oil Viscosity) Minimum 12.5 cSt @ 100°C (212°F)	ASTM D445 Kinematic Centistokes @ 100°C (212°F)
TOTAL BASE NUMBER	50% Reduction from New Levels 4.0 (mg. KOH per gm.) minimum	ASTM D4739 Preferred Method
TOTAL BASE NUMBER	5.0 (mg. KOH per gm.) SCREANER TEST	ASTM D5984
WATER (Maximum)	0.2%	ASTM D95
SOOT, OXIDATION, SULFATE	Instrument and software dependent; must be correlated to GE lab for reference	Infrared Spectra
WEAR METALS	Trend line	ICP, AA

15.2.6. Engine Oil Sampling Procedure

GE recommends that oil samples be collected for analysis every 150 – 250 hours of engine operation. Before beginning to take the sample, be sure to write all pertinent information on the sampling bottle. The oil sample should be taken while the engine is at idle. Clean the sample valve and purge it by allowing approximately 2-3 ounces of oil to flow out prior to taking the sample. Refer to Figures 15-1 and 15-2.

NOTE: If it is necessary to collect the sample when the engine is shut down, the oil sample should be collected within 15 minutes after shutting down the engine.

The oil sample bottle should be filled between 2/3 to 3/4 full.

NOTE: If samples are to be taken from multiple engines, ensure there is no cross-contamination of oil samples by cleaning the sampling equipment between taking samples.

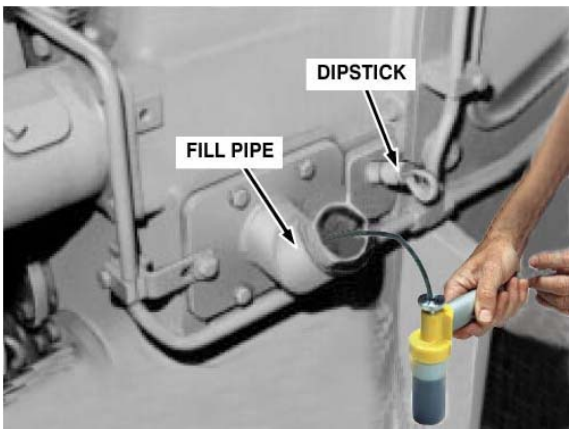

Figure 15-1. Lubricating Oil Sampling From Fill Pipe. (E-46020)

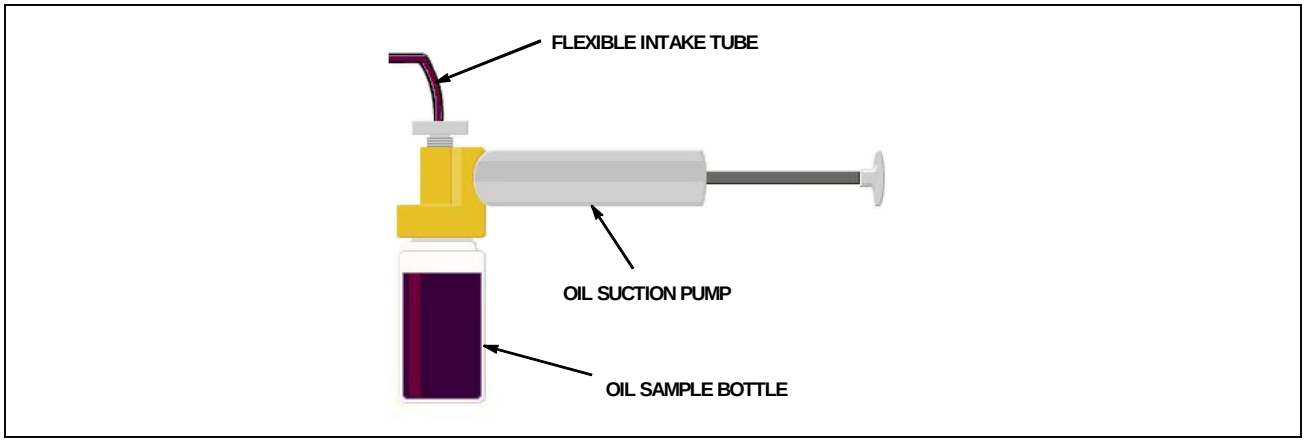

Figure 15-2. Lubricating Oil Sample Suction Pump And Bottle. (E-46019)

15.2.7. Engine Oil Life

In addition to frequent oil sampling and trend analysis, General Electric recommends that the engine oil be drained after a period of operating hours. Refer to **Table 15-2** for recommended oil change intervals for various engine duty cycles. Draining and refilling with new oil at these limit intervals, even though the used oil has not reached the condemning limits in **Table 15-1**, will ensure that the additive package is able to maintain cleanliness and durability of the engine.

TABLE 15-2. RECOMMENDED OIL CHANGE INTERVALS

Duty Cycle	V228 Fuel Consumption per Cylinder (liters per cylinder per hour)	Oil Change Interval
Heavy Duty	35	2000 hours
Medium Duty	25	3000 hours
Light Duty	15	4000 hours

NOTE: The best measure of average fuel consumption is the total fuel consumed, divided by the engine operating hours. For example, if a 16V228 engine consumed 55200 liters of fuel over 1450 hours of operation, the average fuel consumption would be 23.8 liters per hour per cylinder, making it a "medium duty cycle" application. The average fuel consumption should be measured over a period of time sufficient to represent typical service conditions for the application.

If the environment is excessively hot (sustained operation over 32°C [90°F]) or if airborne dust and dirt are prevalent, more frequent oil changes than those shown in Table **15-2** are recommended.

CAUTION: When engine oil change intervals are overextended, severe engine problems may result which would affect engine component durability and increase unscheduled maintenance. Precautions should be taken to regularly inspect for excessive deposits on the internal engine components to ensure the oil has not gone beyond its useful life.

15.2.8. Engine Oil Changeout Procedure

1. Drain the used diesel engine oil from crankcase (recommend draining oil when engine is hot).
2. Fill the diesel engine crankcase with new, **approved** engine oil.

15.3. FRESH WATER COOLING SYSTEM

The cooling system will remain in excellent condition for the life of the engine if proper control is exercised over water conditioning and water treatment. If inadequate attention is given to the preparation and control of cooling water, the consequences are just as severe as those for insufficient maintenance of any other engine system.

CAUTION: If the system is shut down when the temperature is below freezing, the water must be drained from both cooling circuits.

Untreated water contains impurities in varying amounts. Impurities include dissolved minerals, dissolved gases and suspended solids. Even water that is entirely suitable for human consumption must be considered contaminated and requires conditioning before being used in a diesel engine cooling system.

Minerals in untreated water will form hard scale deposits on heat transfer surfaces, and some minerals will form sludge at high water temperatures. Sludge and sediments often settle in water passages where the water flow velocity is low. The deposits act as an insulator and will reduce heat transfer. Additionally, corrosion occurs much more rapidly beneath such deposits.

Figure 15-3 shows the consequences of inadequate cooling system maintenance.

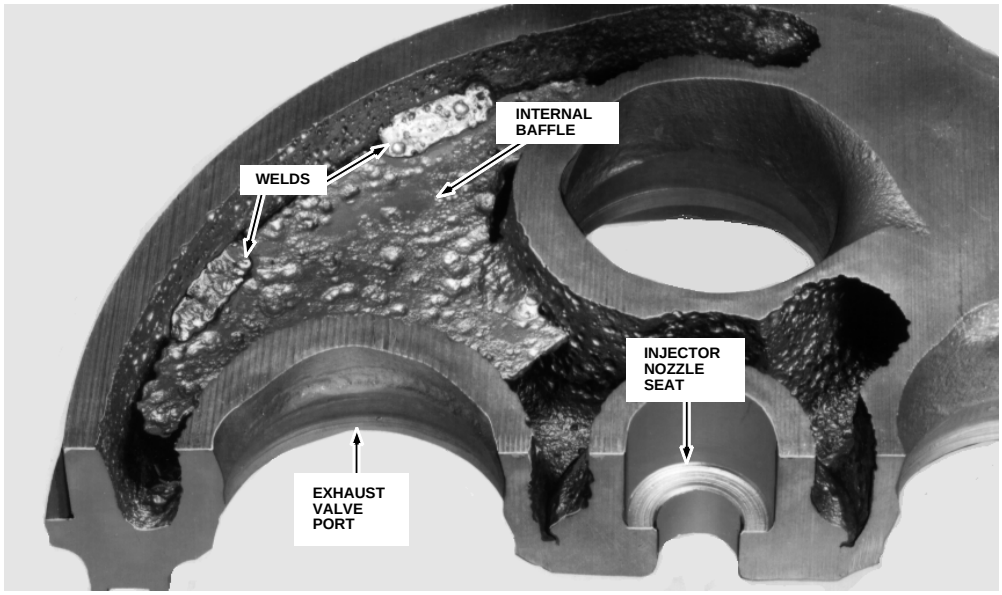

Figure 15-3. Cylinder Head Extreme Internal Corrosion Due to Inadequate Water Treatment. (E-26551)

15.3.1. Conditioning the Water

CAUTION: Distilled, demineralized or deionized water is corrosive since the water is mildly acidic, and must not be used in a cooling system without further treatment.

Before using untreated water it should be analyzed for impurities. **Table 15-3, Maximum Concentration of Cooling Water Impurities**, lists the maximum concentration of impurities that would permit using water without pre-conditioning. If analysis indicates that the untreated water meets these limits, add water treatment inhibitors directly to the untreated water to protect against corrosion. If the untreated water contains impurities in excess of the concentrations listed in **Table 15-3**, the water must first be processed by distillation, demineralization, or deionization before adding the inhibitor.

TABLE 15-3. MAXIMUM CONCENTRATION OF COOLING WATER IMPURITIES

Impurities	Maximum	
	Parts Per Million (ppm)	(Grains/Gal)
Chlorides	40	2.5
Sulfates	100	5.8
Total Dissolved Solids	340	20
Total Hardness	170	10
Suspended Solids	17	1

15.3.2. Choosing a Corrosion Inhibitor

Many commercial water treatment compounds are available for inhibiting corrosion. While it is important that these additives be effective against corrosion, they also must not be harmful to the various synthetic materials found in the cooling system. An inhibitor that is successful in another application is not necessarily suited for a particular diesel engine cooling system. Differences in coolant velocity, temperature and types of materials affect such comparisons.

The primary concern in protecting against corrosion is maintaining the proper level of alkalinity in the coolant. Alkalinity and acidity are expressed as numbers on the pH scale, which runs from 0 to 14:

- Numbers above 7 indicate an alkaline solution — the higher the number, the stronger the alkaline solution.
- Numbers below 7 indicate an acid solution — the lower the number, the stronger the acid solution.
- A pH value of 7 is neutral — neither acid nor alkaline.

Generally, coolant on the acidic side will corrode ferrous materials such as cylinder jackets, liners, heads, and water tanks. Coolant that is highly alkaline will corrode non-ferrous materials such as those found in heat exchangers, intercoolers, the lubricating-oil cooler, and the fuel oil heater.

Note in Figure 15-4 that borate-nitrite inhibitors are typically formulated to maintain a pH range between 9 and 11. Since this pH range is relatively high (i.e., alkaline), chemicals are added to the packages for the protection of non–ferrous materials.

The second concern in corrosion protection is the choice of inhibitor type, the principal types being borate-nitrite and chromate.

WARNING: Chromate inhibitors are no longer recommended due to health and environmental concerns. Chromate is a potentially serious skin irritant, and various governmental regulations restrict its disposal without special treatment.

CAUTION: Do not mix a borate-nitrate inhibitor with a chromate inhibitor. Do not mix different brands of the same type of inhibitor. The formulations may vary, and inhibitor characteristics may be adversely affected if mixed. Follow the inhibitor manufacturer's recommendations.

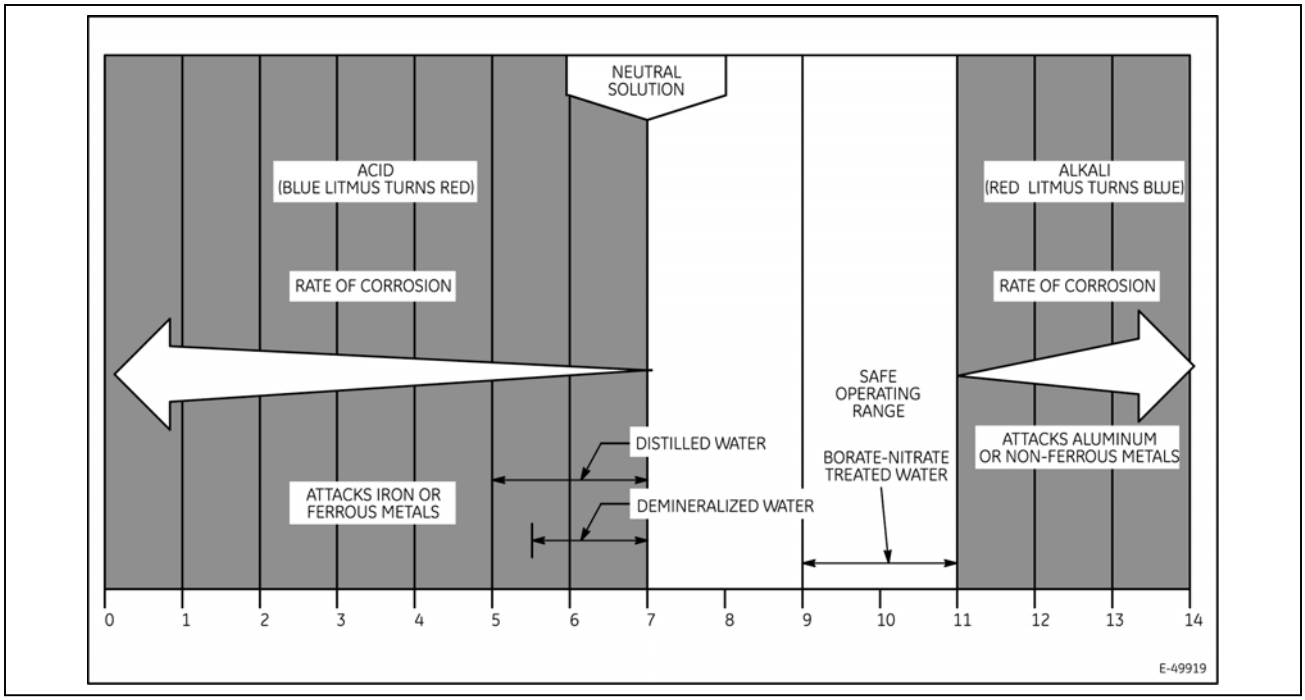

Figure 15-4. Chart Showing pH factors for Cooling Water (E-49919)

15.3.3. Maintaining the Coolant

The recommended normal concentrations of borate and nitrite vary depending on manufacturer and formulation. With a new cooling system, it may be necessary to double or triple this recommended concentration until the system stabilizes. Make-up dosages should err on the rich side to compensate for normal depletion. Note, however, that extremely high concentration of borate-nitrite inhibitor (five to ten times the recommended concentration) can cause loss of bond between the heat exchanger silicone rubber tube sheet and the brass ferrules around each tube in that type of cooling system. If in doubt about the correct concentration, it is best to adhere to the recommended inhibitor concentrations.

WARNING: All water treatment compounds are toxic to some degree. Persons handling treatment compounds should avoid inhaling the fumes or dust and avoid skin contact and eye contact with either solids or solution.

CAUTION: Any dry form of treatment compound must be completely dissolved before it is added to the cooling system. Solutions should be prepared in open containers, with adequate ventilation. Parts and decks should be washed clean of dried-on or spilled compound.

15.3.4. Checking the Coolant

Coolant should be checked weekly in a new engine until the coolant's condition reaches a steady state. Thereafter, the coolant should be checked monthly. Generally, maintenance of pH is not a problem if the inhibitor concentration is maintained at the proper level.

The most accurate way to measure inhibitor concentration is by standard laboratory techniques. However, laboratory analysis is time-consuming and is not suited for routine checking. Several other methods are available, but each has its disadvantages. Color comparison against known color standards is rapid and simple, but contaminants such as lubricating oil or carbon reduce the accuracy of this method. Chemical tests suitable for routine use rely on pre-mixed materials. Some of these have relatively short shelf life, and results obtained with aged solutions are not conclusive.

Another method, using a lightweight (less than 0.5 kg [(1 lb.]) battery-powered dissolved solids meter, gives very rapid and reasonably accurate results.

The method uses the principle that the electrical conductivity of a liquid solution increases as the concentration of dissolved salts increases. Specific concentration can therefore be easily measured. The dissolved solids meter, with a range of 0 to 10,000 ppm, is available from GE as Tool 147X2261.

Use the dissolved solids meter as follows:

1. Allow the sample being tested to cool to below 72°C (160°F).
2. Push the red button (Figure 15-5) to check the internal standard calibration.
   - The calibration value is marked on the bottom of the meter.
   - The calibration adjustment is under the snap-in disk on the bottom.
   - Adjust calibration until meter reading agrees with calibration setting marked on the bottom of the meter.

   NOTE: Replace the battery if the meter reading is less than full scale at the maximum setting of the calibration control.
3. Rinse cell cup three times with the sample to be tested, then fill with the sample.
4. Push the black button (Figure 15-6) to read parts per million.

Periodically, the meter should be calibrated using the standard 3000 ppm solution (GE Tool 147X2262) provided with the meter. Note that the meter reads total dissolved solids, not just the concentration of inhibitor. Other salts and minerals (if present) will affect the reading. This means that the water used in the cooling system must have been pre-conditioned as described previously before the inhibitor was added.

Figure 15-5. Checking Internal Calibration of Dissolved Solids Meter (E-26415)

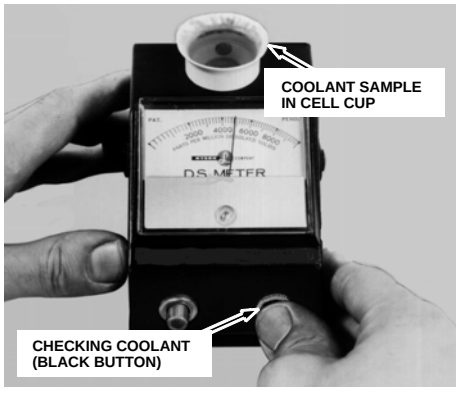

Figure 15-6. Checking Concentration of Water Treatment. (E-26416)

Different brands of commercial inhibitors vary in the proportions of borate and nitrite. Therefore, a reference must first be established by laboratory analysis or by consulting with the inhibitor manufacturer to determine the meter reading at which one of the inhibitor constituents has reached a low value. This reading can then be used as a "go-no go" limit on subsequent checks.

The recommended meter readings listed in **Table 15-4, Recommended Dissolved Solids Meter Readings** are supplied by the manufacturer. Always consult the inhibitor supplier for detailed recommendations and testing methods.

NOTE: Brands of water treatment are noted only because of their wide use in diesel engine applications, and are used only for example. Other brands of water treatment (of equal quality) may also be used.

Make–up dosages should err on the rich side to compensate for normal depletion. For example, if the coolant level is down 170 liters (45 gallons) and make–up water is added, then a minimum of 5.4 liters (180 fluid ounces) of one of the liquid inhibitor packages should be added as well. To compensate for depletion, the 5.4 liters (180 fluid ounces) could be rounded up to 7.6 liters (2 gallons).

On the other hand, if the system is full, but either the borate or the nitrite has reached a low concentration, pre-dissolved inhibitor alone must be added to re-establish normal concentration. For example, to strengthen a full system from half the normal concentration to normal concentration requires one-half of a full dose of treatment.

TABLE 15-4. RECOMMENDED DISSOLVED SOLIDS METER READINGS

Dosage/Reading	Powder*	Liquids*			
	Dearborn 1167	Dearborn 1160	Dearborn 1162	Nalco 2100	Nalco 39
Dosage per liter (Dosage per gallon)	18.1 g (0.64 oz.)	15.6 ml (2 fl. oz.)	15.6 ml (2 fl. oz.)	15.6 ml (2 fl. oz.)	15.6 ml (2 fl. oz.)
Borate Level (ppm as $Na_2B_4O_7$)	2700	2700	2700	1150	1150
Nitrite Level (ppm as $NaNO_2$)	1650	1650	1650	950	950
Dissolved Solids Meter Reading	4000 to 5000	3500 to 4000	3500 to 4000	2700 to 3200	2700 to 3200
Color	Green	Red	Green	Pink	Pink

**Contact supplier for initial dosage recommendations for new or newly overhauled engine.*

15.3.5. Antifreeze

CAUTION: Under no circumstances should a chromate-type inhibitor, automotive-type antifreeze, or antifreeze containing anti-leak compounds be used.

NOTE: The water in the system should still be pre-conditioned with a borate-nitrate treatment as described in Section 15.3.3, Maintaining the Coolant.

NOTE: For the LT system, the addition of glycol will reduce the heat transfer coefficient of the fluid and, in hot climates, may cause the manifold air temperature to exceed its maximum limit due to lack of cooling capacity. Antifreeze application to the LT system should be minimized unless needed for freeze protection during engine shutdown times.

In applications where the customer wishes to use antifreeze in the V228 engine cooling system, pure monoethylene glycol may be used, along with pre-conditioned water. The suggested concentration of antifreeze should fall between 33% and 68% by volume. A 50% solution will protect the engine to temperatures of -40°C (-40°F), whereas a 68% solution will protect the engine to temperatures of -52°C (-62°F). Concentrations should never exceed 68% antifreeze by volume, since this will actually cause the freezing point to rise and will not provide satisfactory heat transfer.

