CE02

DELAVAL

INSTRUCTION MANUAL

Volume I

Model DSRV-20-4 Diesel Engine
Serial Nos. 75041-2803
75042-2804

SOUTHERN CALIFORNIA EDISON COMPANY
San Onfre Nuclear Power Station, No. 1

PRELIMINARY

ENGINE
AND COMPRESSOR
DIVISION

29 MAR 1976

DELAVAL ENGINE AND
COMPRESSOR DIVISION
550-85TH AVENUE
OAKLAND, CALIF. 94621

DELAVAL

ENGINE DATA SHEET

Manufactured for:	Sales Order No.
Southern California Edison Company	75041 & 75042
For Installation: San Onofre Generating Station Unit No. 1	Purchase Order No. B-8273001

ENGINE DATA

Model: DSRV-20-4
Serial No(s).: 75041-2803, 75042-2804

☒ Stationary ☐ Marine ☒ Diesel ☐ Dual Fuel ☐ Heavy Fuel ☒ V-type ☐ Inline

No. Cylinders	Bore	Stroke	Cycles	Total Displacement	Controls
20	17 in.	21 in.	4	95,332 cu-in.	☒ Right Hand ☐ Left Hand

BMEP	Brake Horsepower	Crankshaft Rotation	Starting System
154.6 psi	8375 @ 450 rpm	CW, viewed from flywheel end	Pilot air, gear driven distributors

Firing Order: 1L–10R–3L–8R–5L–6R–7L–4R–9L–2R–10L–1R–8L–3R–6L–5R–4L–7R–2L–9R

Fuel Injection Timing: Left Bank 24, Right Bank 23 °BTDC, set Left Bank 18-7/8, Right Bank 18-1/8 inches BTDC on a 90 in. diameter flywheel

Fuel Injection Pump Rack at Full Load: DIESEL 29 mm PILOT OIL NA

Valve Clearance – Cold Engine: INTAKE NA EXHAUST NA ☒ Equipped with hydraulic valve lifters

FACTORY TEST RESULTS (Average Full Load Data)

Item	Diesel	Dual Fuel	
EXHAUST TEMPERATURE	880° F		
AIR MANIFOLD PRESSURE	32.2 In.-hg		
AIR MANIFOLD TEMPERATURE	125° F		
AMBIENT TEMPERATURE	74° F		
BAROMETRIC PRESSURE	29.88 in.-hg		

NOTE: Exhaust temperatures are the average for all cylinders during factory test under LOCAL AMBIENT CONDITIONS. Temperatures in the field, therefore, may exceed this average temperature. Always include serial numbers when communicating with DELAVAL Engine and Compressor Division concerning engine performance, or when ordering spare or replacement parts.

GUARANTEE

Unless otherwise specifically stated, all machinery and equipment purchased hereunder is subject to the following warranty: DELAVAL TURBINE INC., Engine and Compressor Division (hereinafter called Company) warrants that machinery and equipment manufactured by Company and furnished and delivered to the Purchaser hereunder shall be of the kind and quality described in the Company's specifications, and no other warranty or guaranty except of title is made or shall be implied. If any part of said machinery and equipment thus manufactured by the Company fails because of defective workmanship or material within one year from the date of starting the engine after delivery, but not exceeding fifteen months from the date of shipment, the Company will, provided such machinery and equipment has been used for the purpose and in the manner intended and the Company's examination shall disclose to its satisfaction that such parts are defective, replace such defective parts free of charge, f.o.b. cars at its warehouse in Oakland, California, but the Company will not be liable for repairs or alterations unless the same are made with its written consent or approval. The Company will not be liable for damages or delays caused by such defective material or workmanship, and it is agreed that the Company's liability under all guaranties or warranties, either express or implied, is expressly limited to the replacing of parts failing through defective workmanship or material within the times and in the manner aforesaid. Parts claimed to be defective are to be returned to the Company at its option, transportation prepaid. The Company makes no guaranties or warranties whatsoever in respect to products other than that manufactured by the Company as they are sold under the regular warranties of the respective manufacturers, copies of which will be furnished if requested. All warranties and guaranties as to efficiency and capacity are based upon shop tests when operating under specified conditions, but do not apply to any condition varying from the foregoing. The liability of the Company (except as to title) arising out of the supplying of said machinery or equipment or its use, whether on warranties or otherwise, shall not in any case exceed the cost of correcting defects in the machinery or equipment as herein provided, and upon the expiration of said warranty, as herein provided, all such liability shall terminate.

PRODUCT IMPROVEMENTS

The Company reserves the right, where possible, to include changes in design or material which are improvements. Also reserved is the right to furnish equipment of design modifications best suited to a particular installation, location, or operating condition, as long as such modification exceeds Purchaser's design specifications. The Company cannot be responsible for including improvements made after start of production on Purchaser's equipment.

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INTRODUCTION

PURPOSE.

The purpose of this instruction manual is to assist the owner and operating personnel in the operation, maintenance, adjustment and repair of the DELAVAL Engine and Compressor Division's "Enterprise" engine. Maximum efficiency and continuous, trouble-free service will be the result of careful study and application of the contents.

NOTES, CAUTIONS AND WARNINGS.

Notes, cautions and warnings, as used in this manual, are intended to convey the following meanings.

a. NOTES – Operating procedures, conditions, etc., which it is essential to highlight or emphasize because of their importance to the proper operation of the machinery.

b. CAUTIONS – Operating procedures, practices, etc., which, if not strictly observed, could result in damage to, or destruction of equipment.

c. WARNINGS – Operating procedures, practices, etc., which could result in personal injury or possible loss of life if not correctly followed.

MAINTENANCE PRACTICES.

Continuous design refinement and many years of experience in the manufacture of large diesel, dual fuel and spark ignited engines have become a part of the "Enterprise" engine. Each engine is thoroughly tested and inspected before shipment. To realize the longest operating life with a minimum of engine down time for unscheduled maintenance or repair, a program of cleanliness, inspection, preventive maintenance and record keeping is essential.

a. Cleanliness, because it makes a thorough inspection easier, helps keep dirt out of moving parts and indicates in large measure the care the machine receives in other ways.

b. Inspection, because areas of minor wear will be revealed before they become major and require repair or replacement.

c. Preventive maintenance, because it, in combination with cleanliness and inspection, will permit the repair or replacement of wearing parts before they can cause serious malfunction and/or damage to the engine.

d. Record keeping because, when kept on adequate forms and at regular intervals, records will keep operating personnel informed of the current running condition of the engine. Comparison of present and past log sheets will reveal gradual changes in temperatures, pressures, noise and performance, all indicators of the engine's condition which can be of assistance in the planning of overhaul and repair schedules.

CUSTOMER ASSISTANCE.

DELAVAL Engine and Compressor Division maintains a staff of factory trained service personnel who are available at nominal rates to assist or advise in the installation, overhaul and repair of "Enterprise" machinery. It is recommended that one of these service men be requested when extensive repairs are being made on the equipment. If assistance is required, write or wire DELAVAL Engine and Compressor Division, Service Department, furnishing complete information including serial numbers.

PARTS MANUAL.

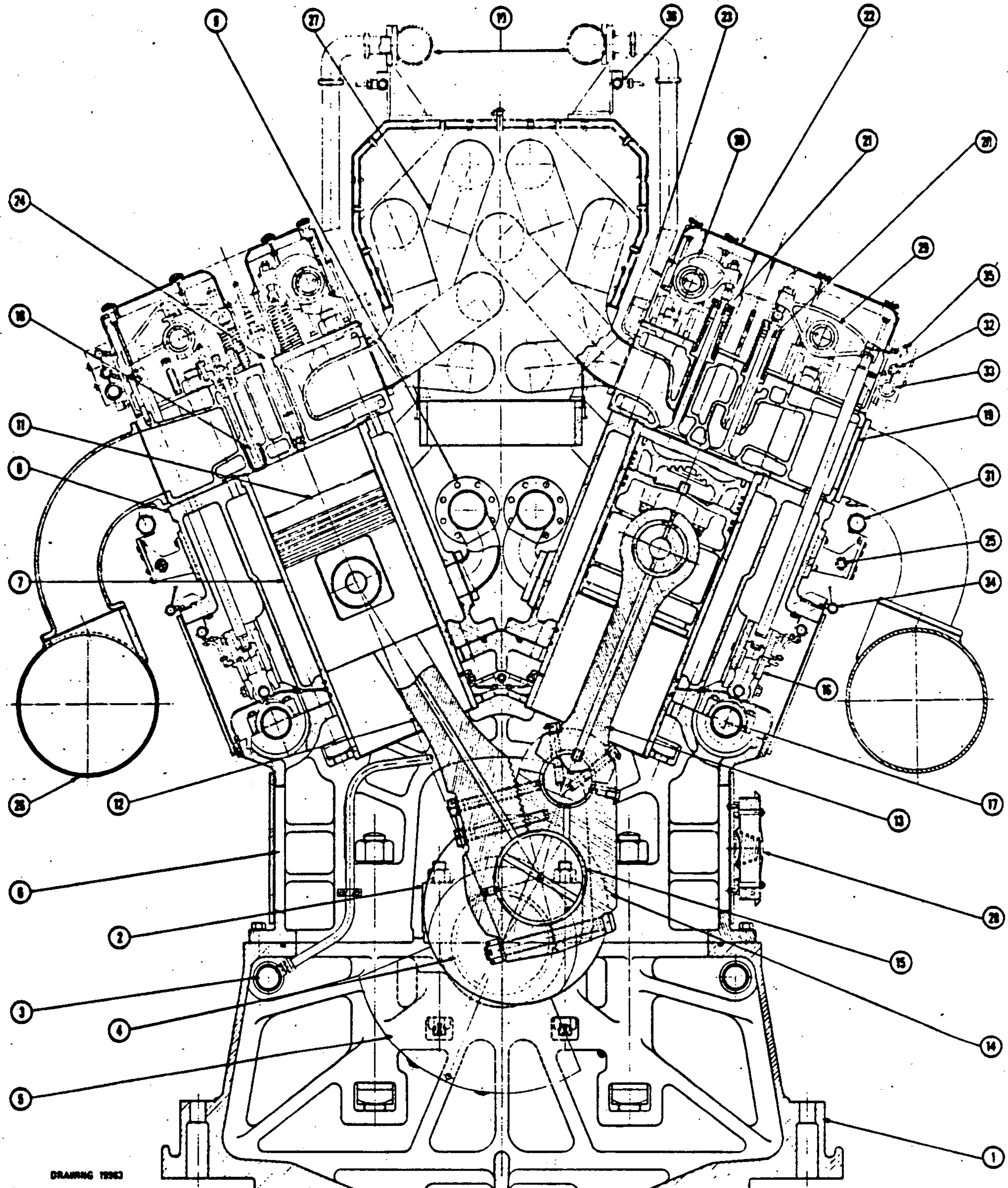
The *Parts Manual* furnished with the engine contains engine specifications, parts lists and part numbers for all furnished equipment together with instructions for ordering spare and replacement parts. Assembly drawings are also included in the manual to assist in the identification of parts, however, part numbers appearing on the assembly drawings should not be used when ordering parts. Always use the part numbers appearing on the appro, riate Group Parts List in the *Parts Manual.*

ASSOCIATED PUBLICATIONS MANUAL.

The *Associated Publications Manual* is a companion publication to this instruction manual, and contains manufacturer's instructions, bulletins and parts lists applicable to parts and equipment not manufactured by DELAVAL engine and Compressor Division, but which are furnished with the engine and which require servicing and/or adjustment.

GENERAL ENGINE DESCRIPTION.

The Model RV engine is a four-stroke-cycle, turbocharged, aftercooled, V-type engine, built in 12, 16 or 20 cylinder arrangements. The engine is available in either diesel or dual fuel versions and may be equipped to operate on heavy (residual) fuel. The angle of the Vee is 45 degrees. Trunk-type pistons, removable wet-type cylinder liners, pressure lubrication and mechanical fuel injection are features of the RV engine. Individual fuel injection pumps are provided for each cylinder, and as they are of standard design, are interchangeable. The fuel lines are of equal length and are relatively short, reducing line surge to a minimum. Fuel pumps, nozzles and orifice size and angle are all carefully matched to the engine and the fuel to be used to give maximum thermal efficiency. A gear-driven starting air distributor provides a timed distribution of pilot air to open the air start valves, permitting the engine to be started cold in a few seconds with a 250 psi starting air supply. Engine rotation and cylinder bank designation are determined while facing the engine at the flywheel end, number one cylinders always being the pair farthest from the flywheel.



Item	Description	Group Parts List
1	Engine Base	305
2	Main Bearing Cap	305
3	Lubricating Oil Header	307
4	Crankshaft & Bearings	310
5	Crankshaft Counterweight	310
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7	Cylinder Liner	315
8	Engine Block	315
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12	Master Rod	340

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14	Connecting Rod Box	340
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16	Tappets	345
17	Camshaft & Bearings	350
18	Air Starting Valve	359
19	Cylinder Head	360
20	Intake Valve	360
21	Exhaust Valve	360
22	Cylinder Head Cover	362
23	Cylinder Head Sub Cover	362
24	Fuel Injection Nozzle	365

Item	Description	Group Parts List
25	Fuel Pump Linkage	371
26	Intake Manifold	375
27	Exhaust Manifold	380
28	Crankcase Relief Valve	386
29	Rocker Arm, Intake	390
30	Rocker Arm, Exhaust	390
31	Starting Air Manifold	441
32	Fuel Oil Return	450
33	Fuel Oil Header	450
34	Fuel Oil Drain	450
35	Rocker Arm Oil Header	465
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TYPICAL MODEL DMRV—4 ENTERPRISE DIESEL ENGINE

CROSS SECTION

SECTION 2
INSTALLATION

GENERAL.

The installation of a DELAVAL Engine and Compressor Division "Enterprise" engine may vary from site to site, therefore, the instructions contained in this section of the manual are representative of a typical installation and not necessarily the exact procedure for a specific site. Certified installation and foundation drawings are furnished to each customer which detail the dimensions and installation requirements for that particular unit.

FOUNDATION DRAWING.

The foundation drawing will be accurately dimensioned and must be carefully observed. Carelessness in locating foundation bolts, pipes, conduits and drains will cause difficulty during installation and alignment. It is essential that the foundation be constructed to standards of the highest accuracy.

INSTALLATION DRAWING.

The installation drawing details the measurements for machinery location, distances required for normal maintenance tasks and the overhead clearances necessary for piston removal. In addition the drawing will indicate the location and size of connection points for pipes and the electrical requirements for alarm and control mechanism.

SYSTEM SCHEMATIC DRAWINGS.

Electrical and flow diagrams are furnished for the various systems. Flow diagrams specify pipe sizes and the type and location of fittings and apparatus. These represent minimum requirements. To insure compatibility, any changes should be approved by DELAVAL Engine and Compressor Division engineers before installation.

HANDLING AND SHIPMENT.

Care must be exercised during the shipment and handling of the engine and associated equipment during installation to avoid damage. The unit should be lifted only from the lift pads on the side of the engine base (where provided) as indicated on the installation drawing. When securing the engine during shipment or other movement, make sure no binding stresses are imposed on the engine base or crankshaft.

FOUNDATION.

Make a foundation bolt template, using the certified foundation drawing to determine the location of the equipment mounting bolts. See figure 2-1 for a suggested method of building the template. Exercise care in locating bolt centers. Place and support the template from the foundation forms. Anchor securely to prevent movement of the template. Thread foundation bolt into lower nut in pipe sleeve being careful not to damage cap at bottom of nut. Insert foundation bolts and sleeves in holes provided in the template then tighten the upper nuts. Sleeves must be securely held in correct position to prevent any movement when pouring concrete. A suggested method is to use reinforcing rods welded to each sleeve or on top of each anchor plate in both rows of bolts, running the length of the engine, and adding "X" bracing between the two rows of bolts. Another suggestion is to tie the bolt assemblies to other reinforcing rods already in the foundation. *Recheck template position, alignment and elevation before pouring concrete.* It is recommended that a DELAVAL Engine and Compressor Division service representative be present to check bolt layout. The foundation is to be poured monolithic and must be suitably reinforced with reinforcing steel. Let concrete set for 10 days before installing equipment, and 30 days before running equipment.

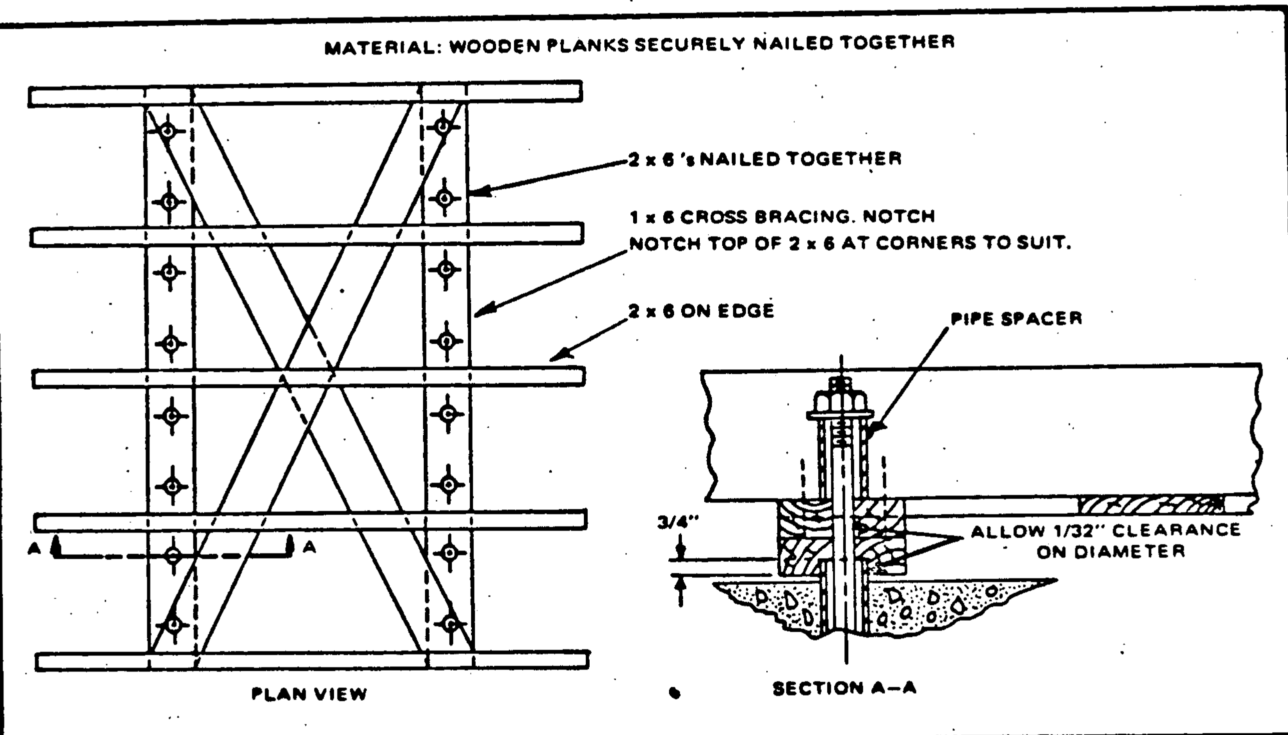


Figure 2-1. Suggested Foundation Bolt Template

FOUNDATION BOLT ASSEMBLIES.

The foundation bolts are so designed that the anchor studs can be removed from the anchors after the foundation has been poured. This permits the engine to be placed over the foundation without any interference or danger of damage to the studs. Once the engine is in place, the studs are installed and screwed into the anchor assemblies.

PREPARATION FOR INSTALLATION.

Before landing the unit on the foundation, the surfaces of the foundation must be roughened wherever grout is to be applied. Chip and clean as necessary to remove all laitance and foreign matter so that the clean, dry, sharp aggregate required for a good bond to epoxy grout is exposed. The machined surfaces of the sole plates and chocks must be thoroughly cleaned and the leveling screws waxed to prevent their sticking to the grout. The machined bottom faces of the engine base must also be cleaned thoroughly. Remove engine foundation bolts. Place steel plates at jacking screw locations, level plates and grout in place.

PLACING ENGINE OVER FOUNDATION.

Position engine over foundation and insert four toe jacks, one at each corner of the engine, inboard of the shipping skids. If engine is rolled into position, the ends of the jacking screw shields and foundation bolt shields must be protected to avoid damaging shield ends with the rollers. Do not place jacks in the center of the engine as this could cause damage to the engine base. Insure that the combined capacity of the jacks is at least fifty percent greater than the total weight of the engine. See Installation Drawing for weights.

a. Remove shipping skids, thoroughly clean mounting rails and then lower engine to grade. Be sure the foundation bolt holes in the engine base are correctly aligned with the foundation bolt sleeves in the foundation for easy installation of the foundation bolts.

b. Clean sole plates and chocks with a degreasing type solvent. It is recommended that after the sole plates are washed, they be primed with a primer recommended by the grout manufacturer. Lubricate the threads of the jacking screws with a mixture of powdered graphite and engine lubricating oil. The lower end of the jacking screws should be coated with wax to prevent the epoxy grout material from binding to the screws.

c. Place sole plates and chocks in position under the engine as shown in the foundation drawing. Install sole plate retainers on the front and rear sole plates, making sure the sole plates are forced tightly against the shoulder at the inner edge of the engine mounting rails.

d. Lubricate lower threads of the foundation bolts with standard graphite and oil mixture, install bolts in sleeves and screw firmly into the threads at the bottom of the sleeve. Lubricate threads at the upper end of foundation bolts with oil and graphite powder then place washers and nuts on bolts.

e. Level and align the engine, following the crankshaft alignment on DELAVAL Engine and Compressor Division Form D-1063. Record deflection readings on the form. Insure that all sole plate jacking screws are so adjusted as to distribute the weight evenly on all sole plates. When leveling and alignment is satisfactory, snug down the foundation bolt nuts to prevent movement of the engine during installation of the driven equipment and grouting.

CRANKSHAFT WEB DEFLECTION AND THRUST CLEARANCE RECORD

CUSTOMER ______________________ ENGINE MODEL __________ SERIAL NO. __________

Use this form to record crankshaft deflection and thrust clearance information. Thrust clearance should be measured by the dial indicator method. Deflection and thrust clearance should be checked and recorded immediately after grouting or chocking the unit, the day before unit start-up, after 7 days (168 hours) of continuous operation, and each 6 months thereafter. Deflection and thrust clearance checks made after the unit is in service should be made while the engine is hot, i.e., within 4 hours after the unit has been shut down. Record the temperature of the oil in the engine lube oil sump tank or engine base.

When an engine in which the connecting shaft is solidly coupled to the flywheel is grouted on a concrete foundation, the desired deflection at crank position No. 3 is zero to plus (+) 1 mil (one thousandth) in all cranks except the crank adjacent to the flywheel which should be minus (-) 1/2 mil. This deflection allows for thermal distortion of the concrete foundation.

When an engine is mounted on a steel foundation, i.e., marine installations, appropriate compensations for thermal distortions of the foundation will be based on the locations and temperatures of fuel and lubricating oil tanks adjacent to the engine foundation.

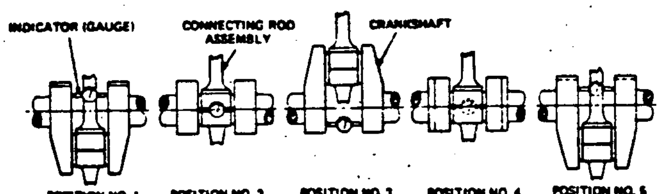
If the deflection in any crank in an engine in service exceeds 3 mils, corrective action must be taken. Also, if the total deflection value in any two adjacent cranks exceeds 3 mils, corrective action must be taken. Example, a +2 mils in any crank with a -2 mils in the next adjacent crank adds up to a total of 4 mils deflection between these adjacent cranks. The exception to the above will be engines that have a flexible coupling between the flywheel and the connecting shaft. These engines may have in excess of 3 mils deflection at position No. 3 in the crank adjacent to the flywheel. In engines with solidly coupled connecting shafting, excessive deflection at positions No. 2, 3, or 4 in the crank adjacent to the external shafting usually indicates misalignment between the connecting shafting and the engine crankshaft.

Set the deflection gauge at zero at position No. 1 and turn the crankshaft in the direction of normal rotation.

Position No. 1 for placing the deflection gauge is as follows:

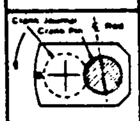
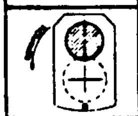
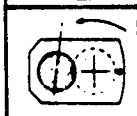
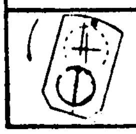
ALL INLINE ENGINES	15° AFTER BOTTOM CENTER
HV, HVA & GVB ENGINES	38° AFTER VERTICAL BOTTOM CENTER
RV ENGINES	52° AFTER VERTICAL BOTTOM CENTER

Record oil sump temperature and thrust clearance and *sign the form.*



DATE	SUMP TANK TEMP.	THRUST CLEAR.	SIGNATURE

Record readings in mils, i.e., 1-¼ rather than 0.00125 inches.

POSITION	CYLINDER NUMBER STARTING AT GEARCASE END										DATE
	1	2	3	4	5	6	7	8	9	10	
Place indicator here only 											
											
											
											
											

Form D-1063 (R-2) 1/75

Figure 2-2. Crankshaft Alignment Record, Form D-1063.

MOUNTING FLYWHEEL AND CONNECTING SHAFT.

Carefully clean and de-burr the bores and mating surfaces of the flywheel, the crankshaft flange and the connecting flange. Dirt or burrs will cause misalignment between the crankshaft and the connecting shaft.

a. Apply a thin coat of anti-seize lubricant such as "Molykote" or "Lubriplate" to the mating surfaces of the flywheel and the flange, then mount the flywheel on the engine crankshaft flange. Make sure no dirt is allowed between the mating surfaces while the flywheel is being mounted. Install three retaining plates (see figure 2-3) and draw the flywheel up on the flange until it is seated.

b. Bring the connecting shaft into position, lubricate the mating surfaces with anti-seize lubricant, align the half-inch locating hole in the connecting shaft flange with the locating hole in the flywheel and move the connecting shaft into engagement with the flywheel. Keep dirt from entering the mating area. Use two long one or one and one-quarter inch diameter temporary bolts with washers and nuts to draw the connecting bolts with washers and nuts to draw the connecting shaft to the flywheel until it is seated. Check with feeler gauges between face of connecting shaft flange and flywheel to be sure the flange is fully seated and square with the flywheel.

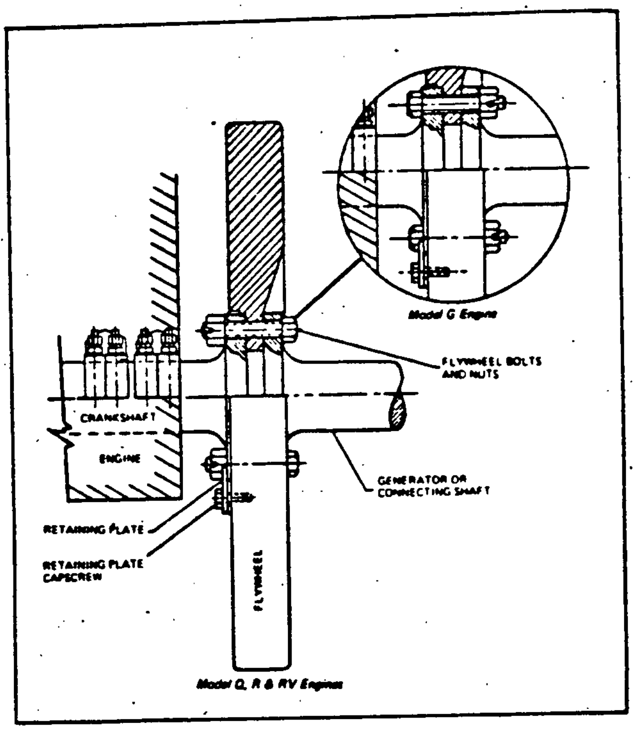


Figure 2-3. Flywheel Mounting

c. Special tapered aligning dowels and a flywheel bolt reamer are available from the DELAVAL Engine and Compressor Division Service Department for use in aligning and fitting the flywheel bolts. Lubricate the two aligning dowels with a thin coat of anti-seize lubricant then tap them into two opposite flywheel bolt holes, aligning the bolt holes with those of the shaft flanges. *Do not drive dowels up hard.* Ream two flywheel bolt holes with the special reamer and measure diameter of reamed hole to the nearest 0.0005 inch, and compare diameter of reamed hole with diameter of bolt. Reamed holes should be approximately 0.0005 inch larger than the bolts to allow for an easy tap fit. *Do not drive the bolts in with a sledge, hydraulic ram or jack.* Coat bolts with an anti-seize lubricant and fit into reamed holes. Lubricate threads with powdered graphite and engine oil, assemble nuts on bolts and draw up tight. Remove two temporary bolts and aligning dowels and fit remaining bolts. Torque all bolts to the torque specified in Appendix IV.

GROUTING.

Check alignment of crankshaft, then align driven equipment. Tighten foundation bolts on driven equipment moderately with jacking screws in place, then recheck entire alignment including crankshaft. Record crankshaft deflections on *Form D-1063, Crankshaft Alignment Record.* A DELAVAL Engine and Compressor Division service representative must be present to supervise alignment procedures.

a. Pour and vibrate the grout under the engine and driven equipment. It is recommended that a representative of the grout supplier be present at the installation to be sure that grout is prepared and placed in accordance with specifications. Do not fill bolt shield holes with grout.

b. After grout has cured, back off the sole plate jacking screws one turn each and torque the foundation bolts to the specified value. Snug all bolts in a criss-cross pattern, then apply a light torque to each, using the same criss-cross pattern. Continue applying torque in increments and in the same pattern until the final torque value is reached.

PIPING SYSTEMS.

DELAVAL Engine and Compressor Division furnishes suitable piping diagrams to the purchaser or his design agent, recommending minimum pipe sizes for all service lines. In addition, the following should be observed in the fabrication and installation of piping not furnished with the unit, but procured from other sources.

a. Piping must never cause deflection in the mounting of reciprocating or rotating auxiliary equipment, nor should heavy auxiliary equipment ever be supported by service piping.

b. Whenever there is a possibility of deflection, flexibility must be designed into the piping.

c. Chill rings should not be used in welded pipe joints as they tend to retain scale, welding slag and beads which can come loose as the pipe becomes hot during operation.

TREATMENT OF PIPING.

It is strongly recommended by DELAVAL Engine and Compressor Division that all lubricating oil and fuel gas system piping be pickled by a company specializing in this kind of work. Such a company will have the necessary equipment and possess the technical knowledge to completely clean and prepare the pipe for service. Piping which is furnished by DELAVAL Engine and Compressor Division with the unit will have been pickled at the time of fabrication. All piping procured from other sources should be pickled and prepared as follows:

a. Accessible welds inside carbon steel pipes and fittings must be visibly inspected and the welding beads ground off. All fabricated steel pipes, valves and fittings must be blown clean with steam or air to remove loose scale, sand and welding beads, and be cleaned by the following procedure before the pickling process.

(1) Wirebrush the entire surface, including the interior with boiler tube brushes or a commercial pipe cleaning apparatus, then blast thoroughly with air to remove loose particles.

(2) Depending on the degree of contamination, submerge parts for 15 minutes or longer in a solution containing seven to ten ounces of anhydrous trisodium phosphate or sodium hydroxide and one ounce of detergent, Military Specification MIL–D–16791 to one gallon of water at 200° F (93.3° C) to insure complete removal of paint and grease.

(3) Rinse parts in warm, fresh water at 120° F (48.9° C) to prepare them for the acid treatment.

(4) Pickle fabricated carbon steel pipes and fittings by submerging them for 30 to 45 minutes in an acid bath containing one part of sulphuric acid, 66° Baume to 15 parts fresh water, supplemented with an inhibitor. The acid bath must be maintained at a temperature between 160° F (71.1° C) and 186° F (82.2° C). While the parts are submerged, agitate the bath. At the end of the pickling procedure, rinse parts in warm, fresh water. After the rinse the parts must be momentarily submerged in a cooling solution containing four ounces of sodium carbonate per gallon of water, then rinsed in cold fresh water and dried by air blast.

b. Immediately following pickling and rinsing, coat both the inside and the outside of the fabricated steel pipes and fittings with a rust and corrosion preventive compound and seal the ends to prevent entry of dirt. The compound must be soluble in the lubricating oil that will be used, and compatible with it so as not to contaminate the oil. Ordinary lubricating oil will not prevent rust in the pipes. Mechanical cleaning will not completely clean the pipes, therefore, this method is not acceptable. Apply the compound by spraying or flooding the pipes—swabbing with rags or mops will leave lint.

Note

The above procedure is a minimum requirement to produce acceptable clean piping. Substitute methods may produce pipes and fittings of equal or better cleanliness.

JACKET WATER SYSTEM (See Figure 2-4).

The jacket water system should be individual for each engine. The recommended water treatment is sodium dichromate and boiler compound. Refer to Section 6 of this manual for the method of treatment. The typical jacket water system consists of the following major components.

a. An engine-driven pump to circulate the coolant.

b. A heat exchanger for cooling the water. It may be either a shell and tube type, or a radiator.

c. A temperature control valve to regulate the temperature of the water out of the engine.

d. Passages within the engine through which the water flows and where heat is absorbed from the engine.

e. A surge tank or standpipe to maintain a constant head on the pump and also for expansion and bleeding of entrained air.

The pump, engine and heat exchanger are best connected in a series circuit and should be provided with a bypass around the exchanger. The standpipe must be installed above the highest point of the system and connected with vent lines from the top of the exhaust manifold and from any other points that may cause an air pocket. These pipes must be configured to avoid air pockets. Sizes are shown on the piping diagrams furnished with the engine. Vent and surge lines should be provided with globe valves that can be cracked to vent air from the system. Proper valving or thermostatic control around the heat exchanger must be provided to allow for jacket water temperature regulation. Drain valves must be installed at the lowest points in the system and are desirable at the heat exchanger. The system may be filled at the standpipe, or in the line between the surge tank and the pump suction.

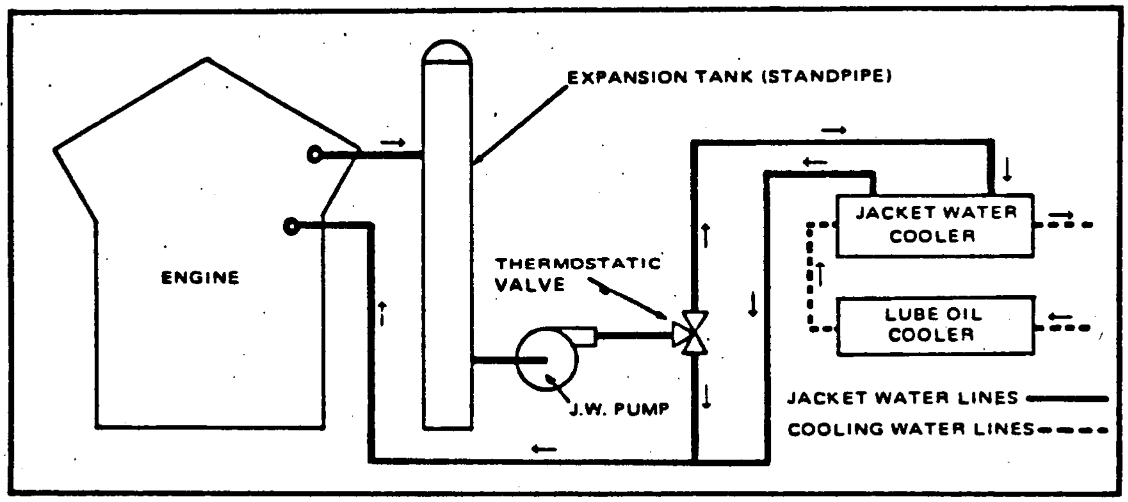


Figure 2-4. Typical Jacket Water Piping System

PRELIMINARY
TO BE REVISED

orm E-177a

RAW WATER SYSTEM.