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NEW 04-09 KMA / MDB

GE TRANSPORTATION
2901 EAST LAKE ROAD ERIE, PA 16531

12V228
CONTROL
&
ALARM MONITORING & SAFETY
INTERFACE SCHEMATIC

OWNER: PANAMA CANAL AUTHORITY
CUSTOMER: MARINSA – MIAMI CORP.
FAR: 1417
CLASSIFICATION: LR

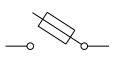
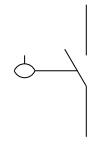
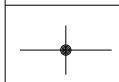
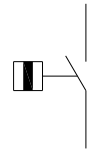
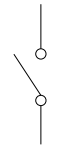
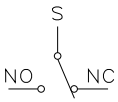
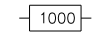
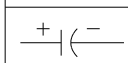
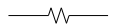
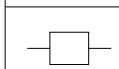
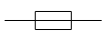
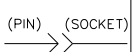
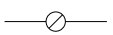
REFERENCE DRAWINGS

ACCESSORY LIST: 41A113574ALG1
ENGINE LIST: 41A113574DLG1 (CCW)
PANEL OUTLINE: 84C626424

GENERAL NOTES

CONTACTS SHOWN IN DE-ENERGIZED POSITION

ACRONYMS	DESCRIPTION
AMSC	ALARM MONITORING SAFETY AND CONTROL
BOS	BAR OVER SWITCH
CAN	CONTROLLER AREA NETWORK
CNR	CRANK SPEED SENSOR
COPS	CRANKCASE OVER PRESSURE SENSOR
DGU	DISTRIBUTED GENERIC UNIT
DIN	WOODWARD DISCRETE INPUT MODULE
DOUT1	WOODWARD DISCRETE OUTPUT MODULE 1
DOUT2	WOODWARD DISCRETE OUTPUT MODULE 2
DSS1	DIESEL SPEED SENSOR 1
DSS2	DIESEL SPEED SENSOR 2
ECA	ENGINE CRANK ANGLE HARNESS
EGT	EXHAUST GAS THERMOCOUPLE OUTPUT CABLE
EGU	ENGINE GOVERNING UNIT
EPS	ENGINE POSITION SENSOR
ESU	ENGINE SAFETY UNIT
FIEWT	ENGINE WATER TEMPERATURE
FILP1-6	FUEL INJECTION LEFT PUMP 1-6
FIMAP	MANIFOLD AIR PRESSURE
FIMAT	MANIFOLD AIR TEMPERATURE
FIOP1	LUBE OIL PRESSURE
FIP	FUEL INJECTION PUMP HARNESS
FIPTS	FUEL INJECTION PUMP TEST SWITCH (POP TEST)
FIRP1-6	FUEL INJECTION RIGHT PUMP 1-6
FIS	FUEL INJECTION SENSOR HARNESS
FIWPS	ENGINE WATER PRESSURE
FOT	FUEL OIL TEMPERATURE
FOTS	FUEL OIL TEMPERATURE HARNESS
FPR	FUEL PUMP RELAY
HPFLD	HIGH PRESSURE FUEL LEAK DETECTION
ISO	ISOLATOR
LCP	LOCAL CONTROL PANEL
LOT	LUBE OIL TEMPERATURE
LPTB	LEFT PRETURBINE TEMPERATURE BOTTOM
LPTT	LEFT PRETURBINE TEMPERATURE TOP
OMD	OIL MIST DETECTOR
RAI-10TC	10 CHANNEL THERMOCOUPLE ANALOG INPUT MODULE
RAI-16	16 CHANNEL DIGITAL/ANALOG INPUT MODULE
RDO-16	16 CHANNEL DIGITAL OUTPUT MODULE
REMOTE MOS	MIDI OPERATING STATION (HMI IN BRIDGE)
RPTB	LEFT PRETURBINE TEMPERATURE BOTTOM
RPTT	LEFT PRETURBINE TEMPERATURE TOP
SAP	STARTING AIR PRESSURE SENSOR
SRLC	WOODWARD 723PLUS SPEED CONTROLLER
TB	TERMINAL BOARD

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	FUSE DISCONNECT		SINGLE PHASE MOTOR		LEVEL SWITCH
	NO CIRCUIT CONNECTION		THREE PHASE MOTOR		
	CIRCUIT CONNECTIONS		STEPPER MOTOR		PRESSURE SWITCH
			Estop PUSH BUTTON		
			RELAY CONTACT (NO)		FORM C CONTACTS
	RESISTOR				
	CAPACITOR (NON - POLARIZED)		RELAY CONTACT (NC)		FAN
	CAPACITOR (POLARIZED)				SHUNT COIL RELAY OR CONTACTOR
	RELAY/CONTACTOR COIL		TWISTED SHIELDED PAIR/ MULTI CONDUCTOR		
	FUSE				
	PLUG TERMINATION		TERMINAL BOARD POINT		
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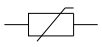
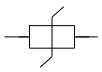
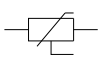
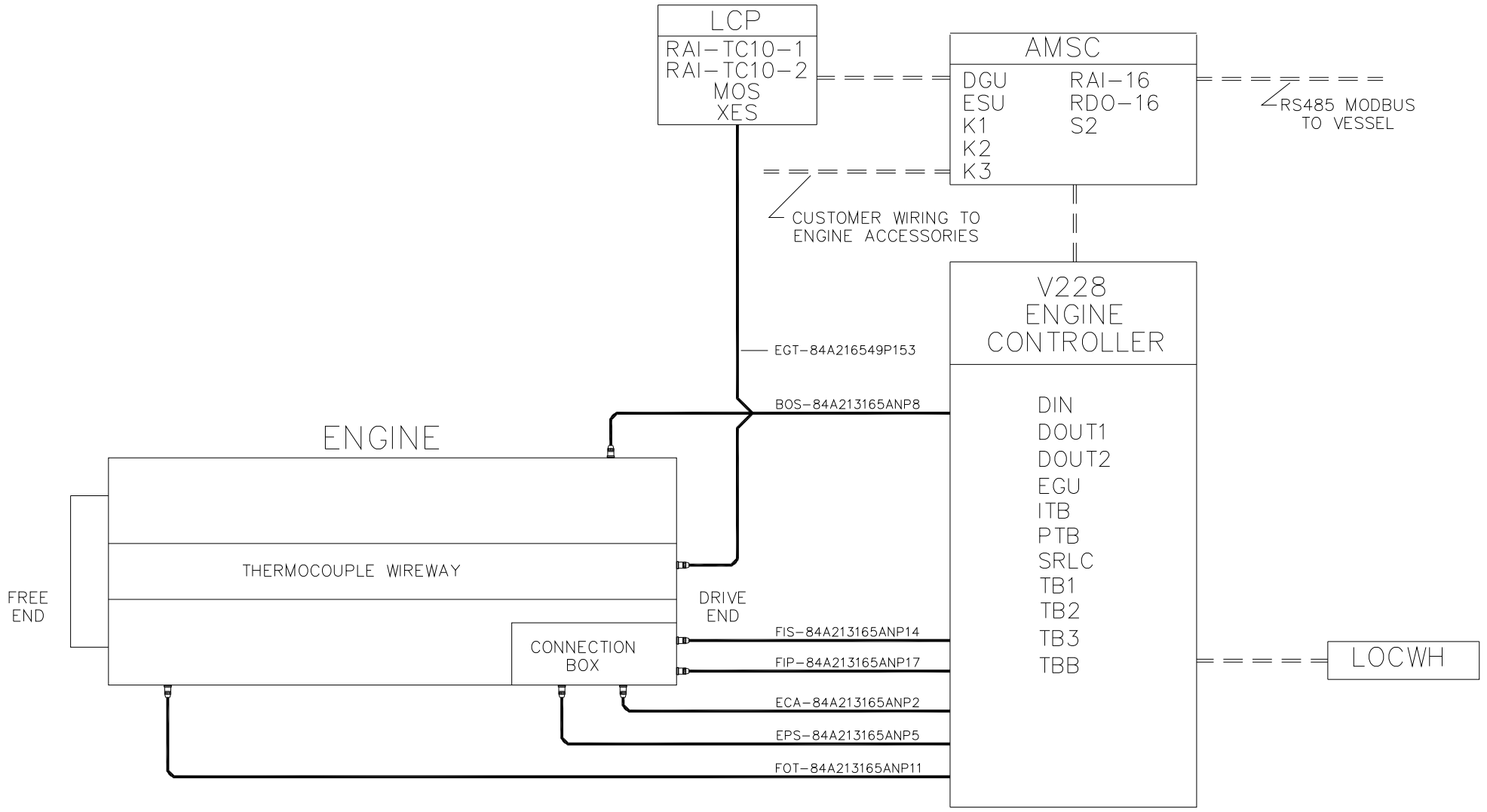
	THERMISTOR		SHIPS GROUND		
	THERMISTOR (MOV TYPE)		INDICATES DEVICE OR COMPONENT NOT FURNISHED BY GE		
	RTD		SWITCH (OPERATED BY TURNING)		

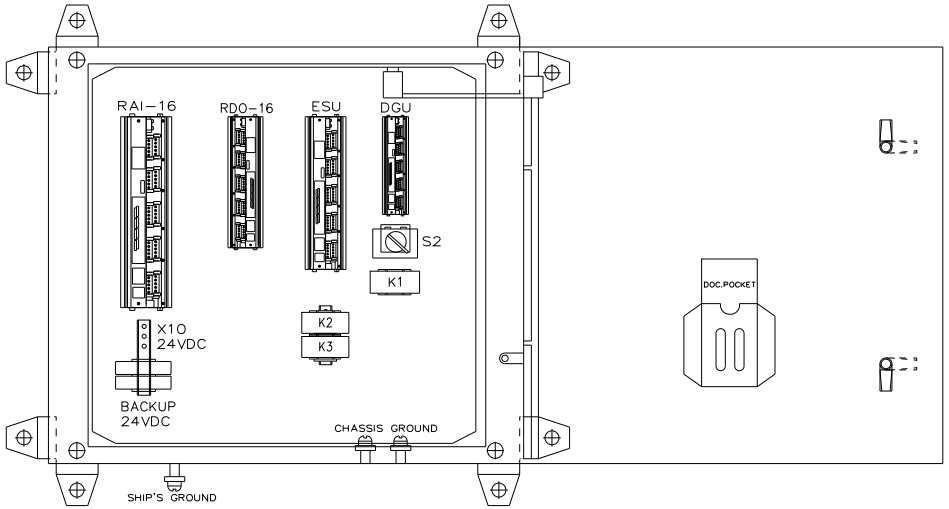


= = = DENOTES CUSTOMER SUPPLIED WIRING

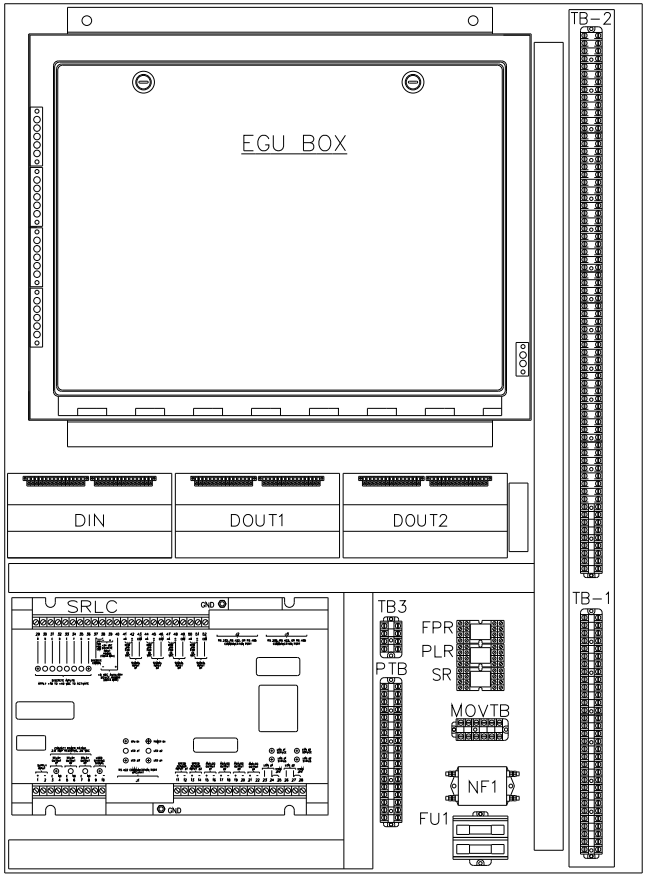
NOTE:
CUSTOMER SUPPLIED WIRING TO ACCESSORIES NOT INCLUDED IN ENGINE OUTPUT CABLES

AMSC MAIN CABINET

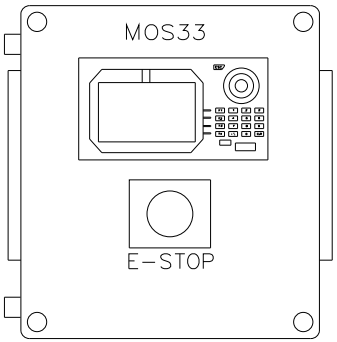
INTERNAL VIEW



V228 ENGINE CONTROLLER (INTERNAL VIEW)



LCP (FRONT VIEW)



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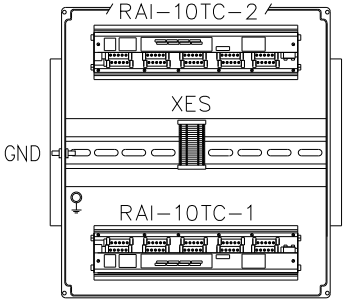

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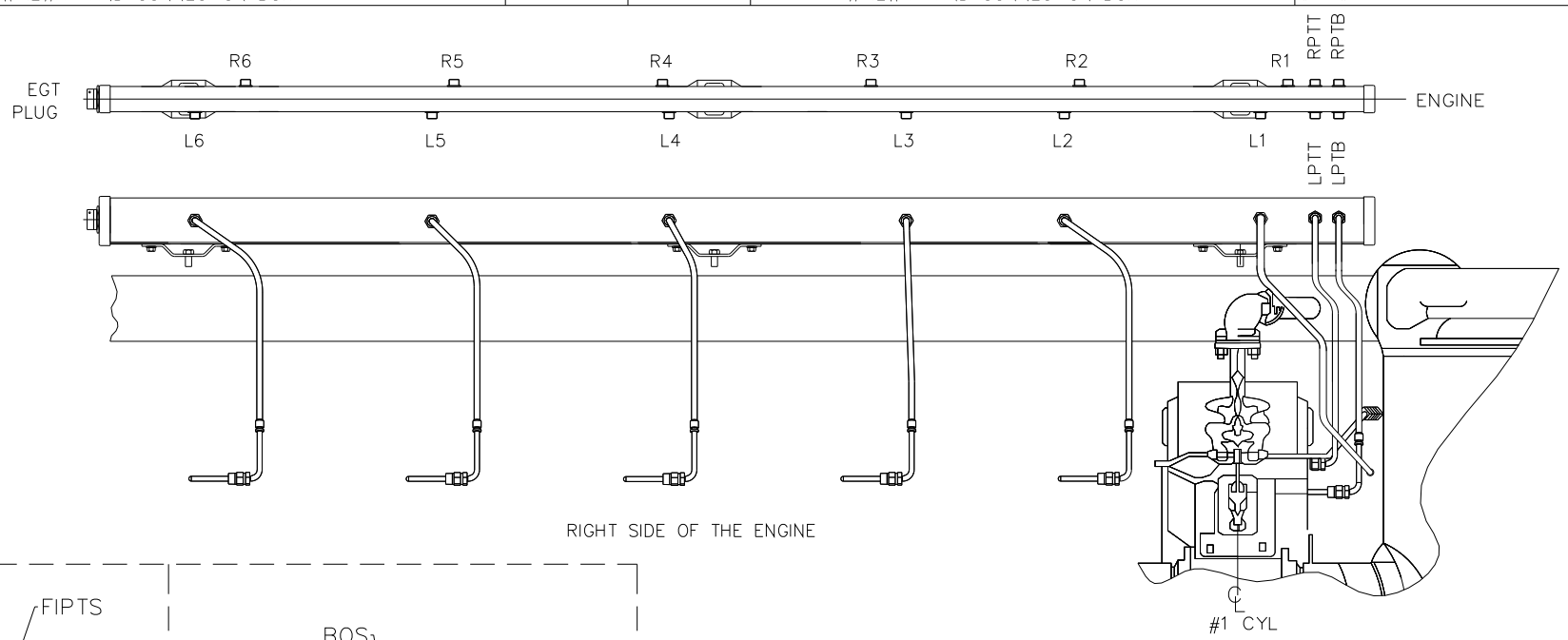
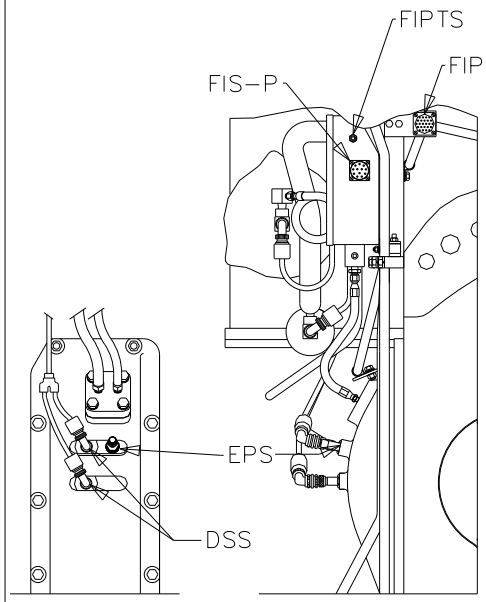


RIGHT SIDE OF THE ENGINE



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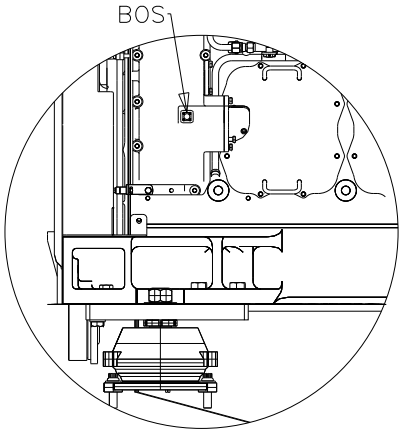

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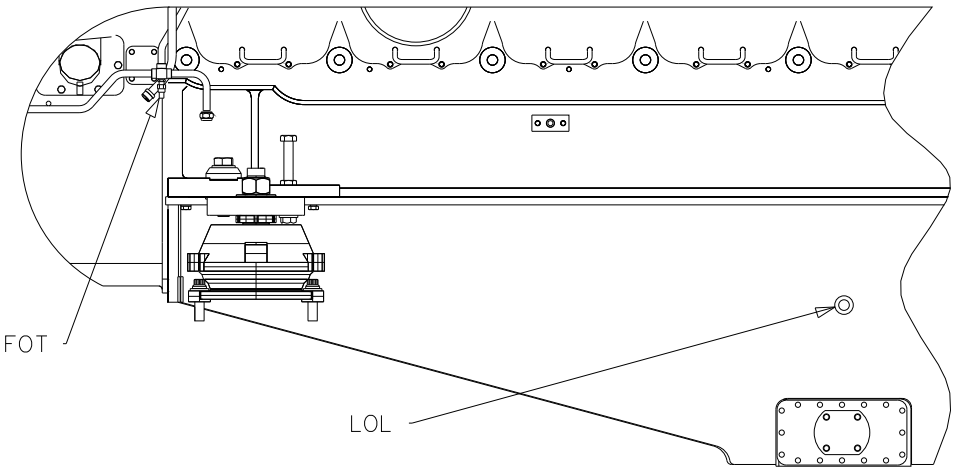
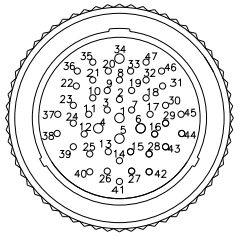


LEFT SIDE OF ENGINE

REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH. 7 SH. NO. 6

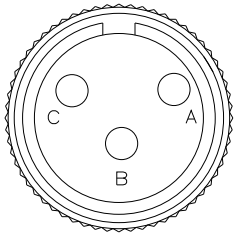
RC

CONNECTOR DETAIL | SECT. 7A | SECT. 7B | CONNECTOR DETAIL



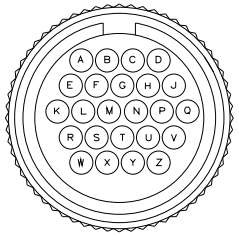
EGT

CABLE SIDE



BOS

CABLE SIDE



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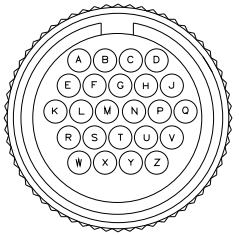
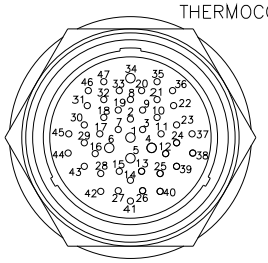


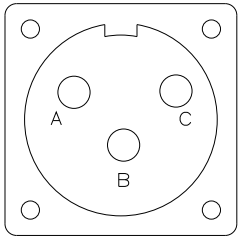
FIP

CABLE SIDE

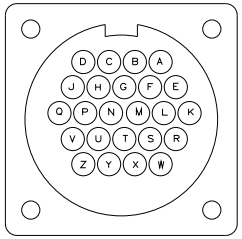
THERMOCOUPLE WIREWAY

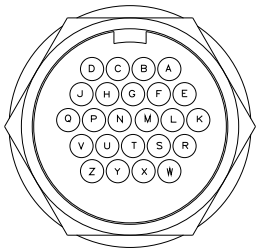


ENGINE

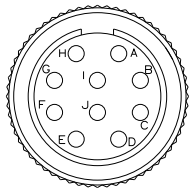


CONNECTION BOX

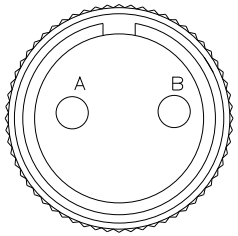




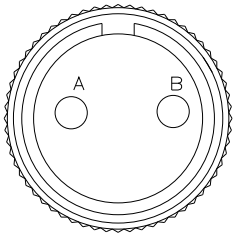
CONNECTION BOX



ECA



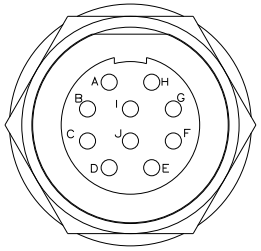
EPS

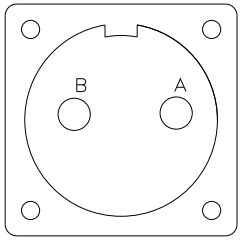


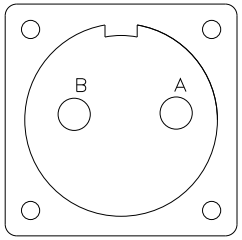
FOT

CABLE SIDE

ENGINE







			REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO. RC	ERIE PLANT	84B533512 CONT. ON SH. 8 SH. NO. 7

LUBE OIL & COOLING
WATER HEATER
480VAC-60Hz

(480VAC-60Hz)
(480VAC-60Hz)
(480VAC-60Hz)

LOCWH

+24VDC
V228C
TB2-4
(SEE APPENDIX A)

CTRL PLL
1.0 K 2M

V228C
TB2-16
(SEE APPENDIX A)

V228C
TB2-19
(SEE APPENDIX A)

10

2

V228C
PTB-6
(SEE APPENDIX A)

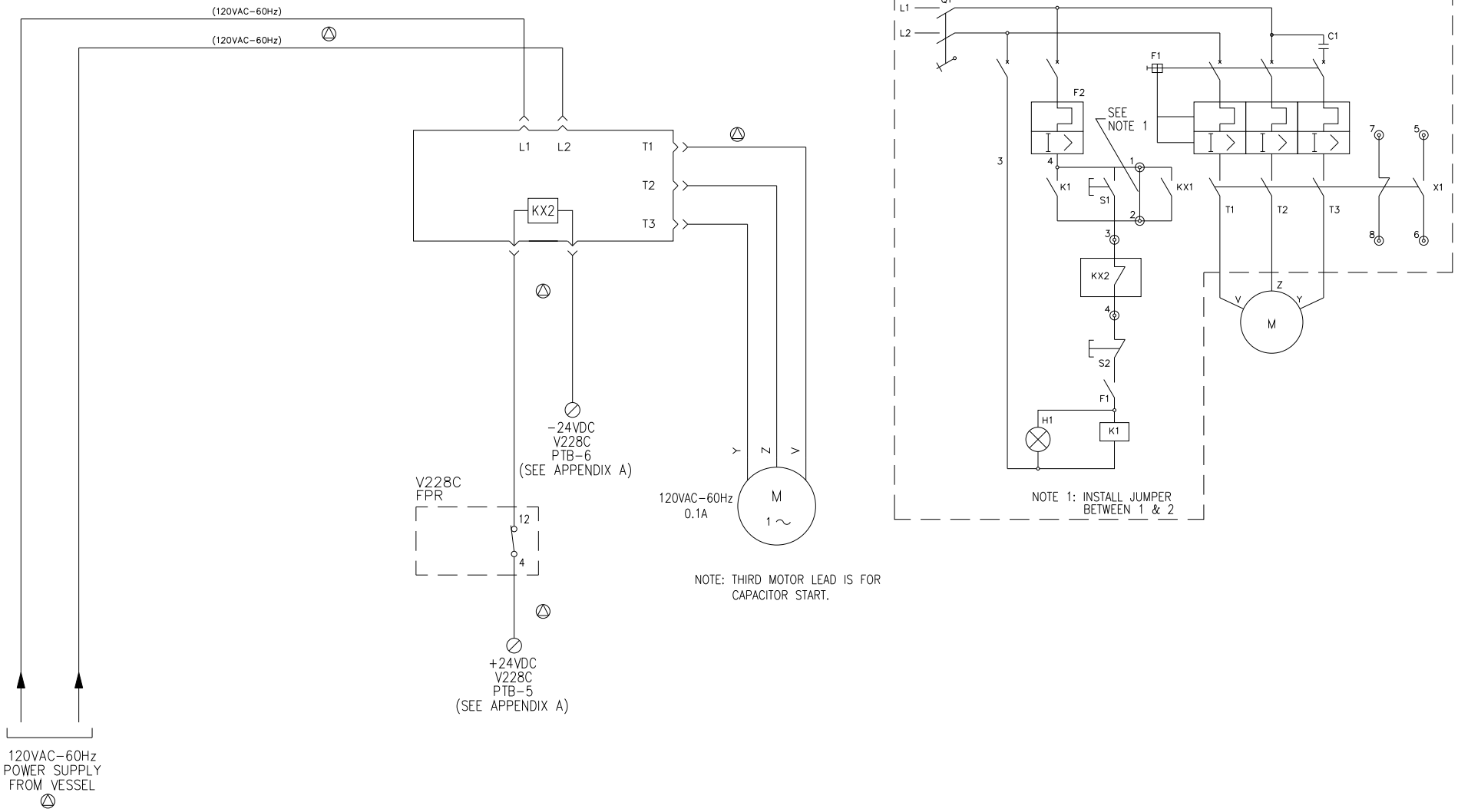
+24VDC
V228C
PTB-5
(SEE APPENDIX A)

(480VAC-60Hz)
POWER SUPPLY
FROM VESSEL

NOTE: NORMALLY CLOSED CONTACT OF PLR NEEDS TO BE WIRED TO PTB-5 (+24VDC).

120VAC–60Hz
POWER SUPPLY
MANUAL SWITCH

ALFA LAVAL
FUEL FILTER
MOTOR CONTROL BOX
120VAC–60Hz



REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT 84B533512 CONT. ON SH. 10 SH. NO. 9

RC

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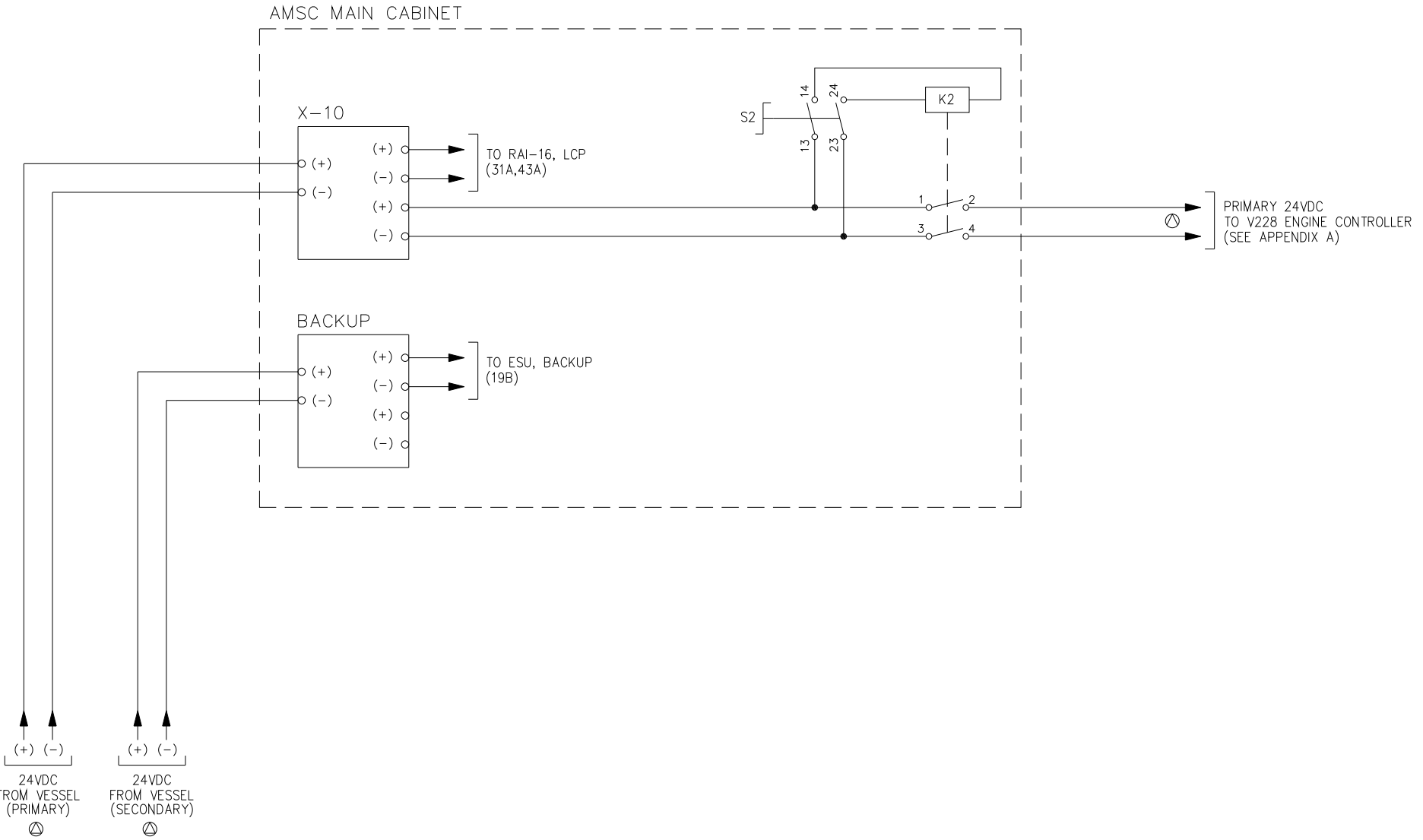
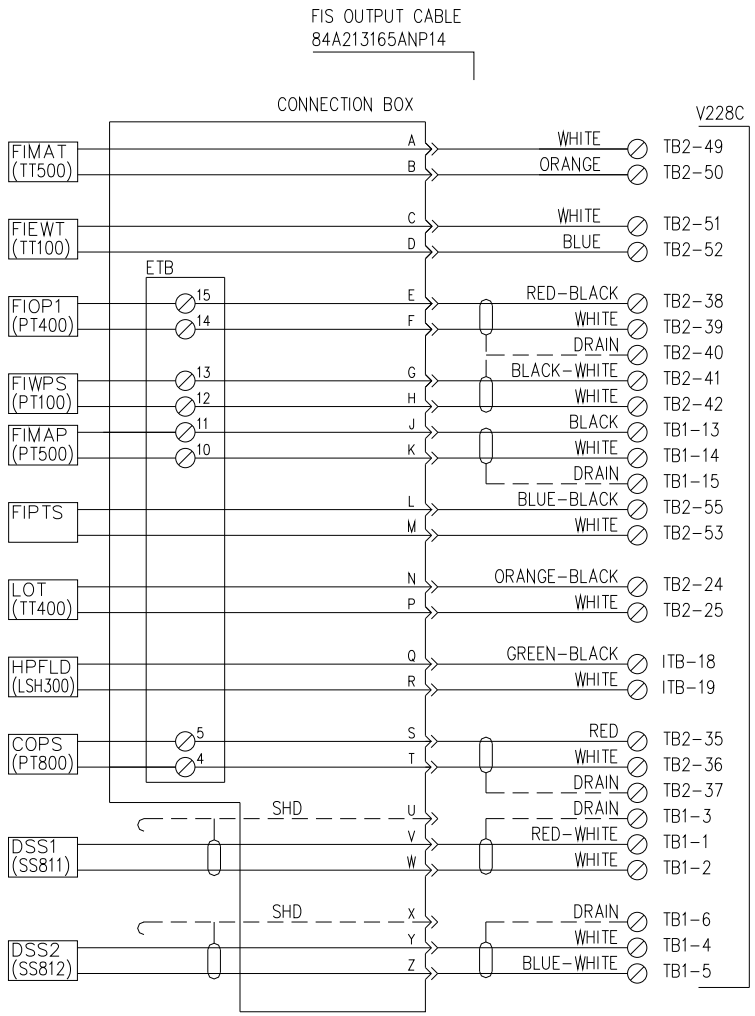
24VDC FROM VESSEL (PRIMARY) | 24VDC FROM VESSEL (SECONDARY) | AMSC MAIN CABINET



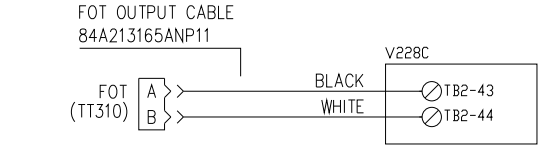
REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH. 12 SH. NO. 11

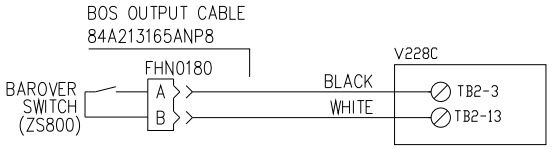
RC

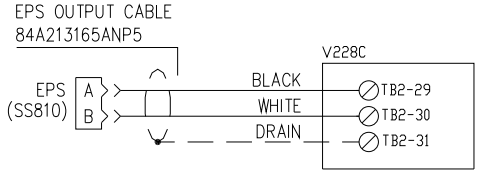
INTENTIONALLY BLANK

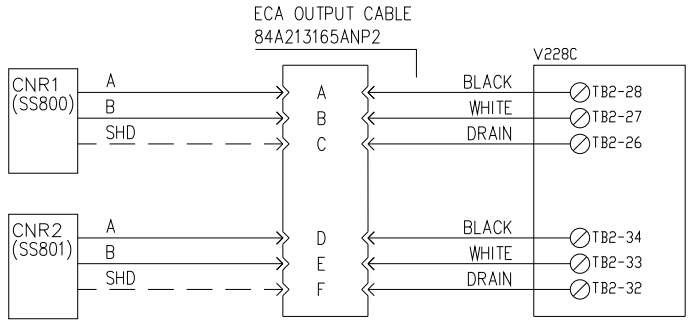


FIS OUTPUT CABLE SUPPLIED BY GE.
(INSTALLED BY CUSTOMER)









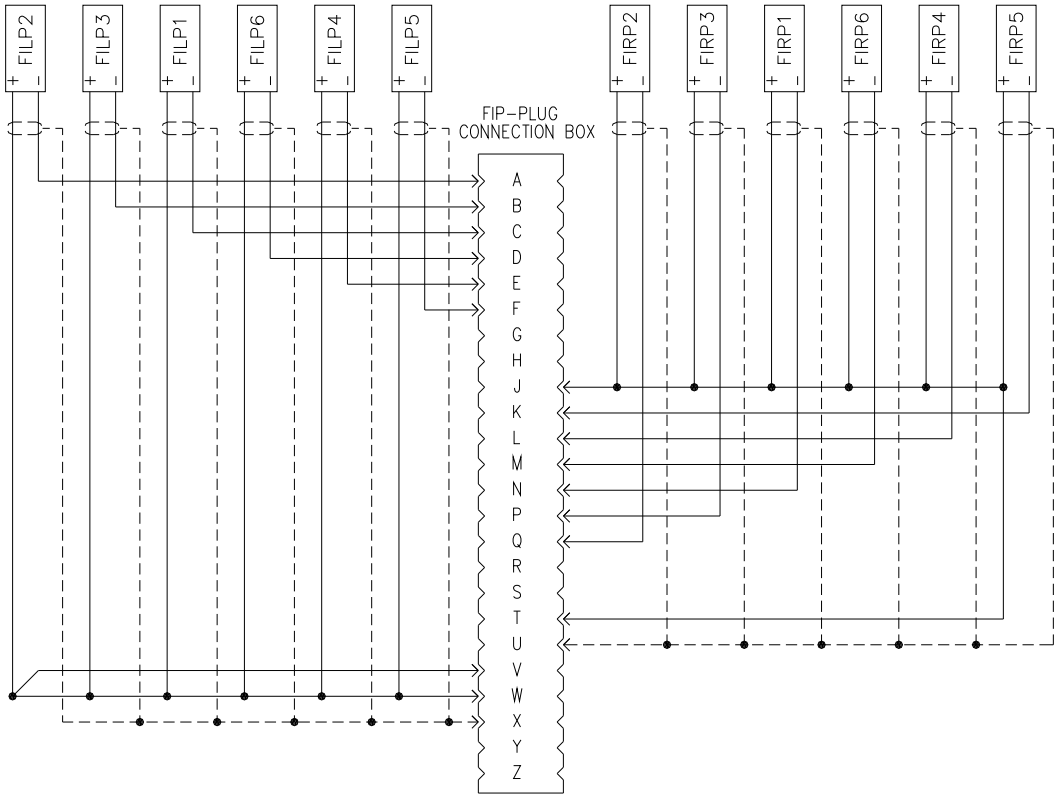
FIP OUTPUT CABLE
84A213165ANP17

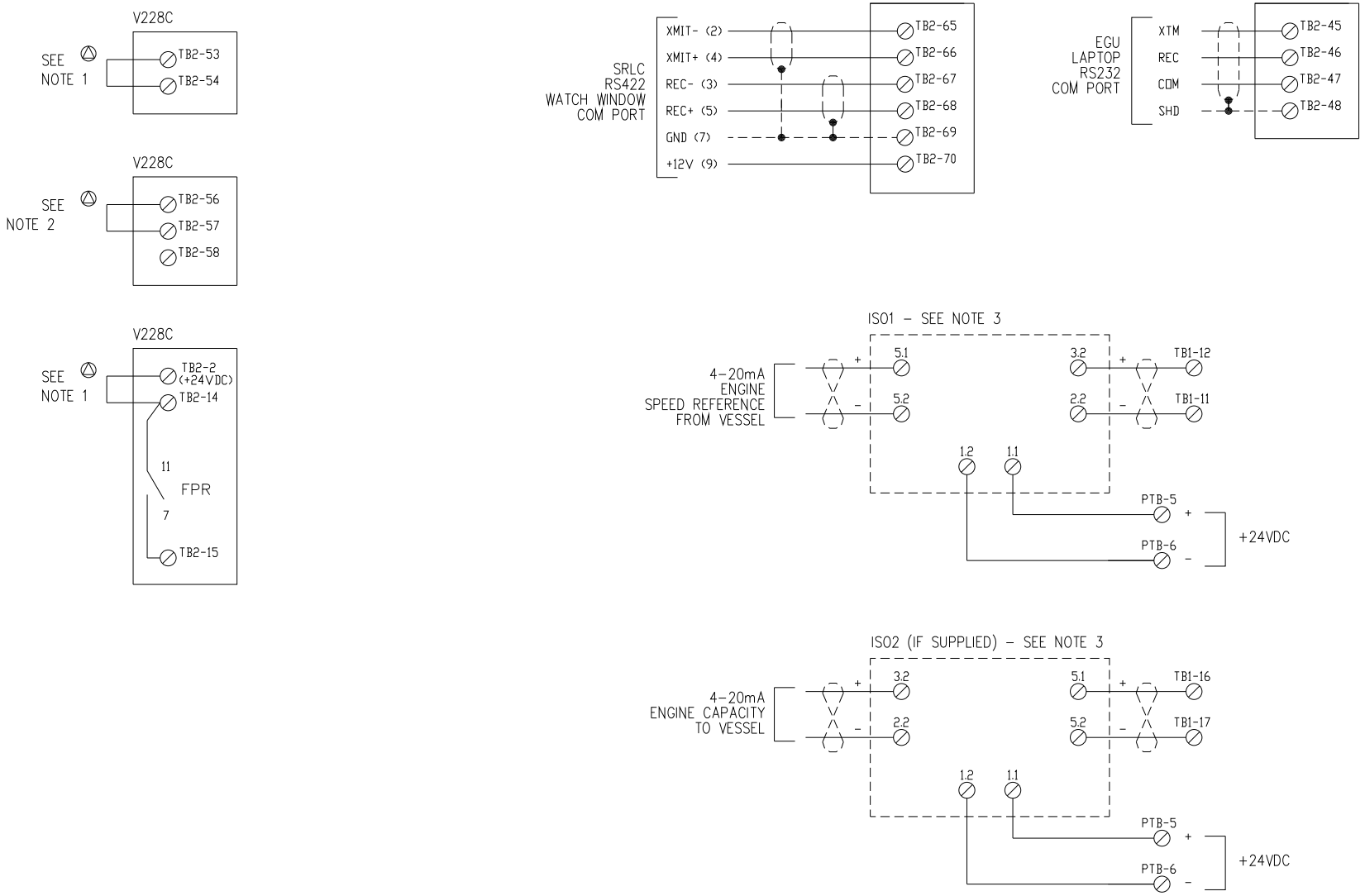
FIP–PLUG
CONNECTION BOX

V228C

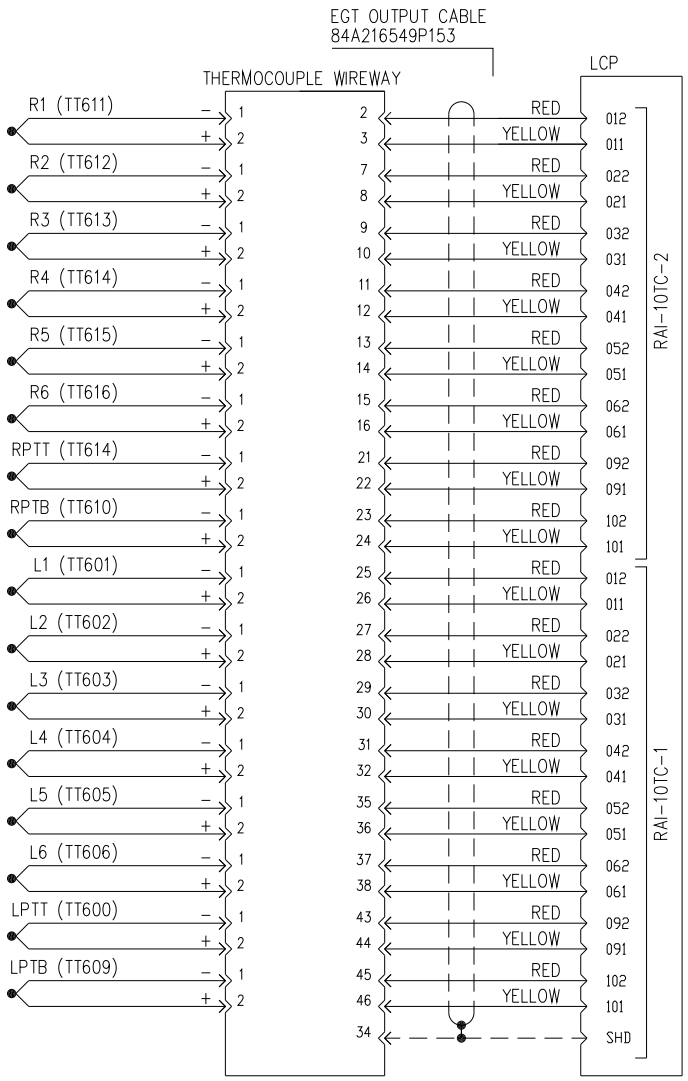
A	BROWN	TBB-13	
B	BLACK–WHITE	TBB-19	
C	PURPLE–WHITE	TBB-14	
D	ORANGE–WHITE	TBB-16	
E	YELLOW	TBB-20	
F	GRAY–WHITE	TBB-18	
G	PINK	TBB-15	
H	PINK–BLACK	TBB-17	
J	RED–WHITE	TBB-1	
K	WHITE–BLACK	TBB-5	
L	ORANGE	TBB-11	
M	GRAY	TBB-6	
N	YELLOW–WHITE	TBB-8	
P	BLUE–WHITE	TBB-12	
Q	VIOLET	TBB-10	
R	BLACK	TBB-7	
S	RED	TBB-9	
T	BLUE	TBB-2	
U	GREEN–WHITE	GNDBR	
V	BROWN–WHITE	TBB-4	
W	WHITE	TBB-3	
X	GREEN	GNDBR	
Y			
Z			

FIP OUTPUT CABLES SUPPLIED BY GE.
(INSTALLED BY CUSTOMER)





NOTES:
1. INSTALL JUMPERS IN DIRECT PROPULSION APPLICATIONS.
2. INSTALL JUMPER BETWEEN TB2-56 AND TB2-57 FOR CCW ROTATION.
3. PROVIDED IN 84A213165AL KIT.



EGT OUTPUT CABLE SUPPLIED BY GE.
(INSTALLED BY CUSTOMER)

BLANK	SECT. 17A	SECT. 17B	BLANK

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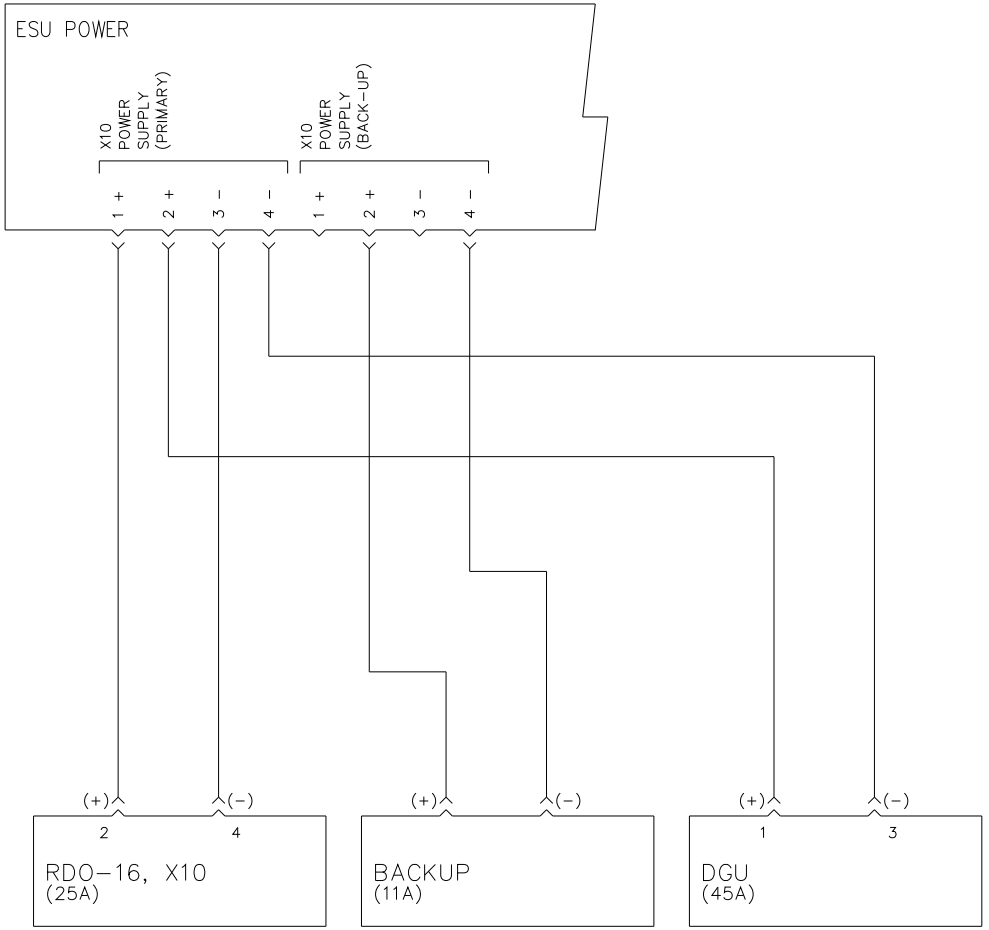
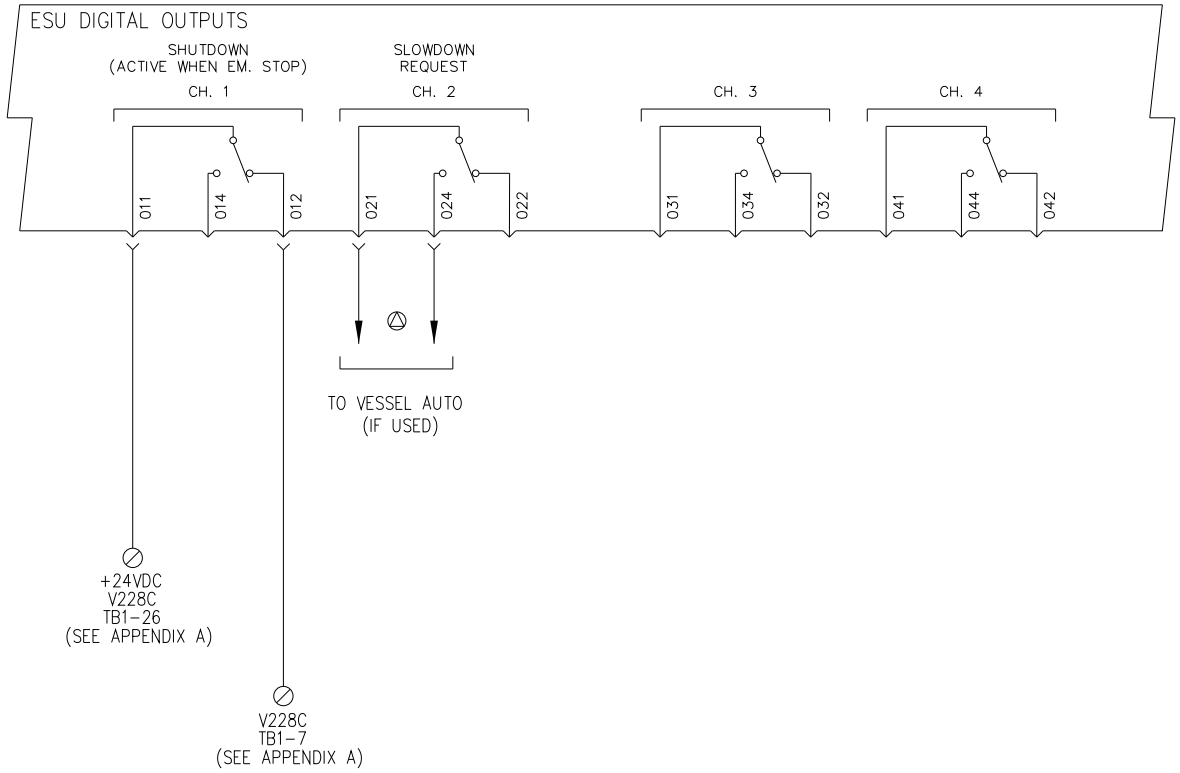
BLANK	SECT. 18A	SECT. 18B	BLANK