The raw water system, if used, provides a cooling medium for various engine units and accessories as required. Raw water may be pumped from its source through a lubricating oil cooler and heat exchanger then returned to its sump. Provisions are necessary to maintain control over jacket water and lubricating oil temperatures. Such control can be achieved by means of bypasses in either the liquid-to-be-cooled, or in the raw water lines. In some applications it may be necessary to run raw water lines to accessory equipment coolers.

INTERCOOLER LINES.

When an intake air cooler is used, it is located between the turbocharger air discharge and the air manifold. Raw water is usually used as the coolant and is piped as indicated in the piping diagrams furnished with the engine.

FUEL SYSTEM.

The fuel system must be maintained in as clean a condition as is possible. Every precaution must be taken to keep water from mixing with the fuel. Fuel injection on the engine is hand lapped to extremely close tolerances, and, therefore, fuel filtration equipment must be of the highest quality and carefully maintained. Engine mounted fuel system components will include:

a. A fuel oil strainer.

b. An engine driven booster pump with built in relief valve.

c. A duplex absorbent type filter.

d. Fuel oil supply and return headers.

e. Fuel injection pumps and nozzles, individual for each engine.

f. Pressure regulating valve at downstream end of header.

g. Necessary drains and drip lines.

LUBRICATING OIL SYSTEM.

The lubricating oil system is of the dry sump type which has a sump tank for holding the lubricating oil supply. Lubricating oil is circulated through the system under pressure by a positive displacement, gear type pump. Refer to Figure 2-5 for an illustration of a typical system. Reference should be made, however, to the lubricating oil system schematic drawing provided in the drawing section of this manual for the specific details of the system used on this engine.

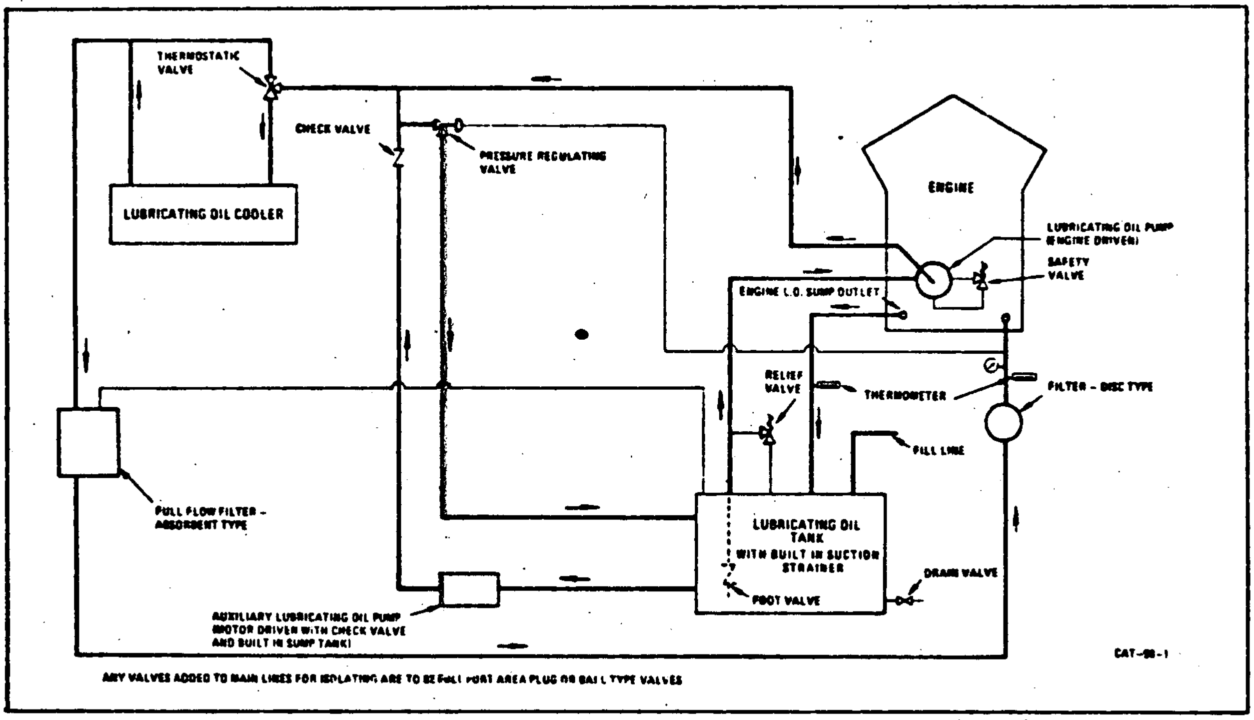


Figure 2-5. Typical Lubricating Oil System

FLOW PRINCIPLE.

Pump suction draws the lubricating oil from the engine sump tank through a built in strainer and directs pump discharge to a thermostatic valve where, depending on the temperature of the oil, oil is either passed through the cooler, or sent directly to the full flow filter. From the filter oil flows through a pressure strainer to the engine lubricating oil header. Return flow is by gravity flow from the engine base to the sump tank. Branches from the main lubricating oil header in the engine provide for pressure lubrication of the working parts of the engine. To prevent damage to the pump and supply lines, a safety relief valve at the pump discharge opens as a preset pressure to bypass excess oil back to the suction side of the pump. Refer to Section 3, Part B of this manual for a description of the operation of the lubricating oil pressure regulating valve.

PRELIMINARY
TO BE REVISED

AUXILIARY LUBRICATING OIL PUMP.

An auxiliary lubricating oil pump, sometimes called a Before and After (B&A) pump is normally furnished with the engine. It is motor driven and installed in the system to provide a means for pre-lubrication of the engine before starting and to aid in cooling the engine after it has stopped.

INSTALLATION PRECAUTIONS.

The following precautions are among those which must be considered in the procurement and installation of lubricating oil servicing equipment when that equipment is not furnished with the engine.

a. The lubricating oil pump must be of the positive displacement type and provided with adequate relief valves.

b. A strainer should be provided in the line where the lubricating oil enters the main lubricating oil header, and be of a type that can be cleaned without being disassembled.

c. An auxiliary (B&A) lubricating oil pump is recommended for pre-lubricating of the engine before starting.

d. Provisions should be made for controlling the temperature of the lubricating oil.

e. Provisions should be included to temporarily bypass the oil cooler in the event of a leak in the cooler.

f. Flexible connections are recommended wherever there is a possibility of deflection.

PLACING LUBRICATING OIL SYSTEM IN SERVICE.

Before the engine is first started, the assembled lubricating oil piping system must be thoroughly flushed with oil. Disconnect the pipe at the pressure strainer inlet and arrange a temporary bypass from this pipe to the sump tank. The bypass will permit oil circulation through the pipes without filling the internal lubricating oil system of the engine. Several thicknesses of cloth sack should be secured to the outlet of the bypass to catch debris as it is flushed out. The sump tank and engine base must be thoroughly cleaned before being filled. An auxiliary lubricating oil pump, or any other continuous duty pump of sufficient capacity, can be used to pump oil during flushing operations. Flushing should continue for at least eight hours if care was exercised during fabrication of the system. As much as 24 hours of flushing may be required for a dirty system. When oil is circulating through the system, the pipes should be thoroughly pounded several times with a heavy hammer to loosen dirt and debris. Hot flushing oil will clean better than cold oil. Piping around the oil cooler requires special attention to insure that the pipes and oil cooler are properly flushed. Precautions must be taken to insure the complete removal of testing fluids, water or other liquids before attempting to flush the cooler.

Note

Engines may be received with the strainer mounted on the engine and connected to the engine lubricating oil header. If it is certain that the connections between the strainer and the engine oil header have not been disconnected since the engine left the factory, the following paragraph may be omitted.

Disconnect jumper tubes between the engine lubricating oil header and the main bearings, and between main headers and auxiliary headers. Secure a fins screen such as a nylon stocking over each main header fitting to catch debris that may be washed through as the system is flushed. Cover main bearing fittings and open ends of auxiliary header feeders to prevent the entry of dirt. Engine oil should be pumped through the open system for at least four hours to be sure that any foreign material remaining in the headers is removed. Reassemble internal tubes and brackets as required.

PRELIMINARY
TO BE REVISED

INTAKE SYSTEM.

Each engine has an independent intake system, the combustion air being piped from outside the engine room through a remotely installed air filter. An inline silencer is fitted in the pipe just ahead of the turbocharger air inlet. The air filter protects the working parts of the engine from the entry of dust. Filters should be cleaned at regular intervals to maintain adequate protection against abrasion and wear.

EXHAUST SYSTEM.

Each engine is provided with an individual, independent exhaust system. The water jacketed, multi-pipe passage manifold discharges directly into the engine mounted turbocharger(s), and the gas then discharges from the turbocharger(s) through exhaust piping and a silencer to atmosphere. As few bends as possible should be used when laying out exhaust piping. Necessary bends should be of long radius. If three to six bends are used, the entire pipe should be increased to the next nominal size. If more than six bends are necessary, pipe size should be increased two nominal sizes. The length of exhaust piping is not critical, however, if an unusually long pipe is used, the pipe size should be increased to reduce back pressure. A length of flexible metal tubing should be installed in the exhaust line as near the engine as possible to allow for movement, heat expansion, and for isolation of vibration. The exhaust line should be lagged to minimize heat radiation in the engine room. A separate support should be provided so the weight of the exhaust silencer and line is not borne by the engine.

STARTING AIR SYSTEM.

Compressed air from the starting air tanks at 250 psi (17.6 kg-cm^2) is applied to the upstream side of the starting air admit valve where it is blocked until a starting signal is applied to the pilot of the starting air admit valve. When a start signal is applied to the starting air admit valve pilot, the valve opens and admits starting air to the starting air manifold on the engine and to the gear-driven starting air distributor. Timed pilot signals are sent to the air start valves on the engine in the correct sequence, and as each air start valve opens, starting air is admitted to the cylinder, causing that piston to be forced downward, rotating the crankshaft. The starting air tanks are provided with isolating valves and pressure relief valves. Refer to the starting air schematic drawing for the location of filters, strainers, regulators and valves, and for the direction of air flow.

PRELIMINARY
TO BE REVISED

INSTRUCTION MANUAL FOR ENTERPRISE ENGINES	DELAVAL ENGINE AND COMPRESSOR DIVISION 550-85TH AVENUE OAKLAND CALIF. 94621

DELAVAL

SECTION 3

OPERATING PRINCIPLES

PART A – GENERAL

WORKING PRINCIPLE.

ENTERPRISE engines operate on the four stroke cycle principle. The complete cycle for each cylinder consists of the intake, compression, power (or expansion) and exhaust strokes, and requires two complete revolutions of the crankshaft.

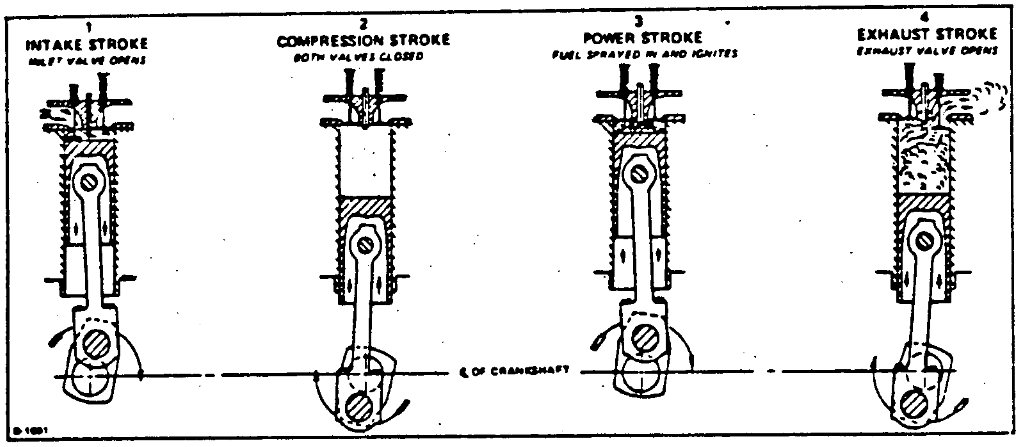


Figure 3-A-1. Diagram of Working Principle

INTAKE STROKE.

During the downward movement of the piston on the intake stroke, the intake valve is open and combustion air enters the cylinder. The exhaust valve remains open during the early part of the stroke to scavange the cylinder of any unburned gases from the previous power stroke. Combustion air enters the cylinder from the turbocharger under pressure.

COMPRESSION STROKE.

Shortly after the piston passes bottom center and starts upward, the intake valve closes and the air is compressed, raising the temperature of the air to well above the ignition temperature of the diesel fuel. Just before the piston reaches top center, diesel fuel is injected into the combustion chamber by a nozzle which atomizes the fuel and sprays it in a pattern that will achieve optimum combustion efficiency. The heat of compression ignites the fuel.

POWER STROKE.

The burning fuel-air mixture expands and forces the piston downward. This downward thrust transmits power through the connecting rod to the crankshaft, causing it to rotate. Towards the end of the power stroke the exhaust valve opens and exhaust gases start to leave the cylinder.

EXHAUST STROKE.

As the piston moves upward, past bottom center, exhaust gases are forced out of the cylinder through the open exhaust valves. During the last half of the exhaust stroke the intake valve opens to admit combustion air into the cylinder for scavenging purposes.

PART B – LUBRICATING OIL SYSTEM

GENERAL.

An engine-driven pump draws oil from the sump through a strainer, and discharges it to a thermostatic valve where, depending on the temperature of the oil, it is either passed through the lubricating oil cooler, or directly to the filter. Filtered oil is then passed through a strainer to the engine lubricating oil header. Oil return to the sump tank is by gravity flow. An integral safety valve on the pump prevents excess discharge pressure, and a pressure regulating valve controls the pressure in the engine lubricating oil header. Refer to the lubricating oil system schematic drawing for the relative location of components and for the direction of flow.

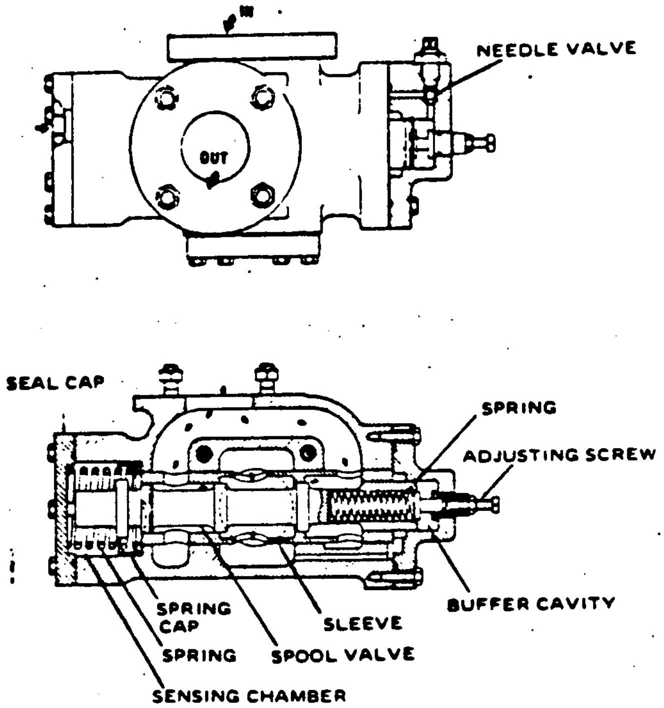


Figure 3-B-1. Oil Pressure Regulating Valve

PRESSURE REGULATING VALVE.

Lubricating oil header pressure in the engine is regulated by a pressure regulating valve, mounted on the pump discharge piping so that the pump discharge is directed to this valve before reaching any other system components. Set at 50 psig, it senses header pressure and regulates the bypass volume to maintain the set header pressure. Besides regulating header pressure, the valve protects the system from excessive pressure during starts with cold oil, or when flow in the system is restricted between the pressure regulating valve and the header pressure sensing point. The functioning of the valve is as follows.

a. The "IN" port of the valve is connected to the pump discharge line and the "OUT" port is connected to a bypass line leading back to the engine base. A sensing tube, connecting the valve seal cap to a point on the main engine oil header, applies header pressure to the valve pressure sensing chamber.

b. The pressure in the sensing chamber acts against the end of a spool valve, compressing a spring at the adjusting screw end of the assembly. If the sensed pressure rises above the set point, the lands of the spool valve will clear the lands on a sleeve. Oil then flows from the inlet section to the outlet-section of the regulating valve and back to the engine base to bypass a part of the pump discharge to reduce the pressure in the header.

PART B – LUBRICATING OIL SYSTEM (Continued)

c. A drilled passage connects the inlet section of the valve to the annular space around the spool valve at the adjusting screw end. This allows pump discharge pressure to act against the end of the sleeve and oppose the spring force at the other end. When an excessive pressure differential exists between the pump discharge and the header pressures, such as when starting with cold oil, or because of an obstruction in the system between the regulating valve and the header pressure sensing point, the sleeve is forced towards the sensing chamber end, compressing the spring. This will uncover the lands of the spool valve and the excess oil will bypass through the spool valve and the excess oil will bypass through the outlet side of the valve back to the engine base.

d. The oil in the annular space around the spool valve, at the adjusting screw end, will leak past the sealing grooves of the spool valve and into a cavity in the cap. This cavity functions as a buffer chamber. To stop valve oscillation, an adjustable needle valve controls oil spillage from the buffer cavity to the outlet-section of the valve.

e. The oil header pressure is set by increasing or decreasing the spring force acting against the header pressure in the valve sensing chamqer. Turning the adjusting screw in will increase header pressure, and backing it out will decrease pressure.

FILTERS AND STRAINERS.

The full flow filter continuously filters all of the lubricating oil from the pump before it passes to the oil strainer. The length of time that the lubricating oil and the filter elements may remain in service can best be determined by carefully watching the result of oil analysis and the pressure drop across the oil filter. Change periods will vary with the operating conditions to which each individual engine is subjected. During the first two or three days of engine operation after initial installation, or after a major overhaul, the basket-type strainers at the pump suction and at the oil header inlet should be checked and cleaned as necessary to remove any debris and foreign matter that may be present. If at any time the oil pressure gauge shows a low reading, the following should be done to the degree necessary to correct the situation.

a. Check the oil level in the sump tank, or engine base.

b. Inspect strainer, filter and lubricating oil cooler. A leak in the cooler may be detected by a sudden increase in oil consumption, and by the presence of oil in the cooling water system. Leakage may occur in the packing between the tubes and the tube sheet, or may be due to tube erosion, depending on the construction of that particular cooler.

c. Inspect all external and internal piping for tightness and freedom from obstructions.

d. Dismantle and inspect pump. Refer to manufacturer's instructions on the *Associated Publications Manual.*

PART C – FUEL SYSTEM

GENERAL.

Fuel oil should be maintained in as clean a condition as is possible. Every precaution must be taken to keep water from mixing with the engine fuel. The fuel injection equipment on the engine is hand lapped to extremely close tolerances and, therefore, fuel filtration equipment must be of the highest quality and carefully maintained.

SYSTEM COMPONENTS.

Engine mounted fuel system components include the following:

a. A duplex fuel oil strainer.

b. An engine driven booster pump with built in relief valve.

c. A duplex absorbent type filter.

d. A d-c motor driven fuel oil booster pump.

e. Fuel oil supply and return headers.

f. Fuel injection pumps and nozzles, individual for each cylinder.

g. Pressure regulating valve at downstream end of header.

h. Necessary drains and drip lines.

OPERATION.

Fuel is drawn from the day tank by the engine driven booster pump and the d-c motor driven booster pump, operating in parallel. The engine driven pump draws fuel through the strainer and discharges it through the filter to the engine headers. The d-c motor driven pump dischargers directly to the filter. The fuel pumps, actuated by fuel cams on the camshafts, deliver fuel to the cylinders, depending on the position of the fuel control racks of the pumps. In the event of engine driven pump failure, an isolation valve and a check valve prevents fuel from being pumped back to the engine driven pump. Return flow is back to the day tank. A fuel waste return pump on the fuel oil waste tank returns waste fuel oil to the day tank.

PART D – CONTROL SYSTEM.

GENERAL.

The following is a description of the local engine control system and its operation. The system will start, stop, protect, operate and monitor the integrity of the diesel generator in the various modes of operation under guidelines specified by various regulatory and standards committees.

REFERENCES.

The *Associated Publications Manual* contains manufacturer's literature covering the various components of the system. Of special significance are the ARO Corporation's publications which give a clear, concise explanation of the functions of the various logic elements as well as a parts breakdown and repair procedures. When ordering spare and replacement parts for the system, refer to the *Parts Manual* for the correct part numbers.

DRAWINGS.

The drawings provided with these instructions include system schematics, layouts and connections pertaining to the logic board assembly, showing the location and orientation of the components on the board, the circuit diagram and checkout procedures. Refer to the control panel group parts list 02-500 for 75041 in the *Parts Manual* for a listing of drawings applicable to the system.

OPERATING MODES.

There are two base modes incorporated into the system, the STANDBY mode and the MAINTENANCE mode. In the STANDBY mode the unit may be started in response to an emergency start signal, or manually to exercise it on a routine basis. The MAINTENANCE mode permits routine maintenance, or repair.

a. While in the STANDBY mode the unit will accept a manually injected starting signal from a local or remote location. If the unit's entire protective system is permissive, it will start, come up to speed and build voltage automatically. Controls provided by the owner are then used to load the unit onto an energized bus. While running in this mode, both the speed/load and voltage setpoints are adjustable from either the local or remote location. Provided the generator circuit breaker is open, the unit can be stopped from either location by momentarily pressing a guarded stop button.

b. If an emergency "Start Diesel" signal is generated by the owners equipment while the unit is in the STANDBY mode, the unit will start with only overspeed and generator differential protection permissive, and if d-c power is available. The unit will come to speed and voltage as required and a "Ready To Load" signal will be generated for use in the owner's sequencing equipment. No other protective device is functional under this condition, and control air need not be available to effect a start.

c. If the unit is undergoing its periodic "Exercise Test" at the moment a "Start Diesel" signal is received, whether it is starting, running disconnected, running loaded, tripping on a fault other than overspeed or generator differential, or coasting to a stop, the control system will cause the unit to return to its rated speed and voltage, and will disarm all protection except overspeed and generator differential. The "Ready To Load" signal will be sent to the sequencer as above.

d. While running as a result of a sequencer signal, both speed/load and automatic voltage setpoints are adjustable, either locally or remotely. Every time the engine is shut off, or given a sequencer start signal, the setpoint of the governor and the automatic setpoint of the voltage regulator are reset to normal. Fifteen seconds after going to normal, the reset signal is released to allow the operator to control voltage and speed.

PART D – CONTROL SYSTEM (Continued)

e. To change the unit from the STANDBY mode to the MAINTENANCE mode, the circuit breaker must be locked out. This is accomplished by turning the circuit breaker control switch to "Trip" and pulling the handle out. It will remain in this position until manually returned to "Normal". While in the "Trip/Lockout" position, the circuit breaker cannot be closed, either manually or automatically, and the "Unit In Maintenance" light is lighted. The engine may be run manually while the circuit breaker is locked out.

f. When in the MAINTENANCE mode the unit may be "Locked Off", i.e., prevented from starting. To place the unit in "Engine Lockoff", the two "Engine Lockoff" pushbuttons, one in the local engine control panel and one in the remote diesel generator panel, must be pressed simultaneously. A light in the remote panel indicates when the unit is in "Lockoff". Return to "Engine Operative" is accomplished by turning the handle of the "Engine Operative/ Lockoff" switch in the local engine panel to the "Operative" position. While in "Lockoff" the "Engine Roll" pushbutton or barring device may be engaged to rotate the engine for maintenance purposes.

g. Mode selection is accomplished so as to afford maximum protection for the plant and also for maintenance personnel. If the system is in "Engine Lockoff", only the local operator can place it back in "Engine Operable". If the unit is in the MAINTENANCE mode, simultaneous operation of pushbuttons, local and remote, is required to place the system in "Engine Lockoff". Status lights report the system's status in the remote location. Furthermore, the barring device cannot be engaged in the STANDBY mode. While in the "Engine Lockoff" position in the MAINTENANCE mode, the barring device must be disengaged and locked out in order to switch back to the engine operable state.

PROTECTIVE SYSTEM.

The unit's protective system is a hybrid electro-pneumatic system. Since pneumatic devices function better than other types in the diesel environment, vital shutdown functions are performed pneumatically. All faults, both alarm and shutdown, are displayed on a solid state, dual rate flashing annunciator with horn silence provisions. Handoff contacts for use with a remote annunciator or mimic display are provided. When running as a result of a sequencer start signal, even though most of the shutdown system is not able to effect a unit trip, the action of the individual tripping devices is monitored and displayed on the annunciator so that the operator will be aware when a vital device has acted. Status lamps, separate from the annunciator, are used to show the condition of the unit as it proceeds through a starting sequence. The engine starting circuits are duplicated in total, and can receive d-c power from two separate conduit entries, if desired. Further, ancillary devices are arranged so that, even if they fail to function as intended, the unit will start and generator voltage will build up. It is possible that starting air will not be shut off as intended after a start if certain devices fail, but the balanced design of the engine's air start valves will keep them closed as soon as combustion occurs.

PANEL ELECTRICAL CONTROL (See Drawing 52189).

The local engine control panel electrical circuitry is shown in schematic form on sheets 1 of 4 through 4 of 4 on the referenced drawing.

a. Starting circuitry is shown on the left side of sheet 1. Note that there are two redundant circuits, each having a separate d-c power source. These circuits are physically spaced as far apart as possible on the panel. Solenoid valves SOL-1R, SOL-1L, SOL-2R and SOL-2L are located on the engine, and when energized admit starting air headers on the engine, and when energized admit starting air to the starting air headers on the engine. They are controlled by contacts of relays R3, R4, R6 and R7. Relays R3 and R6 are the emergency start relays, and R4 and R7 are for normal starting.

b. The redundant "Start Diesel" signal (SDS) contacts are from the owner's equipment. When either set of contacts close, an emergency start is initiated, provided SS-1 is closed (i.e., if the unit is not running at rated speed), and if pressure switch PS-7 or PS-8 is closed, indicating at least 150 psi starting air is left in the receivers. These pressure switches are present so that, if for some reason the unit does not fire (valve closed in fuel supply line, for instance), there will be enough starting air left for several manual starts.

PART D – CONTROL SYSTEM (Continued)

c. Note that when relay R3 or R6 is energized, R9 or R10 is also energized. Contacts of these relays operate solenoid valves SOL-6 or SOL-7, either of which cause the shutdown system to disarm instantly except for overspeed and generator differential protection. Also, if SS-1 fails to transfer, or if the device is faulty and fails to function at all, SS-1 remains closed and the unit will start. If SS-1 fails to open at the prescribed speed, combustion pressure will close and the air start valves and engine operation is not affected.

d. For a manual start, either of the switch contacts (local or remote) are closed which causes relay R4 or R7 to energize for three seconds. The shutdown system deactivating relay is not operated. Rather, solenoid valve SOL-3 is activated by either relay which arms the shutdown system. The "Engine Operable/Lockoff" must be in the "Engine Operable" position for any of the above to take place. If it is in the "Engine Lockoff" position, the "Engine Roll" button on the local panel only is operative. If the barring device is locked out, the pressure switch shown will be closed and the unit can be turned over on starting air without starting – a useful maintenance procedure.

e. When the unit receives a start signal, either of the four start relays will latch the four run relays, R1, R1A, R1B or R1C if pressure switch PS-33 or PS-34 shows the unit not tripped. Note that a SDS will cancel trips and the pressure switches will remain latched. In the generator shunt trip circuit, relays R1 and R1A contacts are connected in series in such a manner that if either relay latches, the generator circuit breaker may be closed. The contacts are connected in parallel to allow the field to be flashed through either relay R13 or R14. As in the start circuit, SS-2 failure will not prevent field flashing. At normal voltage and/or 430 rpm engine speed, the VR-1 and/or SS-2 series contacts will open to prevent energizing time delays TD-5 or TD-4. Time delays TD-4 and TD-5 are present to reset relay R1 should the unit fail to achieve "Ready To Load" status for any reason. Once voltage is close to normal, VR-1 and VR-2 energize relays R11A and R11B, the "Ready To Load" relays. One normally open contact of each relay should be connected in parallel to the owner's sequencer so that when either closes, the power delivery cycle is initiated.

f. The three R2 relays shown are responsive to the latching of relay R1 or R1A, but there is a 20 second time delay (TD-3) before R2 latches. Contacts of R2, R2A and R2B are used to disarm various alarm functions which are normally in a fault state when the unit is stopped, starting or stopping.

PNEUMATIC CONTROL.

The shutdown system is a network of vent-to-fault pneumatic devices which are arranged in the various systems on the engine. The venting of such a device is sensed by the pneumatic logic circuitry. This circuitry then produces a 60 psi pressure signal which operates a cylinder on the engine to shut off fuel. This showdown signal is automatically vented after the unit has rolled to a stop, retracting the cylinder and readying the unit for a restart. Note that the sensor network is always pressurized; it is merely the shutdown signal which is inhibited in the emergency condition. This allows sensors to be electrically monitored under any condition. Upon application of starting air, several things occur directly from the air start header. The governor oil pressure is pneumatically boosted, and the stop/run valve on the engine is pressure driven to the run position. Only the overspeed trip remains active.

LOCAL ENGINE CONTROL PANEL (See Drawing 52191).

The engine local control panel houses those control components which are not engine or remotely mounted. Access to the panel is through hinged doors in the back and removable access panels on either side. A 60 point annunciator is mounted in the upper portion of the face of the panel. Beneath this, and at eye level, are ten pressure gauges which monitor lubricating oil, fuel oil, jacket water, combustion air and starting air systems. An electronic temperature indicator with digital readout and integral linearization and cold junction compensation is used to monitor thermocouples inserted in the engine exhaust, lubricating oil and jacket water systems. Temperature alarm sensing is done in the lubricating oil and water systems.

PART D – CONTROL SYSTEM (Continued)

a. Status lamps are provided as follows:

1. DC Control Power ON – Lights if all d-c circuits are energized.

2. AC Power ON.

3. Unit Available For Start – Lights when following conditions are met.

   (a) DC Booster Pump in AUTO.

   (b) Mode selector in STANDBY.

   (c) DC power available – sufficient circuits to start.

   (d) Starting air pressure available.

   (e) Overspeed device not tripped.

   (f) Generator lockout relay not tripped.

4. Unit Starting – Lights when any of the four starting relays energize.

5. Unit Loaded – Lights when generator breaker closed.

6. Ready To Close Generator Breaker – Lights when voltage normal.

7. Test Trips Set – Lights when armed and functional.

8. Unit Stopped – Lights when fuel shut off on the engine.

9. Engine Lock Off – Lights when mode selector is in ENGINE LOCK OFF.

b. There are three level gauges used, one to indicate fuel oil day tank level, one to indicate lubricating oil sump tank level, and one to indicate main fuel oil tank level.

c. An engine hour meter is provided which is responsive to relay R1. A tachometer is also included, reading the speed in rpm directly from the speed transmitter. A remote output is available from this transmitter by removing the burden resistor and connecting on the 4-20 MA terminals.

Note

Since overspeed protection and generator fault tripping are the only active trips during an emergency, "two out of three" logic is not used. Overspeed shutdown is inherently safe from nuisance tripping. Generator fault tripping is derived from the owner's protective relaying.

d. De Laval engines are arranged so that the engine-driven fuel oil pump is driven from the free end of the overspeed trip drive assembly. For nuclear service, a d-c booster pump is used in parallel with the engine driven pump. If the drive fails the operator would have no indication that there is no longer overspeed protection. An annunciator is provided which senses loss of engine driven fuel pump pressure and, therefore, alerts the operator of possible loss of overspeed protection.

PART D – CONTROL SYSTEM (Continued)

AUTOMATIC SAFETY SHUTDOWN SYSTEM (See Drawing 52187).

The engine/generator set is protected by an automatic system which senses certain operating conditions and, when any of these sensed parameters exceeds a pre-set trip point, an automatic shutdown sequence is initiated. During emergency operations in response to a "Emergency Start Diesel" signal, however, the engine will stop only due to an engine over-speed or a generator differential, all other shutdown sensors being disabled in this mode of operation. There are other monitored conditions that will alarm when they reach their alarm point to inform operating personnel of adverse operating conditions which, though not of sufficient gravity to cause a shutdown, nevertheless should be attended to. Shutdowns are placed into two groups, Group I shutdowns are those which must be "GO" in order for the engine to start, and Group II shutdowns are those that would be in a shut down (venting) condition until the engine is running. Lubricating oil pressure, for instance. Group II shutdowns are locked out during engine starts for a fixed time period. The Shutdown Logic Board, 1A-5907 (3) functions to provide the necessary shutdown signals to the engine and, when operating in an emergency situation, prevents the engine from shutting down while still giving panel indications of an existing shutdown condition. During a start, Port 12 of the board is momentarily pressurized which results in an output from Ports 2, 9 and 10, and 90 seconds later an output from Port 3 and a loss of output from Port 9. Ports 2 and 10 pressurize the shutdown sensor circuits. If an unsatisfactory condition should develop which would trip one of the shutdown sensors, there will be a loss of pressure at either Port 10 or Port 2, resulting in an output from Port 8. This pressure is transmitted through a shuttle valve (21) to connection E-89 to the pilot of a pressure actuated valve (13, Dwg. 52186) then through a shuttle valve to extend the shutdown cylinder (6, Dwg. 52186) which moves the fuel rack to the "No Fuel" position, shutting the engine down. A shutdown due to engine overspeed is accomplished in a different manner. Air pressure supply at 60 psi from connection E-53 is applied through an orifice (12, Dwg. 52186) to the overspeed trip valve (11, Dwg. 52186) and, as the trip valve is blocking flow, the pilot of a three-way valve (13, Dwg. 52186) is pressurized, venting the air shutoff cylinder (8, Dwg. 52186). Tripping of the overspeed trip valve will extend the air shutoff cylinders, moving the air butterfly valve in the intake air manifold. The shutdown cylinder (6, Dwg. 52186) is also extended, moving the fuel rack to the "No Fuel" position. The engine is stopped due to both fuel and air starvation. During operation in the emergency mode, solenoid valves SOL-6 and SOL-7 are energized, allowing 60 psi air to be applied to Port 7 of the Shutdown Logic Board. This blocks output from Port 8 and there will be no shutdown signal. Shutdown indications, however, will still be displayed on the control panel to inform the operator that a shut-down condition does exist. Overspeed and generator differential protection are retained, however.

SECTION 4

ENGINE OPERATION

GENERAL.

If the engine is being started for the first time, remove any preservative materials that may have been applied to the control and exterior surfaces of the engine. Rust preventive which has been sprayed inside the engine will mix with the lubricating oil without causing contamination. To reduce the amount of preservative absorbed by the oil charge, however, it may be desirable to wash and clean the interior surfaces of the engine before circulating oil for the first time. Do not attempt to wash connecting rods, crankshaft or pistons as this may deposit dirt between the bearing surfaces. The following inspections and checks are recommended prior to starting the engine for the first time, or after a long shutdown or major overhaul.

a. Check bolts, nuts and capscrews, both inside and outside the engine to insure that all locking wires, clips and cotter pins are in place and secure.

b. Inspect all piping systems. Trace out each system to insure that all connections are secure and that all valves and other control devices are properly positioned for engine operation.

c. Check lubricating oil strainers and filters for cleanliness and proper assembly.

d. Check that lubricating oil and cooling water systems are clean and filled to the proper level.

e. Check starting air system for cleanliness and absence of moisture.

f. Check all control linkages for proper adjustment and freedom of movement.

g. Check crankshaft alignment (see Section 2).

h. Open indicator cocks on cylinders and bar engine over four revolutions to make sure cylinders are clean, and that engine is ready to run.