INTENTIONALLY BLANK

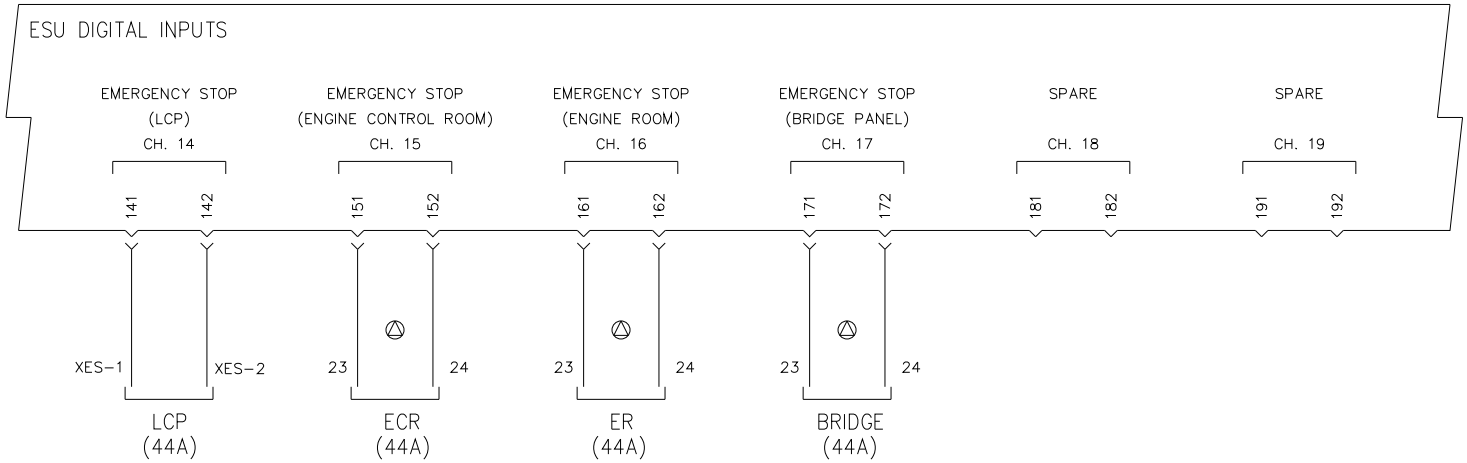




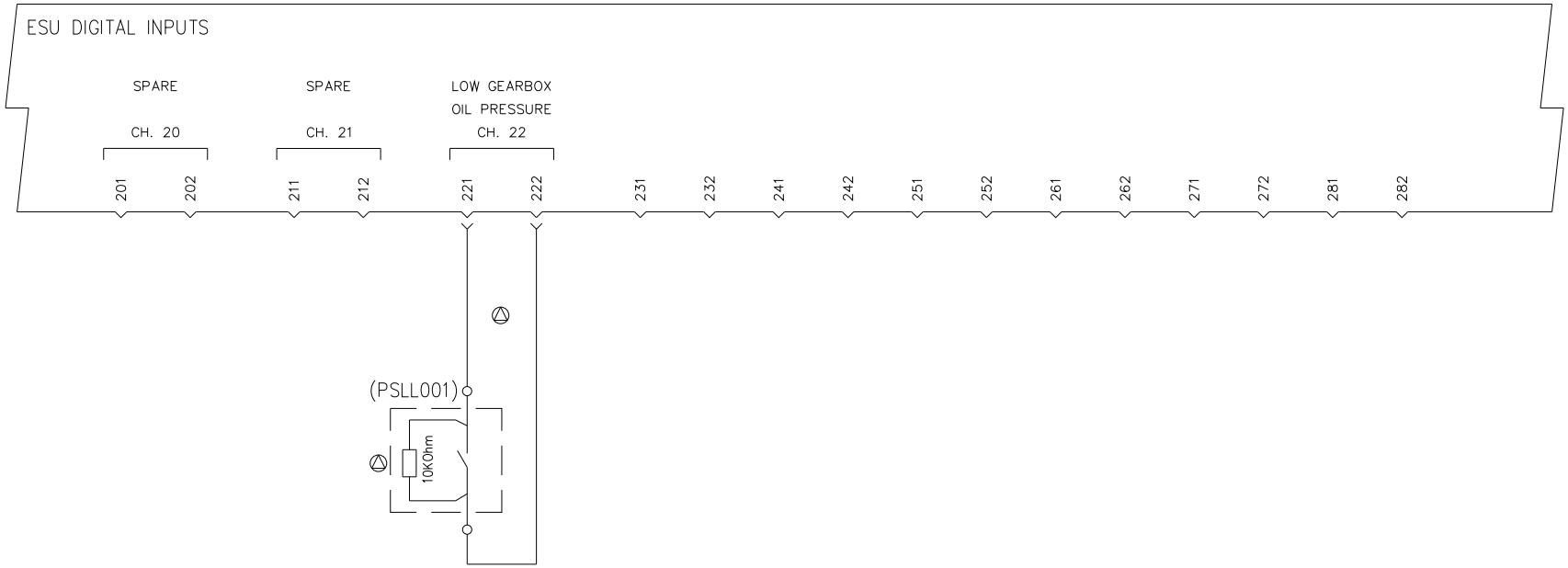
ESU SOLENOID OUTPUTS

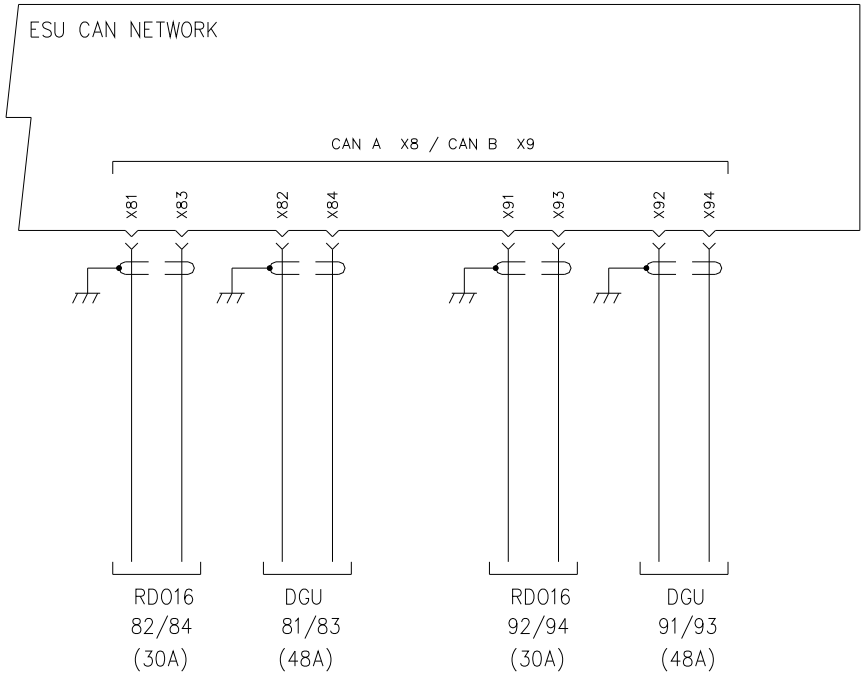
SOLENOID OUTPUT X1 (NOT USED)

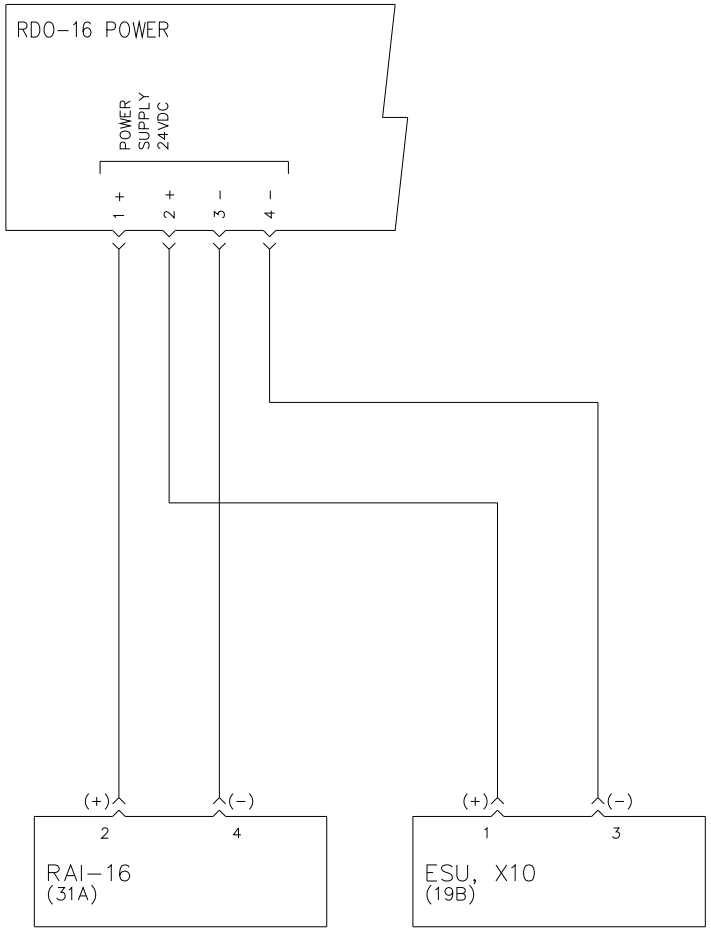
051 052 061 062 071 072 081 082 091 092 044 101 102 111 112 121 122 131 132

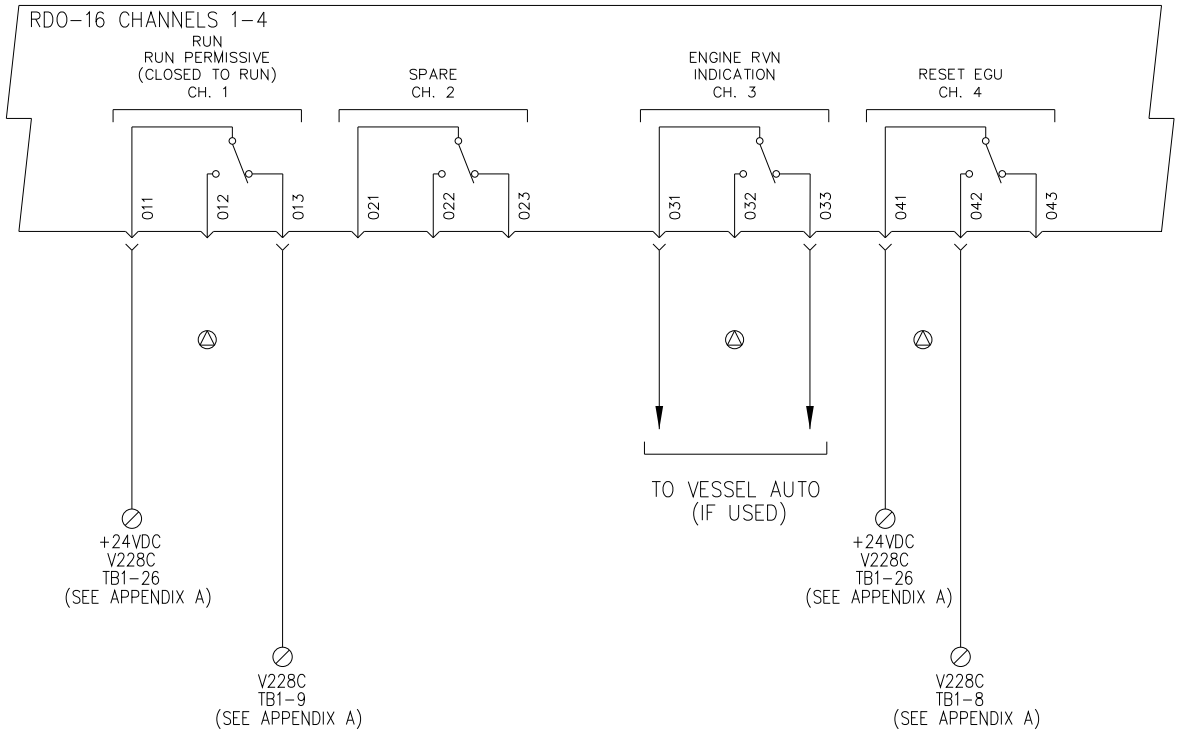


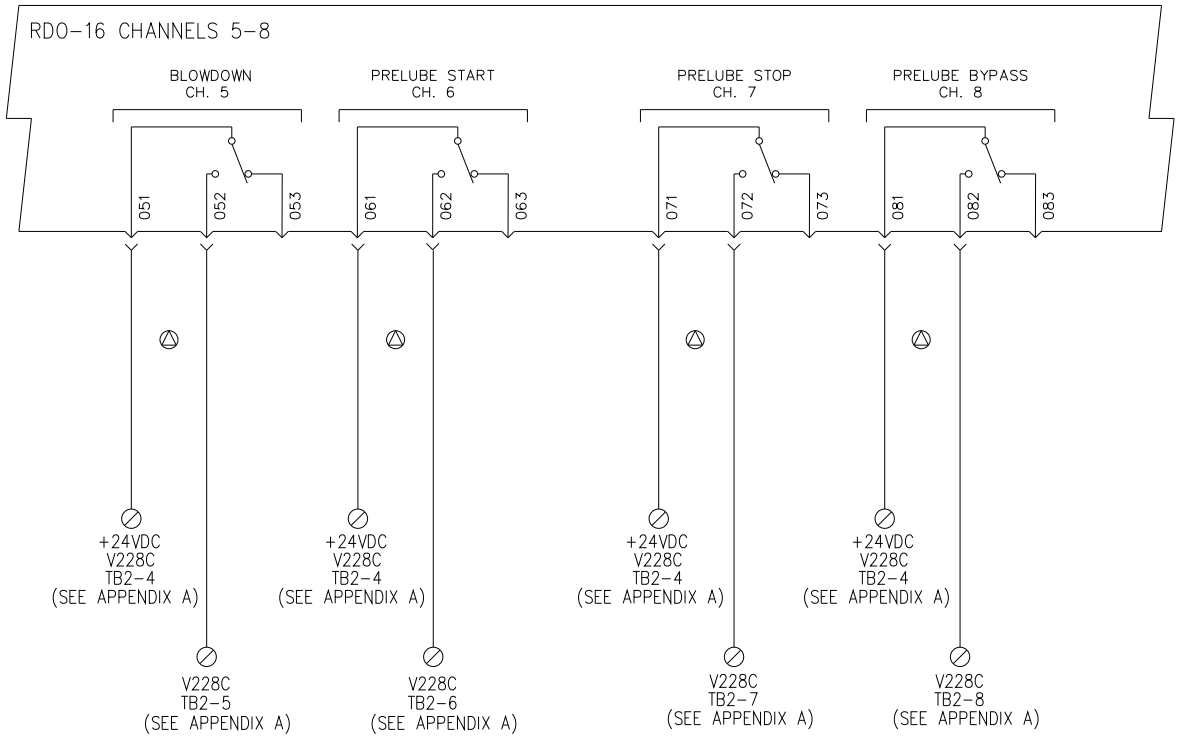
△ NOTE: E-stops PROVIDED BY CUSTOMER.

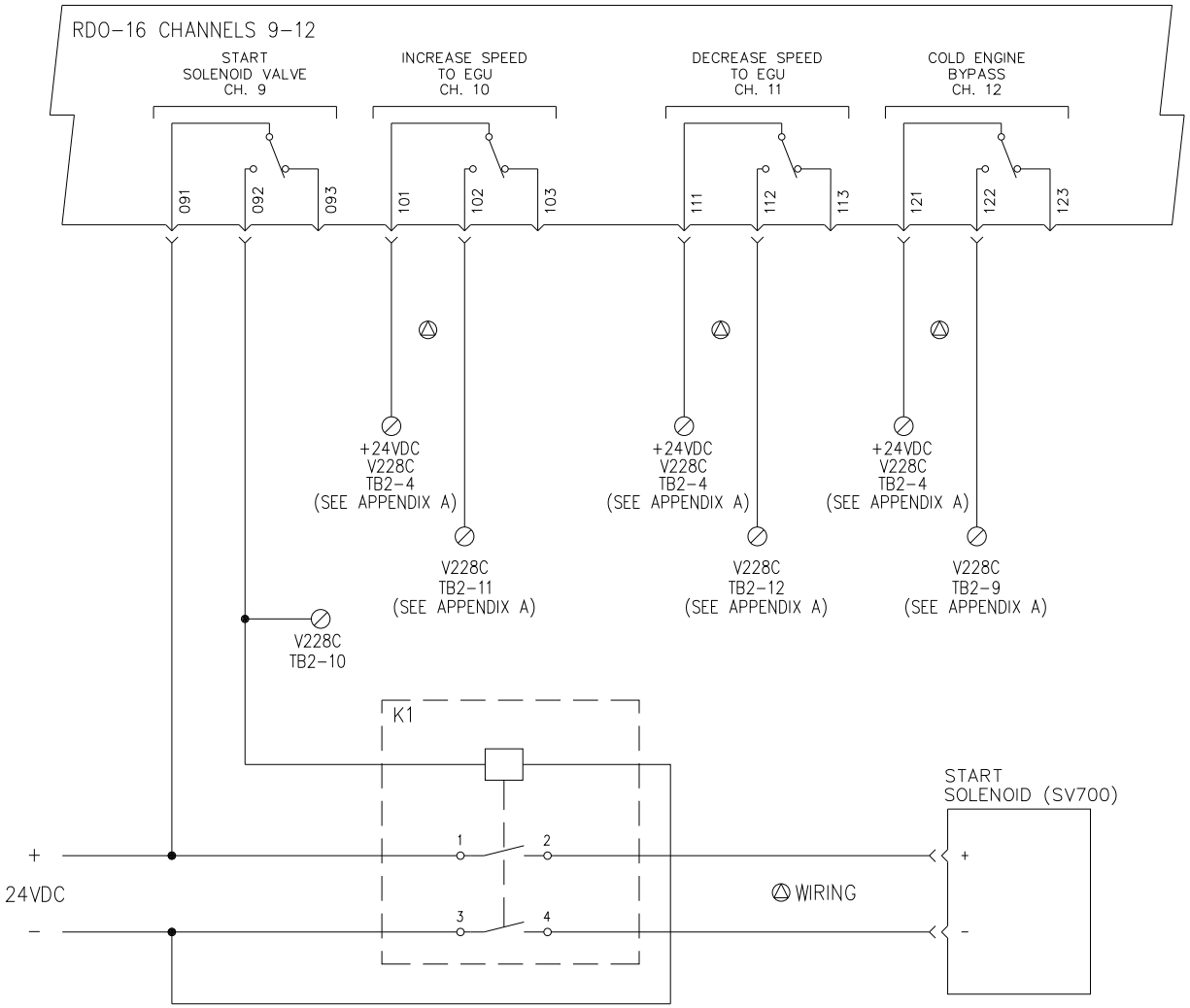






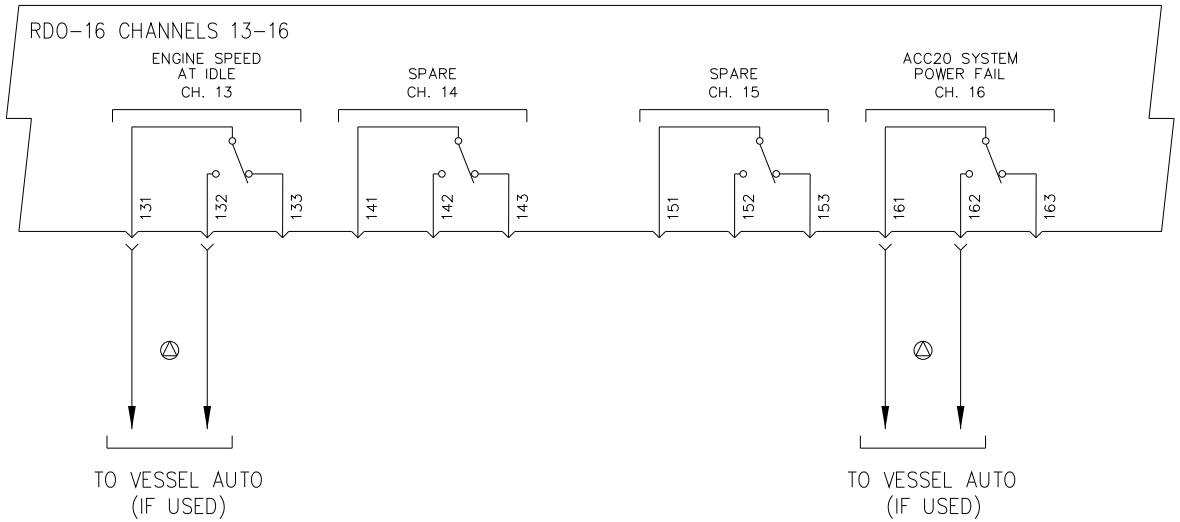


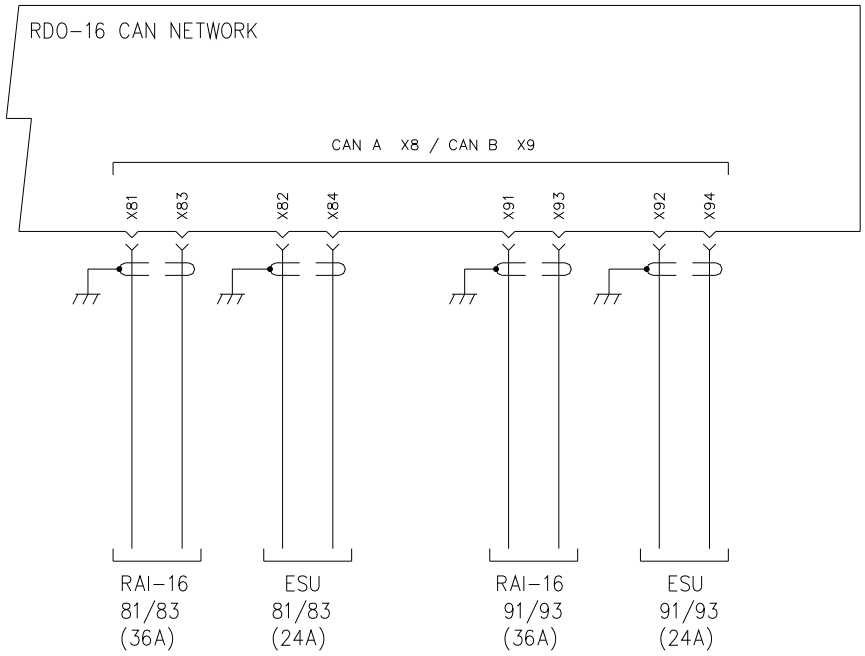


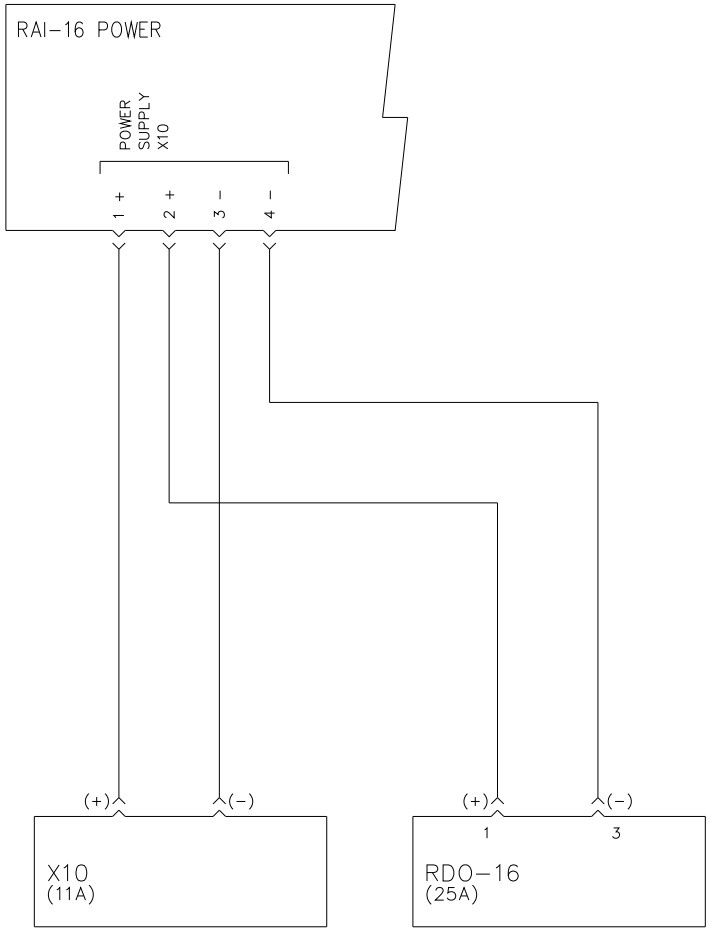


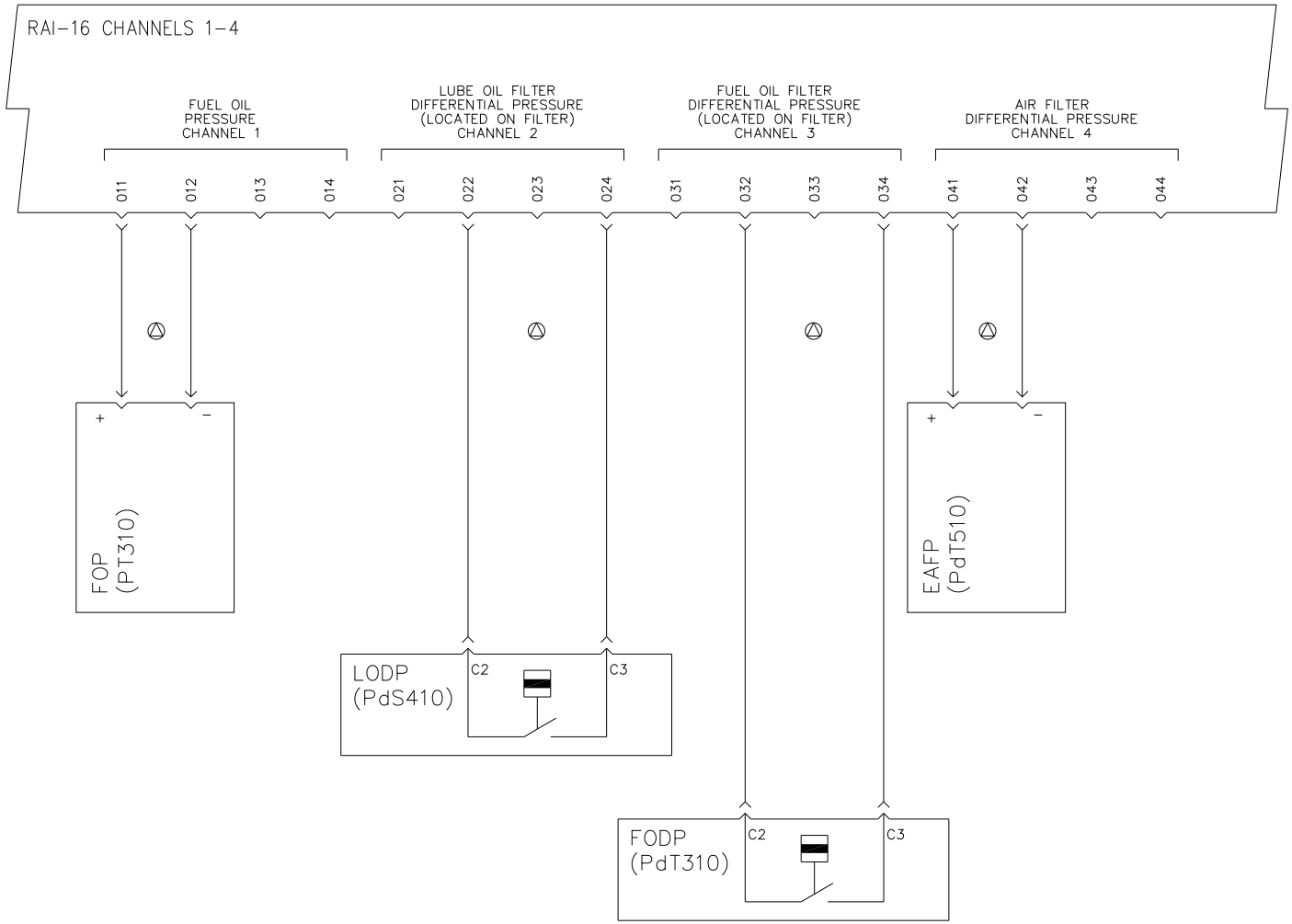
			REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL - MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH. 29 SH. NO. 28

RC



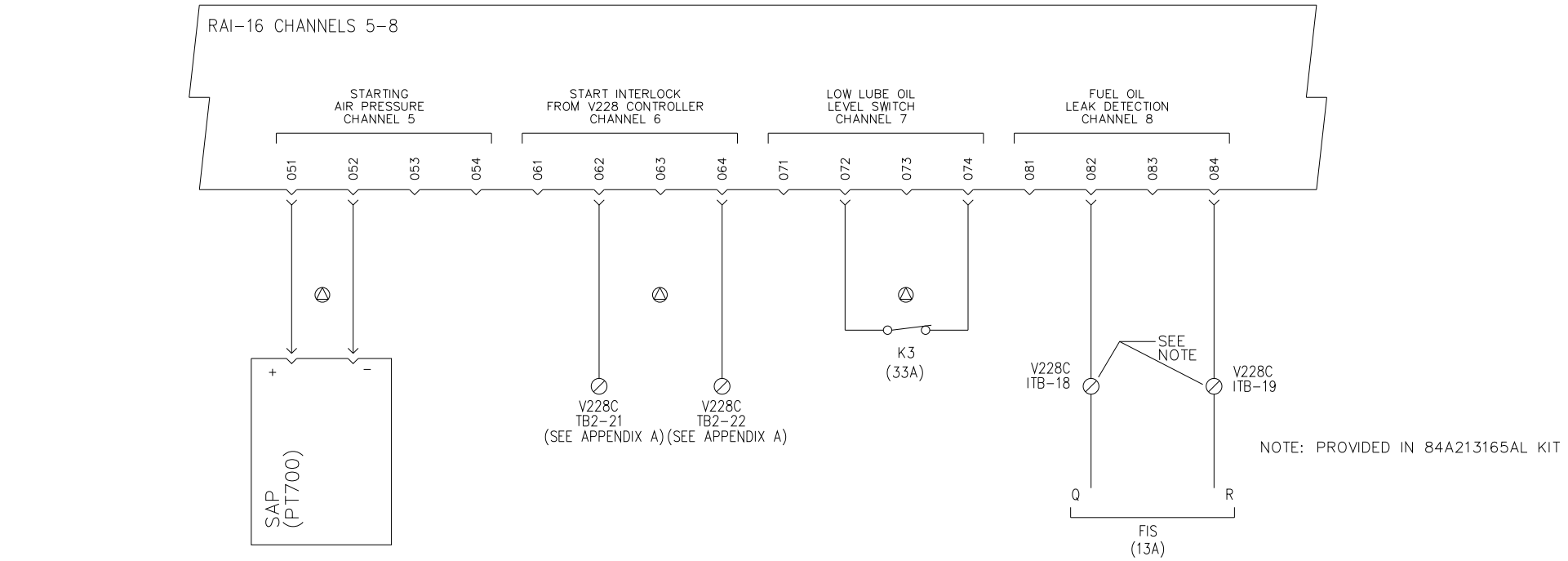


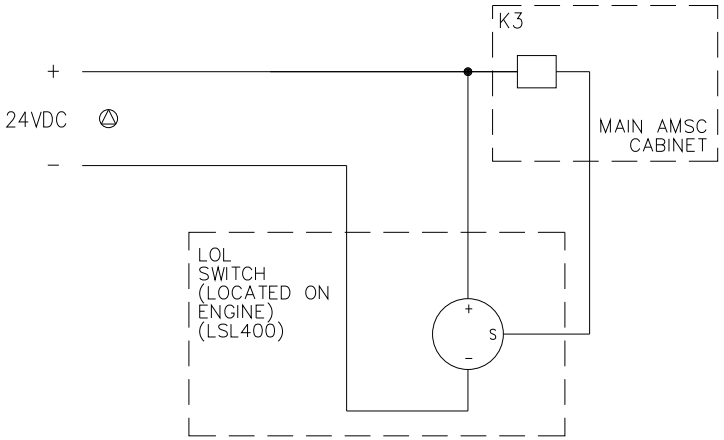




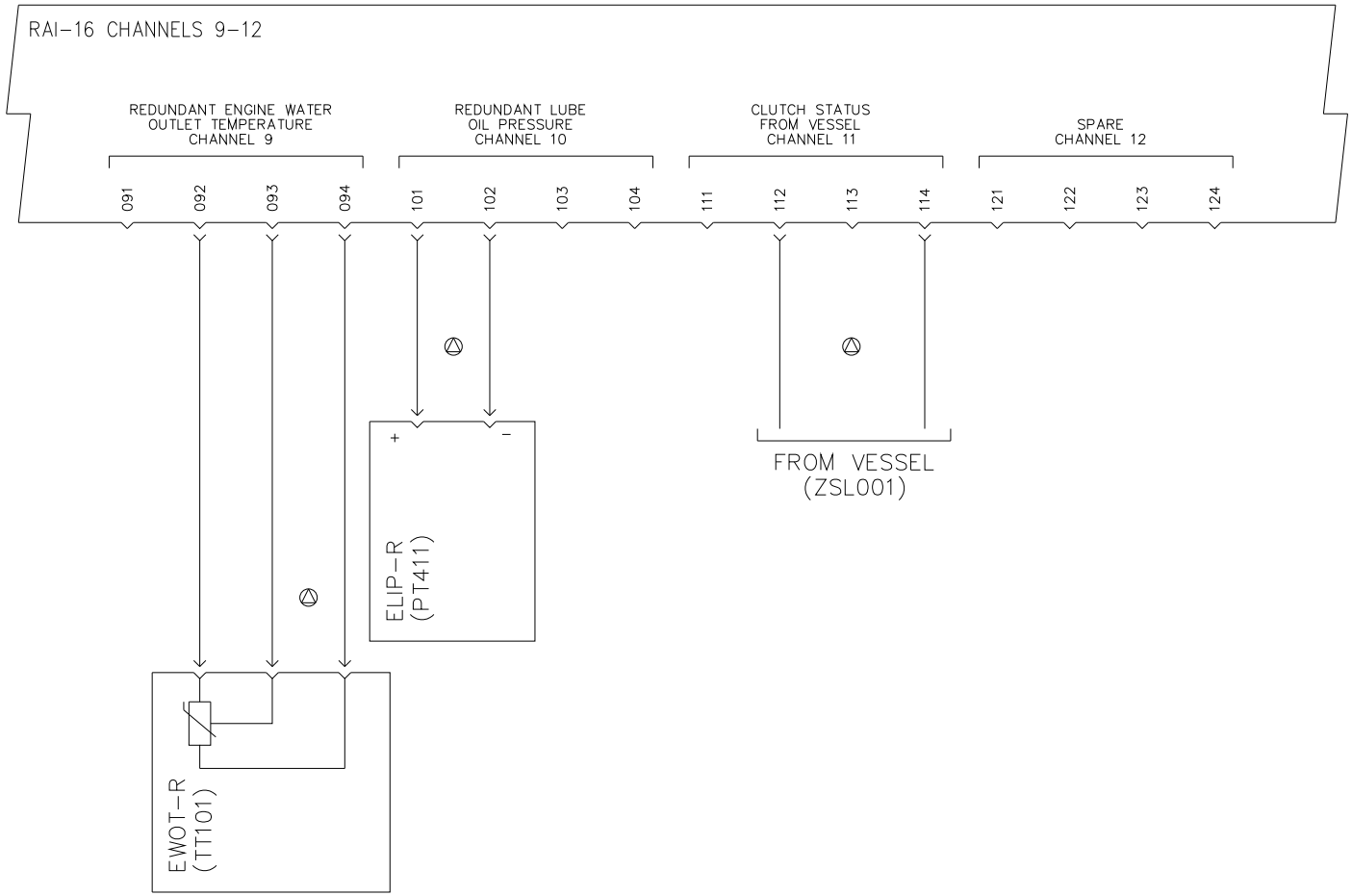
REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY	CDICADD(MAC) 3.19.09	APPROVAL	CONTROL	ERIE PLANT	84B533512 CONT. ON SH. 33 SH. NO. 32
		ISSUE	CDICADD(MAC) 3.19.09	B. LARSON	GENERAL ELECTRIC CO.		

RC

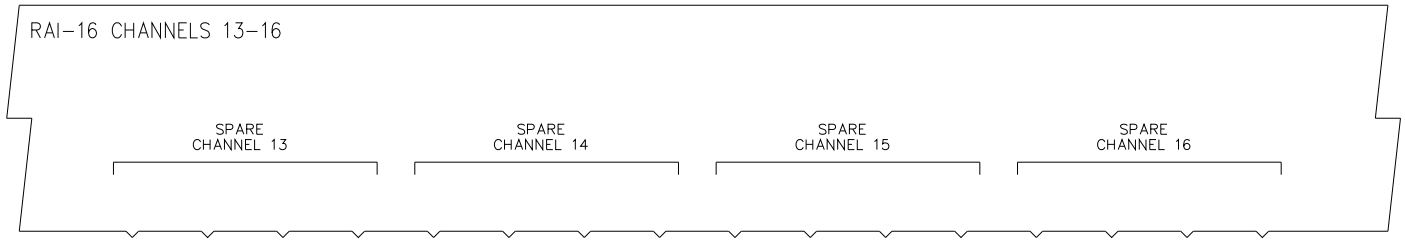


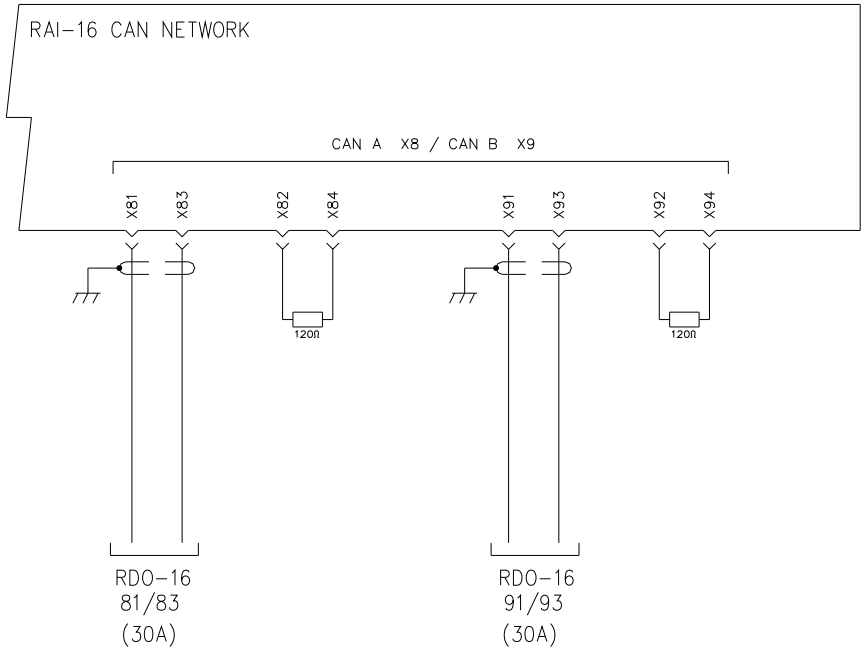


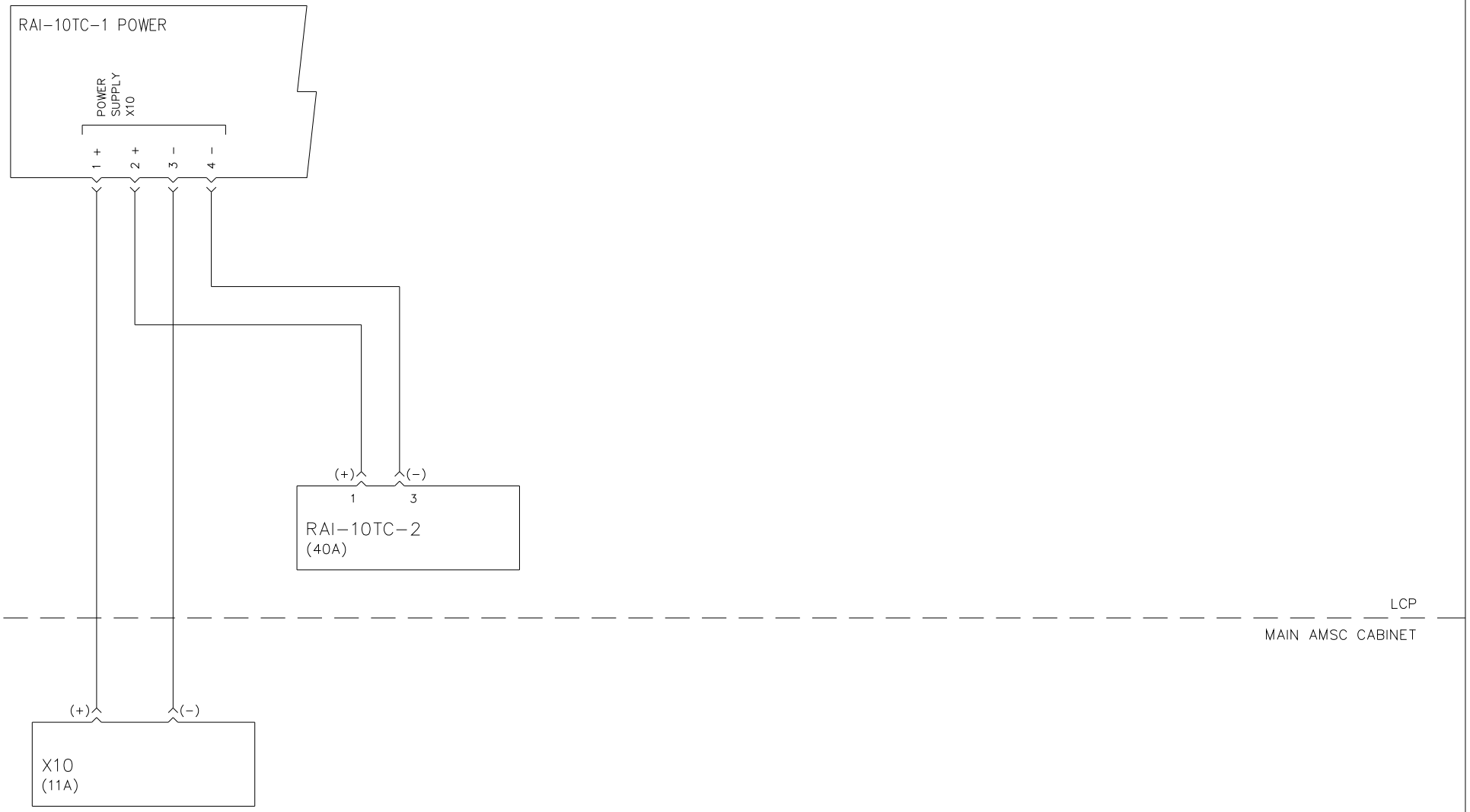
RAI-16 CHANNELS 9-12 | SECT. 34A | SECT. 34B | RAI-16 CHANNELS 9-12