CAUTION

Any resistance to free turning must be investigated and corrected before engine is started.

i. With the indicator cocks open, fuel controls off, crank engine several revolutions.

j. Close indicator cocks. If all conditions for starting are satisfied, the engine may be started, using the procedures contained in subsequent paragraphs.

DEFINITIONS.

Certain terms used in these instructions require definition to ensure that their exact meaning is understood.

a. STANDBY MODE – The "Operable" mode in which the unit will accept an "Emergency Start Diesel" signal from the owner's equipment, or a manual start signal from either the local or remote position for periodic test.

b. MAINTENANCE MODE – The routine maintenance or repair condition. Unit may be run in this mode, or prevented from starting, depending on the positioning of controls.

c. LOCKED OUT – The engine is locked out while in the MAINTENANCE mode by positioning the main circuit control switch in "Trip". Unit may be manually operated, the circuit breaker cannot

d. LOCKOFF – When the engine is in LOCKOFF, in the MAINTENANCE mode, the engine cannot be started. Simultaneous action by both the local operator and the remote location is required to place the unit in LOCKOFF. Only the local operator can place the unit back in the "Engine Operable" (STANDBY) condition.

PRE-START PROCEDURE.

When starting a cool engine after a shutdown, it is very important that the following procedure be carried out prior to attempting a start in the MAINTENANCE mode, or prior to placing the unit in the STANDBY (Operable) mode.

a. Ensure unit in MAINTENANCE mode.

b. Place unit in LOCKOFF.

c. Barring device interlock locked out.

d. Open indicator cocks on all cylinder heads.

e. Push the "Engine Roll" pushbutton on local engine control panel, allow engine to roll at least two revolutions, then release pushbutton.

f. Inspect all indicator cocks. If liquid has been ejected from any of the cocks, the source must be found and the defect corrected before proceeding.

g. Close indicator cocks.

MANUAL START – MAINTENANCE MODE.

The following actions must be performed by the local operator to start the unit in the MAINTENANCE mode.

a. Ensure pre-start checks have been completed.

b. Open all flow valves.

c. Electrical power (a-c and d-c) ON.

d. Control air ON.

e. Lockoff/Operative selector in OPERATIVE.

f. Rotate keyed Manual Test Start switch to START position. As soon as the engine has fired once or twice, release switch.

MANUAL STOP – MAINTENANCE MODE.

Depress "Stop" pushbutton on local control panel.

PLACING UNIT IN LOCKOFF.

To place the unit in Lockoff while in the MAINTENANCE mode, perform the following.

a. Simultaneously depress the "Engine Lockoff" pushbuttons on both the local and remote panels.

b. A light on the remote panel will show the unit in lockoff.

PLACING UNIT IN MAINTENANCE MODE.

Turn the main circuit breaker control switch to "Trip" and pull handle out. It will remain in this position until manually returned to "Normal". The "Unit In Maintenance" light on the control panel should light.

PLACING UNIT IN OPERABLE (STANDBY) MODE.

The following must be performed to return the unit to the STANDBY (Operable) mode from the MAINTENANCE mode.

a. Check levels of fuel oil and lubricating oil day tanks.

b. Select fuel oil transfer pump to be used if day tank requires filling. Select either AUTO or HAND operation.

CAUTION

If HAND operation is selected, operator attendance is required to prevent overfilling of tank.

c. Lubricating oil heater, jacket water heater and fuel oil standby pump in HAND or AUTO as desired.

d. Check lubricating oil and jacket water keep warm pumps ON.

e. Check a-c and d-c power ON.

f. Check starting air pressure.

g. Place Lockoff/Operative control to OPERATIVE.

h. Place main circuit breaker control switch in NORMAL.

i. Check "Unit Available For Start" light ON.

MANUAL START – STANDBY (OPERABLE) MODE.

To start the unit manually, either locally or from the remote location, while in the STANDBY mode, perform the following.

a. Rotate keyed Manual Test Switch to START. As soon as the engine has fired once or twice, release switch.

b. If unit's entire protective system is permissive, it will start, come up to speed and build voltage automatically.

Note

If an "Emergency Start Diesel" signal is received while the unit is being manually operated, whether starting, running disconnected, running loaded, tripping on a fault other than overspeed or generator differential, or coasting to a stop, the control system will cause the unit to return to its rated speed and voltage, and will disarm all protection except overspeed and generator differential.

MANUAL STOP.

The unit is manually stopped by opening the main circuit breaker then depressing the "Emergency Stop" pushbutton on either the local or the remote panel.

EMERGENCY STOP.

Perform one of the following actions to stop the engine in an emergency situation.

a. Open main circuit breaker and depress "Stop" pushbutton.

b. Manually place the Stop/Run valve on the engine to STOP.

c. If none of the above procedures work, the engine may be stopped by pushing a fuel pump lever towards the engine block. This will rotate the fuel shaft and cut off pump delivery. Hold the lever until the engine stops.

STARTING, STOPPING AND OPERATING PRECAUTIONS.

As soon as the engine is running, all gauges should be checked for proper operating pressures and temperatures as shown in Appendix II. If running in other than the STANDBY (Operable) mode, and in response to an "Emergency Start Diesel" signal from the owner's equipment, shut down engine and determine cause before restarting if conditions are not normal.

WARNING

Use only compressed air for starting. Substitution of compressed gasses, especially oxygen, may result in a violent explosion.

SECTION 5

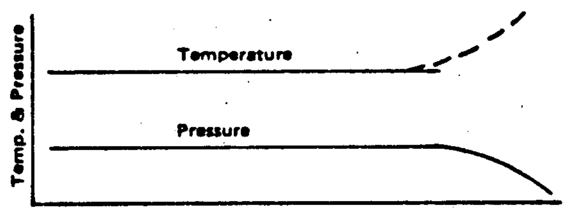
ENGINE MAINTENANCE

GENERAL.

The DELAVAL Engine and Compressor Division does not recommend the type of progressive maintenance system practiced by railroad maintenance shops, nor is any specific time interval between major overhaul or cylinder head valve reconditioning recommended. The inspection and maintenance schedules outlined in this section are intended as guides only. Experience and operating conditions will dictate the actual frequency of upkeep, overhaul and repair actions.

PREVENTIVE MAINTENANCE.

The following is intended as a supplement to the normal maintenance schedule which provides up to date information concerning the mechanical condition of the engine. When the following curves are maintained daily, then summarized monthly and plotted on a yearly curve, small troubles can be detected and corrected before they become major problems. The data for the curves should be taken at the same load each time. This load should be selected according to average operating conditions and be in the range of 75% to 100% of the rated load.

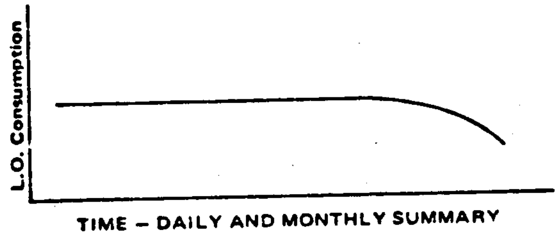


TIME – DAILY AND MONTHLY SUMMARY

a. If lubricating oil pressure starts to fall off but the temperature holds constant, it would indicate that the bearings are starting to wear to excessive clearances, that the lubricating oil pump is wearing excessively, or that the relief valve is not functioning properly. It could also indicate excessive fuel oil dilution. If the lubricating oil pressure falls off and the lubricating oil temperature increases, it might indicate that the heat exchanger equipment is plugging up.

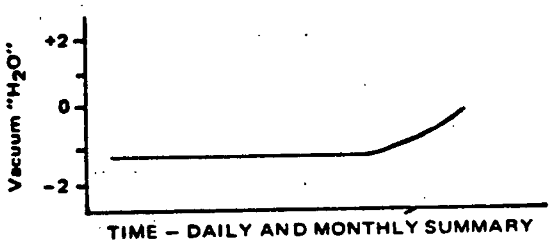
WARNING

A sudden increase in lubricating oil temperature with an increase in the amount of vapor from the crankcase ventilation discharge can indicate some overheated internal part of the engine. This could signal an approaching piston seizure and a possible crankcase explosion. A sudden increase in lubricating oil temperatures requires immediate reduction or removal of the load and an investigation of the cause.

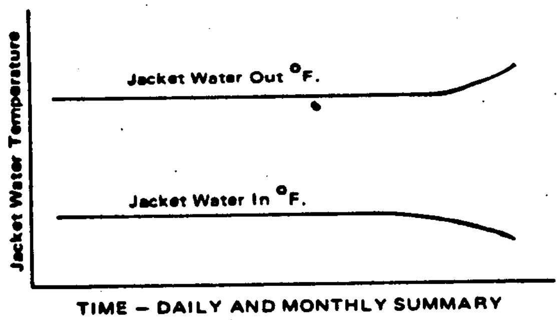


$$\text{Specific Lube Oil Consumption} = \frac{\text{No. of Hours} \times \text{Rated BHP}}{\text{No. of Gallons added}}.$$

b. If the lubricating oil consumption starts to increase, it could mean that the piston oil control rings are starting to foul or have excessive wear. If this is the case, the oil is being burned and should show up in the exhaust gases as a light blue or grey smoke. It could also mean that the inlet or exhaust valve guides have worn excessively. A third possibility is a leak in the lubricating oil cooler which can be checked by looking for signs of oil in the cooling water.



c. If the crankcase vacuum starts to reduce and go towards a positive pressure, it would indicate that the compression rings on the piston have worn excessively. This can be checked by taking a set of compression cards.



d. If the jacket water temperature starts to increase it could mean that the cooler is starting to foul. However, it must be remembered that the Amot thermostatic valve starts to open 5° F before the set point and is not fully open until 10° F above the set point. This means that the controlled outlet temperature can vary 15° F, depending upon ambient weather conditions. If the inlet temperature starts to drop, indicating a greater temperature differential across the engine, it could mean the following.

(1) Poor combustion.

(2) Leaky head gasket.

(3) Scuffed piston.

(4) Faulty venting of the jacket water system.

(5) Faulty water pump.

MAINTENANCE SCHEDULES.

The daily operating report is the basis for the preparation of the weekly and monthly charts and curves, recording temperatures, pressures and other significant data. Comments and remarks which clarify any abnormal readings or conditions should be entered at the bottom of the sheet. Inspection frequency may be keyed to either calendar time or engine operating hours, and may vary for certain items due to local conditions. The following maintenance schedules are suggested for use with the preventive maintenance system.

a. HOURLY INSPECTION

(1) Read all instruments carefully and record in engine log. Note any unusual change in readings, and investigate.

(2) Walk around the engine and listen for any unusual noise. Also check for any fuel, lubricating oil, and water leaks.

(3) Check level in lubricating oil tank, governor, turbocharger, pedestal bearing, and thrust bearing if marine.

(4) Turn handles on all knife edge strainers at least once every eight hours.

(5) Check lube oil filter differential pressure at least once every eight hours.

b. DAILY INSPECTION

(1) Drain water or sludge from lubricating and fuel oil filters and strainers, and air tanks.

(2) Oil linkage pins and shaft bearings on the governor and fuel controls.

(3) On reversible engines, also, oil starting and reversing mechanism through holes in housing.

(4) Plot daily engine data on Preventive Maintenance curves. Plotted data should be selected at the same engine load daily for best results.

c. WEEKLY (168 Hour) INSPECTION

(1) Clean strainer screens in fuel oil and lubricating oil strainers. (Lube oil suction strainer inspection for babbitt material is a check on conrod and main bearing condition.)

(2) Check and clean air inlet filter system as required. Visually check air inlet piping system for leaks.

(3) Check lube oil for fuel dilution with a Viscosimeter.

d. MONTHLY (720 Hour) INSPECTION

(1) Remove the alternate left side door covers and examine the inside of engine for any abnormal conditions. Check with light for any babbitt flakes. If excess water or sludge is present, drain crankcase and determine cause.

(2) Check PH factor of the cooling water and correct as recommended by chemical supplier (suggested PH 8.25 to 9.75).

(3) Lube oil sample should be taken and sent out for analysis as to viscosity at 210° F and 100° F, T.B.N., B.S. & W. and Flash Point °F.

(4) Plot the summary of this month's operating data on the Preventive Maintenance curves. Note any deviation from normal and take corrective action if necessary.

(5) When equipped with Brown Boveri Turbocharger, drain lube oil, clean, examine for any abnormal condition and refill with lube oil. See Brown Boveri Instruction Manual (Approximately 1000 hours.)

e. THREE MONTH (2190 Hour) INSPECTION

(1) Adjust all valve clearances by the "go" and "no go" feeler gage method. Excess clearance indicates the possibility of a worn cam roller bushing.

(2) Remove, clean, and reset fuel injector nozzles as determined by operating data.

(3) On dual fuel and spark engine, check adjustment of gas admission timing.

f. SIX MONTH (4380 Hour) INSPECTION

(1) Review the Preventive Maintenance curves and take necessary steps to correct the engine if so indicated.

(2) Check connecting rod clearance by the bump method with dial indicator. (On RV engines also check link rod clearances.) Main bearing clearances cannot be satisfactorily checked by the bump or feeler gage method. However, main bearing condition can be checked by web deflection indications, babbitt in the lube oil suction strainer (weekly inspection) and noting a drop in lube oil pressure with a B & A pump.

(3) Take crankshaft web deflections and record. On marine engines check Kingsbury thrust clearance.

(4) Check foundation for breaks in bond between the base or soleplate and the grout.

(5) Check foundation bolts for proper torque, after which recheck web deflections and compare with deflections taken before torquing. (See (2) above.) If retorquing is necessary see Appendix IV.

(6) Inspect gears, check backlash of all gears and note general appearance. Check gear lubrication oil jets for plugged or broken lines.

(7) Inspect valve lifting mechanism. Remove cam covers, cylinder head covers and inspect cams, tappets, rollers, rocker arms, push rods, springs, valve guides, and rotators. Operation of rotators can be checked by wear on end of valve stem made by the swivel pad. Cam roller bushings can be checked by placing a pry bar under the tappet and lifting the roller off the cam to check the freeness of the roller. Excess up and down movement between the roller and pin is an indication of bushing wear and must be replaced.

(8) On direct reversing marine engines, check for excess clearance between the reversing piston thrust hub and the camshaft gear thrust ring. Also for excess clearance in the reverse mechanism interlock pins. Excess clearance in either allows the camshaft to float fore and aft thereby damaging both cams and interlock pin cone-tips and seats. See Appendix III.

g. ANNUAL (8760 Hour) INSPECTION

(1) Review the Preventive Maintenance curves and take necessary steps to correct the engine if so indicated.

(2) Inspect and clean the entire engine. Dismantle only those parts that indicate further checking is necessary.

(3) On turbocharged engines, remove the turbocharger, disassemble and clean thoroughly. Inspect bearings and replace if worn as per turbocharger instruction manual.

(4) Remove governor, drain, clean, flush-out, and refill with new lube oil. (Twice a year, if located in a humid climate.)

(5) Check cold compression, maximum firing pressure, and take an indicator card. If indications are such, remove cylinder head, grind valves, check valve guides, liners, and remove carbon.

(6) Replace worn gear if backlash between any pair of gears exceeds clearance given in table of clearances.

(7) Repack all glands.

(8) Remove all fuel injection pumps. Check to see if the racks are free and depress the plungers to see that they are free. If either the rack or plunger is not free on a pump, disassemble, clean, check for scored, worn or broken parts. Replace the necessary parts and reassemble.

(9) Remove end plates from heat exchangers and intercoolers. Examine and if necessary remove scale from tube bundles with a rod. Check the zinc discs and replace as required.

(10) On any major overhaul or problem, it is recommended that a Factory Service Man be called for engine check and personnel instruction.

PRESERVING ENGINE FOR SHIPMENT OR STORAGE.

The following instructions are for preserving an operable engine for shipment, storage or inactivating for an indefinite period of time.

a. COOLING SYSTEM AND WATER PUMPS – Before shutting an engine down, add a water soluble liquid such as Texaco Soluble Oil "C", to the water system and circulate for about 15 minutes, then drain. Disconnect the water line from its source and seal with a blind flange to prevent water seepage into the system. Remove engine water header and make sure all water has been removed from around the liners. Drain all water lines and when sure the system is dry, reconnect all lines and engine header to form an airtight system.

b. FUEL SYSTEM – To preserve the fuel system, disconnect the fuel line ahead of the engine fuel transfer pump and allow engine to burn about five gallons of Tectyl No. 502-C before shutting down. Cap the fuel line to the engine. Drain all fuel tanks and spray insides with Tectyl No. 502-C. Drain all other fuel lines.

c. LUBRICATING OIL SYSTEM – Using an auxiliary lubricating oil pump, circulate a mixture of 50% lubricating oil and 50% Tectyl No. 502-C, then drain. If the turbocharger has a separate lubricating air system, circulate a 50-50 mixture of lubricating oil and Tectyl No. 502-C, then drain.

d. CRANKCASE, CAM GALLERY, CYLINDER HEADS AND FUEL INJECTION PUMPS – Remove camshaft covers and spray cams, tappets, etc. with 100% Tectyl No. 502-C and replace cam covers. Remove crankcase doors and spray 100% Tectyl No. 502-C all over the inside of the crankcase then replace covers. Remove cylinder head covers and spray 100% Tectyl No. 502-C on rocker arms, etc. Remove fuel injection pumps and spray 100% Tectyl No. 502-C down on the tappet parts and up on the fuel pump cup (plunger follower) then reassemble. For all non-painted parts, such as the fuel rack shaft on the outside of the engine, Tectyl No. 502-C can be sprayed on if protection is required for only a short time, that is two or three months. Be sure the exposed parts are cleaned and dryed before spraying. This makes a good seal for such parts as heim joints. Fuel pump racks require a little grease on the edge of the pump body to prevent the compound from entering the pump body and sticking the pump racks.

e. GOVERNOR – The engine governor lubricating oil should be drained and refilled with new oil.

f. OPENINGS – Air intake and exhaust openings to the engine should be sealed with gaskets and blind flanges of the metal type. All other such openings to the engine should also be sealed with gaskets and blind flanges.

g. SHIPPING AND STORAGE – In addition to the above instructions, the engine must be stored in a building out of the weather elements. While in shipment the engine must be protected by a tarpaulin or boxed when shipped overseas.

SPECIFICATION FOR PROTECTIVE MATERIALS

MATERIAL	MANUFACTURE
Tectyl No. 502-C	Valvoline Oil Company Freedom, Pennsylvania
Soluble Oil "C" – Use 3 to 5% mixture in the cooling water	Texaco, Inc.

PRESERVATION EQUIPMENT

In the foregoing instructions it is recognized that many times it is necessary to apply protective materials under difficult field conditions. A common paint brush may be used for applying preservative to accessible parts, and a hand operated pump sprayer with a pointed discharge nozzle of the type commonly used to spray insecticides may be used for inaccessible points. If desired, a small oil pump may be rigged with a motor drive to make a convenient mechanical pressure spray unit. Shop compressor air lines usually carry too much moisture to be safe for this purpose, and should not be used.

TORQUE WRENCH TIGHTENING PROCEDURES AND VALUES

Torque figures given in this manual are based on the use of a thread lubricant composed of equal parts by volume of engine lubricating oil and Dixon Number 2 powdered medium flake graphite, or equal. *They do not apply to dry threads, or to threads lubricated with "Super Lubricants."* Dry thread torque readings can be as much as 50 percent in error.

PROCEDURE

a. Lubricate threads with oil and graphite mixture and tighten nuts hand tight.

b. Tighten all nuts by snugging the first nut, then moving to the one farthest removed and continuing in a crisscross pattern until all nuts are snug.

c. Unless otherwise specified, apply 20 percent of the required torque to each nut in the same sequence as described above, then repeat procedure for 40, 60, 80, and 100 percent of the prescribed torque value.

d. Active nuts which are locked with cotter pins must be brought to the specified torque value before attempting to align the cotter holes. If the cotter pin hole in the bolt is halfway between the slots in the nut, or beyond, the nut should be tightened to make alignment. If the cotter pin hole in the bolt is short of the halfway point the nut may be backed off to the nearest point where it will align.

TORQUE VALUES

See following page for torque wrench values to be used when torquing the various engine parts.

PRE-STRESSED STUDS

Cylinder head studs and main bearing cap studs on Model RV engines are pre-stressed when installed rather than torqued with a wrench because of their size, location and high torque requirements. This is accomplished by stretching the studs with a hydraulic tool, then tightening the stud nuts. When the tool is removed a pre-determined stress remains in the stud. For this type application pre-stressing offers certain advantages.

a. Less physical effort is required.

b. It is easier to accomplish in confined areas.

SECTION 6

DISASSEMBLY, INSPECTION AND REPAIR

PART A – GENERAL

ROTATION AND CYLINDER DESIGNATION.

Crankshaft rotation and cylinder bank designations are determined while viewing the engine from the flywheel end. Number one cylinder on each bank is that nearest the gearcase, or auxiliary end, on the opposite end of the engine from the flywheel (see figure 6-A-1). Engines are designated as either right hand or left hand according to the side of the engine on which the controls are mounted.

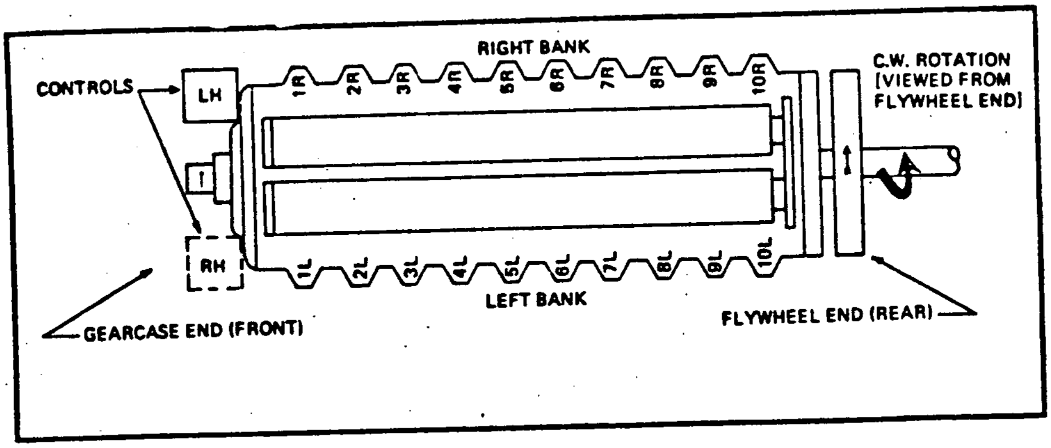


Figure 6-A-1. Engine Rotation and Cylinder Designation

ASSEMBLY OF PARTS.

Before starting any disassembly of the engine, observe that many parts are match-marked and identified by part or assembly number. Engine parts which have been in service should be returned to the same position in the same engine from which they were removed. This applies principally to cylinder liners, pistons, connecting rods and bearing caps. New parts should be marked in the same way as the parts which they replaced. Safety clips, cotter pins and safety wire, where specified, must be re-installed correctly to insure that the parts remain secure in use.

USE OF ASSEMBLY DRAWINGS.

Reference may be made to the assembly drawings in the *Parts Manual* to assist in the disassembly and assembly of various engine components.

Note

Do not use the part numbers on these drawings for ordering replacement parts. The *Parts Manual* should always be used for this purpose.

PART A – GENERAL (Continued)

SPECIAL TOOLS.

Refer to the 590 Group Parts List in the *Parts Manual* for a listing of the special maintenance tools and equipment furnished with the engine.

CLEANLINESS.

Care must be exercised to keep dirt, grit or other debris from entering any of the lubricating oil or cooling water system as well as from the bearing surfaces of pistons, shafts, etc.

TORQUING.

Make reference to Section 5 for the correct method of torquing nuts and bolts, and to Appendix V for the specified torque values.

PART B – CYLINDER HEADS AND VALVES

CYLINDER HEAD REMOVAL.

Each cylinder head may be removed from the block independently of the other cylinder heads. The cylinder head has two intake and two exhaust valves, together with their associated springs, wedges, retainers, etc. Valve springs may be replaced with the cylinder head installed on the engine provided the piston is at top dead center to prevent the valves from falling into the cylinder. To remove a cylinder head from the engine, proceed as follows.

a. Drain jacket water from engine.

b. Remove cylinder head cover.

c. Remove air jumpers.

d. Disconnect exhaust and intake air manifolds.

e. Disconnect fuel injection lines and nozzle drain fittings.

f. Remove rocker assemblies and push rods. Remove hydraulic valve lifters if engine is so equipped.

g. Remove fuel injection nozzles and holder assemblies.

h. Remove cylinder head sub-cover.

i. Attach lifting fixture to the fuel injection studs as shown in Figure 6-B-1. Attach an overhead hoist to the lifting ring of the fixture.

j. Remove cylinder head stud nuts and washers.

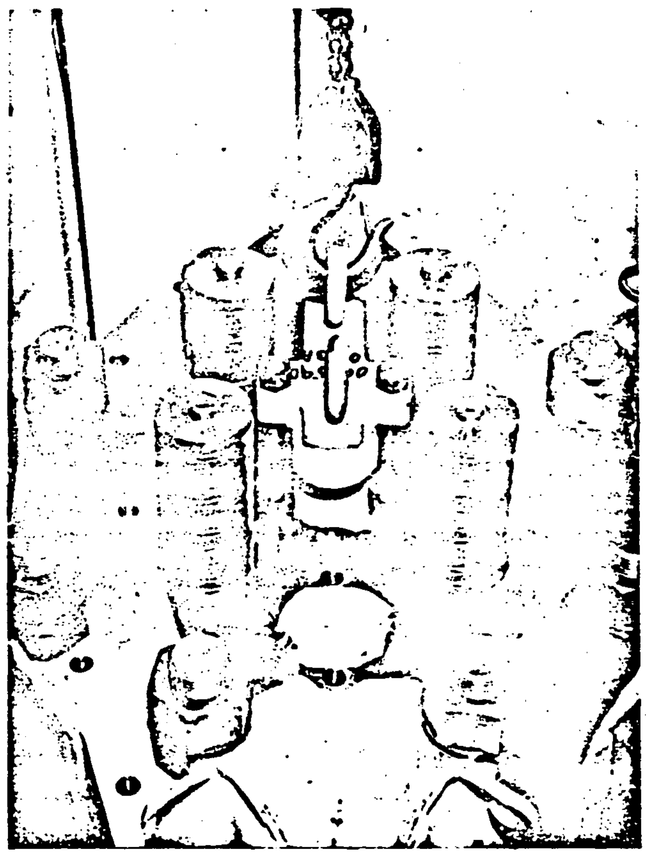


Figure 6-B-1. Cylinder Head Lifting Fixture

k. Lift head from block. If head sticks it may be necessary to take a strain on the hoist and break the head loose by striking the sides with a babbitt or lead hammer.

INSPECTION.

Clean inside of combustion chamber. Bar engine over until piston is at bottom dead center and clean and inspect upper portion of cylinder bore. Clean gasket surfaces of engine block and cylinder head. Remove intake and exhaust valves. Reface and reseat as necessary, following the procedures outlined in subsequent paragraphs.

PART B – CYLINDER HEADS AND VALVES (Continued)

VALVES.

Intake and exhaust valves are constructed of alloy steel, however, the steel alloy specifications differ. Valves may be identified by the marking "IN" for intake valves and "EX" for exhaust valves, stamped on the valve stem. The intake valves on dual fuel engines also serve as gas admission valves and are so constructed that an enlarged portion of the valve stem fits into the lower portion of the valve guide to form a gas admission valve. At the proper point of the intake valve opening stroke, gas is admitted through ports in the valve guide to mix with the intake airstream.

VALVE SPRING REPLACEMENT (Cylinder Head Not Removed).

Valve springs may be replaced without removing the cylinder head from the block. Remove rocker arms assemblies then bar engine over until piston of cylinder being worked on is at top dead center. Attach valve spring removal tool to the two fuel injector studs as shown in Figure 6-B-2. Make sure the nuts are rundown far enough on the studs to hold securely. Tighten nut on cross arm, making sure the cross arm is not bearing on the top of the wedges. Tighten nut until valve springs are compressed. Lift the valve by its stem and remove the two keepers from each valve. Back off on compression nut on tool, then remove tool from cylinder head. Springs may be lifted off valve stems. Spring installation is the reverse of removal.

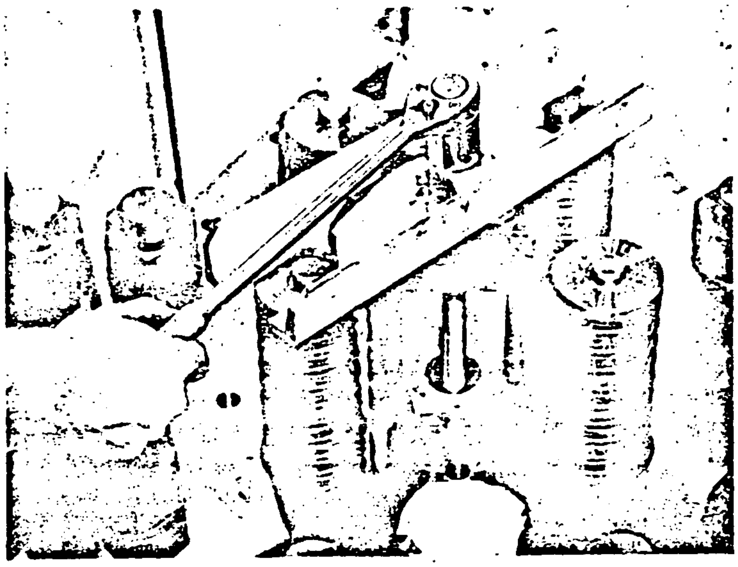


Figure 6-B-2. Valve Spring Removal Tool

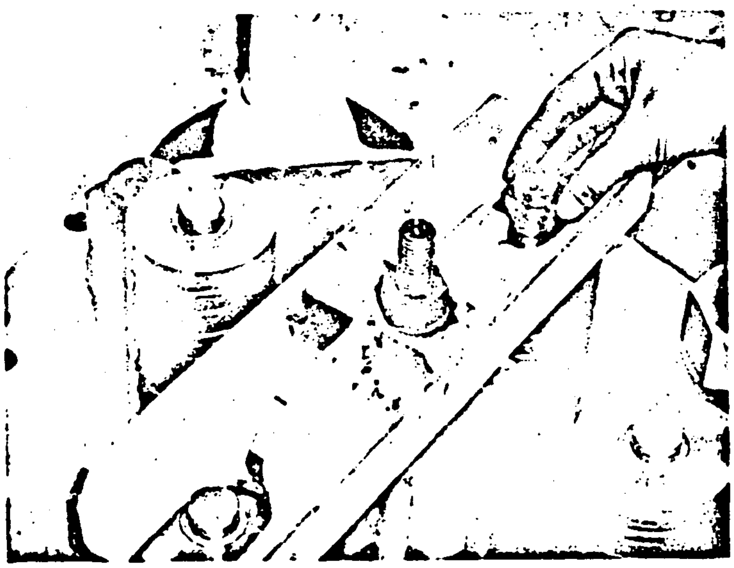


Figure 6-B-3. Removing Valve Keepers.

VALVE REMOVAL FROM CYLINDER HEAD.

With cylinder head removed from engine, install valve spring removal tool as shown above, and remove valve springs. Remove valves from combustion side of cylinder head.

PART B – CYLINDER HEADS AND VALVES (Continued)

VALVE INSPECTION AND RECONDITIONING.

The seating surface of valves, particularly exhaust valves, may have the appearance of pitting due to small carbon particles which may have been trapped on tne seats and impressed on the metal. This condition has no effect on operation unless there is an indication of blowby, in which case the valves should be reseated. Valves may be re-faced on a standard valve re-facing machine, or on an ordinary lathe. The seating should be exactly 45 degrees. If done on a lathe with a cutting tool, be sure to use very fine feed and a sharp tool for the final cut. If a grinding wheel is used, the wheel should be dressed for exact trueness before the final grinding cut is taken. Remove just enough material to eliminate pits and to make the seat run exactly true with the stem. If the valve guide is worn, a new guide should be installed before re-facing valve seats. Re-seat head with a valve grinder. If a grinder is not available, use a 45 degree hand reamer. Face just enough for trueness and removal of pits. Limit width of valve seat to 19/32 ± 1/64 inch (1.51 ± 0.04 cm) with a 45 degree tool. If the engine is equipped with valve rotators, the rotators must be replaced whenever the valves are serviced.

CYLINDER HEAD INSTALLATION.

Use new seals when the cylinder head is installed on the engine block. Make sure all areas are clean and free of dirt or other foreign matter.

a. Attach lifting fixture to cylinder head and hoist head in place over cylinder head studs.

b. Carefully lower head into place, taking care not to damage stud threads or seals.

c. Lubricate cylinder head studs and nut threads with a 50-50 mixture of graphite and lubricating oil. Assemble washers and nuts on studs and run down on the threads.

d. Tighten nuts in increments, and in a criss-cross pattern, following the sequence shown in figure 6-B-4. Torque to the specified torque value. This procedure will pull the head down evenly.

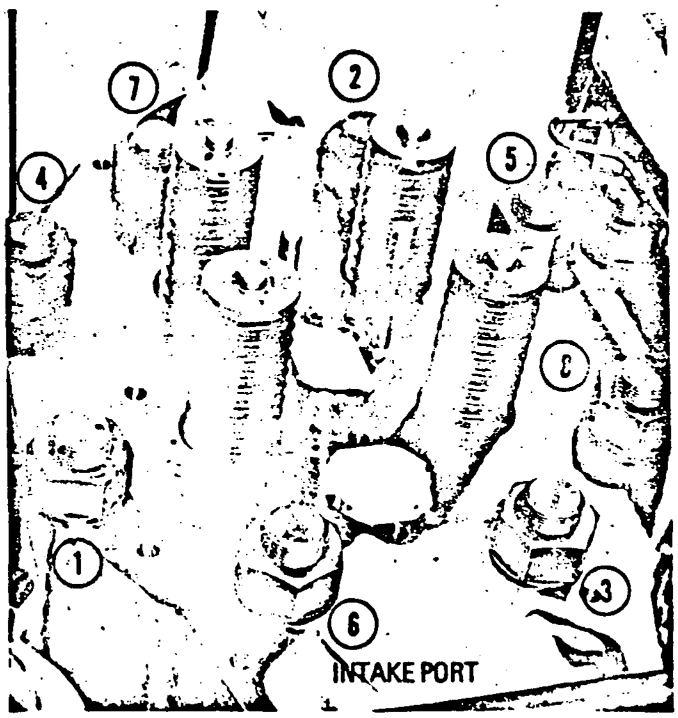


Figure 6-B-4. Tightening Sequence For Cylinder Head Stud Nuts.

PART B – CYLINDER HEADS AND VALVES (Continued)

HYDRAULIC VALVE LIFTERS.

If the engine is equipped with hydraulic valve lifters, the lifters are installed in both the exhaust and intake valve rocker arms, between the adjusting screw and the swivel pad. Pressure oil from the engine lubricating oil system is supplied to the lifters by means of drilled passages in the rocker arms. When the cam follower rollers are on the base circle (off the lobes) the plunger in the valve lifter assembly is extended by a combination of internal oil pressure and plunger spring force. As the valve is lifted from its seat by the rocker arm, the valve lifter plunger is forced into its barrel, increasing the spring force and slightly increasing the internal oil pressure. This causes the lifter check valve to close and trap the oil in the pressure chamber. When the cam follower roller returns to the base circle, force on the valve lifter plunger is reduced, internal oil pressure and spring force extend the plunger, the check valve comes off its seat and oil flows into the pressure chamber to replace any that was lost when the plunger was depressed.