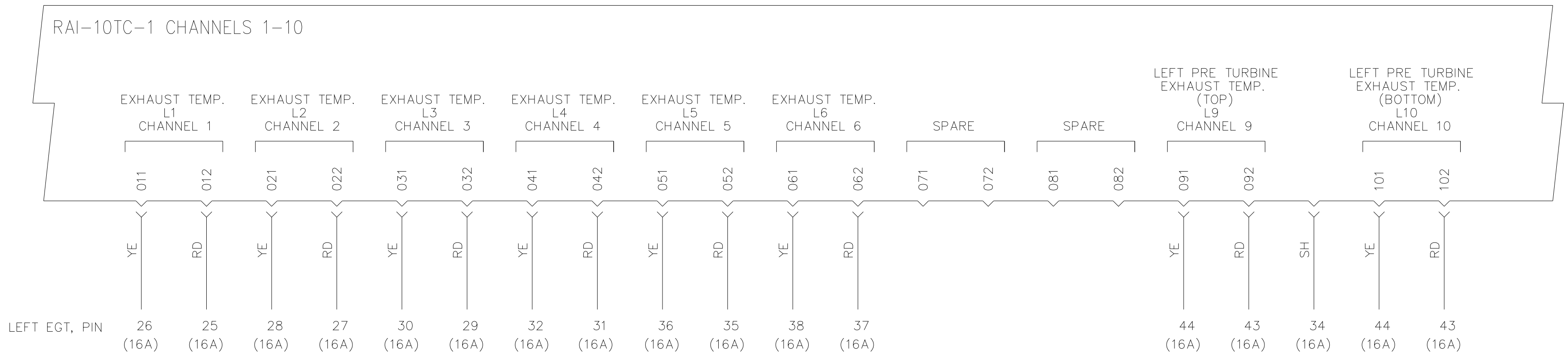


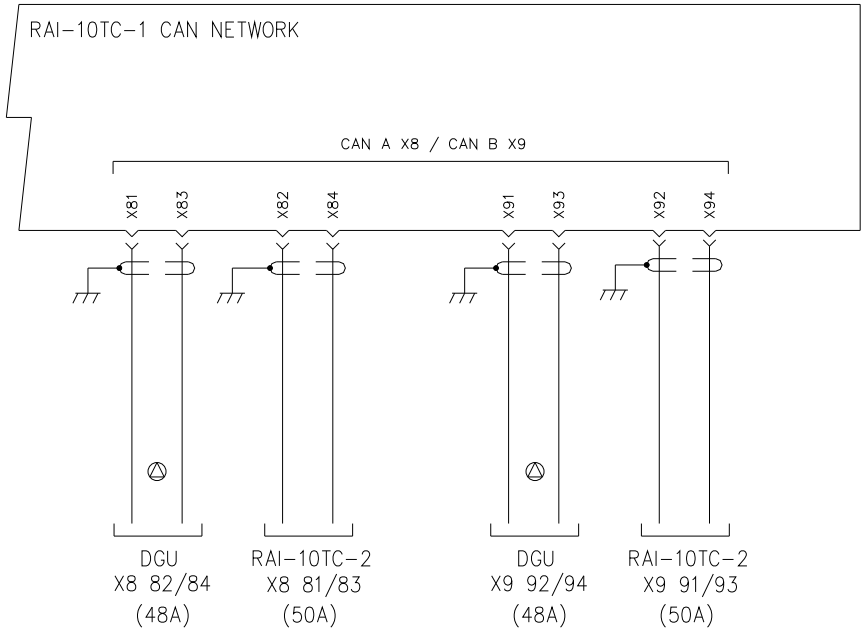
			REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL - MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT RC	84B533512 CONT. ON SH. 35 SH. NO. 34



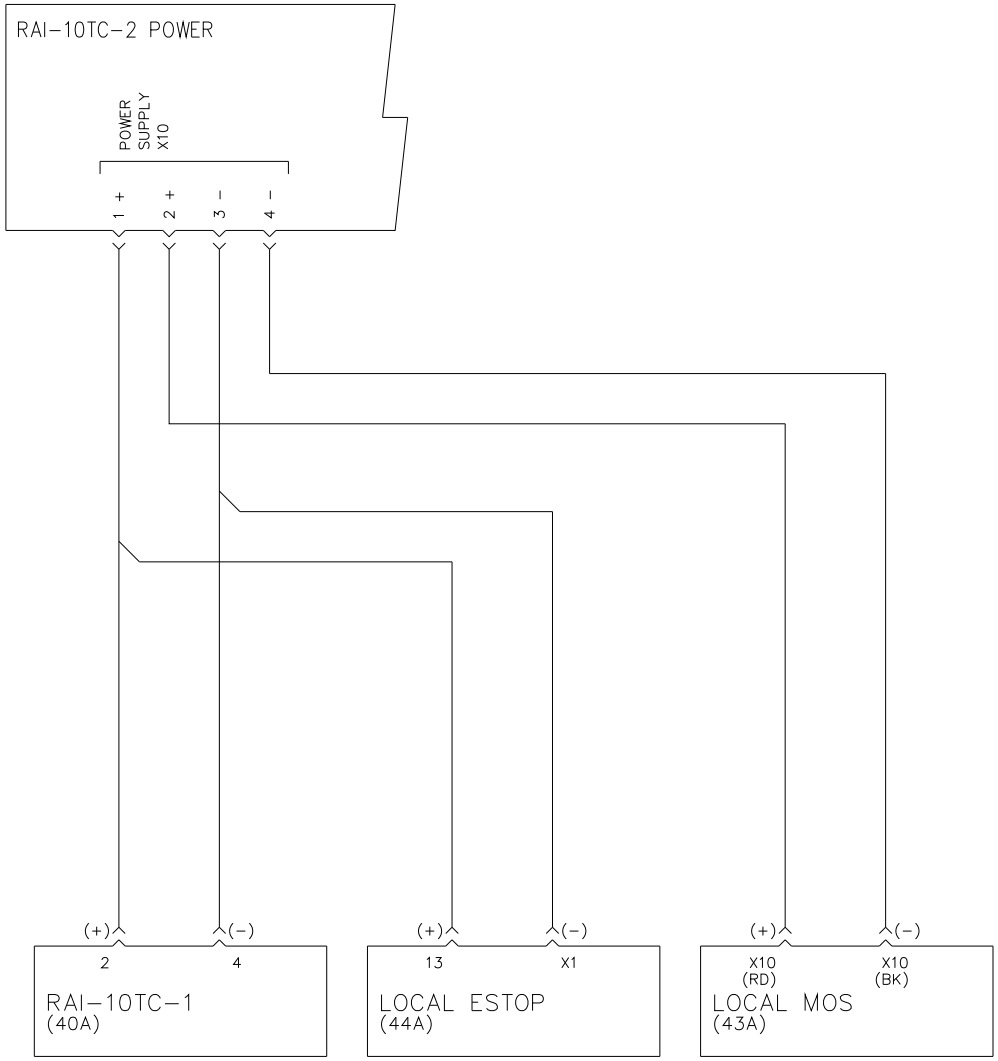






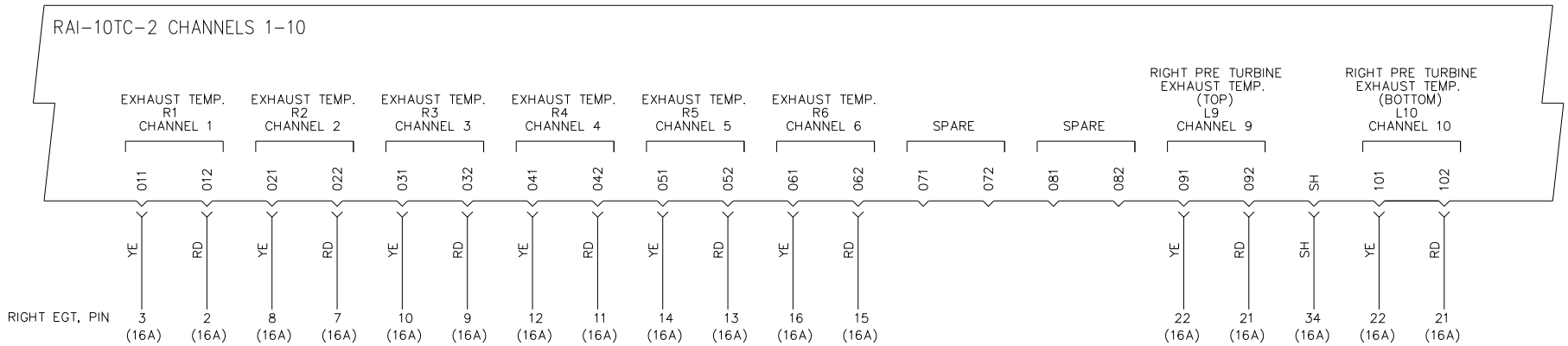


LCP



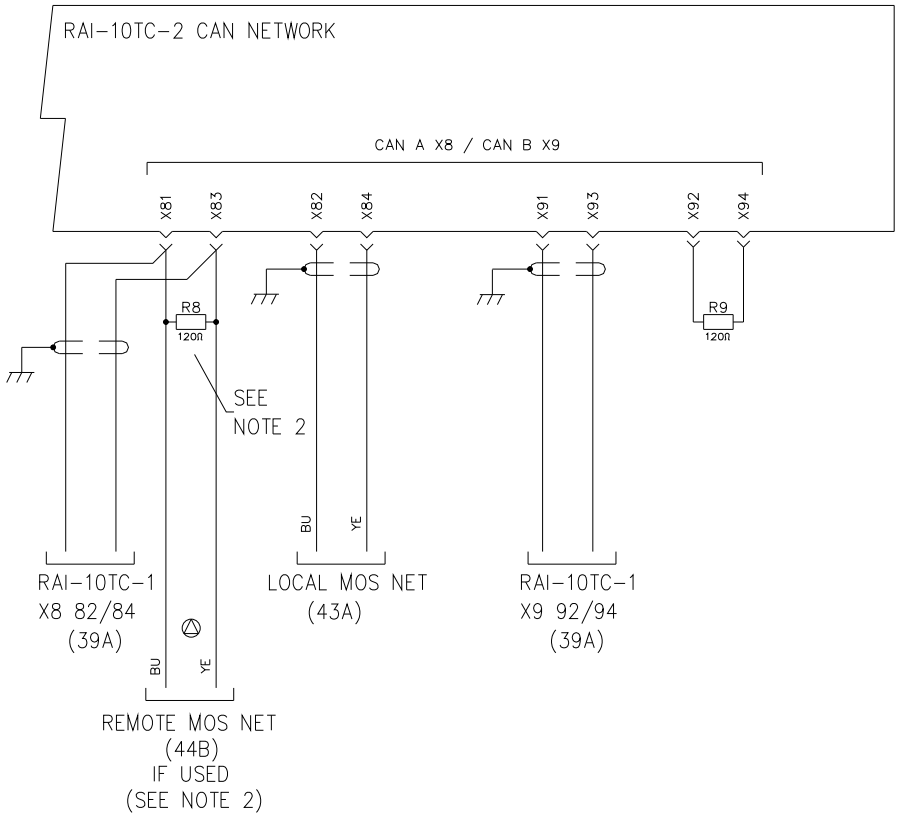
LCP

RAI-10TC-2 CHANNELS 1-10 | SECT. 41A | SECT. 41B | RAI-10TC-2 CHANNELS 1-10



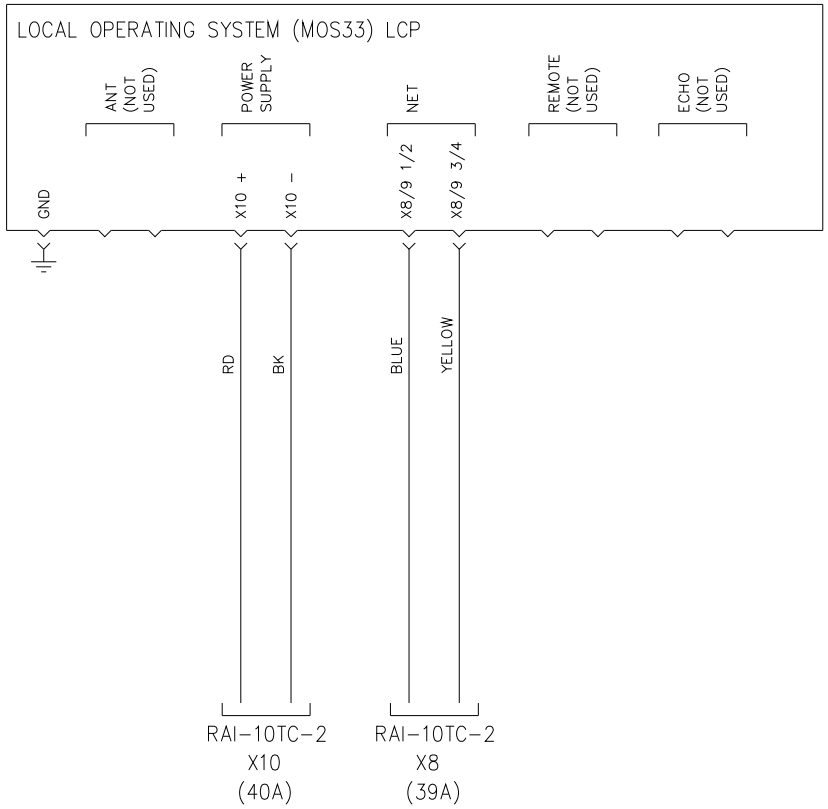
REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL - MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH. 42 SH. NO. 41

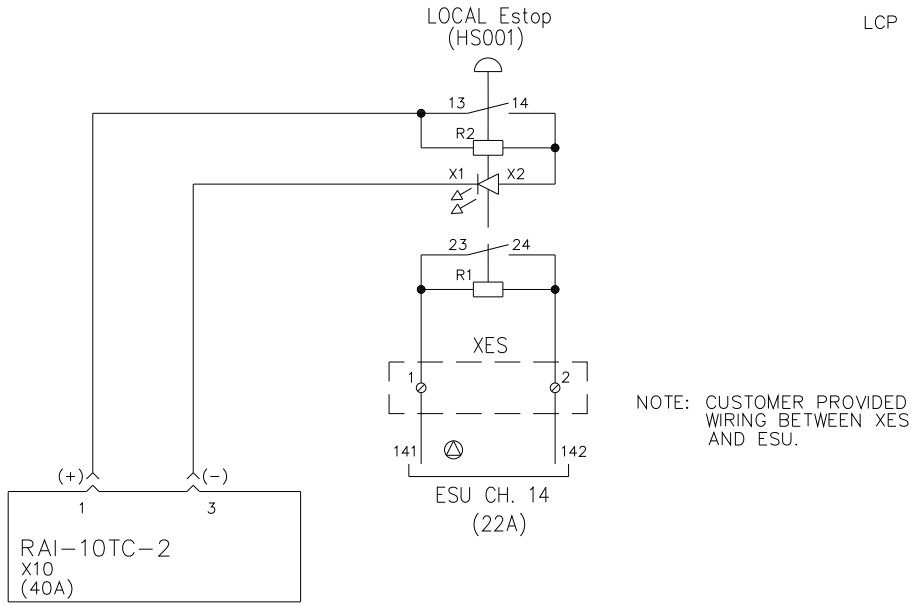
RC

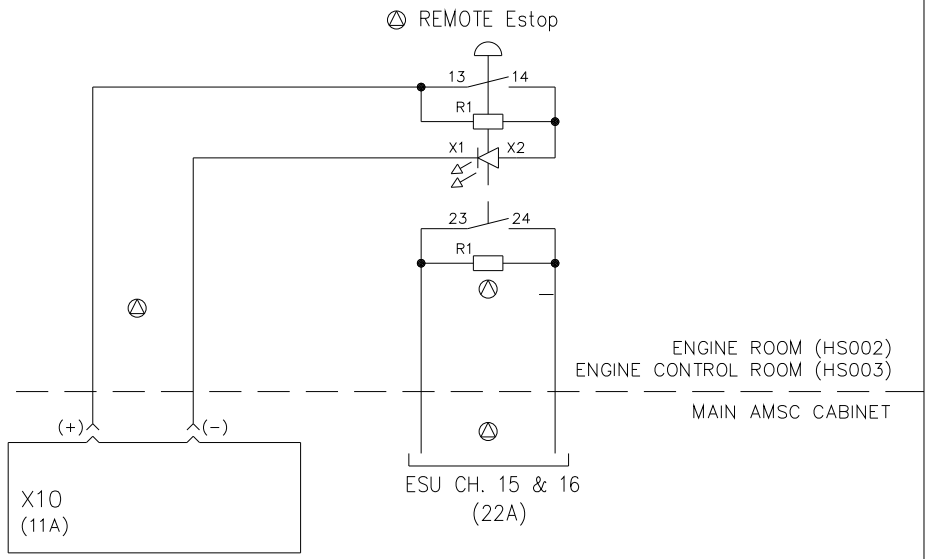


NOTE:
1. TERMINATION RESISTORS R8 AND R9, ARE TO BE PROTECTED WITH CLEAR TRANSPARENT CRIMPHOSE AND THE ENDS FITTED WITH FERRULES.
2. REMOVE TERMINATION RESISTOR R8 IF BRIDGE PANEL IS USED. BRIDGE PANEL CONTAINS TERMINATION RESISTOR.

LCP





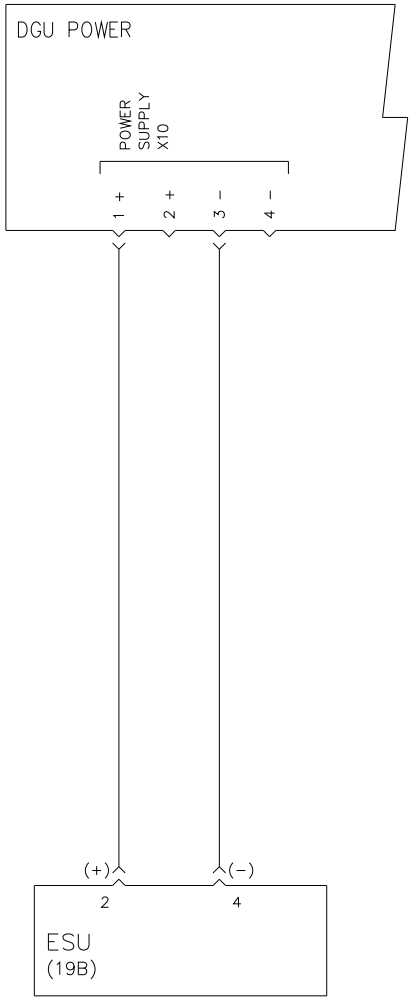


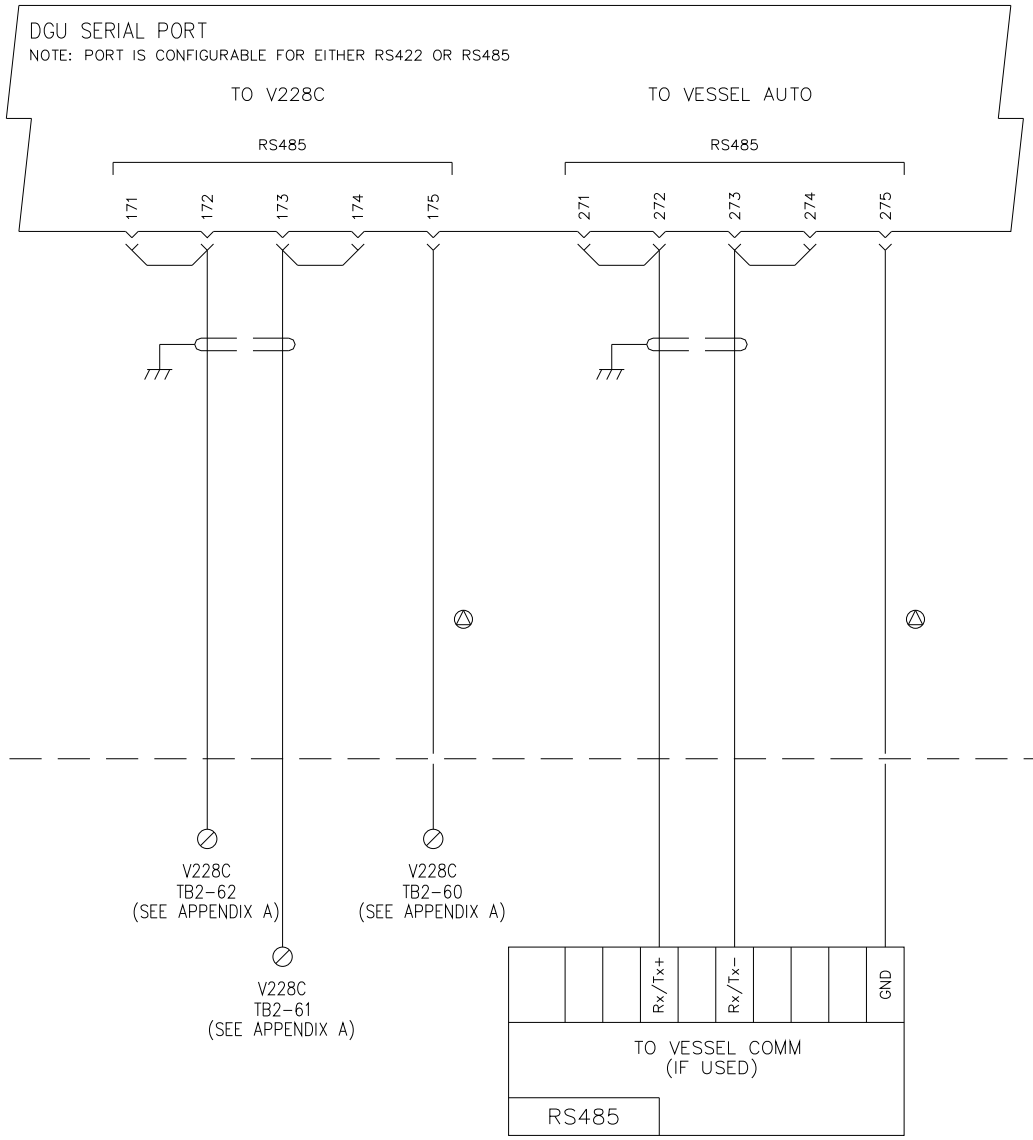
			REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC	
				FIRST MADE FOR PANAMA CANAL - MARINSA FAR 1417	

MADE BY	CDICADD(MAC) 3.19.09	APPROVAL	CONTROL	ERIE PLANT	84B533512
ISSUE	CDICADD(MAC) 3.19.09	B. LARSON	GENERAL ELECTRIC CO.		CONT. ON SH. 45 SH. NO. 44
				RC	