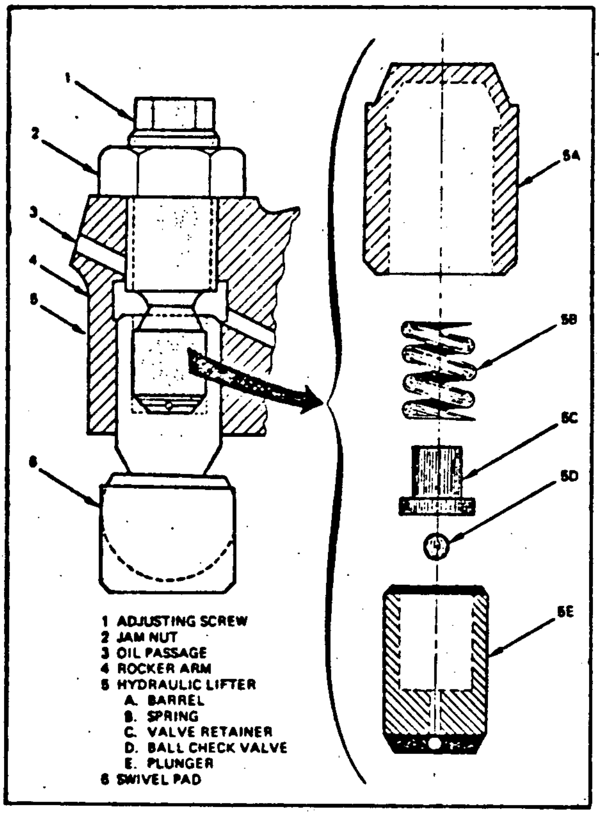


Figure 6-B-5. Hydraulic Valve Lifter

VALVE LIFTER MAINTENANCE.

The valve gear should require little maintenance under normal operating conditions. Since hydraulic lifters compensate for small amounts of wear in the valve mechanism, it is not necessary to make valve adjustments as often as would be necessary with solid valve lifters. If noise should develop in the valves it is usually due to one of the following reasons.

a. Insufficient oil supply to lifters.

b. Air or air bubbles in the lifter mechanism.

c. Incorrect adjustment screw setting.

d. Dirt in the lifter mechanism.

e. Lacquer or varnish deposits in the valve lifter mechanism due to the lubricating oil conditions.

It is not necessary to remove the lifters from the rocker arm assemblies to perform a routine adjustment. When such an adjustment is to be made, omit the following two paragraphs and proceed directly to the paragraph on adjustment.

LIFTER REMOVAL AND DISASSEMBLY.

If it is necessary to remove the lifters from the rocker arms for inspection and/or cleaning, or when installing new lifter mechanisms, the following procedure should be followed.

a. Remove the adjusting screws and pull valve lifter assemblies from cavity in swivel pad with a magnetic pickup tool.

PART B – CYLINDER HEADS AND VALVES (Continued)

b. Insert a soft wire in one of the plunger fill holes then slide the plunger out of the barrel, taking care not to let the ball check valve and the valve retainer drop. Remove the spring from the barrel cavity and wash all items in kerosene. Use lacquer thinner to remove lacquer and varnish deposits caused by lubricating oil conditions. Do not use grinding compound or a hard tool to clean the barrel or plunger as this may scratch the surfaces which are built to close tolerances. Wipe all parts with a clean, lint-free rag.

c. The condition of the unit may be best determined by performing a leakdown test. Specifications for a new unit require that, with the unit completely assembled and filled with kerosene, the plunger should travel 0.125 inch in one and one-half to three seconds when subjected to a 50 pound load. Plungers are not interchangeable in the barrel as the units are factory assembled for a specific leakdown rate.

ASSEMBLY AND INSTALLATION OF LIFTERS.

Assemble lifters in the reverse order of disassembly. Insure that all parts are clean, free of dirt or other foreign matter, and do not stick or bind. Fill and purge the assembled unit then install in the engine as follows:

a. Hold the check valve off its seat by inserting a soft wire about 3/8 inch into one of the fill holes, then submerge the unit in clean SAE-10 or SAE-20 grade oil. Push in and release the plunger repeatedly until air is no longer expelled from the assembly. This will purge the unit of air and fill it with oil.

b. Remove the wire from the fill hole and remove the assembly from the oil. The plunger should extend 1/8 inch from the barrel and should not compress when pushed in by hand.

c. With the rocker arms completely assembled and installed on the cylinder except for the hydraulic valve lifter assemblies and adjusting screws (the swivel pad assembly is held in the rocker arm by a roll pin), fill the cavity of the swivel pad with clean oil.

d. Insert the valve lifter into the swivel pad cavity. The rocker arm must be kept in a near horizontal position after the lifter has been inserted to keep the lifter submerged in oil. Install the adjusting screw and locknuts.

ADJUSTMENT.

After the lifters have been installed, or if a periodic adjustment is to be made, bar the engine over to position the cylinder being worked on at top dead center on the compression stroke and adjust lifters by one of the following methods. The first method (Method "A") involves advancing the adjusting screw until it just contacts the lifter, but does not compress it, then advancing the screw one additional turn. The alternate method (Method "B") is to completely collapse the lifter, then back off one full turn from the point where the valve just seats. Either method, if properly done, will accomplish the same thing. It must be kept in mind, however, that cold oil will increase the time required for the lifter to leak down to complete collapse when using the latter method.

a. METHOD "A".

(1) Hold the rocker assemblies tight against the pushrods to remove all play, then advance adjusting screw by hand until the end of the screw just contacts the lifter under it, taking up all the slack in the valve operating gear. Make sure the swivel pad rests squarely on the valve stem. Due to variations in threads, the feel of turning the adjusting screw is not sensitive enough to make an accurate determination as to when all slack has been removed, therefore, the feel for taking up the slack has to be on the pushrod or cross (intermediate) rod and the swivel pad on the adjusting screw. Lift each swivel pad by hand to make sure that all clearance is removed between the swivel pad and the valve stem.

PART B – CYLINDER HEADS AND VALVES (Continued)

(2) Turn the adjusting screw one full turn (0.070 inch) with a wrench and tighten the locknut. This will locate the lifter plunger near the middle of its 1/8 inch travel.

b. METHOD "B".

(1) Advance adjusting screw with a wrench until the valve begins to lift off its seat, then advance adjusting screw at least two additional turns.

(2) Wait approximately ten seconds (longer if oil is cold) then back off on adjusting screw until valve seats. The point at which the valve seats may be easily felt by the reduced torque required to turn the screw.

(3) Note the position of the wrench at the point where the valve just seats, then advance screw at least one-half turn.

(4) Back out adjusting screw until valve just seats. If the position of the wrench is the same as (3) above, the lifter is fully collapsed. If not, repeat procedure until the position of the wrench is the same each time the valve seats.

(5) Back out adjusting screw one full turn from position where valve seated then tighten locknut.

c. Swivel pads should now be free to be rotated by hand. If they cannot be rotated, the adjusting screw has collapsed the lifter to the end of its 1/8 inch travel and the valve has been lifted off its seat.

d. Swivel pad clearance should be such that the pad cannot be rocked on top of its valve stem. If the swivel pad can be rocked it means that the lifter is either fully extended and not at the mid point of its travel, or that it has not been completely purged of air. This may be due to an improper adjustment caused by burrs or dirt on the adjusting screw threads, or because of incomplete purging of air from the assembly.

PART C – PISTONS AND RODS

GENERAL.

Pistons and their attached rods may be removed from the engine by lifting them straight out of the cylinder liners. To prepare the engine for piston removal, remove the cylinder heads and the engine side doors adjacent to the pistons and rods to be pulled. If, however, it is only desired to remove or inspect the connecting rod bearings, the cylinder heads need not be removed. Follow the procedure in the next paragraph.

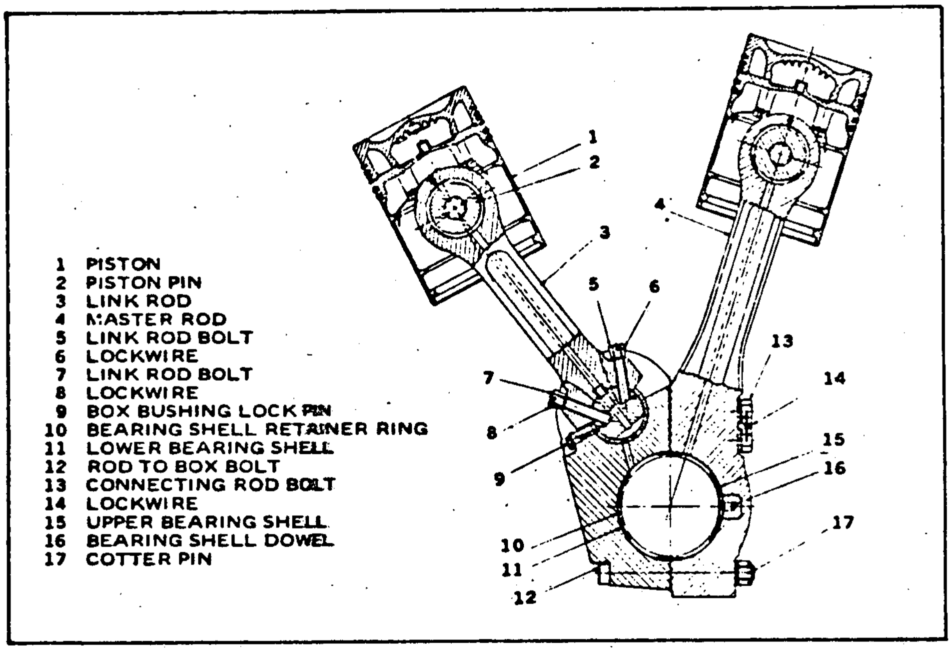


Figure 6-C-1. Pistons and Connecting Rods

CONNECTING ROD BEARING SHELL REPLACEMENT.

With engine side door covers adjacent to the bearing to be replaced removed, proceed as follows.

a. Loosen all connecting rod bolts slightly, but do not remove.

b. Block crankshaft to prevent further movement.

c. Install connecting rod saddle and plate on master rod side of engine. Adjust jacking screw to hold master rod in place against crankpin.

d. Attach chain puller bracket to side of crankcase, then attach chain puller.

e. Attach chains to each end of link pin with capscrews. Attach chain puller to chain and take up slack as necessary to hold the link rod firmly against the crankpin.

f. Place a piston holder spacer ring in the lower end of each cylinder liner, then install two jacking assemblies in each cylinder liner and bolt in place to retain the spacer rings.

g. Adjust locking ring assembly jacking screws until spacer ring is snug against skirt of piston, holding it in place in the liner.

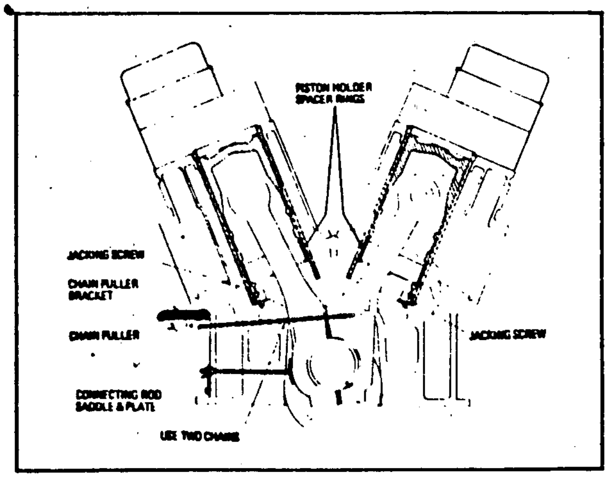


Figure 6-C-2. Bearing Replacement Tool Arrangement

PART C – PISTONS AND RODS (Continued)

h. Remove six bolts which attach link rod box to master rod. Slack off chain puller to allow link rod box to swing clear of bearing shell. Adjust locking ring assembly jacking screw as necessary to prevent binding.

i. Back off on connecting rod saddle jacking screw until master rod is clear of crankpin.

j. Support lower bearing shell by hand and remove locking clips, then remove both bearing shells.

k. Inspect, clean and replace bearing shells before working on any other bearings. Only one set at a time should be removed.

l. Install bearing shells and lock in place with clips.

m. Use connecting rod saddle jacking screw to position master rod firmly against bearing shell. Locking ring assembly and jacking screws may be used to adjust vertical position of rod. It may be necessary to rotate the bearing shells slightly to help with dowel engagement.

n. Tighten chain puller and guide link rod box into engagement with the crankpin and the serrated joint of the master rod.

o. Install connecting rod bolts and torque to the value specified in Appendix IV.

p. Remove all tools and blocking from engine.

LINK ROD AND PISTON REMOVAL.

With the cylinder heads removed and the engine side doors removed, bar engine over until master rod piston is at top dead center, then block crankshaft to prevent further movement. Refer to figure 6-C-3 for installation of the special tools that are required for piston and rod removal.

a. Attach piston pulling tool to the crown of the link rod piston.

b. Place a piece of one-half inch plywood vertically on inner side of outer cylinder head studs to prevent piston from coming into contact with studs.

c. Suspend a one-ton capacity chainfall from plant crank hook and attach hook to side lifting hole of pulling tool.

d. Attach chain puller bracket and chain puller to master rod side of crankcase.

e. Install connecting rod saddle and plate to master rod side of crankcase. Adjust to hold rod snug against crankshaft.

f. Attach a chain to each end of link pin with capscrews and connect other ends to chain puller and take up all slack in chain.

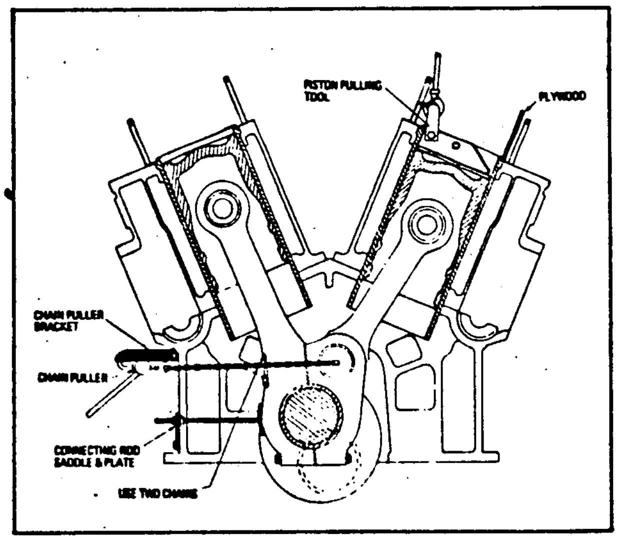


Figure 6-C-3. Tools Installed For Removing Piston and Link Rod.

PART C – PISTONS AND RODS (Continued)

g. Remove six bolts (see figure 6-C-1) which hold link rod box to master rod then slack off on chain puller, allowing link rod box to swing clear of crankpin.

h. Use chain puller as necessary to position connecting rod while clearing box from crankshaft. Adjust until link rod is in line with the axis of the cylinder liner.

i. Coat walls of cylinder liner with clean lubricating oil then place a piece of 3/32-inch compressed asbestos gasket material between link rod box and liner wall to prevent box from scoring liner wall. Coat side of gasket material which contacts liner wall with clean lubricating oil.

j. Carefully hoist piston and rod out of liner with 1 ton chainfall taking care not to allow piston to bind in liner (see figure 6-C-4).

k. When bottom end of connecting rod box is clear of liner, move piston and rod clear of engine and lower to floor or a suitable stand.

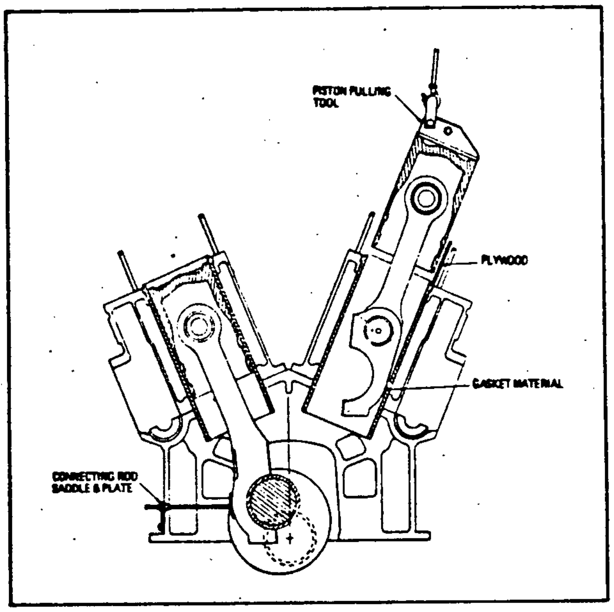


Figure 6-C-4. Lifting Piston and Link Rod From Cylinder Liner.

PISTON AND MASTER ROD REMOVAL.

Attach special tools as shown in figure 6-C-5 and take up slack with chain puller to hold master rod in place against the crankshaft.

a. Loosen connecting rod saddle assembly then slack off on chain puller until master rod swings clear of crankshaft and is in line with the cylinder liner bore. It may be necessary to adjust the position of the piston and rod with the chainfall.

b. Rotate crankshaft approximately 30° past top center, away from master rod to permit rod to clear crankshaft journal.

c. Pull piston and rod in the same manner as piston and link rod were pulled (see figure 6-C-6).

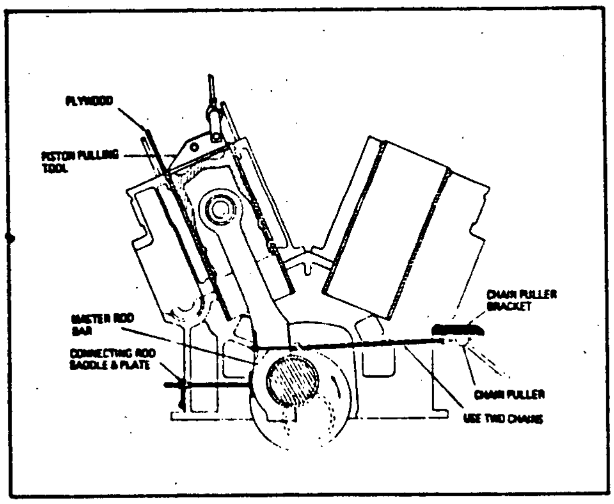


Figure 6-C-5. Tools Installed For Piston and Master Rod Removal.

PART C – PISTONS AND RODS (Continued)

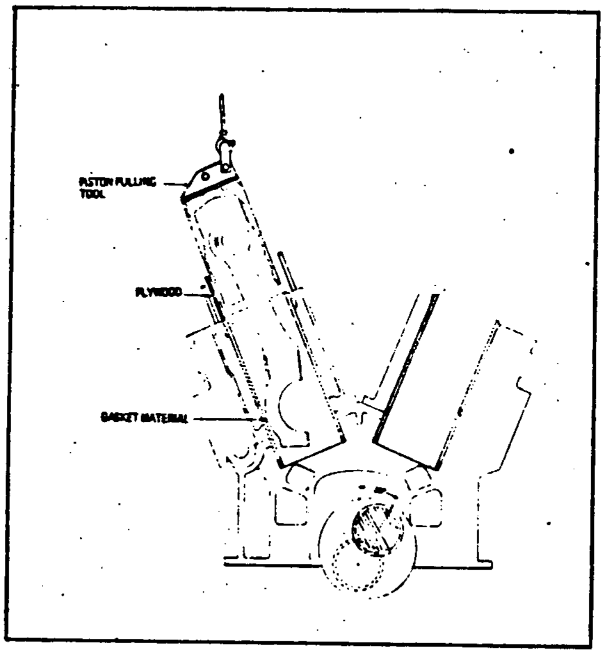


Figure 6-C-6. Lifting Master Rod and Piston From Cylinder Liner.

REMOVAL OF A SEIZED STUD.

When it is evident that a bolt has seized in the connecting rod box, do not attempt to force it. The following procedure is recommended for the removal of a seized connecting rod bolt.

a. Position the crankshaft to place the connecting rod at its closest point to the engine side door and block the crankshaft to prevent movement.

b. Leave at least one good bolt in position to hold the master rod and connecting rod box together while the seized bolt is being removed.

c. Form a shield of asbestos gasket material around the master rod to catch molten metal and slag and prevent it from falling into the engine base.

d. Cut off the head of the siezed bolt with an oxy-acetylene cutting torch. Exercise great care not to damage the master rod with the cutting frame.

e. Clean out the slag and burned metal and remove the gasket shield.

f. Install a master rod retaining bar and plate assembly to hold the master rod firmly against the connecting rod bearing and crank journal.

g. Install the tools and fixtures necessary to remove the link rod and piston.

h. Remove the remaining bolts and carefully disengage the link rod and connecting rod box from the master rod. Carefully guide the headless bolt stud through its hole in the master rod. Allow the link rod and box to rest against the lower edge of the cylinder liner.

i. Place a shallow pan of water beneath the stub of the seized bolt to catch the molten metal and slag when the stub is cut off, then cut the stub off approximately one inch from the surface of the connecting rod box.

j. Clean the debris from the area then remove the link rod and piston assembly from the engine in the normal manner. Remove the connecting rod box from the link rod.

k. Set the connecting rod box up on a good radial drill and drill out the remainder of the seized bolt. Exercise care to drill the bolt on dead center to prevent damage to the threads in the tapped hole in the connecting rod box.

l. Try a new bolt in the hole to be sure the threads are good, and that the bolt will run free in the tapped hole.

m. Reassemble the link rod and connecting rod box and place the piston and connecting rod assembly in the engine in the normal manner. Use new locking devices when assembling the link rod to the link pin.

PART C – PISTON AND RODS (Continued)

DISASSEMBLY.

a. With piston and rod assemblies suspended from a hoist and with the weight of the assembly resting lightly on the piston crown, remove piston pin retainer rings from grooves on ends of piston pins then slide piston pin out of piston. Lift rod assembly (or rod and box assembly) clear of piston.

b. Place link rod and connecting rod box on a suitable support and remove four link rod to pin bolts. Separate rod from box then slide link pin out of link pin bushing.

c. Remove two bearing shell retainer rings from bearing shells and carefully remove bearing shells from crankshaft journal.

INSPECTION.

Carefully inspect the pistons, rods, pins and bushings for wear and/or damage.

a. Inspect connecting rod bearing shells for evidence of scratches, nicks, burrs, excessive heat and wear. Clearance tables should be consulted for the required bearing shell wall thickness.

b. Inspect pistons for wear or abnormal conditions. Remove all carbon and varnish deposits from pistons and accessible areas of the ring grooves. Unless they are to be replaced, do not remove piston rings from grooves. If necessary, disassemble pistons as follows.

(1) Remove roll pin and remove four slotted nuts and spherical washers.

(2) Separate crown from skirt.

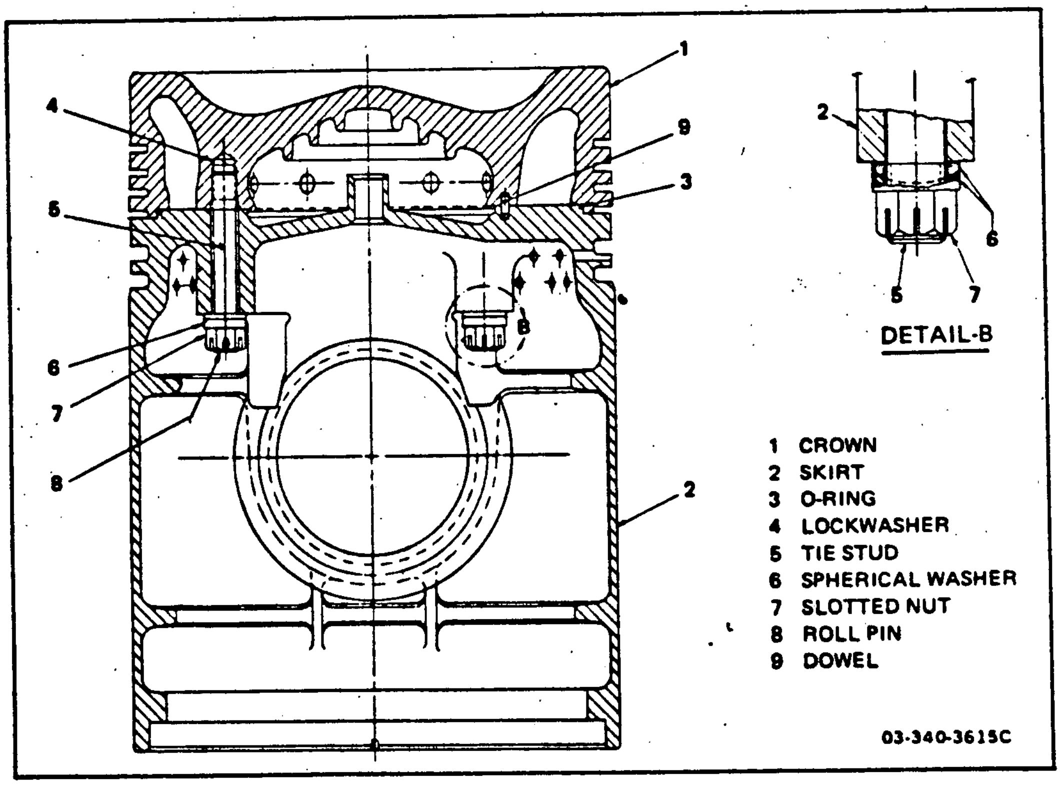


Figure 6-C-7. Piston Assembly

PART C – PISTONS AND RODS (Continued)

(3) Clean parts thoroughly. If crown is to be replaced, place a 3/8-inch steel lockwasher in each of the four tie stud holes, making sure they are resting square in the bottom of the hole. Install four tie studs and bottom out against lockwasher in the hole. Torque studs to 215 ft-lb. Install dowel in dowel hole in crown.

(4) Assemble new O-ring on the crown, then lower skirt over the four tie studs. Correct position is determined by the dowel in the crown.

(5) Install spherical washers on studs. The convex half of the washer must be installed first, flat side against the piston skirt. The concave half is then installed with the flat side towards the nut end of the stud. See Figure 6-C-7.

(6) Assemble the slotted nuts and torque to 120-160 ft-lb. Install roll pin through each slotted nut.

PISTON RING REPLACEMENT.

If piston rings require replacement, remove and install as follows.

a. Starting with top ring, spread and slide piston rings up and off piston. Four brass strips, measuring approximately 1/32" x 1/2" x 8" may be inserted under rings to protect piston during removal and installation of rings.

b. Replace piston rings in reverse order of removal. Intermediate compression rings are marked "UP" on the upper sides. Top compression rings may be installed with either side up. The oil cutter rings must be installed with the cutting edge down.

c. Rotate the rings in the grooves so gaps are staggered around circumference of piston.

PISTON RING GAP AND SIDE CLEARANCES.

Piston ring gap may be measured by inserting piston ring into cylinder liner and sliding it down squarely, measuring the gap at various levels in the liner. The gap clearance should be determined at the smallest diameter, usually near the bottom of the liner. Piston ring wear is usually indicated by excessive ring gap clearance. Refer to "Appendix III" in Section 8 for correct gap clearance. If the recommended gap clearance is exceeded by 1/16-inch or more, the bore of the liner should be measured with an inside micrometer. If the bore at any point is worn more than shown in "Appendix III" the liner should be replaced. Liner wear is usually limited to the last few inches of ring travel near the top.

PISTON PIN BUSHING REPLACEMENT.

Use the following method to replace the piston pin bushing in the connecting rod.

a. If an arbor press is available, press the bushing from the rod, otherwise, carefully split the bushing with a hacksaw and drive it out of the rod. Remove all burrs and clean the connecting rod.

b. Place the new bushing in a suitable container such as a bucket or a deep pan.

c. Fill the container with liquid nitrogen. Nitrogen level should be approximately one inch from the top of the bushing to allow for handling.

d. Lay connecting rod on its side on a suitable support. Both ends of the piston pin bushing bore should be accessible.

PART C – PISTONS AND RODS (Continued)

WARNING

Wear asbestos gloves when handling bushing to avoid injury to the hands.

e. When the nitrogen stops boiling, remove the bushing from the container and insert in the bore, taking care to align the oil holes with the oil passages in the connecting rod. Insure that the bushing protrudes the same distance on both ends. The operation must be done quickly before the bushing expands due to heat pickup.

LINK PIN BUSHING REPLACEMENT.

If the link bushing requires replacement, proceed as follows.

a. Remove the bushing lock pin, split the bushing with a hacksaw to relieve stress, then drive bushing out of connecting rod box.

b. Clean the connecting rod box, removing all burrs and rough surfaces.

c. Place new bushing in a suitable container such as a bucket or a deep pan.

d. Fill container with liquid nitrogen. Nitrogen level should be approximately one inch from the top of the bushing to allow for handling.

e. Lay the connecting rod box on its side on a suitable support. Three pieces of 1-1/2 inch rough stock, laid parallel on a piece of metal plate, will provide adequate support for the box and act as a stop for the bushing so that it will be flush with the side of the box when it is inserted.

WARNING

Wear asbestos gloves when handling bushing to avoid injury to hands.

f. When the nitrogen stops boiling, remove the bushing from the container.

g. Insert the bushing in the connecting rod box, taking care to line up the bushing cutouts with the internal surface contour of the box. Insure that both ends of the bushing are aligned with the side of the box. This must be done quickly before the bushing expands due to heat pickup.

PISTON AND ROD ASSEMBLY.

Assemble pistons, rods and connecting rod box as follows. Make sure pistons and rods are reassembled in the same relative position as they occupied before disassembly.

a. Insert link rod pin in connecting rod box bore and position link rod on link pin.

b. Apply a lubricant consisting of a 50-50 mixture of powdered graphite and lubricating oil to the threads of the link-rod-to-pin bolts. Torque bolts to specified torque and secure with lockwire.

PART C – PISTONS AND RODS (Continued)

c. Place piston upside down, resting on its crown. Lift connecting rod with rod turning plate then lower end of connecting rod into piston, aligning piston pin hole in rod with that of piston.

d. Insert piston pin through piston and rod. Clean piston groove and the outside end of the piston pin retainer rings and insert retainer rings into piston grooves at either end of piston pin. Apply "Locktite" to ends of retainer rings to prevent rings from rotating in the grooves.

PISTON AND MASTER ROD INSTALLATION.

Install a piston pulling tool on piston crown then suspend piston and rod from an overhead hoist then proceed as follows.

a. Lubricate walls of cylinder liner with clean lubricating oil.

b. Install piston ring fixture on top of cylinder liner.

c. Place a piece of one-half inch plywood vertically on inner side of outer cylinder head studs.

d. Position crankshaft with crankpin approximately 30° past top center, away from master rod side.

e. Position piston and rod over cylinder liner.

f. Lubricate one side of a piece of 3/32-inch asbestos gasket material with clean lubricating oil. Wrap around lower end of connecting rod with oiled side towards liner wall.

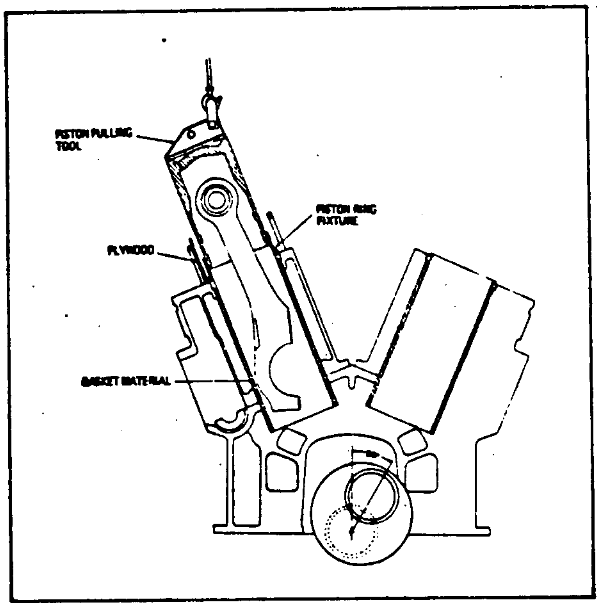


Figure 6-C-8. Piston and Rod Installation

g. Lower rod into cylinder (see figure 6-C-8). Hold piston rings in place as they enter the piston ring fixture. Insure ring gaps are staggered around circumference of piston.

h. Continue to lower piston until connecting rod bore is opposite crankpin. Remove gasket material.

i. Attach chain puller bracket, chain puller, chains and master rod bar then rotate crankshaft towards rod. By adjusting rod and crankshaft positions, bring master rod into engagement with crankpin. Make sure dowel seats in dowel hole – rotation of bearing shell may be necessary.

j. Install connecting rod saddle and plate on master rod side (see figure 6-C-5) and set to hold master rod tight against crankpin.

WARNING

Do not rotate crankshaft until link rod has been assembled and bolted to master rod. Block crankshaft to prevent movement.

PART C – PISTONS AND RODS (Continued)

PISTON AND LINK ROD INSTALLATION.

Use same procedure used for master rod and piston installation to install link rod, connecting rod box and piston in engine, then use the following procedure to attach connecting rod box to master rod.

a. Attach chain puller bracket to master rod side of crankcase and attach chains in same way as was done for removal (see figure 6-C-3) and draw connecting rod box into engagement with crankpin and master rod. Make sure serrated joints are properly engaged.

b. Apply graphite and lubricating oil mixture to threads of connecting rod bolts and washers and install bolts and washers and tighten bolts to the specified torque. Secure bolt heads with lockwire (see figure 6-C-1).

c. Install connecting rod-to-box bolts in lower holes and assemble washers and nuts that are lubricated with oil and graphite lubricant. Torque nuts as specified and insert cotter pins.

d. Remove all installation tools, brackets, fixtures and other installation equipment.

CYLINDER LINERS.

The water contact type cylinder liners fit into the cylinder block. Three sealing rings are recessed in grooves at the lower end of the liner, preventing water from entering the crankcase. The silicone seal goes into the lower sealing ring groove.

LINER REMOVAL.

Remove the cylinder head, piston and connecting rod, then disconnect lubricating lines from lower end of liner. Install liner pulling tool, Part No. 00-590-01-OV to bottom of liner and attach a chain hoist to the lifting pad on the tool. Pull liner straight out of the block. It may be necessary to use blocking and a hydraulic jack to break the liner free of the cylinder block.

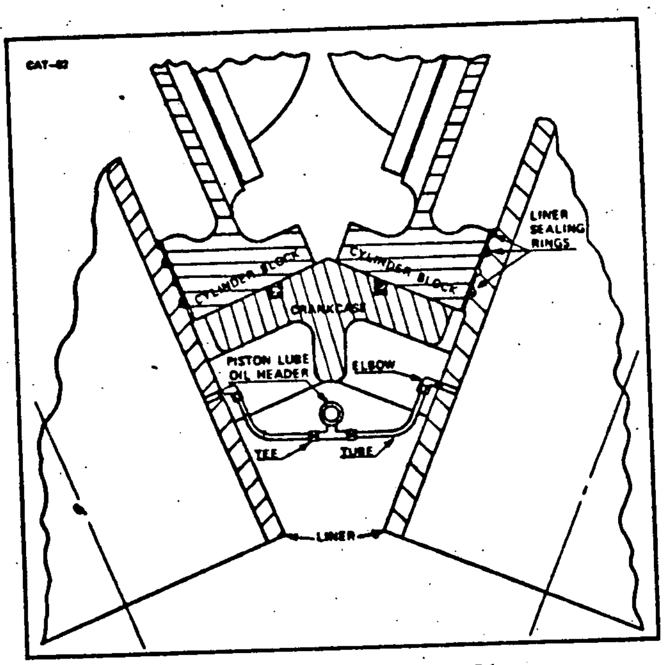


Figure 6-C-9. Liner Sealing Rings

LINER INSTALLATION.

Installation of the liner is the reverse of removal. To prevent damage to the seals, they should be installed in the grooves after the liner has been lowered approximately two-thirds of the way into the cylinder block. Use new sealing rings and coat them with a liquid dishwashing soap, or a tire installing lubricant before installing. The bottom seal is silicone and should be handled carefully to prevent tearing or nicking. It is essential that liners be replaced in their original positions in the block and that the scribe marks on top of the liner be aligned with the mark on the block.

PART D – CRANKSHAFT AND BEARINGS

MAIN BEARINGS.

Main bearings are made of aluminum alloy, the upper and lower bearings being interchangeable. The upper shell is held in place on the bearing cap by two lock rings and socket head capscrews. Main bearings are front, intermediate and rear, the number of intermediate bearings being determined by the number of cylinders. Bearing caps are secured to the engine base by studs (see figure 6-D-1). Oil passages through the bearing cap provide for bearing shell lubrication. To prevent axial movement of the crankshaft, thrust rings are attached to the rear bearing caps, each secured with button head capscrews (see figure 6-D-2).

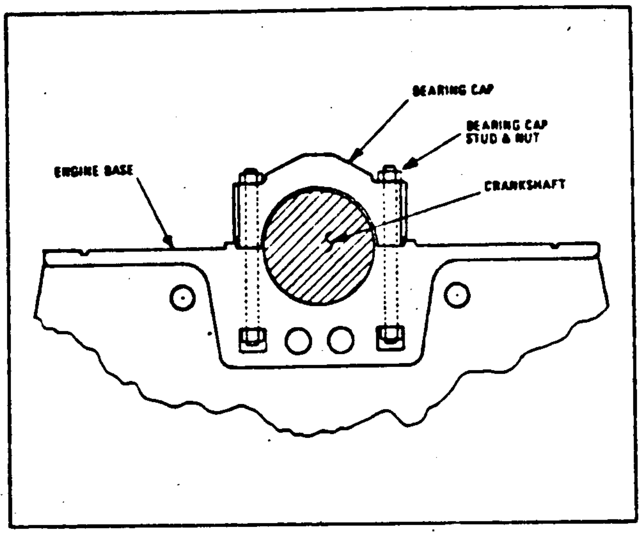


Figure 6-D-1. Main Bearing Cap

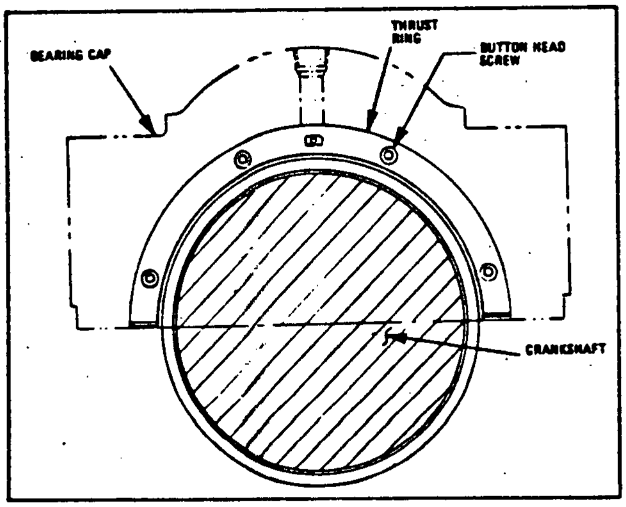


Figure 6-D-2. Crankshaft Thrust Rings

BEARING CAP REMOVAL.

Main bearing caps are pre-stressed by means of a special tool, normally furnished with the engine. The tool consists of a pre-stresser assembly (Part No. 1A-1801), and adapter (Part No. 00-590-01-0K) and a spacer (Part No. 00-590-01-0J).

a. Remove lubricating oil fittings, temperature sensing devices and locking plates from stud nuts.

b. Attach adapters to pre-stresser assemblies and place a spacer over each of two diagonally opposite stud nuts.

c. Use jacking screws on micrometer bar to force piston flange against top of cylinder, then back off jacking screws one-quarter inch.

d. Assemble a pre-stresser to each of the two main bearing cap studs, running them down on the stud threads until pre-stressers are snug against adapters.

e. Attach hydraulic hose between two pre-stressers, and between one pre-stresser and a suitable hydraulic pumping unit. Bleed air from system by opening pipe plug on second pre-stresser then operating pumping unit to supply a small pressure. When all air bubbles disappear, tighten pipe plug.

PART D – CRANKSHAFT AND BEARINGS (Continued)

f. Slowly apply hydraulic pressure to pre-stresser assemblies until bearing cap studs have stretched sufficiently to permit stud nut to be loosened. Approximately 10,500 psi pressure will be required. Use a brass drift pin through the spacer side opening to loosen nut. Do not turn nut up tight against lower face of adapter as it will bind when hydraulic pressure is released. *Do not exceed maximum allowable pressure of 11,500 psi.*

g. Relieve hydraulic pressure on pre-stressers, remove pre-stressers, spacers and adapters from stud. Remove stud nuts.

h. Repeat procedure on remaining studs, following a criss-cross pattern. Remove all stud nuts and lift bearing cap from crankshaft.

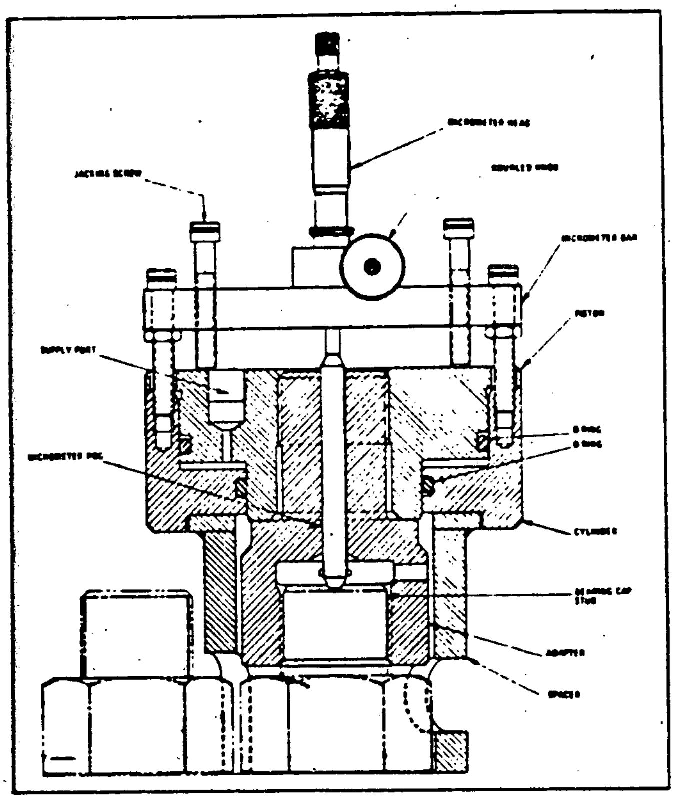


Figure 6-D-3. Pre-Stresser Assembly

BEARING SHELL REPLACEMENT.

If it is necessary to remove the main bearings, remove the two socket head capscrews and lock rings that hold the upper bearing shell to the main bearing cap and carefully remove the shell from the cap. Install a bearing shell removal tool (Part No. 00-590-01-AE) in the crankshaft journal oil hole then slowly rotate the crankshaft until the tool is bearing against the bearing shell. Slowly continue to rotate the crankshaft and roll the bearing shell out of the journal. To remove the thrust rings from the rear bearing caps, remove the button head screws and pull the thrust rings. Reverse the procedure to install thrust rings and bearing shells.

BEARING CAP INSTALLATION.

Install bearing cap in position in the reverse order of removal. Take care not to damage the bearing shells. The bearing cap studs are tightened as follows.

a. Install pins to lock lower stud nuts to studs, then place wedges between lower nuts and the base cavity bottom and side walls. Check that height of stud end is 11-3/16 inch above cap mounting surface to permit proper engagement with the pre-stresser assembly.

b. Lubricate threads with 50-50 mixture of oil and graphite and tighten upper stud nuts hand tight. Place spacers (Part No. 00-590-01-0K) to the pre-stresser assemblies. Use jacking screws to force piston flange tight against top of cylinder. Back off jacking screws 1/4 inch.

c. Install pre-stresser assemblies on two diagonally opposite studs and assemble the micrometer bar on the units.

PART D – CRANKSHAFT AND BEARINGS (Continued)

d. Insert micrometer head into the hole in the micrometer bar, making sure that it is fully seated. Tighten knurled knob to hold micrometer head in place.

e. Attach hoses to pre-stressers and apply pressure to bleed air.

f. Run micrometer spindle against the micrometer pin until the pin is snug against the end of the bearing cap stud. Observe and record the micrometer reading.

g. Loosen knurled knob and remove micrometer head from the micrometer bar. Insure that jacking screws on pre-stressers and backed off one-quarter inch for each stud.

CAUTION

Failure to back off on micrometer spindle will result in damage to the micrometer.

h. Apply 10,500 psi pressure to pre-stressers and hold while using brass drift pin through spacer opening to tighten nut snugly (about 50 ft-lb). Relieve pressure.

Note

This operation is necessary to insure proper seating of parts and to minimize the effect of dirt or high spots on future readings.

i. Apply 10,500 psi pressure and hold. Tighten nuts to a snug fit with drift pin (about 50 ft-lb).

WARNING

Do not exceed maximum allowable pressure of 11,500 psi.

j. Relieve hydraulic pressure and install micrometer head in the micrometer bar. Run spindle snug against micrometer pin and record reading. Subtract the first reading from this reading. This is the amount the stud has stretched. Stud should stretch 0.056"-0.051". Repeat operation if stretch is not within specified range.

k. Remove pre-stresser assemblies and repeat operation on next pair of diagonally opposite studs.

PART E – CAMS, CAMSHAFTS AND BEARINGS

GENERAL.

The induction hardened steel cams are shrink fit on the precision ground camshaft, using hydraulic expansion of the cam bore to position them on the camshaft. Camshaft bearings are aluminum alloy and are pressure lubricated. Cams, camshafts and associated operating gear should be checked periodically for wear and/or damage.

CAMSHAFT BEARING REPLACEMENT.

Should it be necessary to inspect and replace camshaft bearings, do the following.

a. Remove covers over camshaft.

b. Disconnect lubricating oil line from bearing cap.

c. Remove bearing cap, lock rings and upper bearing shell, then roll lower bearing shell out of its saddle.

d. Inspect bearings for evidence of damage or wear. Refer to Appendix III for permissible wear limits.

e. Installation is the reverse of removal.

CAM REPLACEMENT.

Cams are positioned on the camshaft at the factory by hydraulically expanding the cam bore and sliding the cam into position on the shaft. If it ever becomes necessary to remove and replace cams in the field, the following procedure is recommended.

a. Cams are located on the camshaft by scribe marks on the cams and the camshaft, placed there during manufacture. Circumferential marks locate the cams longitudinally on the camshaft, and longitudinal marks locate the cams circumferentially. Cams have a radial scribe mark on the side of the cam which passes through the center of the hole in the side of the cam.

b. Make a sketch of the camshaft assembly, indicating the location of the cams and the distance between each. Make sure the camshaft and all cams are scribed.

c. Clean the camshaft and place on Vee blocks on top of a clean workbench. Make sure all burrs, dents and other irregularities are reduced to the common diameter of the camshaft. Irregularities will prevent removal of the cams.

d. Obtain a hydraulic pump unit, such as a "Porto-Power", complete with a hose and fittings, and a pressure gauge capable to reading up to 20,000 psig.

e. Remove camshaft gear from camshaft, then connect hydraulic unit to the first thrust ring. Raise pressure to approximately 2000 psig and slide thrust collary off camshaft. Repeat procedure to remove other thrust ring.

f. Connect hydraulic unit to first cam nearest the tapered end of camshaft. Apply approximately 16,000 psig pressure (or pressure that will allow the cam to slide on the camshaft) and move the cam towards the drive end of the shaft.

PART E – CAMS, CAMSHAFTS AND BEARINGS (Continued)

WARNING

The camshaft has a taper near the drive end which serves as a starting ramp when installing the cams. As the cams reach the taper there is a strong tendency for them to shoot off the shaft with considerable velocity. Arrange a stop plate at the end of the shaft to keep the cams from shooting off the camshaft.

g. Remove all cams in order.

h. Wash and dry the camshaft and the replacement cams. Check that scribe marks are clean, sharp and clearly visible. Lay cams out on a clean surface in the correct sequence and orientation for installation. Refer to the sketch and make sure the cams are facing in the proper direction.

i. Choose the cam which will be farthest from the drive end of the camshaft and slide it up on the starting ramp as far as it will go.

j. Attach the hydraulic unit to the cam and start raising the pressure. A vigorous effort will be required to move the cam up the starting ramp to the straight part of the shaft. Approximately 16,000 psig pressure will be required.

k. Move the cam to its correct location on the shaft. Align the edge of the cam bore with the circumferential scribe mark and align the radial (longitudinal) scribe mark on the shaft with the mark on the cam. Release the hydraulic pressure when the cam is correctly aligned.

l. Install and position the remaining cams in order, then replace the thrust rings.

PART E – CAMS, CAMSHAFTS AND BEARINGS (Continued)

TIMING GEARS.

Timing gears are enclosed in the gearcase, and are lubricated by jets of oil. Gearcase covers should be removed periodically, and the gears inspected for wear and for backlash. Refer to Appendix III for backlash clearances. If the prescribed backlash clearance is exceeded by 0.006 inch, or if damage is discovered, perform the following disassembly steps to the degree necessary to accomplish the required inspection and repair. Accessories are doweled at assembly. If it is necessary to remove a dowel to reposition an accessory, drill and ream another dowel hole of the proper size in the accessory mounting flange and in the gearcase.

a. Remove the governor, overspeed trip, pumps and other accessories which would interfere with gearcase removal. As the pumps are removed, cover the shaft, drive gears and openings in the pump housing to exclude dirt and to prevent damage. Cover the open ends of connecting pipes and tubing.

b. Remove gearcase from engine. The gearcase is heavy and difficult to handle, therefore, rigging must be done very carefully to insure that it is under control at all times.

(1) Rig chainfalls and slings for handling gearcase.

(2) Remove bolts and capscrews, then lift gearcase from engine. Do not let it drop or swing. Set aside, secured in such a manner that it cannot fall.

c. Remove the governor drive assembly, and the overspeed trip and fuel booster pump drive assembly.

d. Insure that the crankshaft, camshaft and idler gears are match-marked for proper positioning at reassembly. If a new gear is to be installed, check both cylinder banks to insure that the number one fuel injection pumps are correctly timed. Fuel injection pump timing marks will serve as a reference point when reinstalling the gears.

e. Remove idler gear and bracket assemblies.

(1) Rig a small chainfall and wire rope sling to lift the idler gear and bracket assembly from the engine.

(2) Straighten locking clips. Remove top bracket retaining capscrew and replace with a long capscrew to serve as a guide and safety device while removing the gear and bracket assembly.

(3) Remove remaining capscrews and take a strain on the chainfall.

(4) Carefully pry bracket assembly free of the aligning dowels at the top and bottom of the bracket.

(5) Slide gear teeth clear of other gears, taking care not to damage any teeth.

(6) Remove long guide capscrew, and move bracket assembly clear of engine.

f. Remove camshaft gear assemblies.

(1) Remove cotter pins from camshaft gear hub retaining nut. A gear puller may be needed to start the gear hub off the shaft. The gear assembly will usually jump when it breaks free of the taper. If the initial movement is too great the ram effect may cause displacement of camshaft collars or upset thrust clearance. To prevent this, loosen hub retaining nut only far enough to limit this initial movement to 1/16 inch.

PART E – CAMS, CAMSHAFTS AND BEARINGS (Continued)

(2) If the gear assembly will not come loose with a gear puller, use an oxy-acetylene torch and quickly apply heat to expand the hub. Protect the front camshaft bearing from the torch flame. *Do not overheat.*

(3) Remove camshaft gear hub retaining nut and slide gear off shaft.

g. Remove camshaft gear.

(1) Protect the front main bearing with a wet asbestos heat dam.

(2) Make two 3/4-inch diameter handling rods, 24 inches long with 3/4–10 threads at one end, and screw rods into the two tapped holes in the gear.

(3) Use two "Rosebud" type heating torches to quickly heat the gear until it can be slipped off the crankshaft with the handling rods. Be sure the exposed end of the crankshaft is clean and free of burrs.

INSPECTION.

Inspect gears for broken teeth, or other damage. If gears are damaged, inspect camshaft with dial indicator to determine if shaft is bent.

a. Clean camshaft tapers and check fit of drive keys in hubs.

b. Clean gear seat area of crankshaft.

c. If it is necessary to remove the idler gear from the bracket, cut the safety wire and remove the four bolts that hold the idler gear stub shaft in the bracket. Remove the stub shaft then carefully slide the gear out of the bracket. When reassembling the idler gear in the bracket take care not to damage the bushings or the gear teeth.

ASSEMBLY.

a. Install camshaft gear.

(1) Lubricate camshaft taper with white lead and lubricating oil. If a new gear hub is being installed, fit a new key in the key slot.

(2) If a new gear and hub are being installed, position the slotted holes in the hub over the drilled holes in the gear. Install camshaft gear to hub bolts, washers and nuts. Tighten to hold gear and hub together.

(3) Using a chainfall and sling, lift gear assembly into position and slide onto camshaft taper. Assemble washer and nut, tighten, and install cotter pin.

b. Install crankshaft gear.

(1) Heat camshaft gear to 350° F in hot oil. *Do not overheat.*

(2) Screw two handling rods into tapped holes in gear. Lift gear out of the oil with rods, and with one smooth, continuous motion, position heated gear against the shoulder. This must be done quickly before the gear cools. Allow gear to cool, then proceed.

PART E – CAMS, CAMSHAFTS AND BEARINGS (Continued)

(3) Set the flywheel to the left bank fuel injection point (see Engine Data Sheet in front of manuál).

(4) Set the left bank camshaft so that number one fuel injection pump timing marks are matched.

c. Install idler gear and bracket assembly.

(1) Camshaft, idler and crankshaft bears are match-marked at the factory. If the original gears are being replaced, install and align gears with these marks. If a new gear is being installed, the following procedures must be used to insure correct camshaft timing and engine firing order.

(2) Lift the gear and bracket assembly into position with a chainfall and suitable sling. Align with match-marks (if present) and mesh teeth. The camshaft bear may be moved part of a tooth to allow gears to mesh.

(3) Install a long capscrew through the top bracket mounting hole to serve as a guide. Seat bracket on engine block and install all capscrews.

(4) Rotate flywheel in the direction of normal engine rotation to the right bank fuel injection point. (See Engine Data Sheet in front of manual or engine nameplate).

(5) Set right bank camshaft with number one fuel injection pump timing marks matched.

(6) Lift right idler gear and bracket assembly into place and install capscrews. The camshaft gear may be moved part of a tooth to allow the three gears to mesh.

d. Adjust backlash clearance between gears.

(1) Make four brass shims, 0.010 inch thick by one-half inch wide and six inches long. Insert shims between crankshaft gear and idler gears, and between idler gears and camshaft gears.

(2) Loosen capscrews holding idler gear bracket to engine block, and lift idler gear assemblies until shims are held tight between gear teeth. This will establish the required backlash between each gear. Tighten idler gear retaining capscrews on each idler assembly.

(3) Rotate the flywheel and check backlash clearance in at least four places around each gear. Refer to the Table of Clearances. If backlash is within tolerances, tighten all idler assembly retaining capscrew to torque values shown in Appendix IV. Remove shims.

(4) Drill and ream two holes in each idler bracket, install No. 108-2 dowels in holes, and stake in place.

CAMSHAFT TIMING.

The camshafts of four-valve head model engines must be timed to the engine crankshaft by the fuel injection pump tappet lift method only. These camshafts are equipped with hydraulically expanded keyless cams and cannot be timed by the cam key method. Failure to observe the proper camshaft timing sequence can result in an altered firing order and an incorrectly operating engine.

a. Remove number one fuel injection pump on master rod bank.

b. Bar the flywheel over until the tappet roller for number one fuel injection pump, master rod bank, is on the base circle of its cam.

PART E – CAMS, CAMSHAFTS AND BEARINGS (Continued)

c. Set up a one-inch travel dial indicator on the pump base for number one fuel injection pump with the spindle of the indicator bearing on top of the tappet pin for number one fuel tappet, master rod bank, and zero the indicator.

d. Bar the flywheel in the direction of normal rotation until the tappet roller for number one fuel injection pump starts up the lifting ramp of its cam.

e. Continue barring the flywheel until the degree mark for fuel injection for number one master rod bank is directly in line with the flywheel pointer. This degree mark is shown on the Engine Data Sheet in front of the manual, and on the engine nameplate.

f. Observe the dial indicator to determine the lift of the fuel tappet at this point. Lift should be 0.197 inch. If lift is other than 0.197 inch, camshaft timing must be corrected.

(1) Loosen two fitted bolts that fasten camshaft ring gear to gear hub.

(2) Loosen remaining four bolts and rotate camshaft gear within ring gear to raise or lower the tappet as necessary.

(3) If there is not enough travel in the slotted holes in the gear hub to allow the required correction, it will be necessary to lift the gear end of the camshaft until the cam gear teeth disengage from the idler gear teeth, and slip the mesh one or more teeth as judged necessary. Re-engage the teeth of the cam gear and idler.

(4) Observe dial indicator to find tappet lift after correction. Make final correction by rotating the camshaft gear hub within ring gear.

(5) When correct tappet lift is obtained, lock up the four bolts in the slotted holes and drill and ream for two fitted bolts. New holes for fitted bolts should be moved approximately one inch from the original holes.

(6) Torque six bolts that fasten ring gear to hub to a torque value of 70 ft-lb, plus or minus 20 ft-lb as required to align cotter pin holes. Tighten and lock camshaft bearing cap bolts if they were loosened to slip gear tooth mesh.

g. Replace number one fuel injection pump, master rod bank.

h. Bar flywheel to place fuel injection timing point for number one, master rod bank, directly under flywheel pointer.

i. Remove number one, link rod bank fuel injection pump. Set up dial indicator in same manner as was done for master rod bank.

j. Bar the flywheel in the direction of normal rotation approximately 315 degrees to position the degree mark for fuel injection for number one, link rod bank cylinder directly in line with the flywheel pointer. Refer to Engine Data Sheet or engine nameplate for the correct degree mark. This will place the timing and firing order of the master rod bank and the link rod bank in the correct relationship.

k. Time the number one, link rod bank fuel injection pump in the same manner as used to time the master rod bank pump.

l. When both banks are timed, recheck fuel injection pump timing and cylinder head valve lash for both banks.

PART F – FUEL SYSTEM

FUEL INJECTION EQUIPMENT.

Each cylinder is fitted with an individual fuel injection pump and nozzle. The fuel supply to the pumps is from a common header, and a separate high pressure line connects each pump to its respective nozzle. As was stated in Section 2, fuel injection equipment is built to extremely close tolerances and, therefore, requires a great deal of care when being worked on to avoid damage to the parts. Only trained fuel injection equipment mechanics should be allowed to perform this work.

FUEL INJECTION NOZZLES.

Because nozzles and tips are subjected to extremes in pressure and temperature, they normally are the first source of engine trouble. A nozzle in good condition must pop open at the proper pressure without dribble, then close completely almost immediately. When subjected to a steady pressure at the opening pressure, it should "chatter", that is, open and close rapidly. The spray form should be a uniform, finely atomized mist pattern, never a solid stream. If the fuel nozzle is suspected of malfunctioning, remove from engine and test as follows.

a. Disconnect high pressure line and drain connections.

b. Remove nuts from injector studs and remove nozzle retainer.

c. Lift or pry the nozzle holder assembly from the cylinder head.

d. Close opening in cylinder head to prevent dirt or other foreign matter from entering the combustion chamber.

e. Test the nozzle holder and tip assembly on a suitable nozzle tester, checking for the following.

(1) Apply pressure and check nozzle valve for popping action. The valve should chatter if it is seating properly.

(2) Raise pressure slowly to determine pressure at which valve opens. The valve should open at 3000 psi (211 kg-cm^2) pressure. The opening pressure is adjusted by means of shims in the valve assembly, requiring disassembly of the unit. See figure 6-F-1 and "Nozzle Adjustment" instructions.

(3) Dry off spray tip and raise pressure to within 100 psi of the opening pressure and observe tip for dribbling of fuel.

(4) Check to see if any spray tip holes are plugged.

(5) Place a clean piece of paper under nozzle tip and check spray pattern for uniform density and a symmetrical pattern.

(6) Nozzles that fail to perform satisfactorily should be repaired or replaced. Refer to manufacturer's instructions in the *Associated Publications Manual* for overhaul instructions.

WARNING

The penetrating power of atomized fuel under high pressure is sufficient to puncture the skin and serious injury can result. To avoid this danger, the hands must be kept away from a spraying nozzle.

PART F – FUEL SYSTEM (Continued)

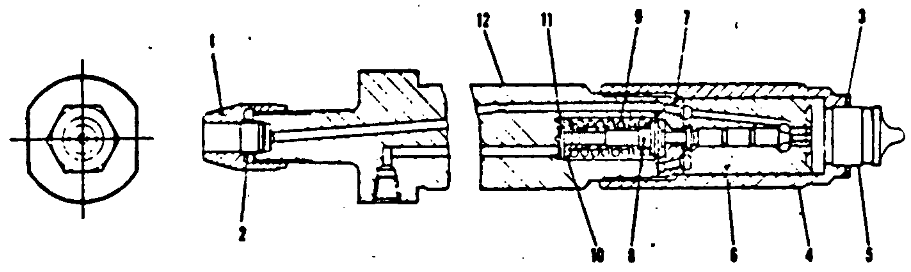


Figure 6-F-1. Sectional View of Typical Nozzle and Holder Assembly

NOZZLE ADJUSTMENT (See Figure 6-F-1).

Nozzle opening pressure is adjusted by means of shims (11), located between the body (12) and the spring seat (10). If the opening pressure does not conform to 3000 psi (211 kg-cm^2), adjust as follows.

a. Install nozzle and holder assembly on a pop tester then rapidly actuate pop tester handle four to six times to allow needle to seat properly. Pump the pressure up to the point where the pressure gauge needle falls away quickly. This point is the nozzle opening pressure.

b. If pressure is not correct, do the following.

(1) Disassemble the holder.

(2) Add shims if opening pressure is too low, or remove shims if opening pressure is too high.

(3) Reassemble and check opening pressure. If fuel leaks around the assembly nut, it indicates poor lapped fits. Re-examine the parts.

(4) Always use a new gasket (3) when installing nozzle and holder assembly on engine.

FUEL INJECTION PUMPS.

The fuel injection pumps are of the constant stroke, variable output type. Equally important with clean, properly adjusted fuel nozzles are clean, properly adjusted and timed fuel injection pumps. Refer to the manufacturer's instructions in the *Associated Publications Manual* for complete details of the fuel injection pump installed on this engine.

PART F – FUEL SYSTEM (Continued)

DESCRIPTION OF OPERATION.

The following is a general discussion of the operation of the fuel injection pumps.

a. The pumps are of the constant stroke design, but the effective stroke, or that portion of the plunger movement in which fuel is actually delivered, is governed by a fuel metering helix in the plunger (see figure 6-F-2). On some pumps there is a second helix to retard the point of delivery at low fuel settings.

b. To pump fuel at high pressure it is necessary to bring it into a pressure chamber through an inlet, close the inlet and apply pressure for injection, terminate injection pressure and re-open the inlet to admit more fuel. The fuel injection cycle is accomplished by the location of inlet and spill ports in the barrel. It is further accomplished by the metering helix and a passage in the plunger that extends from the end of the plunger to the metering helix on the side of the plunger. This passage allows fuel in the pressure chamber to spill into the inlet chamber when the helix uncovers the spill port.

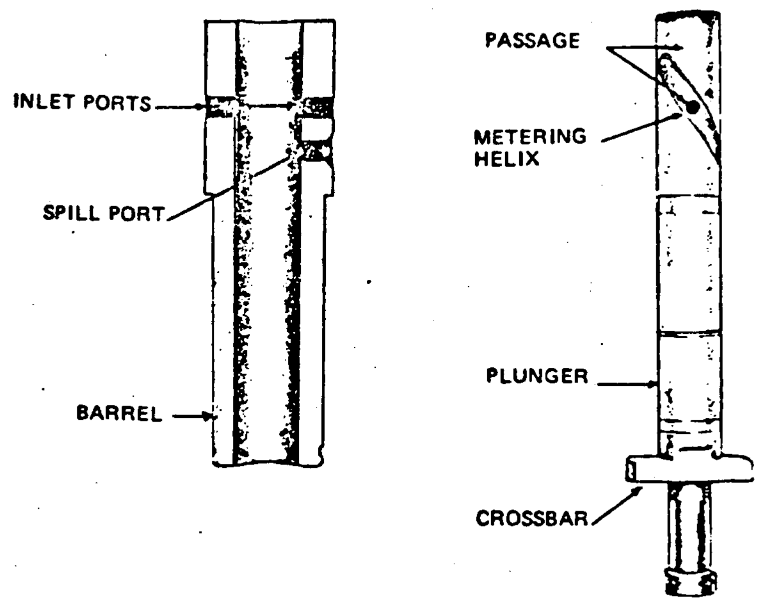


Figure 6-F-2. Pump Plunger and Barrel Arrangement

c. When the plunger is at its lowest point, fuel enters the barrel through the inlet port. As the plunger rises, it closes off the inlet port, pressure starts to rise and the delivery valve opens. Fuel injection continues until the upper edge of the metering helix reaches the lower edge of the spill port. Pressure is then release through the passage in the plunger to the spill port and delivery stops. The delivery valve closes. The effective stroke is the distance between the upper edge of the helix and the lower edge of the spill port at the moment the inlet port closes. The rotation of the plunger and its helix, then, determines the duration of fuel injection.

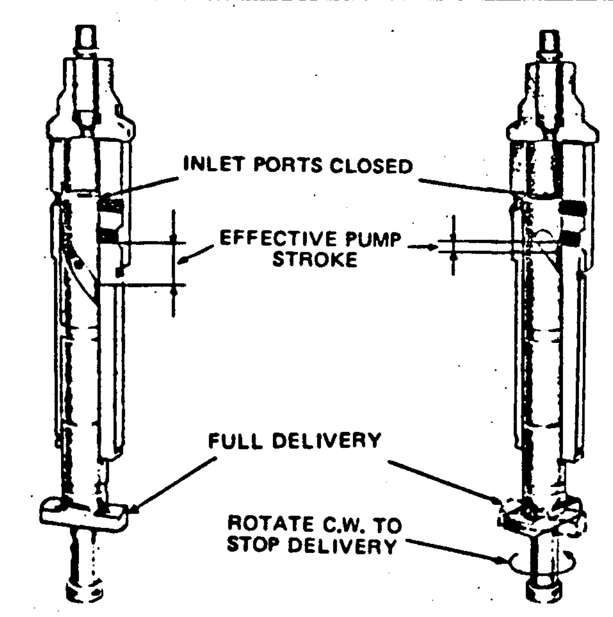


Figure 6-F-3. Effective Stroke

PART F – FUEL SYSTEM (Continued)

MALFUNCTIONING PUMP.

Should a fuel pump be suspected of malfunctioning, the following checks should be made before removing the pump from the engine for inspection and repair, unless it is known for certain that the pump is defective.

a. Check to insure that fuel oil is being delivered to the pump. With the fuel oil system pressurized, loosen air bleed screw on pump. Fuel should flow freely with complete absence of air bubbles.

b. If air is present in fuel oil, loosen nuts on high pressure line connection at nozzle holder end and bar engine over until all bubbles disappear.

c. If fuel oil flow is sluggish at the pump, it is a good indication that the fuel filters are clogged. Check and clean filter.

d. If fuel oil does not flow, check fuel level in tank and for closed valves in lines.

e. Having made certain of fuel oil flow, operate engine and if pump still does not function properly, remove and replace with spare pump.

PUMP REMOVAL.

Fuel injection pumps are removed from the engine as follows.

a. Disconnect high pressure line fitting and remove high pressure line from pump.

b. Disconnect supply and return lines from fuel pump.

c. Disconnect fuel control rack from linkage.

d. Remove hold down nuts and lift pump off mounting studs.

PUMP DISASSEMBLY.

The manufacturer's instructions contained in the *Associated Publications Manual* provide detailed instructions for the overhaul and repair of fuel injection equipment, and should be consulted when any work is being done on fuel injection pumps. Pumps may be disassembled as follows.

a. Secure pump in the inverted position in a soft jawed vise. Depress the plunger follower and insert a 1/8 inch diameter pin in the hole in the pump flange.

b. Remove lock ring by prying it out with a screwdriver. Again depress follower and remove 1/8 inch pin.

c. Remove plunger follower. Take lower spring seat from plunger, then carefully remove plunger from barrel. Carefully submerge plunger in spindle oil.

d. Remove plunger spring, then pull control sleeve using a specially fabricated puller, or a pair of pliars whose jaws are wrapped with masking tape. The upper spring plate will come out with the control sleeve.

PART F – FUEL SYSTEM (Continued)

e. Remove pump from vise and re-secure in an upright position.

f. Remove delivery valve flange and delivery valve holder. Remove and discard preformed packing.

g. Remove delivery valve stop and spring, then, using a delivery valve puller, carefully remove delivery valve.

h. Remove barrel locating screw then slide barrel from housing.

i. Remove control rack locating screw and control rack. Do not remove timing indicator or shims unless pump is to be re-calibrated.

PUMP ASSEMBLY.

Assemble the pump as follows, observing the manufacturer's instructions in the *Associated Publications Manual.*

a. Secure pump housing in a vise in an upright position.

b. Position control rack in housing with teeth facing center of pump. Install lockwasher and control rack locating screw, making sure the screw enters the rack locating groove.

c. Insert barrel in pump housing. Locating groove must be aligned with locating screw hole. Install lockwasher and locating screw.

d. Invert pump and install control sleeve so that tooth directly under timing mark meshes between two teeth indicated by timing dot on control rack.

e. Install upper spring plate and plunger spring then carefully start plunger into barrel. It should settle in of its own weight. Turn plunger so marked end of crossbar will go into control sleeve slot that has a mark adjacent to it.

f. Position lower spring plate on end of plunger. Fit plunger follower into housing. Compress and insert pin in housing flange. Install lock ring and remove pin.

g. Install delivery valve assembly in pump housing. Lubricate and install preformed packing and install delivery valve spring and delivery valve stop. Assemble flange in housing.

h. Install pressure screw and new copper gasket. Install bleed screw and new gasket.

i. After pump is completely assembled, hold it horizontally with the control rack vertical. The rack should settle to its lower extreme by its own weight.

j. If pump will not be immediately installed, fill inlet and outlet with clean, anti-corrosive lubricating oil and close openings with caps.

PART F – FUEL SYSTEM (Continued)

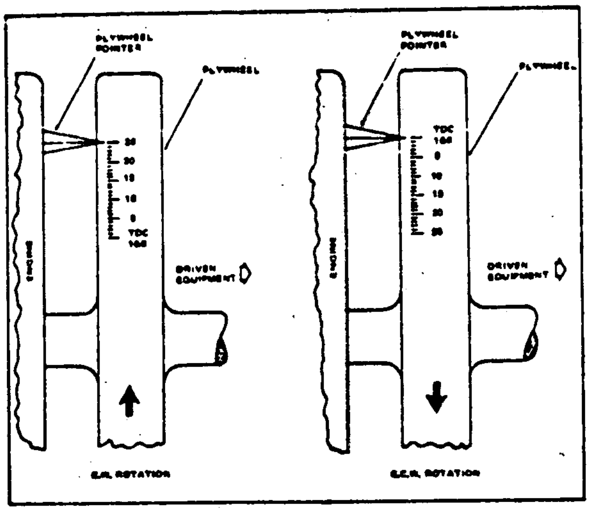


Figure 6-F-4. Flywheel Timing Marks

PUMP INSTALLATION AND TIMING.