BLANK | SECT. 45A | SECT. 45B | BLANK

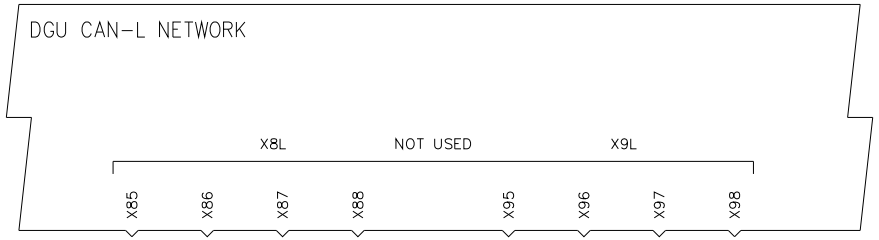
INTENTIONALLY BLANK

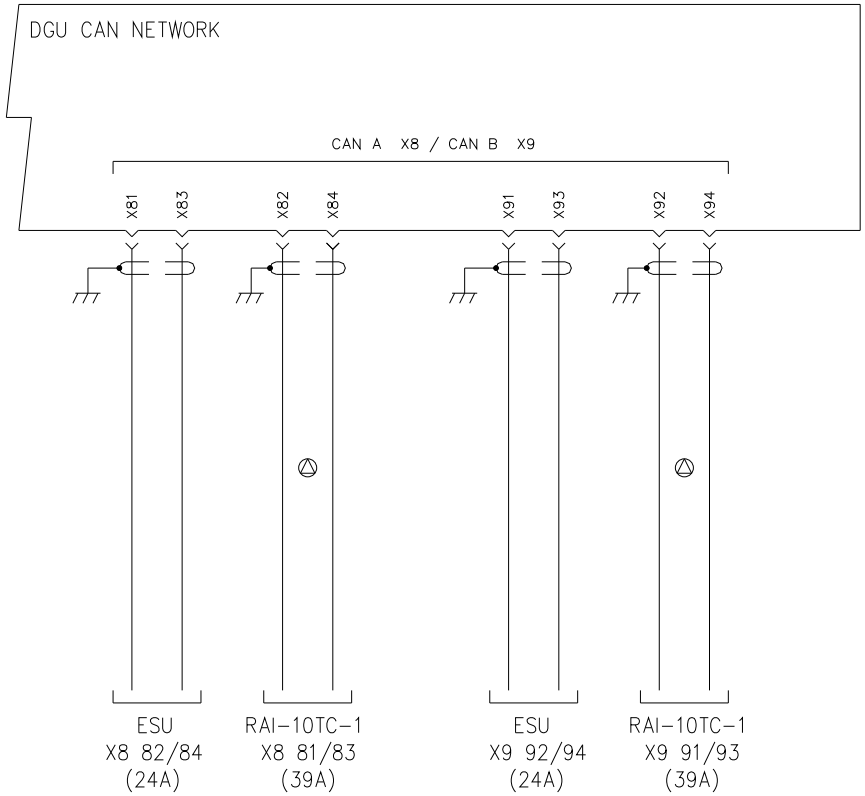




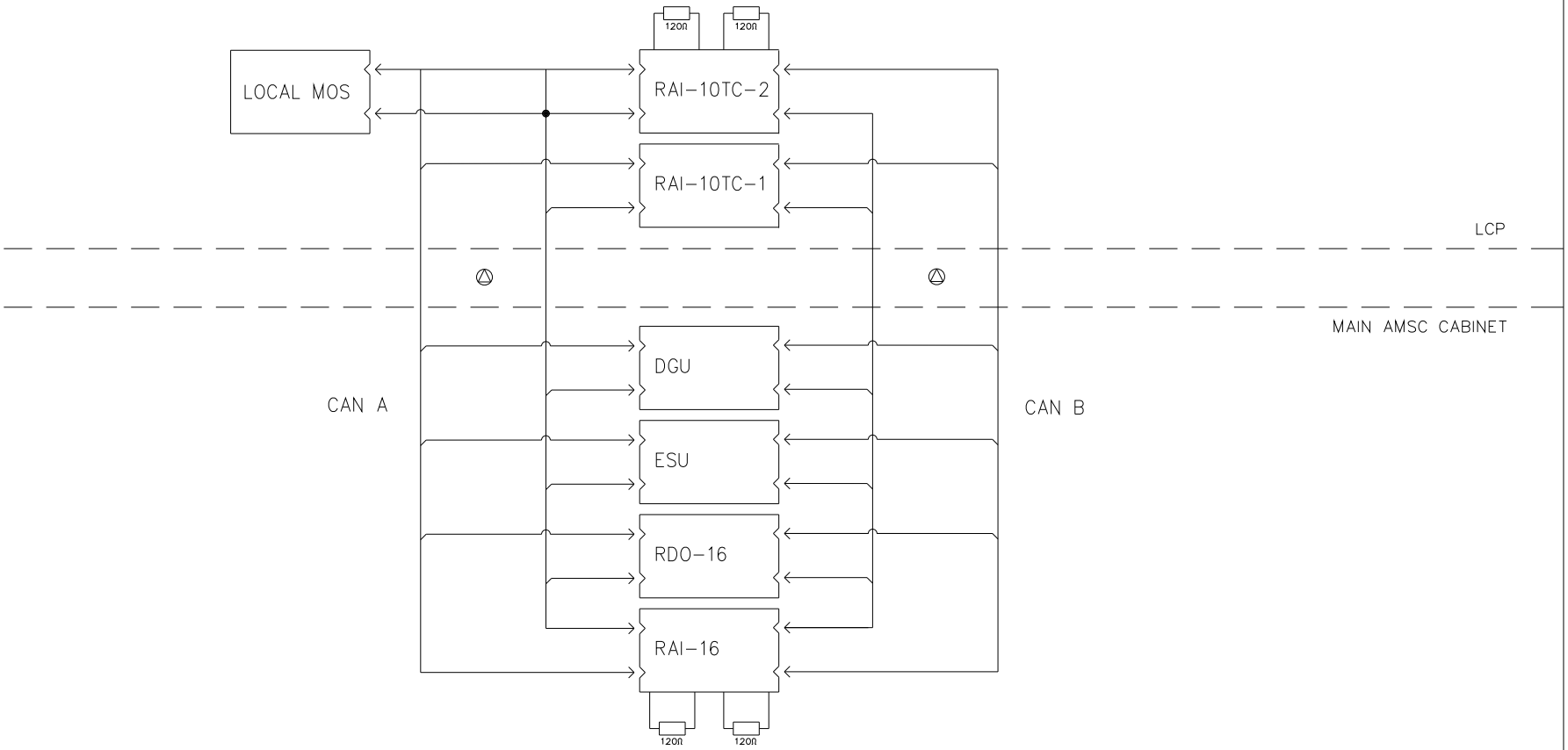
THIRD PARTY RS485 MODBUS PROTOCOL
TO VESSEL:

BAUD RATE: 19,200
DATA BITS: 8
PARITY: NONE
STOP BITS: 1





CAN BLOCK DIAGRAM | SECT. 50A | SECT. 50B | CAN BLOCK DIAGRAM



REVISIONS

TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC
FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417

MADE BY	CDICADD(MAC)	3.19.09
ISSUE	CDICADD(MAC)	3.19.09

APPROVAL B. LARSON

CONTROL GENERAL ELECTRIC CO.

ERIE PLANT

84B533512
CONT. ON SH. 51 SH. NO. 50

RC

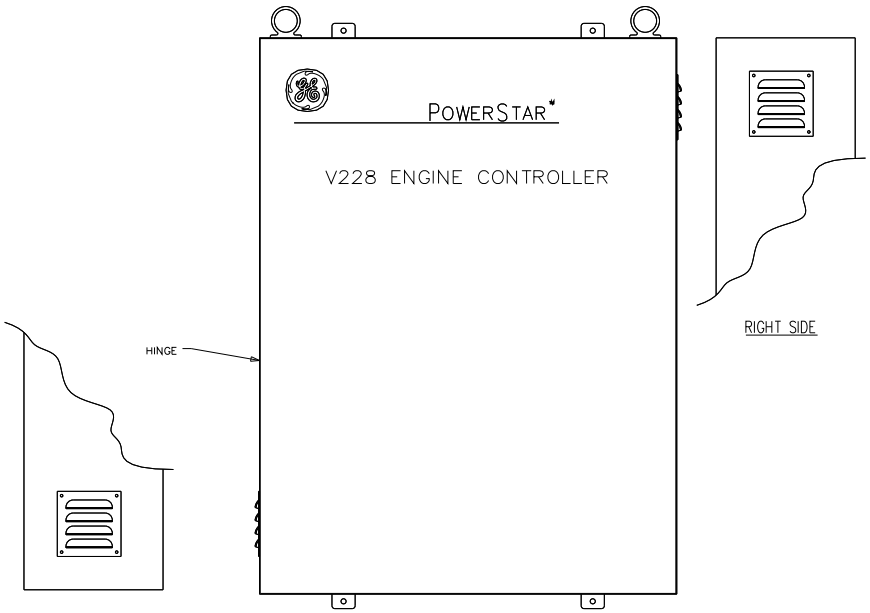
SECT. 51B ALARM AND MONITORING DEVICE TABLE

DEVICE	DESCRIPTION	MODEL OR PART NUMBER	DATA	SCHEMATIC SECTION
AMSC	AMSC MAIN CABINET	84A220319ATP1		5A
BOS CABLE	BAR OVER SWITCH OUTPUT CABLE	84A213165ANP8		13B
CNR1, 2	CRANK SPEED SENSOR.	84A222845P4		13B
DGU	DISTRIBUTED GENERIC UNIT	84A213165AMP2		46A
EAFP	ENGINE AIR FILTER DIFFERENTIAL PRESSURE	84A213165AMP11		32B
ECA CABLE	ENGINE CRANK ANGLE OUTPUT CABLE	84A213165ANP2		13B
EGT CABLE	EXHAUST GAS THERMOCOUPLE OUTPUT CABLE	84A216549P153		16A,B
ELIP-r	REDUNDANT LUBE OIL INLET PRESSURE SENSOR	84A213165AMP27		34A
EPS CABLE	ENGINE POSITION SENSOR OUTPUT CABLE	84A213165ANP5		13B
E-Stop	EMERGENCY STOP PUSH BUTTON	84A213165AMP22		44A
ESU	ENGINE SAFETY UNIT	84A213165AMP6		19B
EWOT-r	REDUNDANT ENGINE WATER OUTLET TEMPERATURE SENSOR	84A213165AMP29		34A
FIP CABLE	FUEL INJECTION PUMP OUTPUT CABLE	84A213165ANP17		14A
FIS CABLE	FUEL INJECTION SENSOR OUTPUT CABLE	84A213165ANP14		13A
FOF	AUTOMATIC BACKFLUSHING SECONDARY FUEL FILTER	84A216343ABP16		32A
FOP	FUEL OIL PRESSURE SENSOR	84A213165AMP27		32A
FOT CABLE	FUEL OIL TEMPERATURE OUTPUT CABLE	84A213165ANP11		13B
ISO1, ISO2	4-20mA OPTICAL ISOLATOR	84A213165BLP1		33B
K1, K2, K3	RELAY	84A213165AMP8		5A,11B,33B
LCP	LOCAL CONTROL PANEL	84A220319ATP3		5A,43A
LOF	ENGINE LUBE OIL FILTER	84A216343P8		32A
LOL	LOW LUBE OIL LEVEL SWITCH	84A213165AMP25		33B
MOS33	MIDI OPERATING STATION	84A213165AMP1		44A,B
OMD	OIL MIST DETECTOR	84A214655P1		11B
RAI-TC10	REMOTE ANALOG INPUT THERMOCOUPLE MODULE	84A213165AMP5		37A
	10 CHANNELS			
RAI-16	REMOTE ANALOG INPUT MODULE	84A213165AMP4		31A
	16 CHANNELS			
RDO-16	REMOTE DIGITAL OUTPUT MODULE	84A213165AMP3		25A
	16 CHANNELS			
SAP	STARTING AIR PRESSURE SENSOR	84A213165AMP26		33A
V228C	V228 ENGINE CONTROLLER	84A213165AJG27		APPENDIX A, 201A
X10, BACKUP	TERMINAL BOARD	X		5A

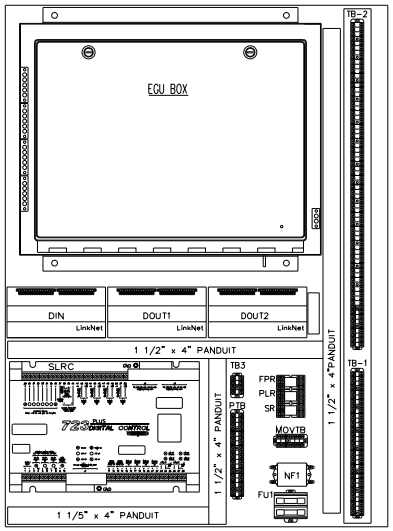
APPENDIX A

GE TRANSPORTATION
2901 EAST LAKE ROAD ERIE, PA 16531

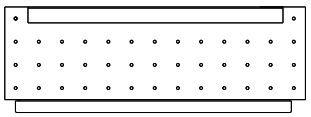
DRAWING NO. 84C603254
SCHEMATIC DIAGRAM
FOR
V228 MARINE ENGINE CONTROLLER
CABINET

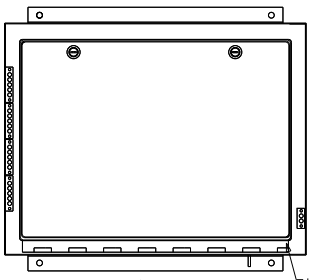


V228 ENGINE CONTROLLER
CONTROL PANEL

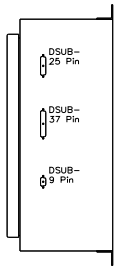


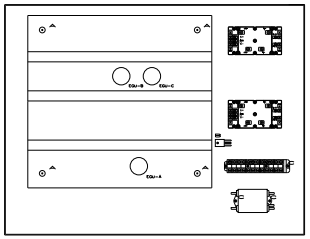
V228 ENGINE CONTROLLER
SUB PANEL



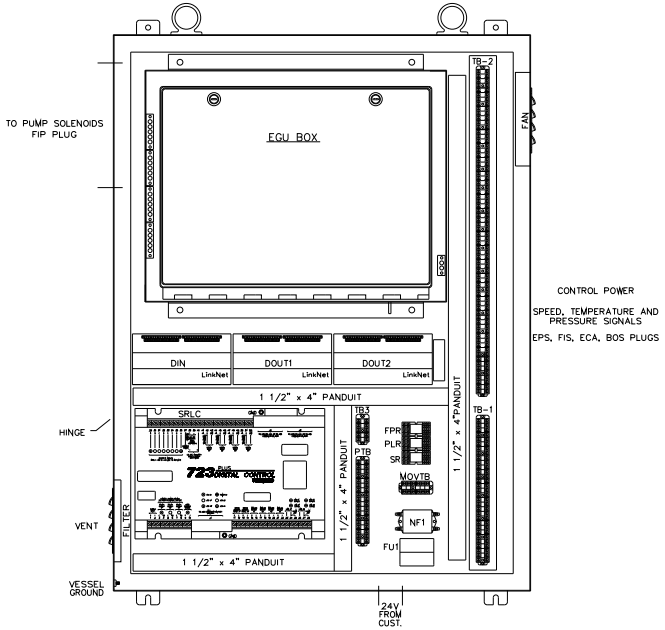


EGU BOX ENCLOSURE



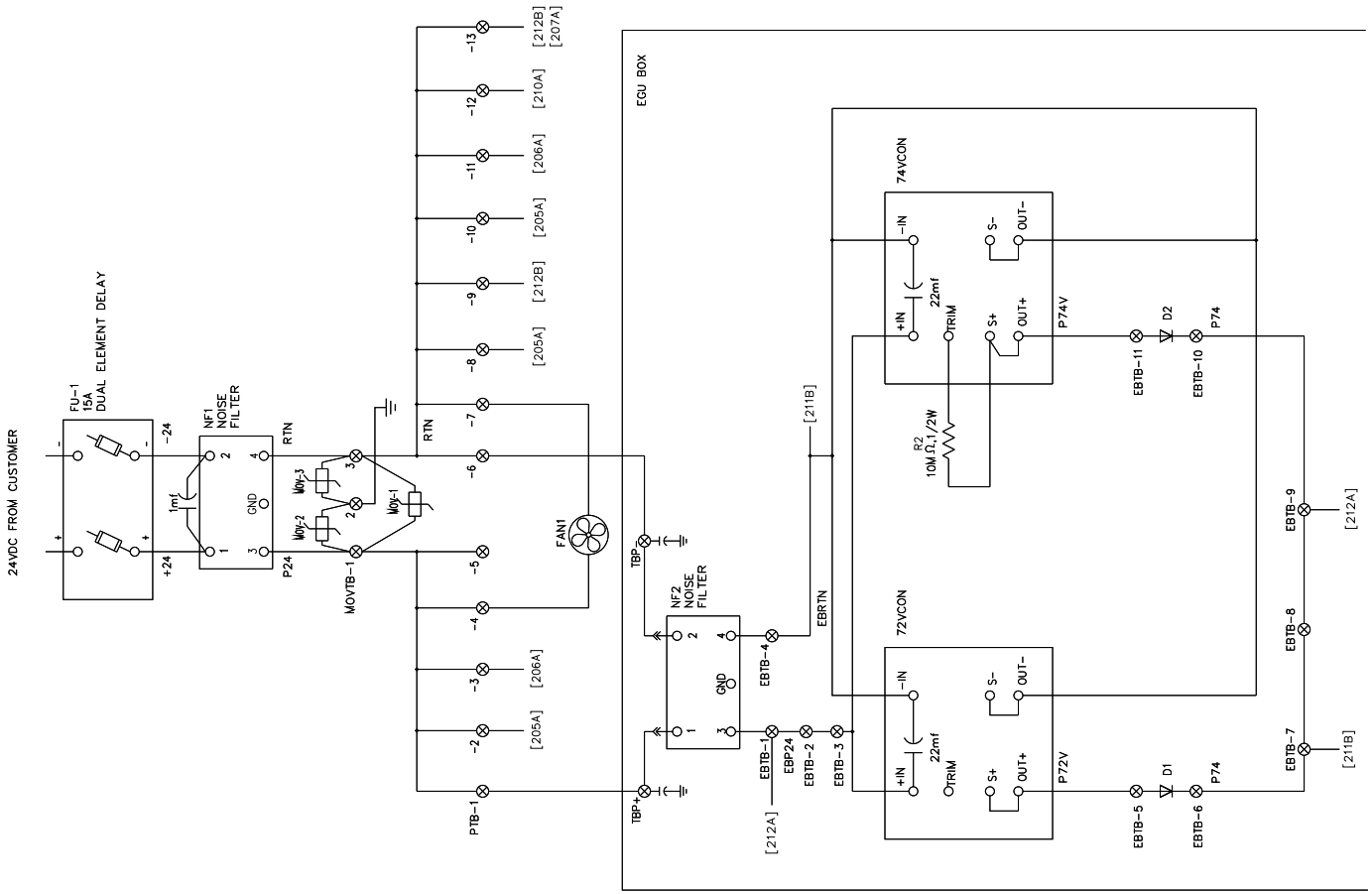


EGU BOX
BACK PANEL LAYOUT



V228 ENGINE CONTROLLER
(CABLING LOCATION)

REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH.204 SH. NO203
						RC

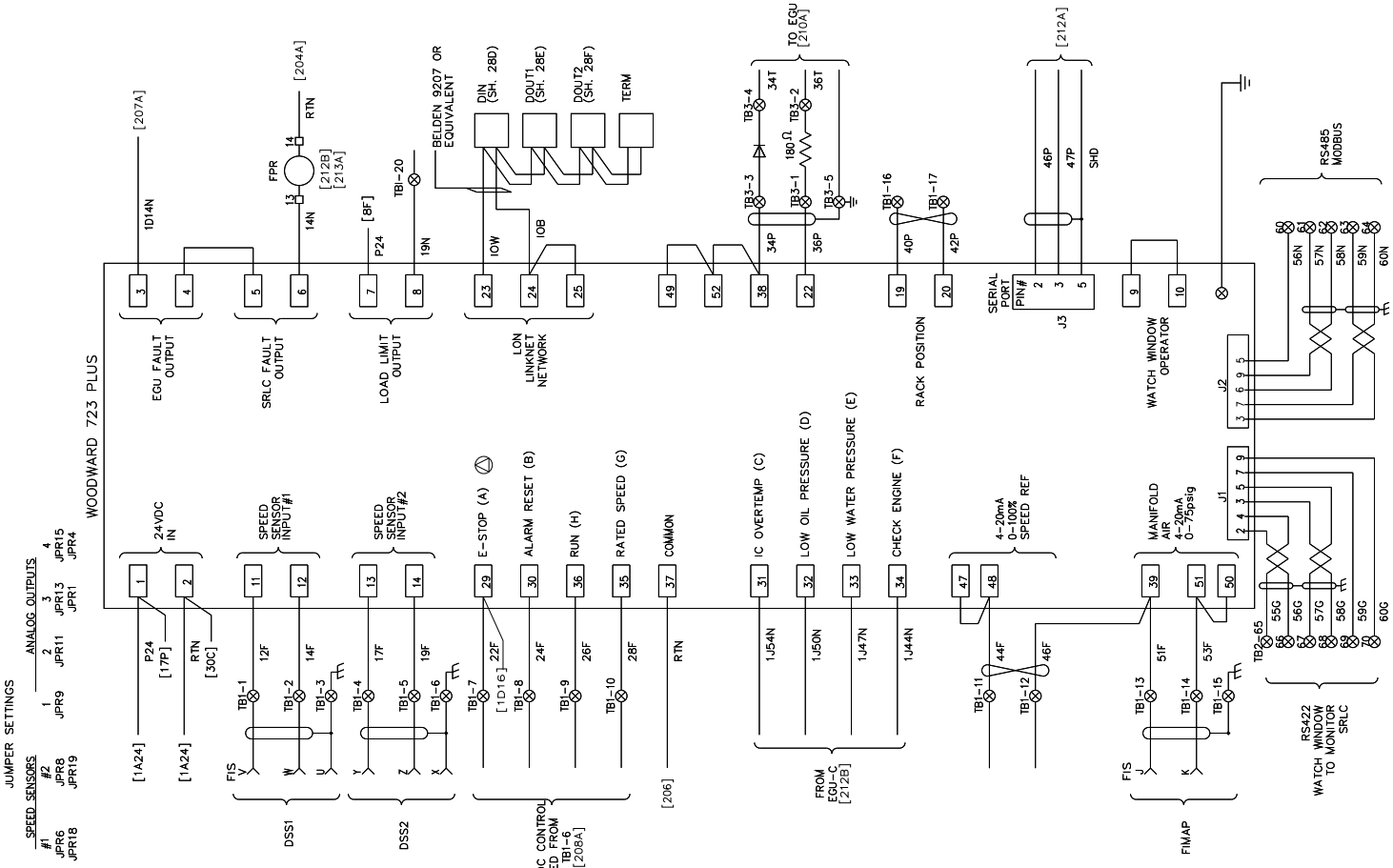


VIEW 1A

		REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH.205 SH. NO.204

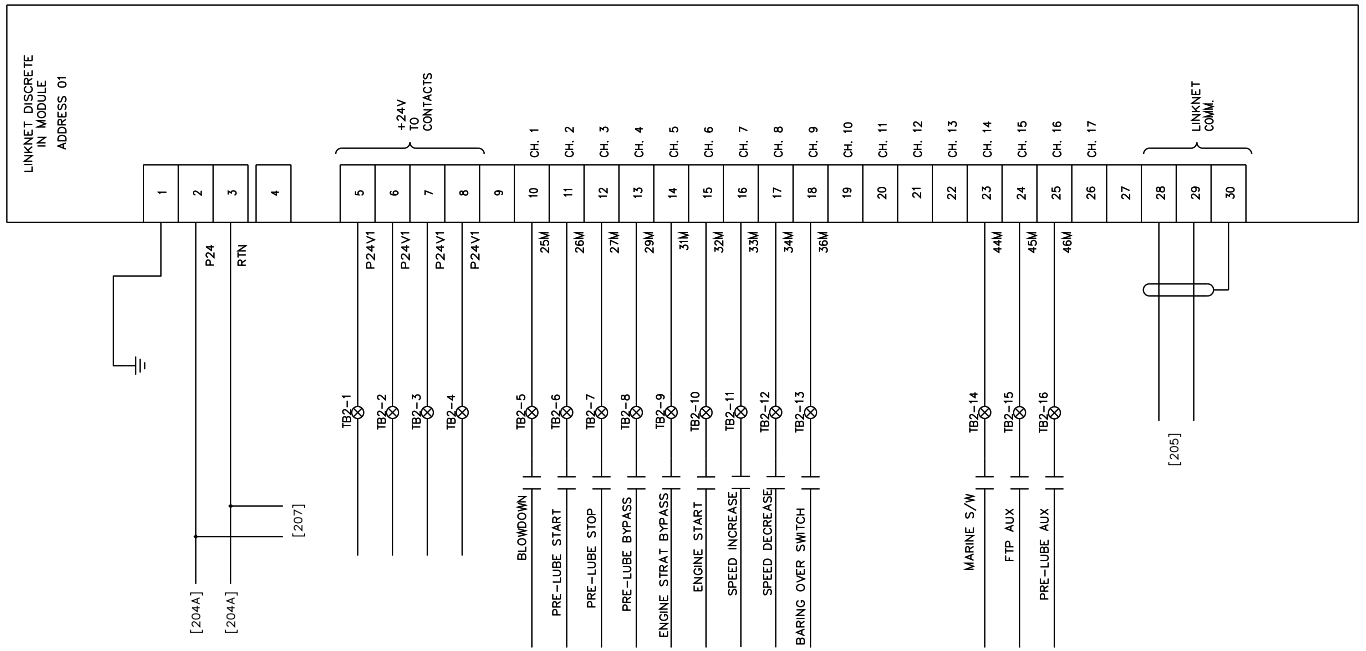
RC

ANALOG OUTPUTS | SECT.205A | SECT.205B | ANALOG OUTPUTS



REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH.206 SH. NO.205

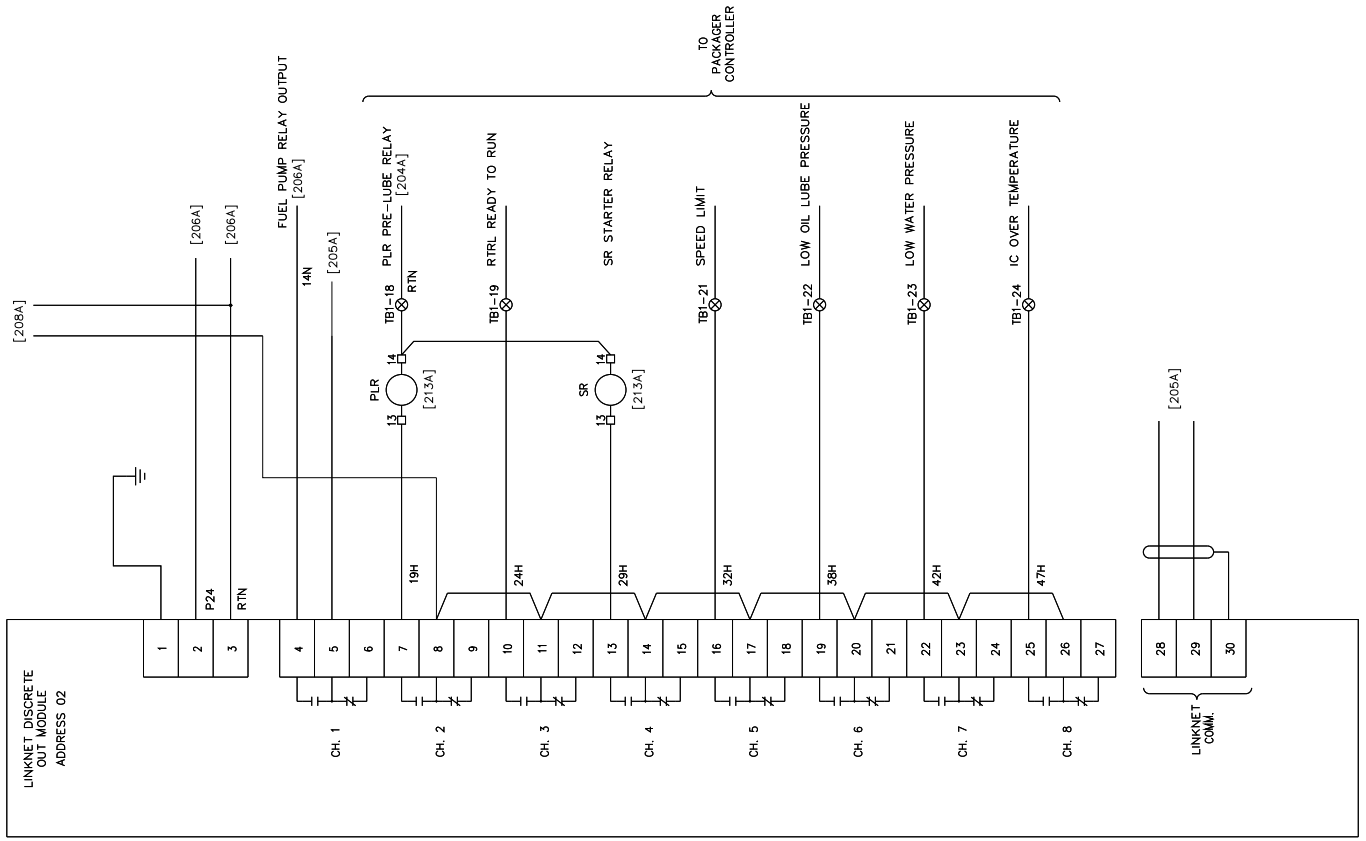
RC



VIEW 1C

			REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH.207 SH. NO.206

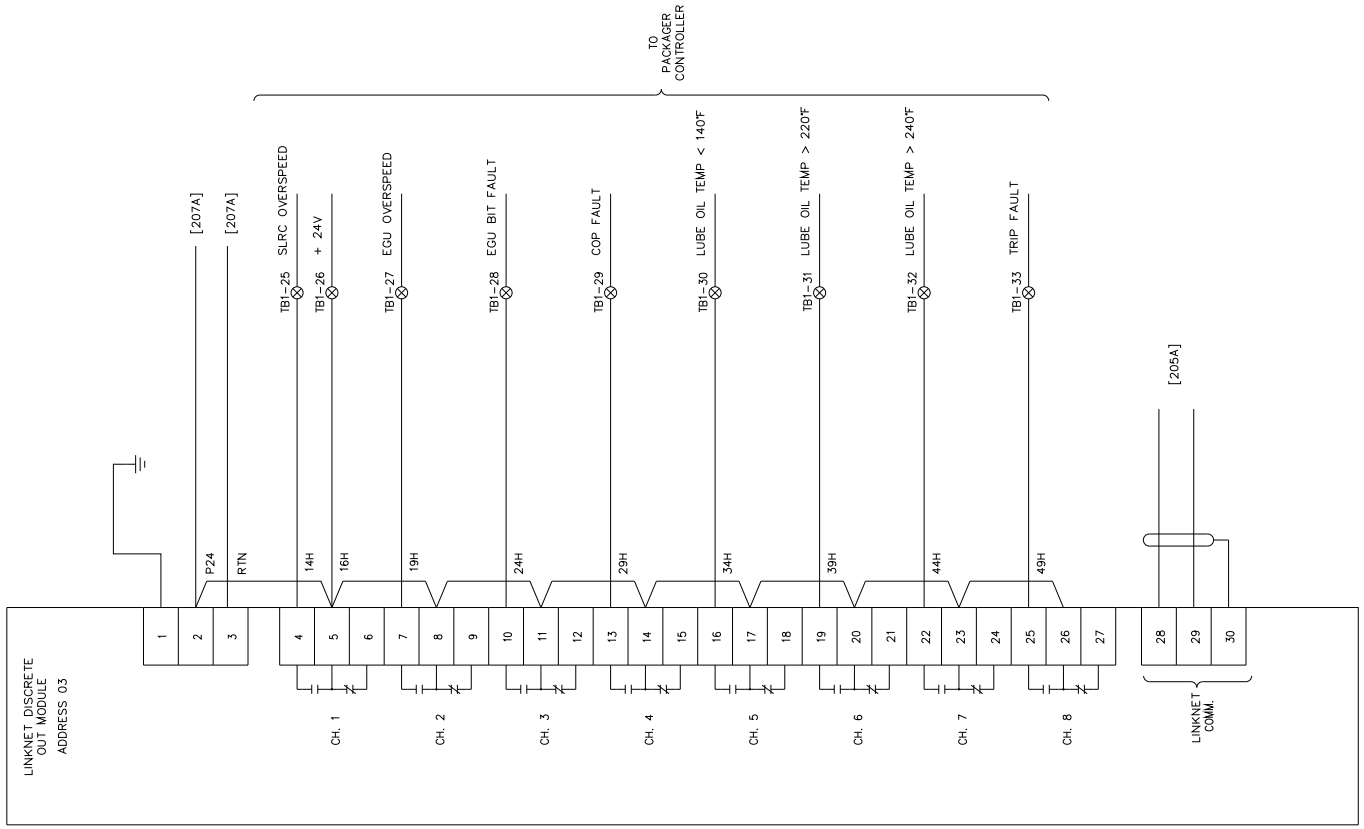
RC



VIEW 1D

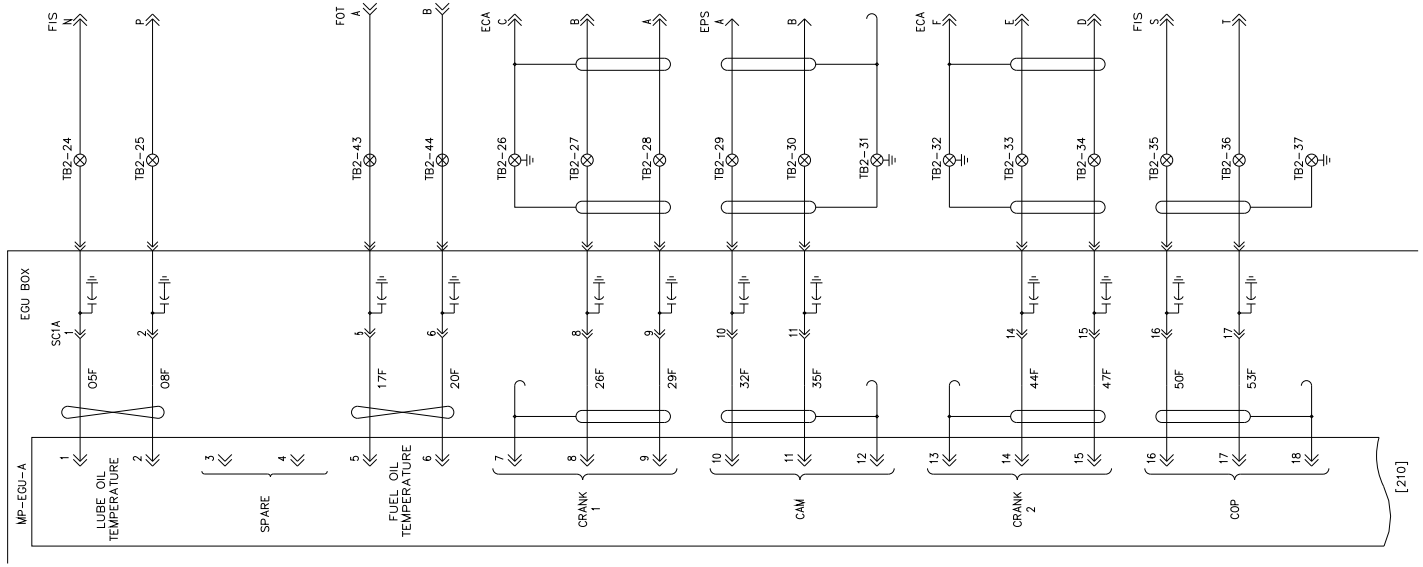
REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH.208 SH. NO.207

RC



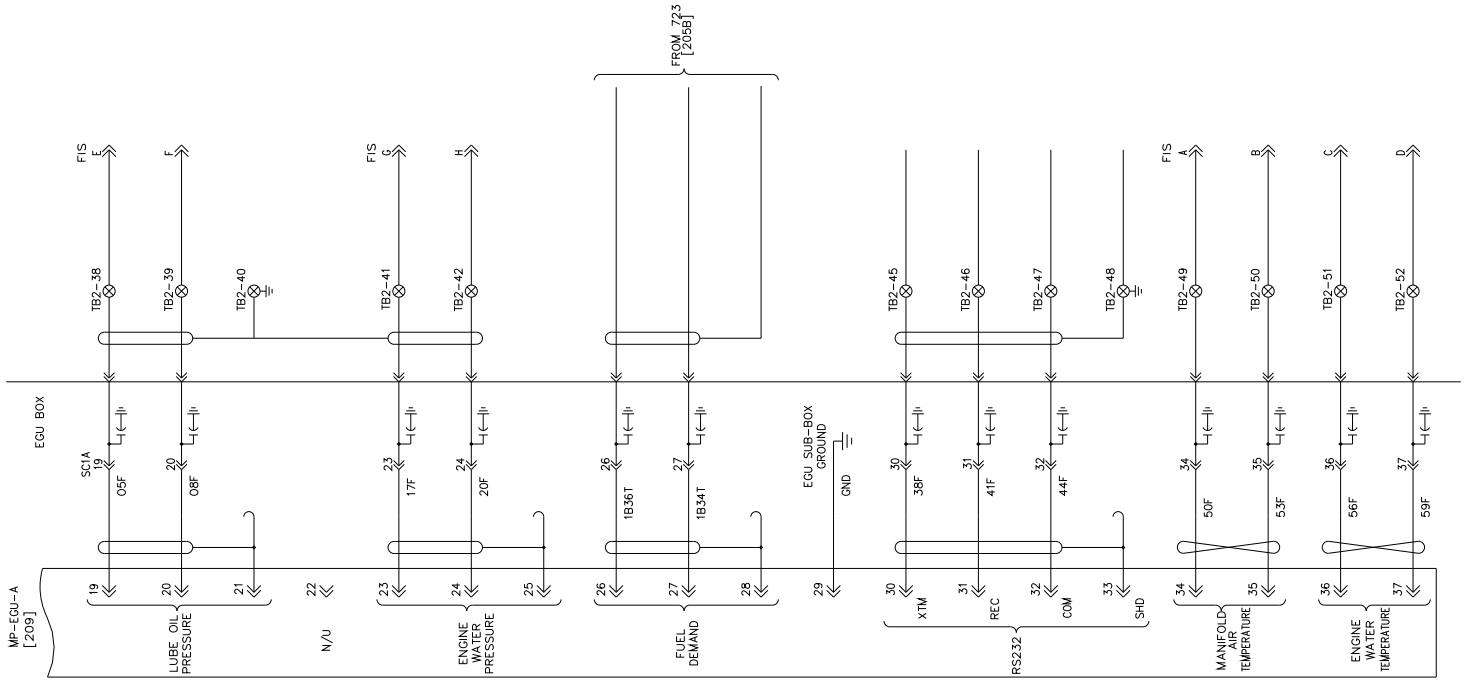
VIEW 1E

			REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT RC	84B533512 CONT. ON SH.209 SH. NO.208



VIEW 1F

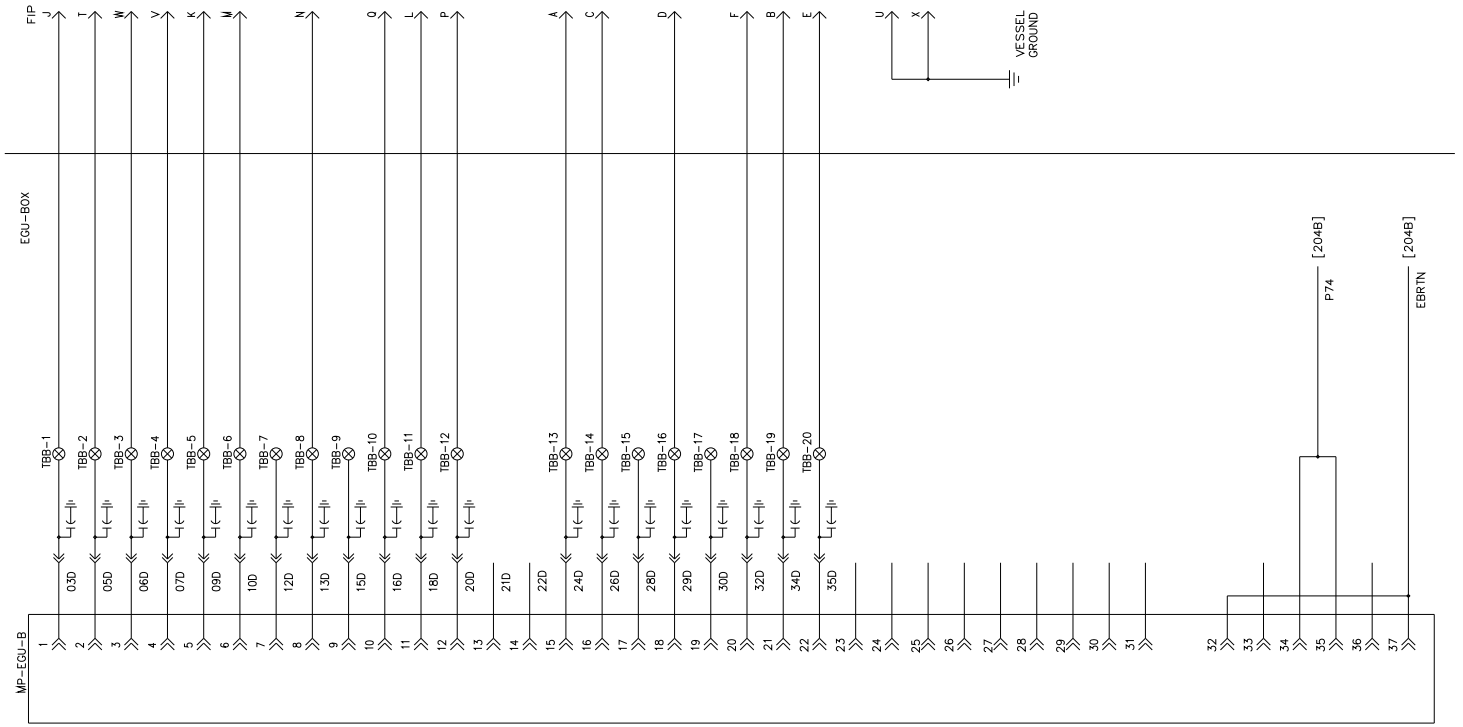
		REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT RC	84B533512 CONT. ON SH. 210 SH. NO. 209



VIEW 1G

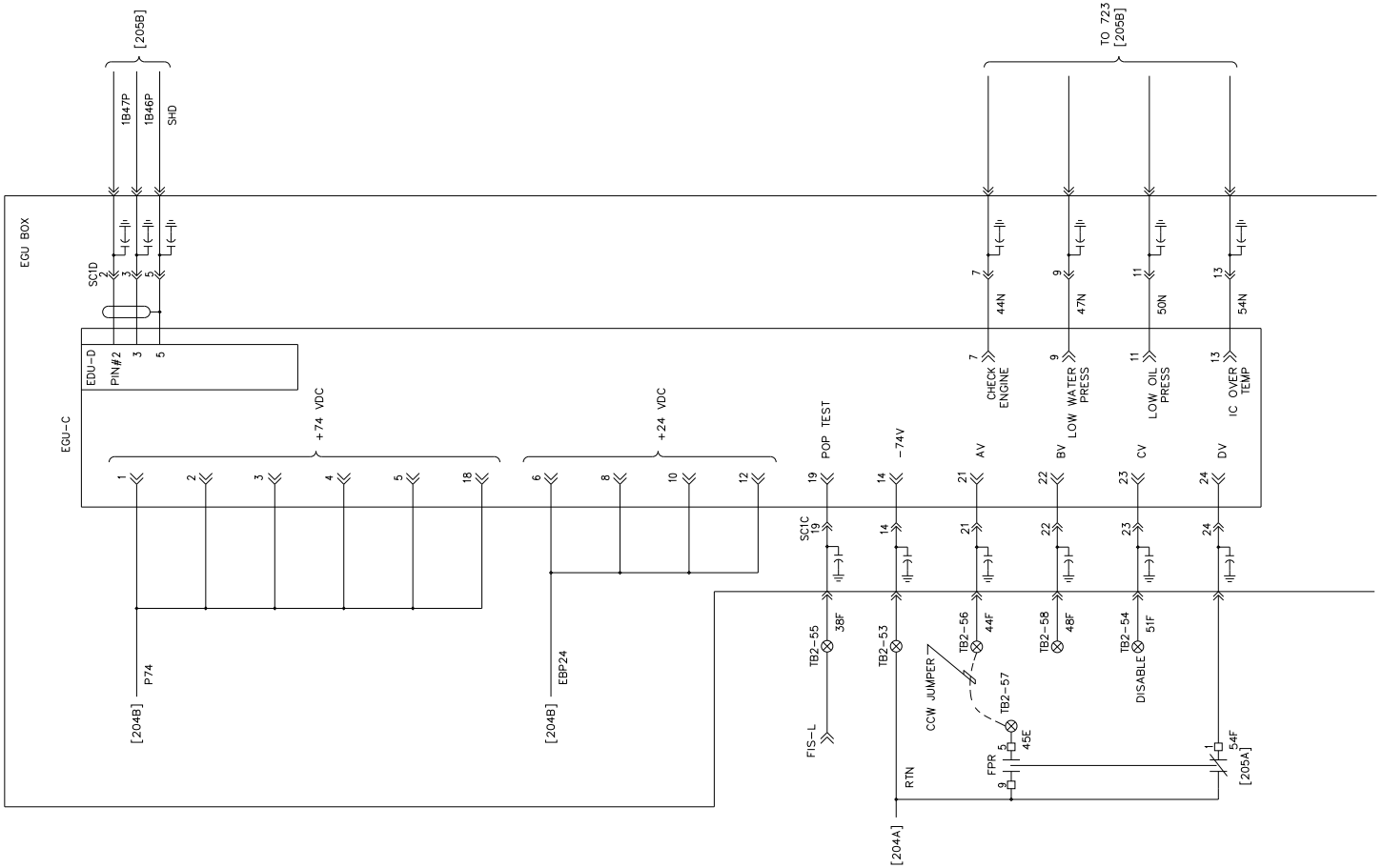
REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH. 211 SH. NO.210
					RC	

84B533512 CONT. ON SH. 212 SH. NO. 211	EGU BOX (MP-EGU-B)	SECT. 211A	SECT. 211B	EGU BOX (MP-EGU-B)	THIS DRAWING, WHICH CONTAINS PROPRIETARY INFORMATION, IS THE PROPERTY OF GENERAL ELECTRIC COMPANY. IT SHALL NOT BE REPRODUCED IN ANY MANNER NOR DISCLOSED TO THIRD PARTIES WITHOUT WRITTEN PERMISSION OF GENERAL ELECTRIC COMPANY.



VIEW 1H

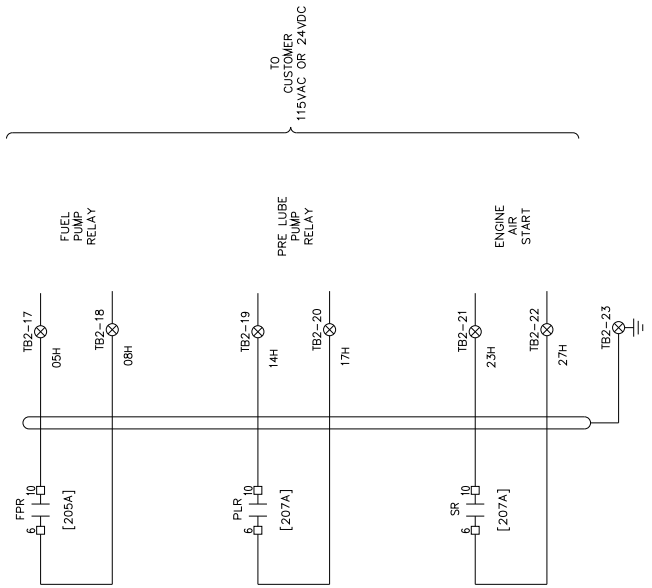
			REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL - MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH. 212 SH. NO. 211
									RC



VIEW 1 J

			REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL - MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT	84B533512 CONT. ON SH. 213 SH. NO. 212

RC



VIEW 1K

REVISIONS	TITLE ALARM MONITORING AND SAFETY INTERFACE SCHEMATIC FIRST MADE FOR PANAMA CANAL – MARINSA FAR 1417	MADE BY CDICADD(MAC) 3.19.09 ISSUE CDICADD(MAC) 3.19.09	APPROVAL B. LARSON	CONTROL GENERAL ELECTRIC CO.	ERIE PLANT RC	84B533512 CONT. ON SH. 214 SH. NO. 213

DEVICE	DESCRIPTION	MODEL OR PART NUMBER	DATA	SCHEMATIC SECTION
DIN	WOODWARD DISCRETE INPUT MODULE	84A213165ACP3		206A
DOUT1, DOUT2	WOODWARD DISCRETE OUTPUT MODULE	84A213165ACP4		207A,208A
EBTB	TERMINAL BLOCK (25A)	84A213165AJP35		204B
EGU	ENGINE GOVERNING UNIT	84A213165AJGLATER		204A,209A,210A,211A,212A
FPR	FUEL PUMP RELAY (24V)	84A213165AJP12		213A
FU	FUSED DISCONNECT SWITCH	84A213165AJP5		204A
MOV	VARISTOR	84A213165AJP20		204A
NF1	NOISE FILTER	84A213165AJP14		204A
NF2	NOISE FILTER	84A213165AJP34		204A
PLR	PRELUBE PUMP RELAY (24V)	84A213165AJP12		213A
PTB	TERMINAL BLOCK	84A213165AJP7		204A
SR	ENGINE AIR START RELAY	84A213165AJP12		213A
SRLC	WOODWARD 723PLUS SPEED CONTROLLER	84A213165ACP1		205A