Refer to the Engine Data Sheet in the front of the manual, and to page 6-A-1 for determination of engine rotation, bank designation (V-type engines) and cylinder numbering. The flywheel is marked to locate top dead center (TDC) of each cylinder, and is laid out in one degree increments for the twenty-five crankshaft degrees preceeding TDC (see figure 6-F-4). For instance, on a six cylinder inline engine, there will be marks "TDC 1&6", "TDC 2&5" and "TDC 3&4", each preceeded by degree marks. On eight cylinder inline engines the markings will be for cylinder pairs 1&8, 2&7, 3&6 and 4&5. Markings on the flywheel for V-type engines follow the same pattern, except that the banks are also designated. Refer to the Engine Data Sheet in the front of the manual for the fuel injection point. Install and time fuel pumps as follows.

a. Before mounting pump on engine, and with the fuel tappet roller on the base circle of the fuel cam (see figure 6-F-5), measure distance from the fuel pump mounting surface on the base assembly to the tappet with a depth micrometer. Add or remove shims from the top of the base assembly to obtain a measurement of approximately 0.197 inch.

b. Place pump on base assembly and install nuts on studs. Torque nuts as specified in Appendix IV.

c. Bar engine over in the direction of normal rotation until the flywheel pointer is aligned with the fuel injection point (degrees BTDC specified on Engine Data Sheet) for the cylinder served by the fuel pump being installed.

d. Observe plunger follower timing mark in pump timing window. If the plunger follower timing mark does not line up with the index mark on the timing window, remove pump and add or remove shims between the pump and the pump base assembly as necessary so that the marks will line up. Re-install the pump and bar engine through one complete injection cycle to insure that marks do align at the fuel injection point.

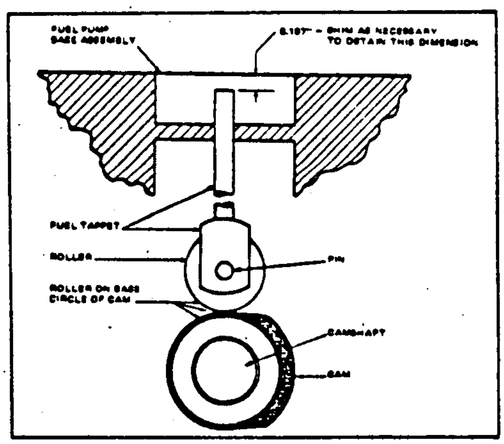


Figure 6-F-5. Pump Base To Tappet Adjustment.

CAUTION

The timing mark on the plunger follower must never go beyond the upper or lower edge of the timing window. If it does, the pump may be severely damaged.

PART G — ENGINE CONTROLS

OVERSPEED TRIP (See Figure 6-G-1).

A Woodward Model SG overspeed trip governor is mounted on the gearcase end of the engine. At a pre-set engine speed (10% above rated speed) it will initiate positive engine shutdown by tripping a dump valve which vents the automatic safety shutdown system. Operation of the overspeed trip governor is as follows.

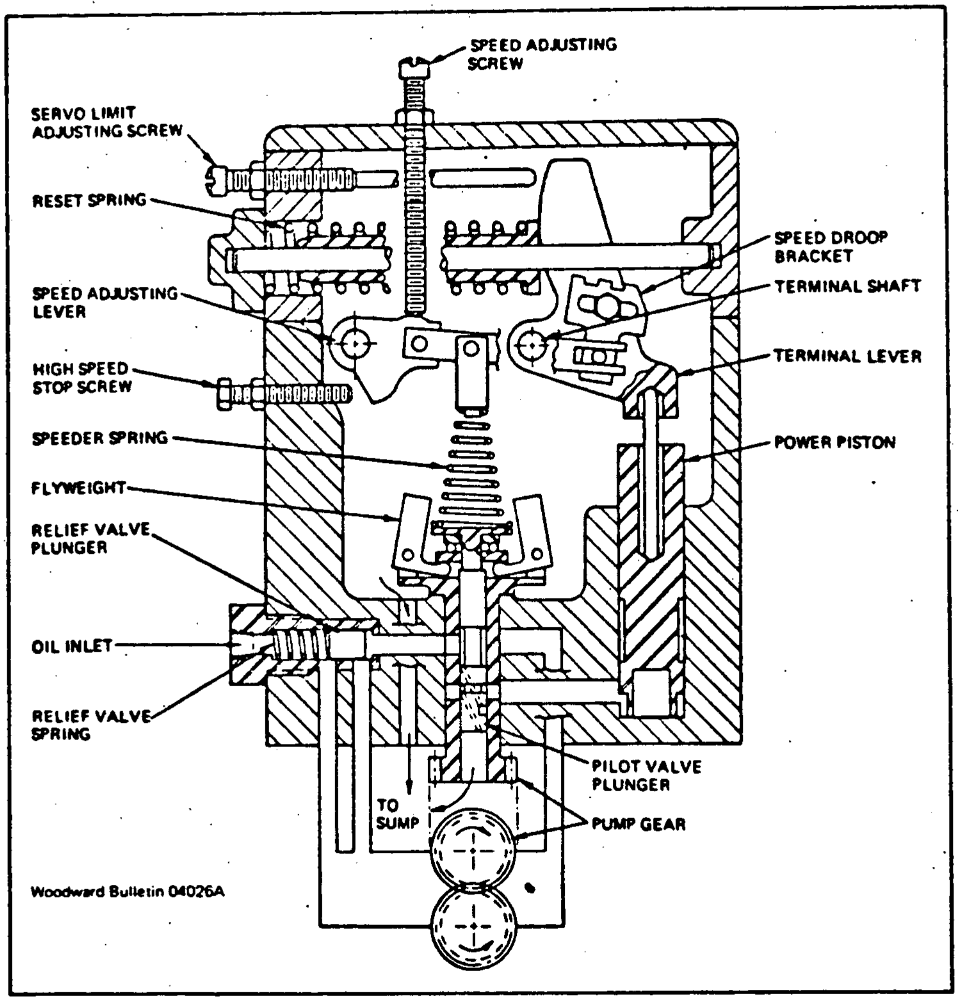


Figure 6-G-1. Overspeed Trip Governor

a. Oil enters the overspeed trip at the oil inlet, drops down into the cavity on the suction side of the pump gears, then around to the pressure side of the pump. If the supply of pressure oil is greater than required, the pump builds up pressure until the relief valve plunger is pushed to the left against the force of the relief valve spring. This uncovers the bypass hole in the relief valve sleeve and oil is recirculated through the pump. If the overspeed trip requires more oil than is being recirculated, pressure will be reduced and the spring will move the relief valve to the right, blocking the recirculating passage to maintain operating pressure. Additional oil, as needed, will enter the pump through the inlet port.

PART G – ENGINE CONTROLS (Continued)

b. The pilot valve plunger controls the movement of the power piston by directing oil to or from the area beneath the power piston. The power piston in turn controls the position of the terminal lever, and, therefore,.the position of the terminal shaft. Two opposing forces act upon the pilot valve plunger - the speeder spring force tends to push the plunger down and the centrifugal force developed by the rotating flyweights tends to lift the plunger.

c. When the engine is operating below the trip set point the speeder spring force holds the pilot valve plunger down and connects the oil under the power piston to drain. The reset spring, pushing the reset rod against the terminal lever, holds the power piston down.

d. If engine speed rises above tripping speed the centrifugal force of the flyweights overcomes the speeder spring force and lifts the pilot valve plunger. As the plunger rises, pressure oil flows to the underside of the power piston, forcing the piston up. As the terminal lever is rotated by the upward movement of the power piston, the pin in the speed droop bracket raises the right end of the floating lever. This decreases the downward force of the speeder spring and the flyweights move to their extreme out position. The power piston then moves to the top of its stroke, as allowed by the terminal lever, which rotates the terminal shaft. The external lever on the terminal shaft then actuates the trip valve.

e. When engine speed drops back below the reset speed the speeder spring pushes the pilot valve plunger down and the area under the power piston is again connected to the sump. The reset spring rotates the terminal lever and pushes the power piston down. Oil is then recirculated through the pump as before.

OVERSPEED TRIP ADJUSTMENT.

The speed at which the unit trips is determined by the position of the speed adjusting screw. Turning the screw into the cover raises the tripping speed, and turning it out lowers tripping speed. The overspeed set point is adjusted at the factory, and under normal conditions should not be changed in the field. If it becomes necessary to reset the trip point, follow these steps.

a. Back out servo limit adjusting screw so that it does not limit travel in the power piston.

b. Make tentative speed droop bracket setting at approximately one-half its travel from minimum to maximum droop.

c. Make preliminary tripping speed adjustment with speed adjusting screw.

d. Readjust speed droop bracket to obtain approximately ten percent excess range, then readjust tripping speed. The speed adjusting lever can be locked in place by tightening the high speed stop screw against the speed adjusting lever.

e. Reset overspeed trip at a speed slightly below the desired reset speed. The servo limit adjusting screw affects only the reset speed. Turn in to raise the reset speed to the desired value.

PART H – ENGINE BALANCING

GENERAL.

The load must be equally divided between all cylinders when the engine is loaded between 75 and 100 percent of its rated capacity. If it is not, one or more cylinders will be forced to carry an overload while the others loaf with resulting loss of operating economy, and possibly one or more of the following conditions.

a. Scored pistons and liners.

b. Excessive vibration which may cause loose foundation bolts, cracked grout and broken pipe connections.

c. Excessive piston, valve, bearing and crankshaft wear.

d. Excessive fuel consumption.

e. Excessive use of lubricating oil.

f. Frequency swings.

All temperature and pressure gauges required for proper operation of the engine are provided. The operator must be able to interpret gauge readings, know why any given pressure or temperature must be maintained, and how or when to make corrections if any change is noted. An engine log is an excellent tool to assist in achieving optimum operating efficiency. Readings should be taken and recorded hourly, and be supplemented with written observations. This will permit a complete evaluation of operating conditions, and provide information for oncoming operators.

FUEL INJECTION EQUIPMENT.

Clean fuel is essential. Injection equipment has close working tolerances, therefore, dirt or other impurities in the fuel can cause pumps or spray nozzles to malfunction. Small depressions in injector valve seats, some so small that they are not visible to the naked eye, may be caused by small particles of dirt and will affect spray patterns in the combustion chamber. Pumps and valves must be checked and cleaned periodically. The frequency of cleaning can best be determined from experience, however, care must be taken not to wait too long before cleaning. Fuel pumps should deliver exact amounts of fuel oil according to the millimeter setting of their fuel pump racks. If one pump requires a two or more millimeter variation from the setting of other cylinders to maintain the desired temperature or pressure, it indicates something wrong with that cylinder as a unit. The engine and pumps are designed to operate and maintain proper temperature with less than one millimeter difference in rack settings.

ENGINE OUT OF TUNE.

Spray nozzles are usually suspect if an engine is out of tune, or is smoking. There are other factors which may also contribute to these conditions. All of these must be considered when evaluating engine performance.

a. Ignition or injection timing.

b. Long or short burning lag in some fuels.

c. Cetane rating of the fuel.

d. Low compression pressure due to leaking valves.

e. Worn piston rings and/or liners.

PART H – ENGINE BALANCING (Continued)

f. A change in fuel oil.

g. Defective fuel injection pumps.

h. Incorrect air-fuel mixture.

i. Maladjustment of valves or linkage.

BALANCING CRITERIA.

The normal values used for balancing an engine, whether diesel or dual fuel, are exhaust temperatures and firing pressures. If there is any question as to the accuracy of thermocouples or pyrometers, they should be calibrated.

a. At full load, the individual cylinder exhaust temperatures should not vary more than 50 degrees fahrenheit (10° C).

b. Firing pressures will vary in direct proportion with exhaust temperatures, and should vary no more than 30 psi (2.11 kg/cm^2) between cylinders.

c. The closer each cylinder is balanced to the next the better the engine performance. Time and patience are necessary to properly balance an engine – there is no short cut.

d. The timing of fuel delivery in relation to piston position in the cylinder, will determine the pressure in the cylinder. Each cylinder is an engine in itself and must be treated as such to insure that it is carrying its share of the load. Exact timing will always depend on engine speed, type of fuel, altitude, etc., therefore, final timing must be done under actual field conditions at the installation site.

PRELIMINARY ADJUSTMENTS.

Before operating the engine for the first time, or after an overhaul, the engine should be checked over, and preliminary adjustments made to the diesel fuel system as follows.

a. Adjust valve clearances or, if the engine is equipped with hydraulic valve lifters, check lifter adjustment. Refer to Part B of this section of the manual for procedures.

b. Check fuel injection equipment as follows.

(1) Remove all nozzle holder assemblies, clean and if necessary, readjust nozzle opening pressure. The correct opening pressure of nozzle holder valves should be maintained within 50 psi (3.52 kg/cm^2) of each other. See page 6-F-1 for opening pressures. Adjustment may be made with an adjusting screw or with shims, depending on the particular installation. Refer to the manufacturer's instructions in the *Associated Publications Manual*. Any great difference in nozzle opening pressure will affect engine balance, nozzle spray patterns, temperatures and smoke.

(2) Check proper spray pattern. This may be done by placing a piece of paper under the nozzle while it is in the test stand. This will reveal non-uniform patterns and plugged nozzle holes.

(3) Nozzle holder assemblies *must not dribble under pressure, or after popping open under the set pressure.*

(4) Re-install nozzle holder assemblies in cylinder head. Carefully tighten nuts with a torque wrench to the value shown in Appendix IV. Improper installation can result in malfunctioning.

PART H – ENGINE BALANCING (Continued)

BALANCING ENGINE.

It is advisable to construct a chart or graph which will show engine load, governor load indicator position, intake manifold pressure and temperature, and individual cylinder pressures and temperatures which are observed while making balancing adjustments. This chart or graph will be very helpful in determining adjustments and corrections required to properly tune and balance the engine. If possible, keep intake manifold air temperature below 100° F while balancing engine to minimize detonation tendencies.

a. After all preliminary adjustments have been completed, start engine and run at idle speed. Record exhaust temperatures and firing pressures for all cylinders to determine condition of injectors. Temperatures should not vary more than 10° F (5.55° C) and firing pressures should be within 10 psi (0.7 kg/cm^2) between cylinders. If a larger spread is recorded, stop engine and remove injectors. Clean, inspect, repair or replace. Install injectors and start engine.

b. If over 10° F (5.55° C) difference is experienced between cylinders after injectors have been cleaned, fuel pumps must be adjusted (see figure 6-H-1).

(1) Cylinders with the lowest firing pressures and exhaust temperatures will be the ones which are not carrying their full share of the load, therefore, they should be adjusted to increase pressure and temperature. This will usually cause the high cylinders to come down as the low cylinders take up their share of the load.

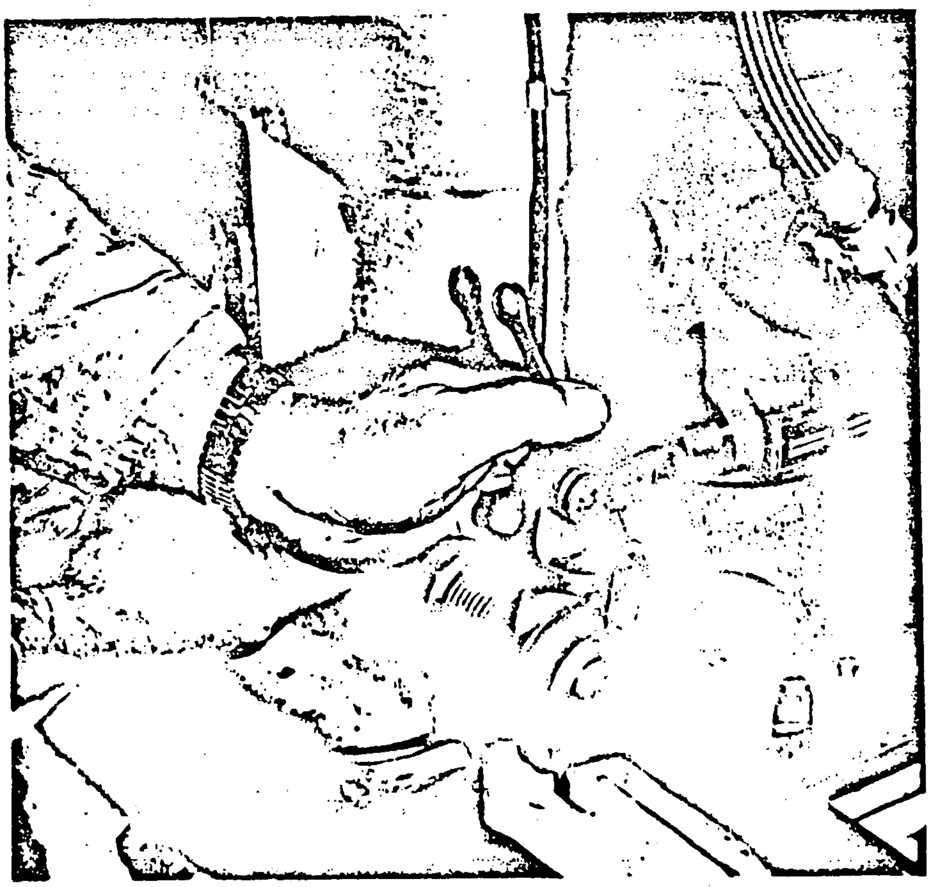


Figure 6-H-1. Adjusting Fuel Injection Pump

PART I – STARTING AIR SYSTEM

GENERAL.

The engine is started by the timed admission of high pressure starting air to the power cylinders during the equivalent of the power strokes of the respective cylinders. The air is admitted at approximately top center of the power stroke, and admission continues until approximately the opening of the exhaust valves. The pressure is then relieved, thereby creating rotation of the engine comparable to the normal power stroke. As the engine accelerates on starting air, the heat of compression of the combustion air plus the starting air develops sufficient temperature to ignite the injected fuel within a few revolutions and the engine then initiates normal combustion and begins to accelerate under its own power without further aid of starting air.

AIR SUPPLY.

There are two separate, independent air supply systems, each consisting of a motor driven air compressor, a refrigerant drier and a storage tank. Each supply is available to the engine, independent of the other. The Starting air supply is stored at 250 psig (17.57 kg/cm²), and the full 250 psig pressure is available to the starting air header without reduction to provide maximum acceleration for extremely fast and reliable starting.

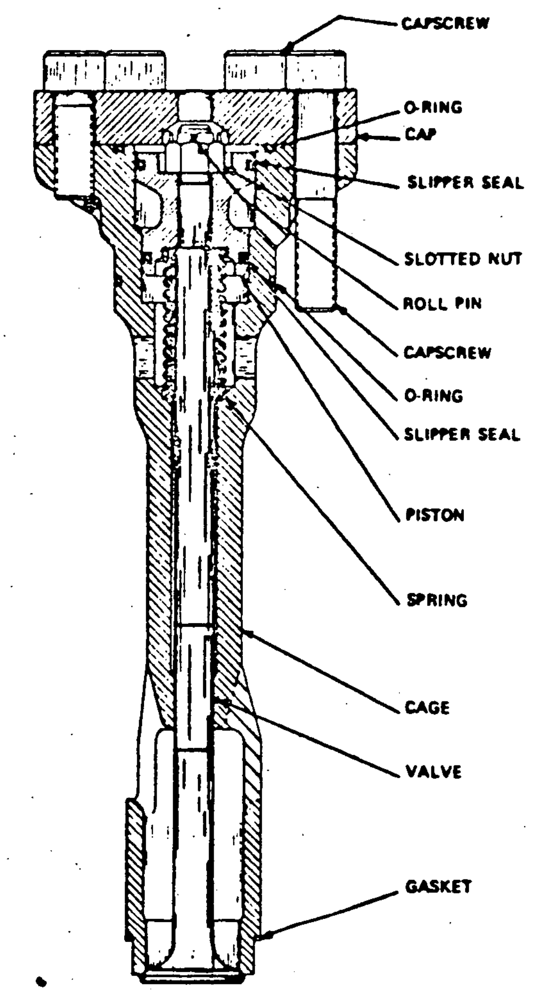


Figure 6-I-1. Starting Air Valve

OPERATION.

The on-engine portion of the air starting system includes a header, two solenoid control valves, two gear-driven distributors, and a pilot operated air starting valve (figure 6-I-1) for each cylinder. During engine starts, starting air is admitted to the header when the solenoid valves are opened. There is a solenoid valve at either end of the header, each provided with a check valve on the header side to prevent pressure loss should either supply be low, or inoperative. Pressure in the starting air header is supplied to the starting air valves in each cylinder, and to each of the two starting air distributors. The pressure in the distributors cause spool valves to engage and follow the profile of the starting air cams on the ends of the camshaft. The cam profiles are so designed that at least one spool valve is always in position to emit a pilot signal to the proper cylinder, causing that cylinder's starting air valve to admit 250 psig air into the combustion chamber, forcing the piston down to rotate the crankshaft. As the engine rotates, timed and sequenced pilot air signals are emitted, starting five degrees before top dead center and ending at 115 degrees after top dead center. When the starting signal is cut off, the spool valves lift off the cam.

PRELIMINARY
TO BE REV...

PART I – STARTING AIR SYSTEM (Continued)

VALVE DISASSEMBLY AND ASSEMBLY (See Figure 6-I-1).

Remove valve from cylinder head then remove socket head capscrews and lift cap from valve. Remove roll pin and slotted nut from valve stem then slide valve out through bottom of cage. Remove piston from top of assembly. Remove slipper seals and O-rings, taking care not to damage them. Inspect all surfaces of valve assembly. O-rings and slipper seals. Replace any defective parts. Assembly is the reverse of disassembly.

TIMING AIR DISTRIBUTOR.

The timing of the starting air distributor should be checked if the distributor is replaced, or if the engine camshaft has been replaced or retimed.

a. Position engine flywheel with number one cylinder (the bank the distributor is mounted on) five degrees before top dead center (BTDC) on the compression stroke.

b. Position starting air distributor so that centerline of spool valve for number one cylinder is in line with the TDC scribe mark on the opening ramp of the starting air cam. Note direction of engine rotation.

c. The spool valve for number one cylinder will not be in position to just start emitting an air signal. Shop air at 125 psig (9.79 kg/cm^2) can be connected to the distributor supply to verify the valve position.

AIR FILTER INSPECTION.

The air filter in the supply line to the air distributor should be inspected and cleaned at regular intervals. The frequency of inspection and cleaning should be determined by operating conditions and experience.

STRAINERS.

Low point water collectors, "Y" strainers and air receiver tanks must be drained daily whether engine-generator is run or not. Inspect and clean "Y" strainers weekly. If the fouling of the strainers are such that more frequent inspections are warranted, then shorten the inspection interval.

PART J – COOLING WATER SYSTEMS

GENERAL.

If, for any reason, there is a disruption in the circulation of the cooling water flow, the engine should be shut down as soon as practicable to prevent a build up of temperatures and possible serious damage to the engine. To avoid thermal shock which could cause damage to the engine, do not admit cold water to the cooling system until the temperature of the cooling surfaces in the engine have dropped to approximately that of the inlet water. All cooling surfaces must be kept free of scale or other deposits as any such accumulation will degrade the cooling capability of the system and, therefore, cooling water temperatures will not accurately indicate the extent of cooling. Any coating of the cooling surfaces will act as an insulating material and will prevent transfer of heat. A check of the pressure differential between the inlet and outlet of coolers will indicate the need for cleaning of the tubes.

JACKET WATER TREATMENT.

It may be advisable to consult a commercial water treatment company concerning the treatment of jacket water to insure that local conditions are taken fully into account. A suggested water treatment material for jacket water systems is sodium dichromate and boiler compound. Sodium dichromate is an inexpensive source of alkaline chromate (CrO_4) which has been found to form a protective film on metallic surfaces that prevents attack by the corrosive elements found in the jacket water. Sodium dichromate is an acid compound which must have an alkaline compound such as boiler compound added to convert the dichromate to an effective alkaline chromate form. The alkaline chromate concentration must be maintained between 700 and 1700 parts per million (ppm). Less than 700 ppm can result in accelerated corrosion while more than 1700 ppm serves no useful purpose and is a waste of material. The pH value of the water must be maintained within a range of 8.25 and 9.75. The minimum pH value is necessary to prevent acid attack on the metallic surfaces, and the 9.75 maximum value will prevent corrosion due to high alkaline content in the water. The chloride content must not be allowed to exceed 100 ppm as the effectiveness of alkaline chromate decreases as the chloride content increases. When initiating alkaline chromate water treatment for the first time, or after the system has been refilled, the water should be tested daily for alkaline chromate concentration and pH value. When the treatment becomes stable, the test interval can be extended to weekly tests. After each addition of chemicals, the water should be circulated through the system then tested to insure that the required limits are met. Where necessary, an anti-freeze coolant solution such as ethylene glycol or similar may be used.

CLEANING JACKET WATER SYSTEM.

Rust can be removed from the jacket water system by filling the system with a solution of 75 pounds of ammonium nitrate in enough fresh water to make 100 gallons of solution. Make enough solution to fill the jacket water system then operate the engine for two hours. The jacket water system must then be flushed with fresh water and neutralized. Scale can be removed from the system by using a scale solvent solution composed of 7 gallons of 20° Baume muratic (hydrochloric) acid, one-half gallon of liquid inhibitor and 92½ gallons of fresh water at 160° F. Make enough solution to fill the system. Circulate the acid solution through the system for one or two hours, depending on the extent of the scale deposit. The temperature of the acid solution must be maintained at 160° F during circulation. After circulating the acid solution, drain the jacket water system and then fill with clean fresh water and flush it thoroughly. After flushing, neutralize the system with a solution composed of 20 pounds of soda ash (sodium carbonate) and enough fresh water at 160° F to make 100 gallons of neutralizing solution. Fill the jacket water system with the neutralizing solution and circulate it through the system for one-half hour. Maintain the temperature of the solution during circulation.

CAUTION

The above methods of cleaning must not be used for systems which have components containing aluminum.

PART J – COOLING WATER SYSTEMS (Continued)

ENVIRONMENTAL RESTRICTIONS.

Alkaline chromate water treatment compounds, such as sodium dichromate, may be considered environmentally objectionable in some locations, or may be prohibited. In these instances, nitrate compounds such as sodium nitrate ($NaNO_2$) are suggested as adequate substitutes. When using $NaNO_2$, the concentration must be 500 ppm with a pH of 7.5 to 8.5 to achieve effective corrosion control. Nitrate compounds for treating engine jacket water systems are available from most commercial chemical supply houses, and instructions for their use are available from the chemical supplier.

PART K – LUBRICATING OIL SYSTEM

FILTERS AND STRAINERS.

The full flow filter continuously filters all of the lubricating oil from the pump before it passes to the oil strainer. The length of time that the lubricating oil and the filter elements may remain in service can best be determined by carefully watching the result of oil analysis and the pressure drop across the oil filter. Change period will vary with the operating conditions to which each individual engine is subjected. During the first two or three days of engine operation after initial installation, or after a major overhaul, the strainer at the pump suction and the strainer at the oil header inlet should be checked and cleaned as necessary to remove any debris and other foreign matter that may be present. If at any time the oil pressure gauge shows a low reading, the following should be done to the degree necessary to correct the situation.

a. Check the oil level in the sump tank.

b. Inspect strainer, filter and lubricating oil cooler. A leak in the cooler may be detected by a sudden increase in oil consumption, and by the presence of oil in the cooling water system. Leakage may occur in the packing between the tubes and the tube sheet, or may be due to tube erosion, depending on the construction of the cooler.

c. Inspect all external and internal piping for tightness and freedom from obstructions.

d. Dismantle and inspect pump.

LUBRICATING OIL PUMP.

A Roper positive displacement, internal gear type pump is used. The pump is mounted on the engine gearcase by means of an adapter, and is driven by the idler gear through a gear carrier assembly. A spline on the pump shaft engages the internal splines on the gear carrier shaft coupling. The pump is a "gear-within-a-gear" design. With every revolution of the pump shaft a definite amount of oil is drawn into the pump through the suction port. The pump rotor, driven by the rotor shaft, in turn rotates the idler. As the teeth draw away from the rotor teeth, a suction is created which draws oil into the pump through the suction port. The space between the rotor teeth and the idler teeth is completely filled with oil which is then carried by the teeth past a crescent which devides the flow. As the teeth mesh again, oil is forced out of the discharge port and the meshed teeth form a barrier between the discharge and the suction ports.

REMOVING PUMP.

To remove the pump from the engine, do the following.

a. Remove the inlet and discharge piping as well as any other interfering piping or accessories.

b. Position a sling on the pump and attach to a chainfall and take up the slack.

c. Remove the capscrews that secure the pump to the adapter and pull the pump directly away from the engine until it is clear.

PART K – LUBRICATING OIL SYSTEM (Continued)

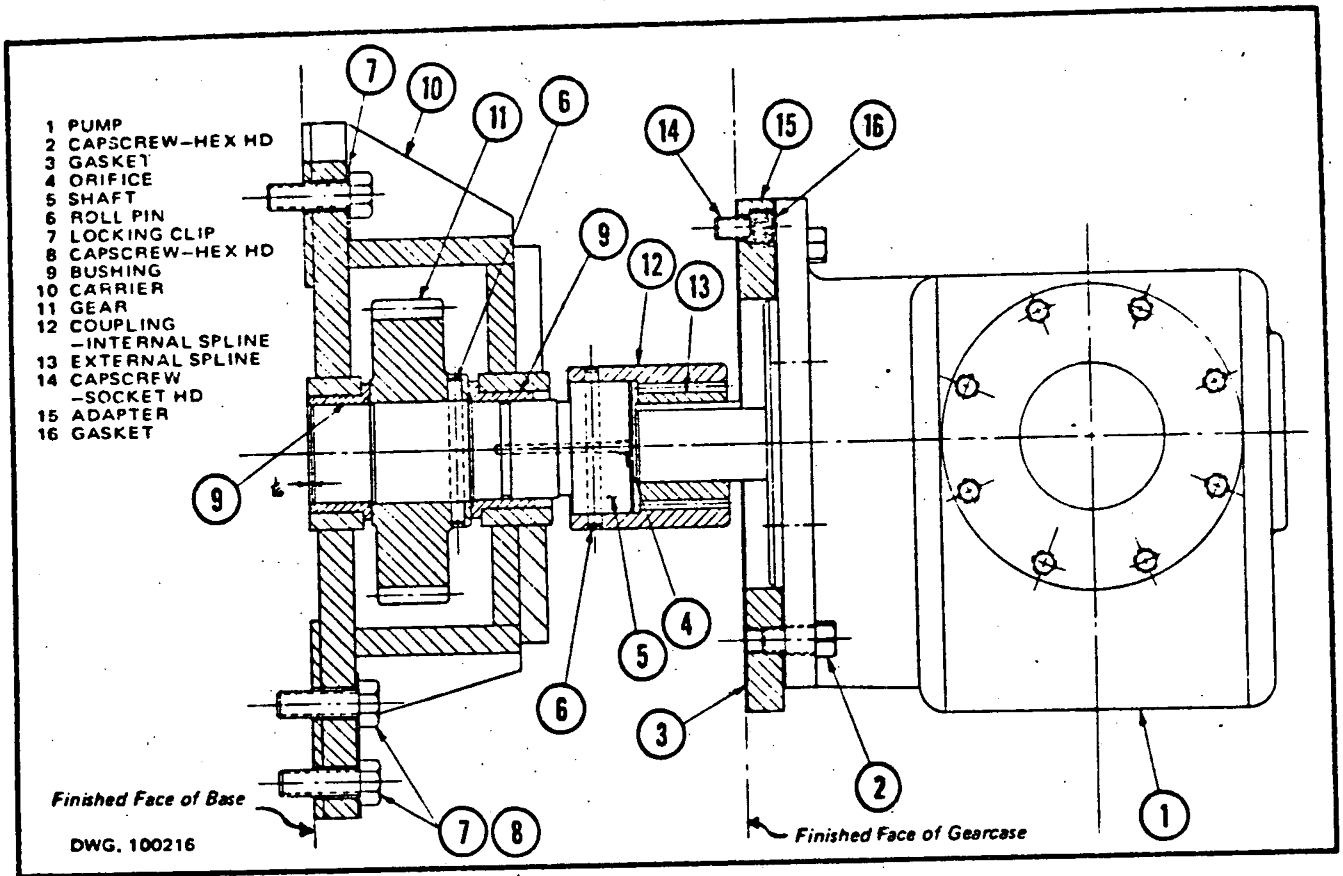


Figure 6-K-1. Lubricating Oil Pump Assembly

PUMP DISASSEMBLY (See Figure 6-K-1).

If it is necessary to disassemble the pump, exercise care to keep the parts clean so that no dirt, grit or other foreign matter will be present when the pump is assembled. Disassemble as follows.

a. Remove spline from pump shaft, taking care not to exert any internal forces on the pump parts.

b. Remove hex head screws from the faceplate end of the pump and remove the faceplate which contains two bearings.

c. Remove idler gear and shaft, then the drive gear and shaft.

d. Remove hex head screws from backplate end of pump housing and remove backplate which contains two bearings.

e. Carefully examine the surfaces of the gears. Slight burrs or feather edges may be removed with a hand stone.

f. Examine bearings and clean oil grooves and passages.

g. Remove burrs and foreign matter on gasketed surfaces of end plate and case.

h. Check bearing wear, using the table of clearances provided on next page.

TO BE REVISED

PART K – LUBRICATING OIL SYSTEM (Continued)

TABLE OF CLEARANCES
Roper Pump Company Figure 2877 Type 1

SHAFT OUTSIDE DIAMETER TO BEARING INSIDE DIAMETER*	
Bearing Inside Diameter	2.0050" – 2.0055"
Shaft Outside Diameter	2.0000" – 1.9995"
Diametric Clearance	0.0050" – 0.0055"
Maximum permissible operating clearance	0.0100"
NOTE: Wear can occur in bearing ID or shaft OD. Total of both not to exceed 0.010".	
GEAR OUTSIDE DIAMETER TO CASE BORE*	
Case Bore	5.667" – 5.669"
Gear Outside Diameter	5.658" – 5.657"
Initial Clearance	0.009" – 0.012"
PUMP LATERAL CLEARANCE**	
Case Width	8.751" – 8.750"
Gear Width	8.750" – 8.749"
Total Compressed Gasket Thickness	0.014" – 0.016"
Total Initial Lateral Clearance	0.018" – 0.014"

*Not considering roundness, concentricity and positioning tolerance.
**Not considering squarness, perpendicularity and positioning tolerance.

PUMP REASSEMBLY.

Assembly is the reverse of disassembly. The spline must be mated to the shaft without exerting any internal forces on the pump parts. The tapered end of the idler gear should be meshed to the opposite end of the drive gear. Taper ends are designated by the letter "T" appearing in the root area of the gear teeth.

INSTALLATION OF PUMP.

Before mounting pump on engine, make sure pump rotates freely. Mount pump to adapter, engaging dowel and the pump shaft spline with that of the gear carrier shaft. Use a gasket between the pump and the adapter. Assemble nuts on studs, and capscrews. Tighten. Lubricate pump through ports with any good grade of light weight oil to insure pump will not be dry at the time of initial starting. When installing piping, do not force as the strain imposed will cause undue wear on the pump. No external lubrication is required as the pump is self lubricated by the oil it pumps during operation.

PUMP GEAR CARRIER ASSEMBLY.

The pump gear carrier assembly consists of a shaft, supported by two bronze bushings, pressed in the carrier assembly with their flanges to the inside. The pump end of the shaft has an internally splined adapter, attached to the shaft with a roll pin, which accepts the spline on the pump shaft. The drive gear is mounted on the shaft between the two bushings and engages the idler gear. The carrier assembly is secured to the engine block by capscrews and locking clips.

PRELIMINARY
TO BE REVISED

PART K – LUBRICATING OIL SYSTEM (Continued)

DISASSEMBLY AND ASSEMBLY OF GEAR CARRIER ASSEMBLY.

To remove the pump gear carrier assembly, the pump must be removed as outlined above, then the gearcase removed.

a. Remove lubricating oil lines from carrier assembly.

b. Bend back locking clips and remove capscrews. Remove carrier assembly.

c. To remove gear, shaft and bushings from carrier assembly, remove gear-to-shaft roll pin then press shaft out of gear. With shaft and gear removed, press bushings out of drive bracket.

d. Assembly is the reverse of disassembly. Use new locking clips.

PRELIMINARY
TO BE REVISED

PART L – MISCELLANEOUS

CRANKCASE PRESSURE.

The crankcase is fully enclosed and theoretically air tight. To remove gases and vapors from the crankcase and to reduce the possibility of fresh air or oxygen being present, crankcase pressure is maintained at a level slightly below atmospheric, measured in inches H_2O by a standard U-type manometer. An electric motor driven blower draws off crankcases and vapor through a draw off pipe and an oil separator to maintain a negative crankcase pressure.

MANOMETER.

The U-type manometer is a primary standard for the measurement of pressure. No other device offers a higher degree of accuracy of result. The vertical distance between the two levels of fluid in the U-tube is a measurement of the difference in pressure between the two sides of the manometer. The difference may be expressed in linear units of the indicating fluid, such as inches of water or inches of mercury. Because the pressure being measured acts directly on the indicating liquid in the tube rather than through any mechanical devices, the column will respond directly and immediately to the slightest change in applied pressure. For example, if water is the indicating medium, a pressure change of one ounce per square inch will change the indicating levels approximately one inch. As standard scales are graduated in tenths of an inch, very accurate readings are possible.

MEASURING VACUUM.

Vacuum and pressure, in the sense used here, are the same thing, vacuum being merely the degree to which the pressure has been brought below atmospheric pressure. Vacuum is normally read in inches of mercury. If a vacuum pump were to be connected to one leg of a U-type manometer while the other leg remained open to atmosphere (see figure 6-L-1), the pressure on the pump side would be reduced as the pump works. Atmospheric pressure, then being the greater pressure, will force the column of mercury down on the open side and consequently, the column of the leg will rise. The resultant difference in the height of the column is the measure of vacuum in inches of mercury created by the pump.

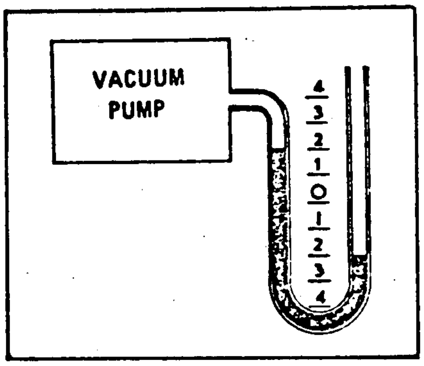


Figure 6-L-1. Manometer with Vacuum Pump

OPERATION AND MAINTENANCE.

With both legs of the manometer open to atmosphere as shown in figure 6-L-2, indicating fluid is placed in the tube until the level is at the center, or zero graduation of the scale. If the level of the two columns is less than zero, fluid should be added. If the reading is more than zero, fluid should be removed. Minor adjustments may be made by moving the scale to obtain an exact zero reading. Application of pressure to the right leg will force the fluid column down in the right leg and up in the left. The instrument is then read by noting the deflection from zero in both legs, then adding the two. In the case of the manometer illustrated on the right side of figure 6-L-2, the difference is the sum of two inches below zero and two inches above, or four inches.

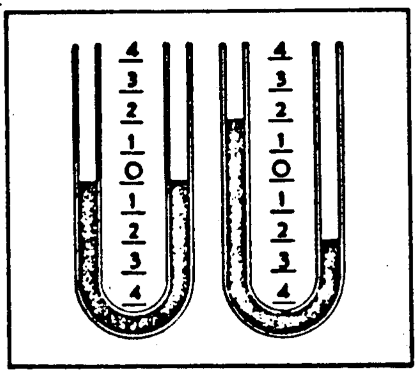


Figure 6-L-2. Reading Manometer

PART L – MISCELLANEOUS (Continued)

CRANKCASE VENTILATION SYSTEM.

If vapors and gases were allowed to accumulate in the crankcase they could be ignited by an abnormal condition within the engine with a resultant crankcase explosion. Such an explosion could cause serious damage to the engine, surrounding structures and to personnel. The crankcase ventilation system is designed to reduce the amount of fresh air and oxygen present in the crankcase and to minimize the possibility of an accidental hot spot from causing a crankcase flash or explosion. The system will also assist in indicating the general condition of the engine, particularly piston ring and liner wear. If piston ring and/or liner wear becomes excessive, piston blowby will cause a rise in crankcase pressure and, therefore, be evidenced by a change in the manometer reading towards a positive reading. A single motor driven blower is used to draw directly from the crankcase and discharges through an oil separator where oil vapors are removed. The discharge should be piped outside the building, or otherwise disposed of to prevent the presence of explosive vapors in the atmosphere surrounding the engine.

a. Air flowing through the separator passes through the filter element where any oil particles are trapped. The oil then drains down the side walls of the filter element to the bottom of the separator where it then drains back to the engine crankcase.

b. The blower motor is normally controlled by a pressure switch, actuated by lubricating oil pressure. The switch, sensitive to rising lubricating oil pressure, reaches a preset pressure during starts and the system is turned on. Refer to the control system drawings for the pressure at which the switch closes.

c. The filter element in the oil separator should be removed periodically and washed in a solvent. After washing, allow the element to dry before placing it back in the separator. Under normal conditions, the filter element should require cleaning no oftener than 1500 hours of engine operation.

d. Crankcase vacuum is controlled by an orifice in the discharge line. The orifice size is determined in the field at the time of installation to suit the specific conditions at the site by the Service Representative.

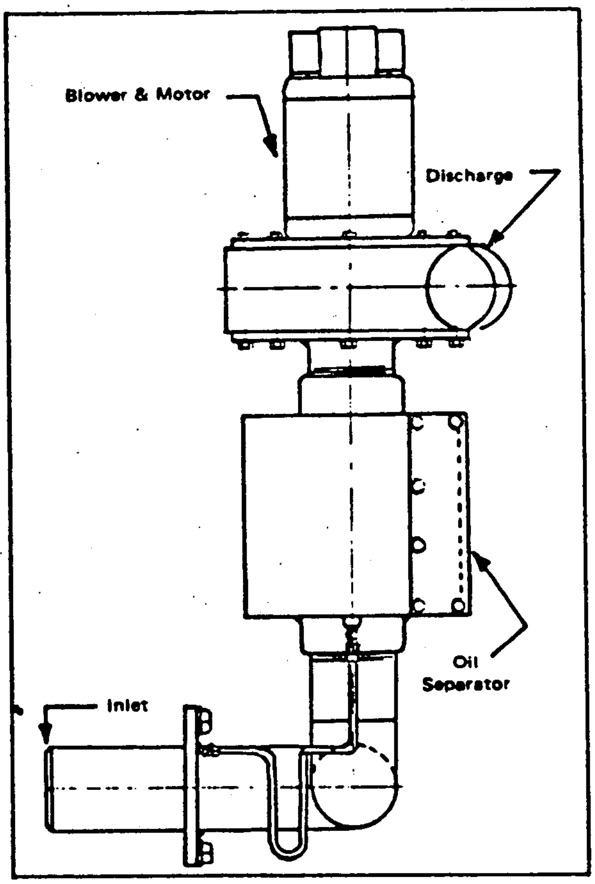


Figure 6-L-3. Crankcase Ventilation System

CRANKCASE VACUUM.

a. While operated at rated load and speed, crankcase vacuum of 0.2 to 0.5 in.-H_2O (0.508 to 1.27 cm-H_2O) should be maintained.

b. Crankcase vacuum readings must be carefully taken, logged hourly, and compared with past readings. In this way, gradual changes can be detected and investigated so that minor problems can be corrected before they reach major proportions. Should the logged readings indicate a loss in crankcase vacuum, the cause should be promptly determined and corrected.

PART L – MISCELLANEOUS (Continued)

c. Crankcase vacuum readings should be carefully observed during heavy load operations. Should the pressure go from a vacuum to a positive reading, the engine should be shut down immediately. The engine should never be operated with a positive pressure inside the crankcase as this indicates that the suction source for purging the crankshaft has been plugged and/or otherwise obstructed, or that some condition exists that is creating abnormal heat. If a hot spot develops in the engine and the oil flows or splashes over it a considerable amount of oil vapor will be formed. This vapor is explosive and the engine must be stopped immediately. Allow engine to rest for fifteen minutes to allow fumes and vapors to dissipate before removing any engine covers. Determine the cause and correct before continuing operation.

SECTION 7

TROUBLE SHOOTING

GENERAL.

Maintenance trouble shooting, to be effective, demands a sound knowledge of the engine in both a theoretical and a practical sense. The mechanic must analyze the causes and effects, and where the cause is not readily apparent, he must employ a fine sense of logic based upon the use of all tools available. Section 1 discussed preventive maintenance. The technique of that program is, to varying degrees, applicable to trouble shooting as well. To assist in determining the causes of improper performance, this section contains a listing of some of the more common engine malfunctions their probable causes and the logical remedies.

RECORDS.

All possible malfunctions and their probable causes cannot be accurately foreseen and recorded in advance. Each engine will develop and display characteristics which may not be common to all engines of the same model or type. Also, the same operator or mechanic will not always perform the trouble shooting and repair work. It is, therefore, suggested that the owner establish a detailed repair and trouble shooting record system. Each malfunction should be recorded in a readily usable form, listing the indications and findings for each malfunction encountered together with the repair action required. This record will be of assistance in determining the cause of any future malfunctions and will be a valuable training aid for all operators and mechanics.

TROUBLE	POSSIBLE CAUSE	ACTION
1. Engine fails to turn over when air start valve turned ON.	a. Air line valves closed.	Check air line valves.
	b. Air pressure too low.	Check pressu [illegible]. Check for clogged strainer.
	c. Air start valve leaking or stuck.	Release cylinder pressure by opening indicator cocks. Remove air start valve and examine.
	d. Air distributor timing (if so equipped).	Adjust timing.
	e. Power to control system OFF.	Turn ON.
	f. Camshaft not fully shifted.	Check and correct controls.
2. Engine turns on air but will not start.	a. Fuel line valve closed.	Open all fuel valves.
	b. Fuel low in day tank.	Fill tank.
	c. Air in fuel system.	Vent system by opening fuel pump bleeder screws.
	d. Fuel lines clogged.	Clean lines.
	e. Fuel filters plugged or dirty.	Clean filters.
	f. Water in fuel oil.	Drain and fill system with clean oil.
	g. Fuel control linkage sticking.	Free and lubricate.
	h. Fuel oil relief valve stuck open.	Free valve.
	i. Fuel oil shutdown cylinder not retracting.	One of the shutdown elements leaking air, or pneutrol orifice upstream of accumulator tank open — open and hold reset valve (if so equipped).
	j. Stuck valve	Free, clean and lubricate.
	k. Air intake blocked.	Check and clean line.
	l. Valves riding open.	Adjust valve clearance.
	m. Valve seats worn.	Reseat valves.
	n. Cylinder head gaskets leaking.	Replace with new gaskets.
	o. Piston rings stuck.	Replace rings as required, using oversized rings if necessary. Replace liners if scored or worn.
3. Running engine slows or stops.	a. Fuel low in day tank.	Fill tank.
	b. Water in fuel oil.	Drain and fill with clean oil.
	c. Fuel filters plugged and dirty.	Clean filters.
	d. Engine overloaded.	Reduce load.
	e. Exhaust line restricted.	Clear obstruction.
	f. Intake air blocked.	Check and clear line.
	g. Piston seized.	Actual piston seizure makes a high pitched, squeking noise. *Stop engine immediately.* Check pistons, liners and cooling system.
	h. Safety shutdown system.	Check indicators and investigate.
4. Engine fires irregularly when running.	a. Low fuel in day tank.	Fill tank.
	b. Air in fuel system.	Vent system by opening fuel pump bleeder screws.
	c. Water in fuel oil.	Drain and fill with clean oil.
	d. Fuel lines clogged.	Clean lines.
	e. Fuel filters plugged and dirty.	Clean filters.
	f. Fuel nozzle stuck, clogged, damaged or worn.	Replace with spare and examine.
	g. Injection tube connectings leaking.	Clean joints and tighten.
	h. Fuel nozzle bleeder valve open.	Close valve.
	i. Injection pump dirty, damaged or worn.	Replace with spare and examine.
	j. Injection pump out of time.	Adjust timing.
	k. Injection pump delivery out of balance with others.	Check exhaust temperatures of all cylinders until temperatures are within 50° F of one another.
	l. Lack of compression.	See paragraph 2 above.
	m. Excessive manifold air pressure.	Reduce pressure.

TROUBLE	POSSIBLE CAUSE	ACTION
5. When running, engine has black exhaust.	a. Fuel nozzle stuck, clogged, damaged or worn.	Replace wit! spare and examine.
	b. Injection pump out of time.	Adjust timing.
	c. Injection pump delivery out of balance with others.	Check exhaust temperatures of all cylinders. Adjust control linkage until temperatures are within 50° F of each other.
	d. Air intake blocked.	Clear.
	e. Engine overloaded.	Check load. Reduce if necessary.
6. Engine has smoky (blue) exhaust.	a. Piston rings stuck.	Free, clean ring grooves and oil drain holes.
	b. Piston rings or liners worn.	Replace rings as required. If necessary, use oversized rings. Replace liners if scored or worn.
	c. Loss of lubricating oil.	Check piston rings, ring grooves and liner.
	d. Crack or hole in piston.	Replace piston.
7. Engine knocks while running.	a. Fuel nozzle stuck, clogged, damaged or worn.	Replace with spare and examine.
	b. Injection pump out of time.	Adjust timing.
	c. Poor grade of fuel being used.	Check specifications of fuel being used against standard.
	d. Defective fuel tappet.	Check, replace worn parts.
	e. Piston loose in liner.	Shut off fuel to suspected cylinder. If knock decreases, check piston and ring clearances. Replace worn parts.
	f. Loose piston pin or pin bushing.	Place piston at bottom dead center. With pry bar, check piston for loose fit. Replace pin or bushing as necessary.
	g. Bad connecting rod bearing.	Check clearances.
	h. Defective main bearings.	Check clearances.
8. Low lubricating oil pressure.	a. Low oil level in sump.	Add oil.
	b. Lubricating oil suction clogged.	Check and clean.
	c. Loose piping.	Check and tighten as necessary.
	d. Loaded filter elements.	Clean or replace.
	e. Sticking relief valve.	Free and clean valve.
	f. Defective lubricating oil pump.	Inspect pump. Repair or replace.
	g. Relief valve set too low.	Adjust.
	h. Loose or worn bearings.	Check clearances.
9. Excessive lubricating oil pressure.	a. Relief valve stuck.	Free and clean.
	b. Dirty lubricating oil cooler or filter.	Clean.
	c. Relief valve improperly adjusted.	Adjust.
10. High jacket water inlet temperature	a. Jacket water pressure low.	Check and tighten connections.
	b. Air in water system.	Check water pump — bleed air.
	c. Pump suction or discharge clogged.	Check and clean.
	d. Pump airbound.	Open vents on pump or on top of suction.
	e. Water passage clogged with scale.	Clean with recognized solvent.
	f. Inadequate heat exchanger coolant.	Inspect and clean as necessary.
	g. Dirty heat exchanger.	Inspect and clean.
	h. Engine overloaded.	Reduce load.
	i. Loose piping.	Check and tighten.
	j. Inadequate raw water supply.	Check.
	k. Vapor phase system (if so equipped) defective.	See Manufacturer's Instructions in *Associated Publications Manual.*
11. Excess vibration	a. Cylinder misfiring.	Check fuel injector nozzles, fuel pump, gas admission valve, cylinder fuel cutoff.
	b. Stuck valve.	Free, re-face and re-seat, or replace.
	c. Mechanical problems.	Investigate all systems and auxiliaries.
12. Excessive exhaust temperatures, all cylinders.	a. Engine overloaded.	Reduce load.
	b. Low manifold air pressure.	Increase pressure.
	c. Piston sticking.	Remove, clean, check clearances.
	d. Bearing failure.	Inspect and check clearances.
	e. Dirty air cleaner.	Clean.
13. Unequal exhaust temperatures (wide spread with engine loaded).	a. High air manifold air pressure.	Reduce pressure.
	b. Valve leakage.	Check valves, grind and re-seat.
	c. Fuel injection pump out of adjustment.	Adjust.

TROUBLE	POSSIBLE CAUSE	ACTION
14. Rising exhaust temperature in one cylinder.	a. Gas admission valve. b. Burned exhaust valve.	Check and adjust valve. Replace valve.
15. High pre-turbine exhaust temperature.	a. Engine overloaded. b. Low manifold air pressure. c. Piston sticking. d. Bearing failure. e. Dirty air cleaner.	Reduce load. Increase pressure. Remove, clean, check clearances. Inspect and check clearances. Clean.
16. Low exhaust temperature in one cylinder.	a. Obstruction in gas supply. b. Gas cutoff in header closed.	Check lines and clear. Open cutoff.
17. Erratic speed variations (hunting).	a. Injection pump improperly timed. b. Injection nozzle tip clogged. c. Injection nozzle improperly adjusted. d. Injection pump plunger stuck. e. Oil level in governor low. f. Fuel oil pressure low. g. Fuel control regulator. h. Governor or linkage sticking.	Time pump. Clean nozzle. Adjust. Free plunger. Fill governor. Increase pressure. Check and adjust regulator. Refer to manufacturer's instructions. Lubricate linkage with engine oil.
18. Constant engine speed fluctuation.	a. Governor. b. Linkage. c. Speed signal air pressure.	See manufacturer's bulletins. Clean and lubricate with engine oil. Check system and air supply.
19. Excessive venting and/or vapors from vent holes in each end of starting air header.	a. Leaking air start valves.	Check valves, repair or replace.
20. Low jacket water pressure.	a. Defective water pump. b. Water pump airbound.	Check and repair. Bleed air.
21. Low raw water pressure.	a. Defective water pump. b. Air in system. c. Dirty strainer.	Check and repair. Bleed air. Clean.
22. Low compression pressure.	a. Worn piston rings. b. Burned valves. c. Valve tappets improperly adjusted.	Replace. Replace. Adjust valve clearance.
23. Low fuel oil pressure	a. Dirty filters or strainers. b. Relief valve stuck open. c. Defective pump. d. Air leak in suction line.	Check and clean. Free and check. Check and repair. Repair.
24. Excessive lubricating oil consumption.	a. Worn piston rings or liners. b. Leak in sump or piping.	Check clearance — Replace if clearance is excessive. Repair.
25. Loss of crankcase vacuum.	a. Faulty manometer indications. b. Blower motor defective c. Defective pressure switch. d. Loose electrical connection. e. Air leak around cylinder head covers. f. Air leak at fuel line entrance to cylinder head sub covers. g. Air leak past valve guides. h. Piston blowing by. i. Lubricating oil fuming. **WARNING** This heavy vapor is very explosive and the engine should be stopped immediately. Allow to rest for 15 minutes to allow fumes and vapors to dissipate before removing any engine covers.	Check tubing for leaks or obstructions. Repair or replace. Replace. Repair. Check for gasket condition and that cover is tightened evenly. Check grommet and fuel line gaskets. Check clearances. Check for stuck piston rings. Check for excessive piston ring wear. Check for hot spots.

TROUBLE	POSSIBLE CAUSE	ACTION
26. No fuel pump delivery or insufficient delivery.	a. Fuel tank empty or valve in line closed.	Refill tank with fuel. Check whether transfer pump delivers fuel to tank. Open all valves in line.
	b. Fuel inlet pipe clogged or third stage filter element dirty.	Clear pipe. Clean filter element.
	c. Air lock in pump.	Vent pump and nozzle.
	d. Pump plunger remains suspended in barrel.	Thoroughly clean all parts, particularly plunger and barrel. If either are damaged, replace both with spares.
	e. Plunger spring broken.	Replace with spare.
	f. Delivery valve does not seat properly.	Clean delivery valve and seating. If either are damaged, replace with spares.
	g. Delivery valve spring broken.	Replace with spare.
	h. Leakage back to suction chamber from surfaces between top of barrel and delivery valve seat.	Clean faces. Remove burrs and scratches from delivery valve seat and barrel.
	i. Worn or defective plunger or barrel.	Replace with spare.
	j. Dirt causes pump plunger to jam, or control rod rack is coated with dirt.	Dismantle and clean.
	k. Supply connection leaks.	Install new gasket or replace connection if damaged.
	l. Leakage past spring guide caused by worn plunger or improper seal of barrel in main body.	Replace defective parts with spares.
	m. High pressure connection leaks.	Install high pressure tube only on the cylinder for which it was factory fitted. Replace line if cone is damaged.
27. Injection nozzle valve sticking.	a. Dirt in nozzle.	Remove and clean nozzle.
	b. Poor lubricating qualities in fuel oil.	*Change to fuel or proper specifications.
	c. Nozzle body and valve corroded or eroded due to acid, water or dirt in fuel oil.	Replace nozzle body and valve with spares. Check fuel and filters.
	d. Joint between nozzle holder and nozzle not tight.	Clean faces. Remove burrs and scratches from nozzle body and holder.
	e. Nozzle valve worn and loose in nozzle body.	Replace nozzle body and valve with spares. Check fuel and filters.
	f. Nozzle valve stuck in closed position or nozzle orifices closed.	Remove and clean nozzle.
	g. Carbon deposits on nozzle.	Clean nozzle.
		*Check fuel being used for conformance to approved specifications. Introduce additive in fuel if recommended.

SECTION 8

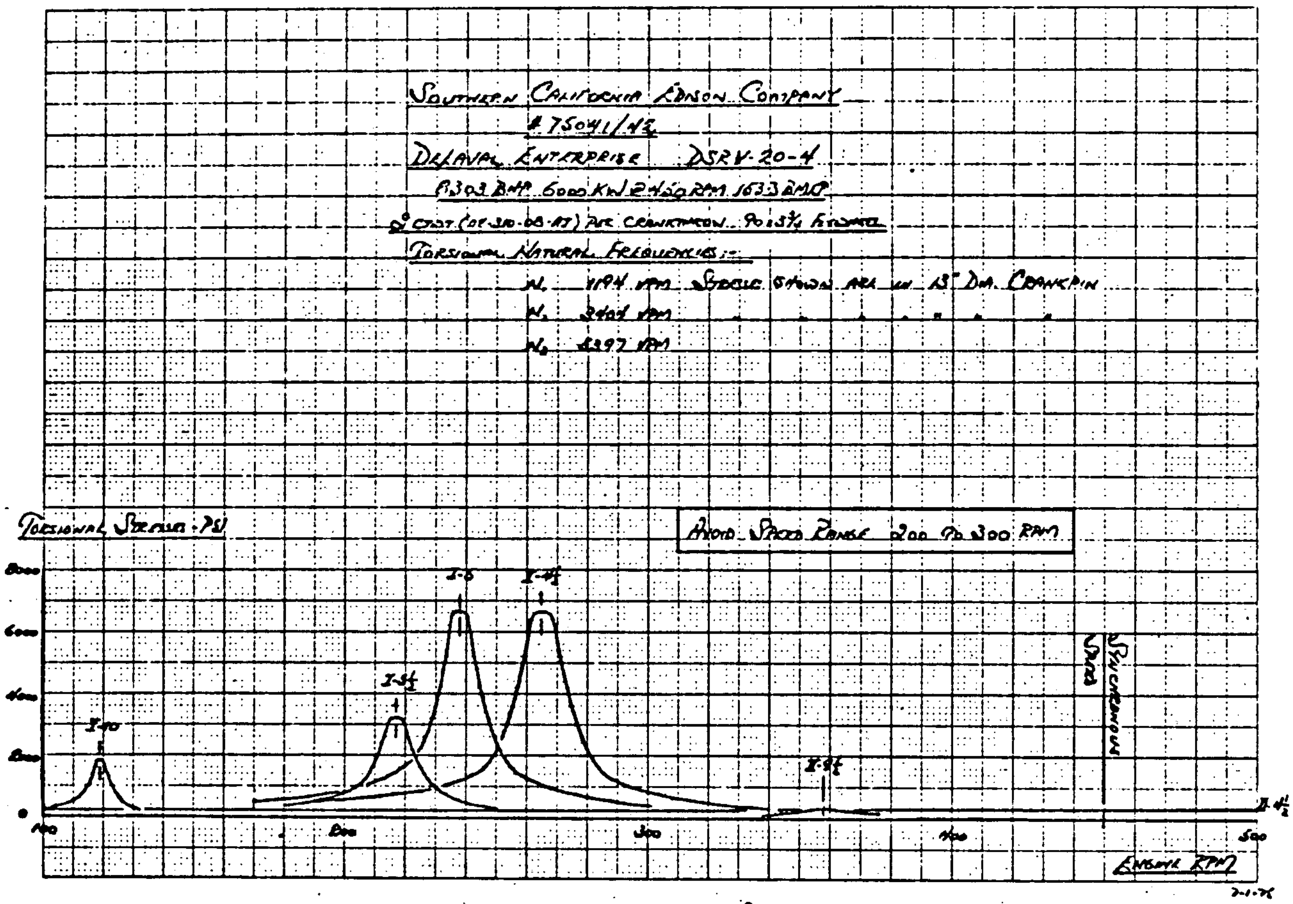
APPENDICES

The purpose of this section of the manual is to provide a single location for specific data which, if located within the body of the manual, would be more difficult to locate. As a general rule, specific values have been omitted from the text and, where appropriate, reference is made to the applicable appendix. The following appendices are contained in this section.

Appendix I	Torsional Stress and Critical Speeds
Appendix II	Operating Temperatures and Pressures
Appendix III	Table of Clearances
Appendix IV	Torque Values
Appendix V	Timing Diagram
Appendix VI	Lubricating Oil Recommendations
Appendix VII	Alarms and Safety Shutdowns
Appendix VIII	Fuel Oil Recommendations
Appendix IX	Power Engine Factory Test Logs

APPENDIX I

TORSIONAL STRESS AND CRITICAL SPEEDS



APPENDIX II

OPERATING PRESSURES AND TEMPERATURES

PRESSURES

The following pressures should be present for starting:

Starting Air Supply	250 psi	17.6 kg/sq cm
Starting Air Header	250 psi	17.6 kg/sq cm

While running at rated speed, the operating pressures should be as follows:

	psi	in.-hg	kg/sq-cm
Lubricating Oil*	45 – 55	91.6 – 112.0	3.16 – 3.87
Lubricating Oil at Turbocharger Inlet	25 – 35	50.9 – 71.26	1.76 – 2.46
Jacket Water	10 – 30	20.4 – 61.1	0.70 – 2.11
Fuel Oil	20 – 30	40.7 – 61.1	1.40 – 2.11

TEMPERATURES

While running under rated load, the outlet temperatures should be as follows:

Lubricating Oil out of Engine*	170° F – 180° F (76.6° C – 82.2° C)
Jacket Water out of Engine	170° F – 180° F (76.6° C – 82.2° C)

EXHAUST TEMPERATURE

The exhaust temperatures shown on the title page are the average for all cylinders during factory test under local ambient conditions. Temperatures in the field, therefore, may exceed this average temperature.

Pressures and temperatures listed are established as a guide to proper operation. They should be held within plus or minus 10 percent. Sudden changes in reading require immediate investigation and correction.

*With SAE 40 lubricating oil in engine.

APPENDIX III

TABLE OF CLEARANCES
MODEL RV ENGINE

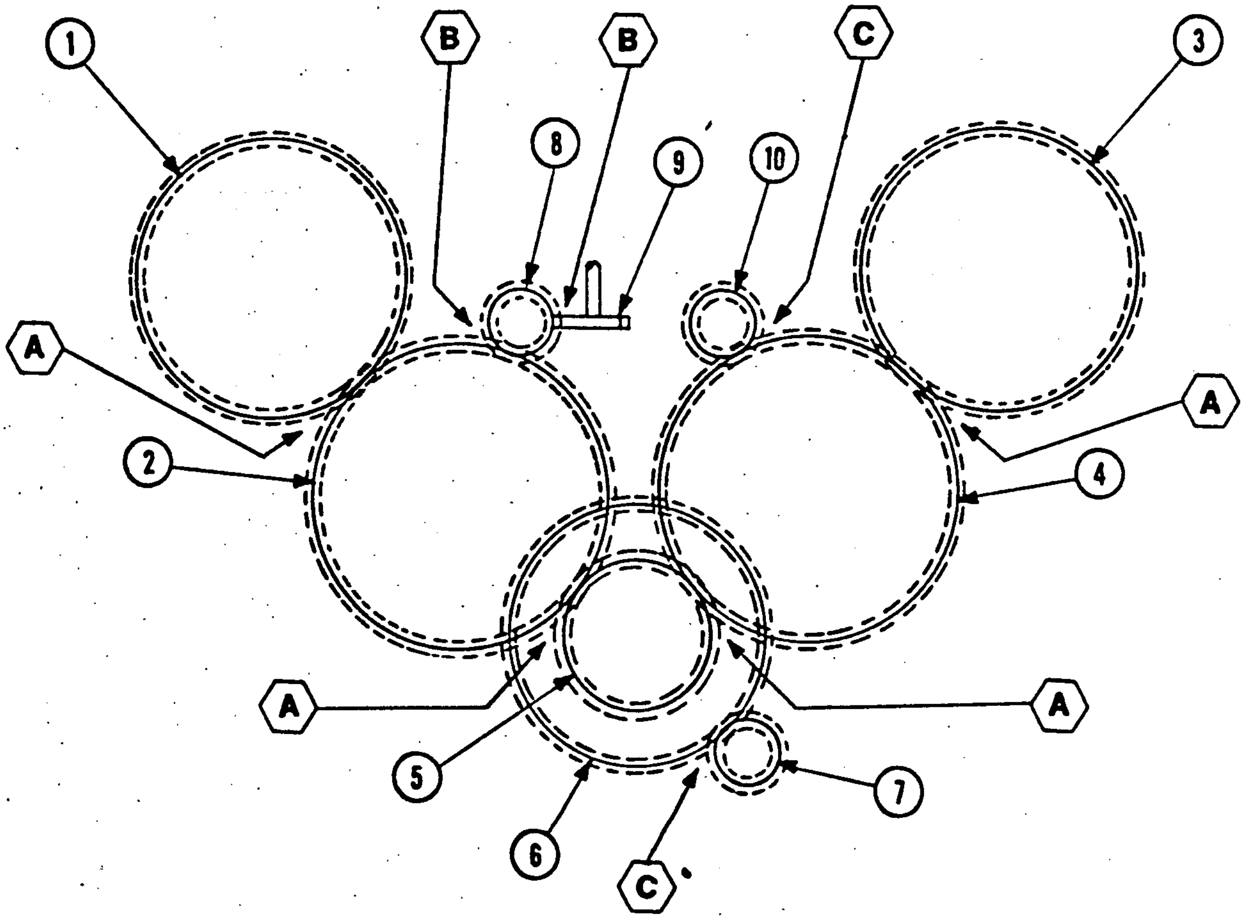
Position	Clearance When New				Replace When Over		Notes
	Minimum		Maximum				
	Inches	Centimeters	Inches	Centimeters	Inches	Centimeters	
Intake valve in guide	0.0035	0.009	0.005	0.013	0.025	0.063	(1)
Exhaust valve in guide	0.0055	0.014	0.007	0.018	0.025	0.063	(1)
Air valve piston	0.0055	0.014	0.0075	0.019	----	----	(1)
Rocker arm bushing on shaft	0.002	0.005	0.0035	0.009	0.010	0.025	(1)
Tappet in guide	0.002	0.005	0.004	0.010	0.015	0.038	(1)
Tappet roller on pin	0.0015	0.004	0.0030	0.008	0.005	0.013	(1)
Conrod link pin to bushing	0.0039	0.010	0.0085	0.022	0.012	0.031	(1)
Idler gear bushing on shaft	0.003	0.008	0.005	0.013	0.010	0.025	(2)
Idler gear bushing to bracket thrust face	0.005	0.013	0.009	0.023	0.012	0.031	(2)
Piston pin in piston	Push fit at 70° F (21.1° C)				0.002	0.005	(1) or (2)
Piston pin in bushing	0.0095	0.024	0.0105	0.027	0.020	0.051	(1) or (2)
BEARING SHELLS*							
Main bearing to crankshaft	0.012	0.031	0.0164	0.042	0.614	0.042	(1)(4)(5)
Rear main thrust bearing	0.022	0.056	0.030	0.076	0.611	1.552	(2)
Conrod bearing to crankshaft	0.011	0.028	0.0154	0.039	0.616	0.041	(3)(6)
Camshaft bearing to camshaft	0.0035	0.009	0.0065	0.017	0.193	0.490	(1)(4)(5)
SKIRT CLEARANCE IN LINER							
Top (land tapered)	0.120–0.074	0.305–0.188	0.126–0.077	0.320–0.196	----	----	(1) or (2)
Bottom (skirt)	0.018	0.046	0.021	0.053			(1) or (2)
Liner bore	----	----	----	----	17.060	43.332	(1)
PISTON RING GAP CLEARANCES							
Top compression rings	0.090	0.229	0.115	0.291	0.200	0.508	(2)
Intermediate compression rings	0.075	0.191	0.100	0.254	0.200	0.508	(2)
Oil control rings	0.040	0.102	0.065	0.165	0.200	0.508	(2)
PISTON RING SIDE CLEARANCE IN GROOVE							
Top compression rings	0.008	0.020	0.011	0.028	0.020	0.051	(2)
Intermediate compression rings	0.006	0.015	0.009	0.023	0.020	0.051	(2)
Oil control rings	0.004	0.010	0.007	0.018	0.020	0.051	(2)

Notes:
(1) Use micrometer and snap gauges.
(2) Use feeler gauge.
(3) Use dial indicator (bump test).
(4) Use plasta-gauge.
(5) Measure at bottom of lower shell.
(6) Measure at top of upper shell.

*Bearing replacement figures are based upon wall thickness, measured as indicated by note.

APPENDIX V-1

GEAR SET AND BACKLASH CLEARANCES
MODEL RV ENGINE



ITEM	DESCRIPTION	GPL
1	CAMSHAFT GEAR, LEFT HAND	350
2	IDLER GEAR, LEFT HAND	355
3	CAMSHAFT GEAR, RIGHT HAND	350
4	IDLER GEAR, RIGHT HAND	355
5	CRANKSHAFT GEAR	310
6	LUBRICATING OIL PUMP DRIVE GEAR	365
7	LUBRICATING OIL PUMP DRIVEN GEAR	420
8	GOVERNOR & TACHOMETER DRIVE GEAR	411
9	GOVERNOR DRIVE AND DRIVEN GEAR	411
10	FUEL OIL PUMP & OVERSPEED TRIP DRIVE GEAR	410

POS	BACKLASH	
	INCHES	CENTIMETERS
A	0.008 – 0.010	0.020 – 0.025
B	0.004 – 0.006	0.010 – 0.015
C	0.005 – 0.008	0.013 – 0.025

APPENDIX IV

TORQUE VALUES
Model RV Engine

The torque values listed below are based upon the use of the lubricant specified on page 5-7 under "Torque Wrench Tightening Procedures". All values are given both in foot pounds and in kilograms per meter. Where applicable, bolt sizes are shown in parenthesis.

Item		Torque ft-lb	Torque kg-m
NUT, Foundation Bolt (heat treated steel*)		3800	525.6
NUT, Main Bearing Cap Stud (1¾")**		3000	415
NUT, Base to Crankcase Thru-Bolt		7000	968
CAPSCREW, Crankcase to Base (1")		285	39.4
NUT, Cylinder Block to Crankcase Thru-Bolt (2½")		4500	622
" " " " " " " (2")		3000	425
NUT, Connecting Rod Bolt (1½")		1600	221.3
" " " " (1-7/8")		1800	248.9
BOLT, Link Connecting Rod to Link Pin (1¼")		735	101.5
" " " " " " " (1-1/8")		1050	145.2
NUT, Cylinder Head Stud (2-8NC)**		3300	456.4
NUT, Spark Plug Tube Retainer	Minimum	60	8.29
	Maximum	65	8.98
NUT, Fuel Injection Nozzle Retainer	Minimum	75	10.37
	Maximum	80	11
NUT, Fuel Pump Stud		80	11
CAPSCREW, Fuel Pump Base (Allen)		120	16.6
NUT, Camshaft Bearing Cap Stud		200	27.6
CAPSCREW, Idler Gear Mount Bracket		120	16.6
NUT, Flywheel Bolt		4500	622.3
NUT, Crankshaft Counter Weight		1000	138
CAPSCREW, Rocker Shaft		365	50.5
CAPSCREW, Sub-Cover to Cylinder Head		120	16.6

*Heat treated bolts are identified by the figure "4" stamped on end of bolt.
**Not applicable if pre-stressing method is used.

GENERAL TORQUE VALUES

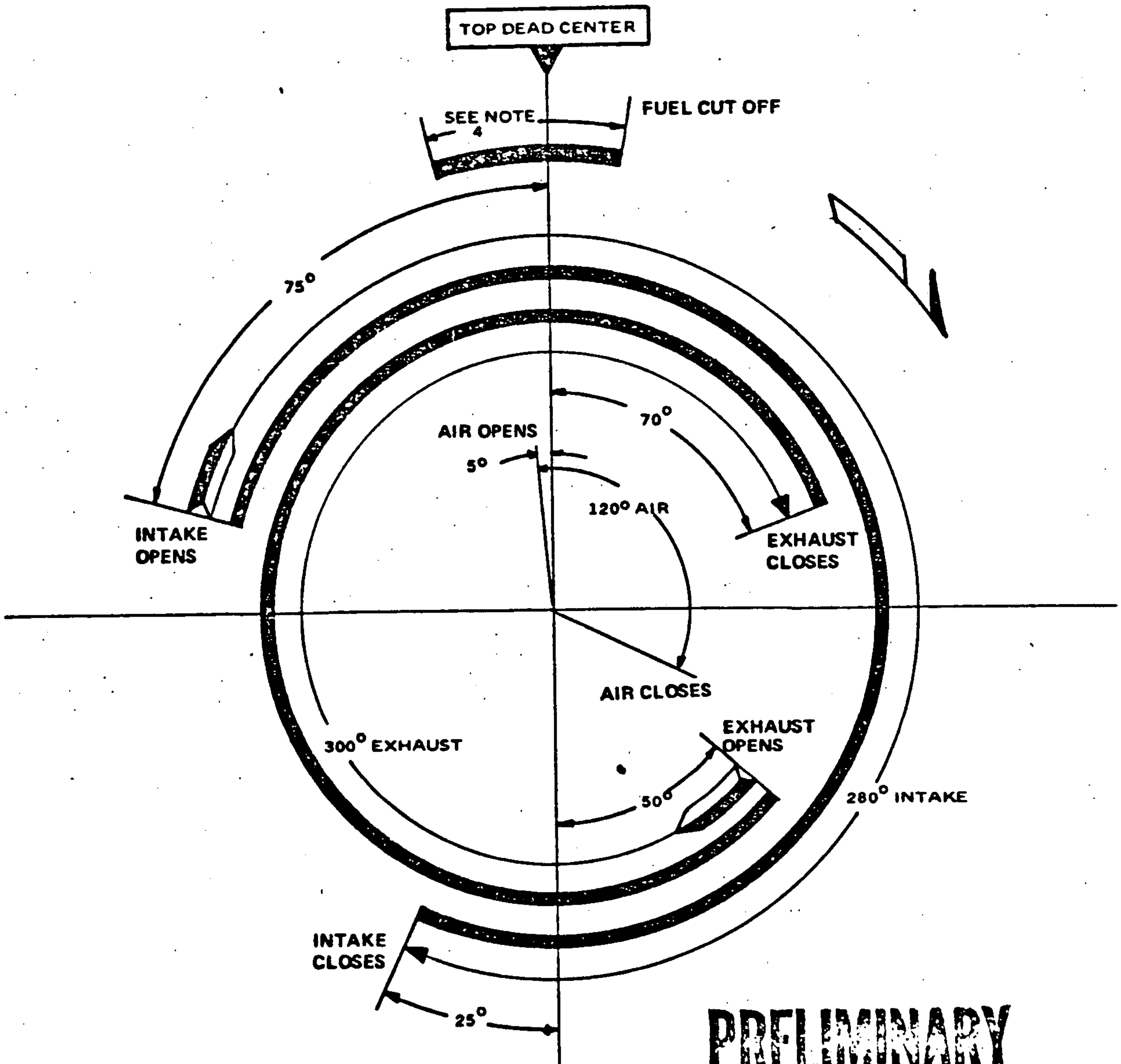
The torque values given on the preceeding page are for specific applications and are to be used. The following torque values are for general application where no specific values are given.

Bolt Size & No. Threads	Torque (ft-lb)	Torque (Kg-m)
3/8–16	12	1.66
3/8–24	15	2.08
1/2–13	30	4.15
1/2–20	35	4.74
5/8–11	60	8.29
5/8–18	70	9.68
3/4–10	100	13.83
3/4–16	115	15.90
7/8–9	160	22.13
7/8–14	180	24.89
1–8	245	33.78
1–14	290	40.11
1-1/8–7	335	46.33
1-1/8–8	355	48.00
1-1/8–12	395	54.53
1-1/4–7	480	66.38
1-1/4–8	500	69.15
1-1/4–12	550	76.07
1-3/8–6	620	85.75
1-3/8–8	680	94.04
1-3/8–12	745	103.03
1-1/2–6	735	101.65
1-1/2–8	800	110.64
1-1/2–12	865	119.63

APPENDIX V

TIMING DIAGRAM

MODEL	TYPE		FUEL
R-8, RV-16, RV-20	Hydraulic Lifters - Long Duration Exhaust Cams		DIESEL
INTAKE CAM		EXHAUST CAM	ROTATION
02-350-04-0T		02-350-06-AF	CLOCKWISE



PRELIMINARY
TO BE REVISED

NOTES:
1. Diagram is in crankshaft degrees.
2. See Engine Data Sheet in front of manual, or engine nameplate for firing order.
3. See engine nameplate for cylinder and bank designation.
4. See Engine Data Sheet for diesel fuel injection point.

APPENDIX VI

LUBRICATING OIL RECOMMENDATIONS

The DELAVAL Engine and Compressor Division does not recommend lubricants by brand name. The final measure of the quality of an oil is its performance in service. The lubricant supplier must work with the fuel oil supplier to insure the use of the proper lubricant. *The consistent quality and performance of a suitable heavy duty oil must, therefore, be the responsibility of the company making the lubricant.*

CAUTION

It must be the concern of the operator to consult with the oil supplier concerning the proper selection of a lubricant which will perform compatibly with the type of fuel to be used in order to insure the most satisfactory performance and life with overall economical operation. In the case of unresolved questions, the DELAVAL Engine and Compressor Division should be consulted.

To determine the condemning limits for oil in service, have the oil supplier take representative samples at regular intervals for oil analysis. His recommendations, then, for either further service or for condemnation will be based on qualitative factors. The following applies to new oil only.

RECOMMENDED LUBRICATING OIL CHARACTERISTICS

SAE GRADE 40 OIL

	Maximum	Minimum
Viscosity Index (ASTM D567)	–	70
Gravity, A.P.I. at 60°F (25.6° C) (ASTM D287)	30	20
Flash Point °F (ASTM D92)	–	425 (218° C)
Pour Point °F (ASTM D97)	–	10 (5.6° C) below coldest oil starting temperature

OIL RECOMMENDATIONS

DUAL FUEL ENGINES: Use low ash lubricating oil of the following specifications.

Engines rated 205 bmep and below – API/SAE Classification "CC" or better.

Engines rated 206 bmep and above – API/SAE Classification "CD" or better.

DIESEL ENGINES (Using fuel oil with less than 1.05% sulfur):

Engines rated 205 bmep and below – API/SAE Classification "CC" or better.

Engines rated 206 bmep and above – API/SAE Classification "CD" or better.

HEAVY FUEL ENGINES:

Engines using fuel oil with less than 1.5% sulfur – Use classification "CD" oil only.

Engines using fuel oil with more than 1.5% sulfur – Use classification "CD" lubricating oil, worked out for high sulfur service in conjunction with lubricating oil supplier.

APPENDIX VII

ALARMS AND SAFETY SHUTDOWNS

The following sensed parameters will initiate an alarm and/or an automatic safety shutdown as indicated.

	ITEM	ALARM SETTING	SHUTDOWN SETTING
TEMPERATURES	Jacket water (outlet)		200° F rising
	Engine lubricating oil		200° F rising
	Engine main bearings		228° F rising
	Jacket water	X	
	Stator winding	X	
	Lubricating oil	X	
PRESSURES	Engine lubricating oil	40 psi falling	30 psi falling
	Turbocharger lubricating oil	20 psi falling	15 psi falling
	Crankcase pressure		High
	Engine fuel oil	20 psi falling	
	Engine fuel oil filter △ P	15 psi rising	
	Lubricating oil filter △ P	20 psi rising	
	Transfer line G74A, G74B (G75A, G75B)	Owner's Equip.	
	Starting air	210 psi falling	
	G74A, G74B (G75A, G75B) strainer △ P	Owner's Equip.	
	Instrument Air Receivers	Low	
	Engine overspeed (10% above rated speed)		495 rpm rising #
OTHER	Generator 4160 V bus breaker	Tripped	
	Generator Differential		Existing #
	MCC Switchgear	Tripped	
	Lockout Relay	Trip position	
	Generator	Under Freq.	
	Engine	Tripped	
	Motor feeder	Tripped	
	Day tank level	H/H or L/L	
	Crankcase door	Open	
	Jacket water level	Low	
	Lubricating oil day tank level	High	
	Storage tank level	Low	
	Engine vibration		Excessive
	Overcurrent with voltage restraint	Existing	

These are only trips operative when unit running in response to an emergency start diesel signal from owner's equipment.

APPENDIX VII (Continued)

	ITEM	ALARM SETTING	SHUTDOWN SETTING
OTHER	Field excitation	Loss of	
	Stator Ground	Present	
	Direct current bus	Low voltage	
	Phase sequence	Negative	
	Fuel pump/overspeed drive	Failure	
	Direction power	X	
	Battery charger	Failure	
	Generator	Over excitation	
	Generator	Over voltage	
	Voltage balance	X	
	Exciter semi conductor	Failure	
	Lubricating oil standby pump	ON	
	Space heater	Trouble	
	Switchgear switch 3, DC	Under voltage	
	Direct current bus 1	Ground	
	Missile resistant doors	Open	
	Direct current bus 1 (or 2)	DC/ACB tripped	
		or low voltage	
	Unit in maintenance	Yes	
	Fire protection system	Activated	
	Alarm contacts	Grounded	
	Panel rear doors	Open	
	Drainage sump level	High or H/H	
	Diesel generator battery room	Below 60° F	
	Barring device	Engaged	

APPENDIX VIII

FUEL OIL SPECIFICATIONS

	Maximum	Minimum
Viscosity, S.S.U. at 100° F	45	32
*Gravity, Deg. A.P.I.	38	26
Sulphur, %	1.05	–
Sulphur, Corrosion Test (Copper Strip, 3 hrs. at 212° F)	Pass	Pass
Conradson Carbon, %	0.20	–
Ash, %	0.10	–
Water & Sediment, %	0.50	–
Flash Point, ° F (P.M.C.C.)		150 or legal
Pour Point, at least 10° F below coldest fuel oil temperature		
DISTILLATION, ° F		
90% Point	675	
IGNITION QUALITY		
Cetane Number		40

*Heat Value – determine from A.P.I. gravity limits shown to determine total or net Btu/lb or gallon.

The above specification covers fuel oils classed as Grade F.S. No. 2.

Fuels heavier than the above can be burned in Enterprise engines provided proper treating and pre-heating facilities are available. In the event it is desirable to use such fuels, DELAVAL Engine and Compressor Division should be consulted for advice as to the arrangements that need to be made. An analysis of the particular fuel to be used must be provided.

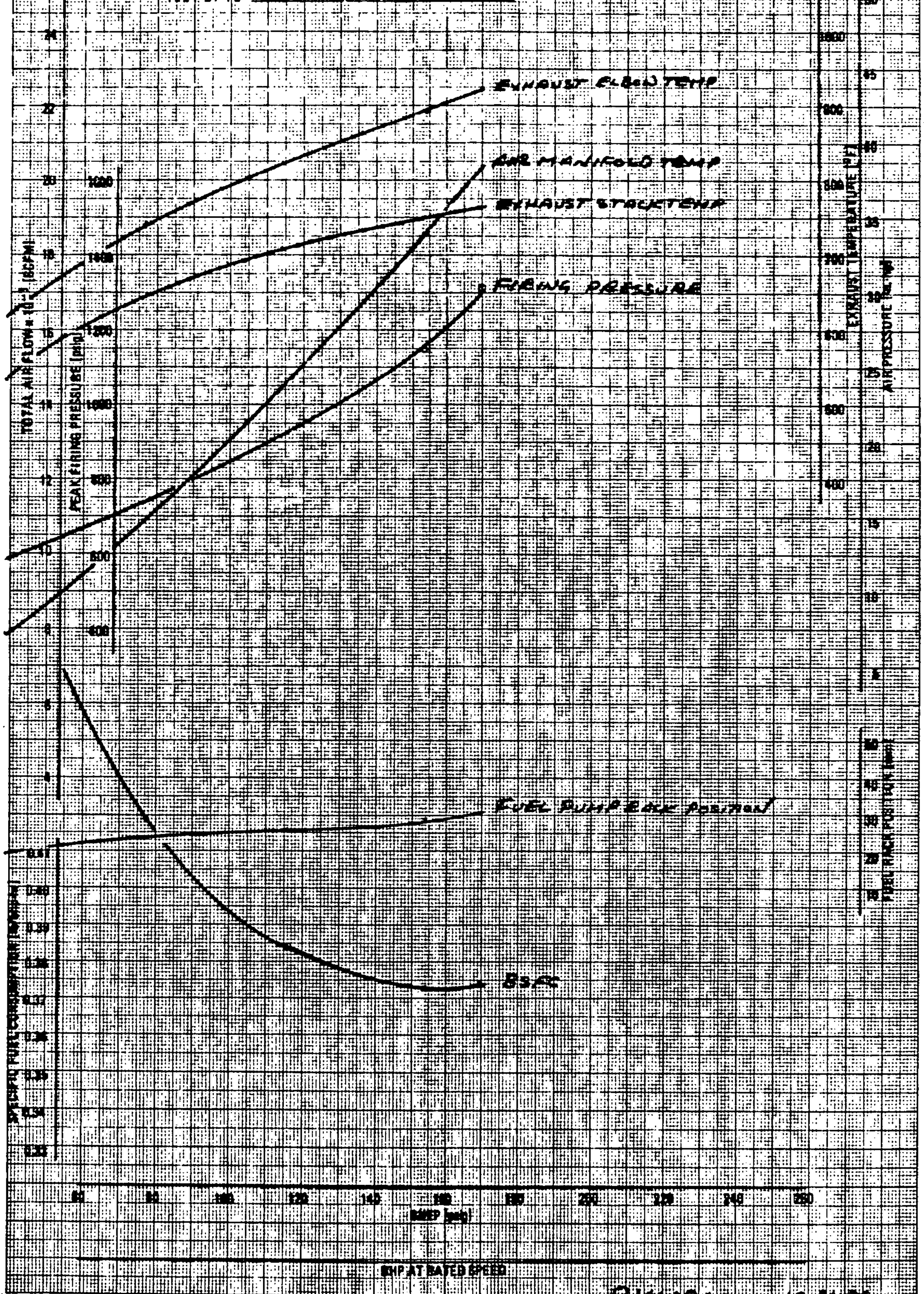
For lubricating oil recommendations, refer to Section 2, Page 5.

APPENDIX IX

POWER ENGINE FACTORY TEST LOGS

Copies of the Power Engine Factory Test Logs are provided in this appendix to assist operating personnel in becoming familiar with the operating characteristics of the engine. The data included is that recorded during actual factory test of the engine.

CUSTOMER SOUTHERN CALIF EDISON
ENGINE MODEL I-SEV-20-4
ENGINE NO 75041
JOB NO 2803
RATED BHP/RPM 5349 @ 450
TEST DATE 5-31-76



BY R. KAISER DATE 10-31-76

Form D-4361 (Diesel) (R-1) 8/76

DELAVAL

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 1 A

CUSTOMER SOUTHERN CA EDISON — MODEL DSRV20-4 — TEST STAND 23 — JOB NO 2803 — ENGINE NO 75041 — FULL LOAD RATING 8349 BHP @ 450 RPM 154 BMEP

LINE	DATE	WALL CLOCK TIME ON LOAD	WALL CLOCK TIME THIS LOG	LOAD (%)	DYNA RPM	SCALE	BHP	BMEP	DISC REVS	TIME	POWER FACTOR	A.C. VOLT	A.C. AMPS	KW	GEN EFF	BHP	GOV. LOAD LIMIT
1	4/27	2245		25	220	24358	1006	38									
2	4/27	2400		25	220	24358	1006	38									
3	4/28	0130	0230	25	220	24358	1006	38									3.1
4	4/28	1500	1600	25	220	24358	1006	38									4.2
5	4/29	1300	1400	25	370	24358	1692	38									4.8
6	4/29	1420	1520	50	370	48727	3428	77									6.6
7	4/29	1820	1920	50	450	48727	4175	77									6.1
8	4/..		2000	75	450	73084	6262	116									7.0
9	4/	0315	0415	75	450	73084	6262	116									6.7
10	4/..	0415		100	450	97442	8349	154									7.5

FUEL PUMP RACK POSITION (MM)

LINE	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R
1																				
2																				
3																				
4																				
5	17.9	17.0	17.0	17.0	17.5	17.0	16.8	16.8	16.0	17.4	17.5	17.5	17.5	17.5	17.5	17.5	17.7	17.7	17.5	17.5
6	22.0	21.8	21.8	21.5	22.0	22.1	21.5	21.2	21.2	22.0	22.0	21.5	21.5	21.5	21.8	21.8	21.9	21.9	21.8	21.6
7	23.5	23.5	23.5	23.5	23.0	23.0	23.0	23.0	23.0	23.0	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.0	23.0
8	26.5	26.5	26.5	26.5	26.0	26.0	26.0	26.0	26.0	26.0	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.0	26.0
9	26.5	26.0	26.5	26.5	26.0	26.0	26.0	26.0	26.5	26.0	26.0	26.5	26.5	26.5	27.0	26.5	26.0	26.5	26.5	26.5
10	29.5	29.0	29.5	29.0	28.5	28.5	28.5	29.0	29.5	29.0	29.0	29.5	30.0	29.5	29.0	29.5	29.5	29.0	29.0	29.5

TURBOCHARGER PRESSURES / TURBOCHARGER TEMPERATURES / AMBIENT

LINE	BLOWER INLET (in H2O) LF	RF	LR	RR	BLOWER DISCHARGE (in Hg) LF	RF	LR	RR	AIR MANIF. LB	RB	TURBINE INLET LF	RF	LR	RR	TURBINE EXHAUST LF	RF	LR	RR	BLOWER INLET (°F) LF	RF	LR	RR	BLOWER DISCHARGE (°F) LF	RF	LR	RR	AIR MANIF. (°F) LB	RB	TURBOCHARGER RPM LF	RF	LR	RR	NOZZLE LF	RF	LR	RR	AIR FLOW SCFM TOTAL	BARO	AIR °F
1																																							
2																																							
3					0.7	0.8	0.8	0.8	0.7	0.8									64		64		77	76	77	78	77	77										29.83	64
4					0.9	0.9	0.9	0.9	0.8	0.8									68		67		82	80	81	82	79	79											68
5					3.6	3.6	3.6	3.6	3.4	3.4									72		68		98	100	100	106	97	96											
6					9.0	8.9	8.0	8.5	8.3	8.3									76		68		127	127	127	135	97	96											
7					16.2	16.1	15.9	16.2	15.6	15.7									65		75		162	166	162	173	117	118										30.02	69
8	6.7		1.3	2.0	25.8	25.5	25.3	25.7	25.0	25.1									64		72		201	209	202	211	120	121											67
9	6.4		1.0	2.0	25.1	24.9	24.7	24.9	24.3	24.3									67		70		200	208	204	209	118	118										30.07	67
10	9.4		1.7	2.0	35.0	34.8	34.6	34.9	34.2	34.1									68		71		240	250	246	250	120	120										30.07	68

FUEL OIL DATA / DIESEL BSFC / FUEL GAS DATA / GAS BSFC / DUAL FUEL BSFC / REMARKS

LINE	?	API GRAVITY AS READ	@ °F	API CORRECTED TO 60°F	LHV (Btu/lb)	LBS MEAS	TIME (sec)	lb/hr	lb/bhp-hr	(Corr.) lb/bhp-hr
1										
2										
3	400	36.8	71	35.7	18400	284	2662			0.386
4	400	37.8	81	36.3	18420					
5	340									
6	340	37.8	81	36.3	18420	1120	3233			0.368
7	345	37.7	81	36.2	18420	1430	2983			0.419
8	340	37.7	82	36.1	18420	1790	2685			0.388
9	340	37.7	77	35.0	18390	1600	2420			0.384
10	32.8	38.0	80	36.0	18415	1600	1879			0.371

INJECTION IGNITION TIMING °BTDC 24 LB 23 RB

FUEL OIL SPEC F10

LUBE OIL SPEC SHELL X-100 40 WT

AIR FLOW NOZZLE COEFFICIENT LF ____ RF ____ LR ____ RR ____ (FLYWHEEL END)

OPERATOR D. CLINE, G. LEVERING, G. MEIER — DATE 4/27/76
ENGINEER ____ — LOG NO 1 A
WITNESS R. ADAMS — JOB NO 2803

Form D-4173 (R-1) 9-74

DELAVAL

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 1 B

CUSTOMER SOUTHERN CA EDISON — MODEL DSRV-20-4 — TYPE SERVICE GENERATOR — JOB NO 2803 — ENGINE NO 75041 — DIRECTION OF ROTATION (AS VIEWED FROM FLYWHEEL END) CW

EXHAUST TEMPERATURES - °F

LINE	TURBINE INLET LFTL	LFTR	LFB	RFT	RFB	LRT	LRB	RRTL	RRTR	RRB	TURBINE EXHAUST LF	RF	LR	RR	ELBOW 1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R	AVG
1																																			
2																																			
3											370	135	355	347	431	441	430	439	424	441	443	431	408	447	401	358	195	390	381	364	383	356	371	366	
4											358	352	173	347	394	399	373	390	404	416	389	375	357	249	402	382	374	377	430	398	419	402	421	406	388
5											459	453	453	133	525	505	495	511	528	523	501	467	446	289	525	507	487	408	572	546	547	550	539	538	500
6											578	574	590	155	630	627	601	662	675	682	651	626	601	373	628	594	578	605	691	665	646	662	641	682	624
7											652	656	—	635	742	735	724	751	772	777	771	712	698	816	717	709	664	704	777	745	749	759	758	745	741
8											729	689	—	684	827	815	822	822	805	798	807	796	790	810	836	829	819	824	838	810	829	834	842	819	819
9											725	690	—	683	829	815	825	832	810	807	816	805	801	796	817	818	808	819	829	816	817	825	831	808	816
10											767	721	—	718	897	887	875	874	825	829	854	838	839	840	902	907	884	892	910	881	880	897	904	885	875

ENGINE WATER / TURBOCHARGER WATER / AFTERCOOLER WATER / FIRING PRESSURES - PSIG

LINE	ENGINE WATER PSIG TO ENGINE	TO ENGINE (°F)	FROM ENGINE (°F)	TURBO WATER OUTLET LF	RF	LR	RR	AFTERCOOLER INLET F	R	OUTLET F	R	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R	AVG
1																																
2																																
3	18	157	157	158	157	158	119	67	67	70	67																					
4	18	152	152	152	152	153	153	67	65	67	65																					
5	17	158	161	161	160	161	161	74	67	73	70	550	540	550	550	560	560	540	540	510	530	550	535	540	540	560	560	545	540	540	565	
6	17	155	160	159	159	160	159	85	92	92	93	695	700	710	700	700	715	700	700	650	680	700	660	660	670	700	700	670	680	660	700	
7	17.5	157	164	163	162	163	163	120	122	88	121	760	750	760	780	760	780	740	750	710	720	760	760	760	750	760	760	750	730	740	760	752
8	18	158	167	166	165	166	165	93	121	123	125																					
9	18	157	166	165	163	165	164	89	120	120	122	765	755	760	780	765	780	750	760	715	720	760	765	760	750	760	760	750	740	740	760	755
10	17	159	170	169	168	169	168	96	120	120	126	1120	1140	1160	1180	1140	1160	1100	1160	1120	1080	1180	1180	1180	1190	1200	1210	1120	1160	1100	1140	1151

LUBRICATING OIL PRESSURE - PSIG / LUBRICATING OIL TEMPERATURE °F / CRANKCASE PRESS / REMARKS

LINE	FROM PUMP	TO ENGINE	CAM HEADER	TO TURBO LF	RF	LR	RR	TEMP TO ENGINE	FROM ENGINE	TURBO DRAIN LF	RF	LR	RR	CRANKCASE PRESS (in H2O)
1														
2														
3		50	50	39	38.5	40	39.5	136	138					-3.0
4		51	44	22	22.5	25.5	25.5	140	141					-2.8
5		51	52	20	22	25.5	28	156	166					-3.3
6		51	52	19.5	20	24	22	156	168					-3.3
7		54	53	19.5	21	24	27	155	173					-3.3
8		55	54	19.5	20	24.5	24.5	154	175					-3.0
9		55	55	20	20.5	24.5	27	155	174					-2.3
10		55	54	19.5	20	24	26	155	177					-1.8

LEGEND: L, LB LEFT BANK; F ENGINE FRONT AT NO. 1 CYLINDER; R, RB RIGHT BANK; R ENGINE REAR, FLYWHEEL END (WHEN VIEWED FROM FLYWHEEL END)

TURBOCHARGER MAKE & MODEL LF ____ RF ____ LR ____ RR ____

OPERATOR D. CLINE, G. LEVERING, G. MEIER — DATE 4/27/76
ENGINEER ____ — LOG 1 B
WITNESS R. ADAMS — JOB NO 2803

Form D-4174 (R-1) 9-74

ENGINE AND COMPRESSOR DIVISION OAKLAND CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 2 A

CUSTOMER SOUTHERN CA EDISON MODEL DSR-24 TEST STAND 23 JOB NO 2803 ENGINE NO 75041 FULL LOAD RATING 8349 RPM 450 BMEP 154

Line	Wall Clock Time On Load	This Log	Load (%)	Dynamometer RPM	Scale	BHP	BMEP	Gov Load Limit	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R
1	1520	1620	100	450	97442	8349	154	7.5	29.5	29.0	29.5	29.0	28.5	28.5	28.5	29.0	29.5	29.0	29.0	29.5	30.0	29.5	29.0	29.5	29.5	29.0	29.0	29.5
2	1630	1730	25	450	24358	2087	37	—	18.5	18.5	19.0	18.5	18.5	18.5	18.5	18.5	19.0	18.5	19.0	19.0	19.5	19.0	19.5	19.0	19.0	18.5	18.5	18.5
3	1730	1830	110	450	107157	9184	170	7.7	30.5	30.5	31.0	30.5	30.5	30.5	30.5	30.5	31.0	30.5	31.0	31.0	31.5	31.0	31.5	31.0	31.0	30.5	30.5	30.5
4	1845	1915	-0-	450	-0-	-0-	-0-	3.4	12.0	12.0	12.5	12.0	12.0	12.0	12.0	12.0	12.5	12.0	12.5	12.5	13.0	12.5	13.0	12.5	12.5	13.0	13.0	13.0

Turbocharger Pressures / Turbocharger Temperatures / Air Flow / Ambient

Line	Air Inlet (in H2O) LB	RB	Blower Discharge (in Hg) LF	RF	LR	RR	Air Manif. LB	RB	Blower Inlet (°F) LF	LR	Blower Discharge (°F) LF	RF	LR	RR	Air Manif. (°F) LB	RB	Nozzle LF	Δp (in H2O) LF	LR	Baro	Air Temp
1	1.6	3.2	34.9	34.6	34.4	34.4	33.8	34.0	76	85	252	263	253		128	128	1.3	1.6	2.6	29.95	81
2	0.4	0.4	7.5	7.3	7.7	7.3	7.1	7.1	77	84	130	133	129	138	109	109	0.9	0.4	0.4	29.95	80
3	2.2	3.2	39.4	39.1	39.8	39.0	39.2	38.3	75	86	269	281	272	286	124	124	1.4	1.3	2.2	29.95	79
4	0.2	0.0	3.3	2.9	2.9	2.9	2.8	2.8	71	82	111	104	104	112	110	114	1.2	0.2	0.4	29.95	75

Fuel Oil Data / Diesel BSFC

Line		API Gravity As Read	°F	API Corrected 60°F	LHV (Btu/lb)	Lbs Meas	Time (sec)	(Corr) lb/bhp-hr
1	32	37.7	81	36.2	18420	1590	1858	.373
2	35	38.8	91	36.5	18938	800	2809	.498
3	31.5	33.8	93	36.4	18438	1700	1806	.374
4	36	38.8	93	36.4	18938	190	1558	

REMARKS: SET OVERSPEED TRIP AT 517 RPM

INJECTION/IGNITION TIMING °BTDC 24 LB 23 RB

FUEL OIL SPEC F10

LUBE OIL SPEC SHELL X-100 40WT

AIR FLOW NOZZLE COEFFICIENT LF ____ RF ____ LR ____ RR ____ (FLYWHEEL END)

OPERATOR D. CLINE, G. LEVERING, G. MEIER DATE 4/20/76
ENGINEER ____ LOG NO 2 A
WITNESS R. ADAMS JOB NO 2803

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 2 B

CUSTOMER SOUTHERN CA EDISON MODEL DSR-24 TYPE SERVICE GENERATOR JOB NO. 2803 ENGINE NO. 75041 DIRECTION OF ROTATION (AS VIEWED FROM FLYWHEEL END) C.W.

Exhaust Temperatures – °F

Line	Turbine Exhaust LF	RF	LR	RR	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R	AVG
1	782	749	735	735	917	899	899	896	852	858	872	872	872	873	908	908	890	899	916	888	885	906	915	893	881
2	550	526	531	531	605	613	618	642	636	630	625	628	632	573	601	612	613	618	630	618	617	617	620	611	618
3	796	747	754	747	956	937	922	914	875	869	905	901	908	920	934	940	914	920	949	913	909	938	956	942	921
4	368	351	350	358	418	422	463	443	488	445	426	439	443	389	406	410	422	415	413	408	402	407	409	387	420

Engine Water / Turbocharger Water Outlet / Aftercooler Water

Line	PSIG to Engine	To Engine (°F)	From Engine (°F)	T/C Water LF	RF	LR	RR	Inlet F	Inlet R	Outlet F	Outlet R
1	18	165	172	172	168	170		102	118	119	126
2	17.5	149	153	152	152	153	152	81	113	109	114
3	17	168	172	179	176	177	176	115	126	128	134
4	16	150	152	150	150	151	151	96	110	115	115

Firing Pressures – PSIG

Line	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R	AVG
2	590	580	600	590	590	600	570	580	580	550	580	580	570	570	580	580	570	560	560	580	578
3	1300	1320	1350	1330	1330	1360	1300	1300	1260	1220	1340	1340	1330	1320	1330	1350	1330	1300	1300	1320	1317

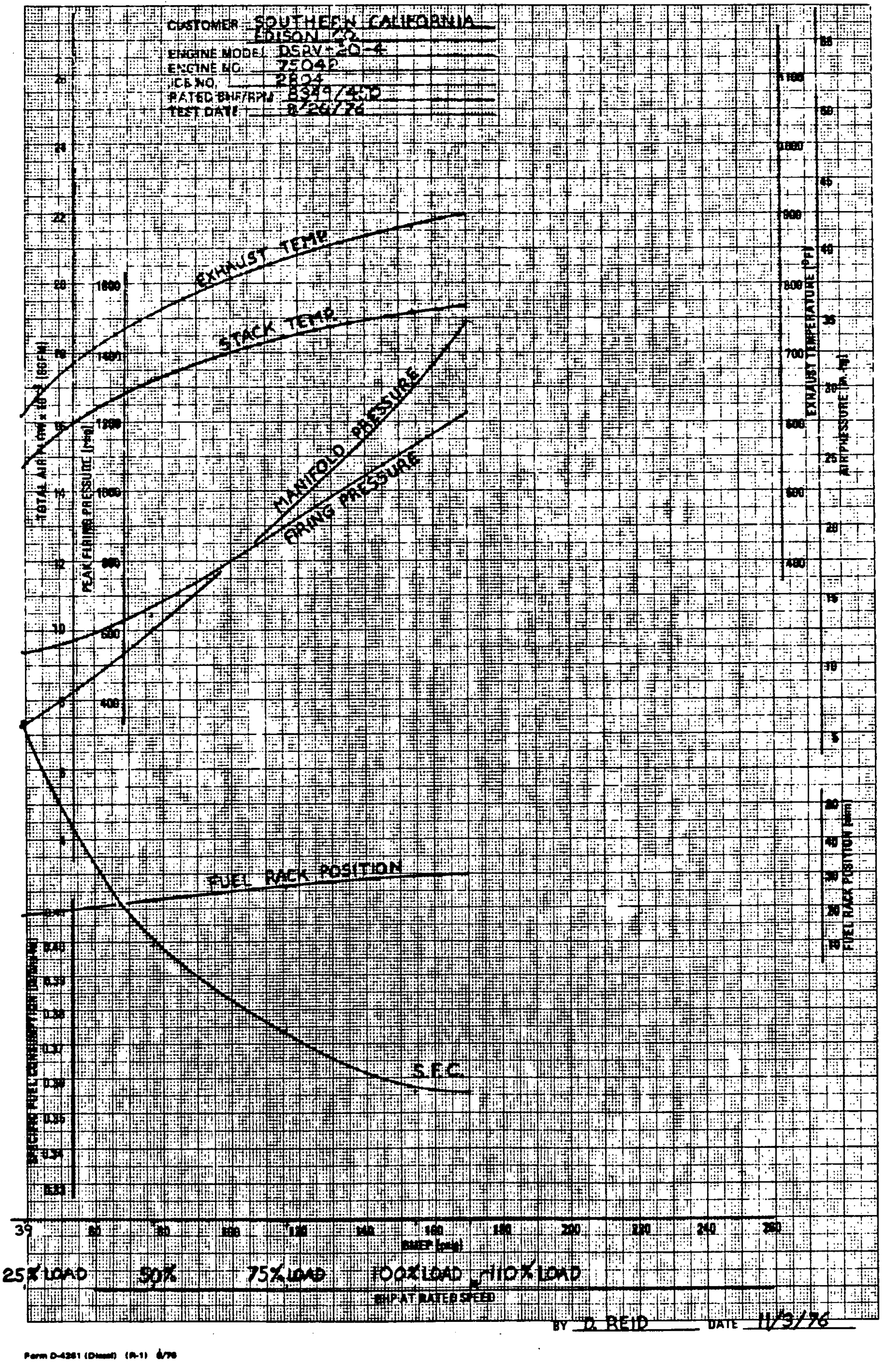
Lubricating Oil Pressure – PSIG / Lubricating Oil Temperature °F

Line	From Pump	To Engine	Cam Header	To T/C LF	RF	LR	RR	To Engine	From Engine	T/C Drain LF	RF	LR	RR	Crank Case Press (in H2O)
1		55	53	19	20	24	26	157	180					-2.0
2		56	55	21	22	26	29.5	155	168					-3.5
3		55	53	19	20	24	26	163	184					-2.0
4		56	55	22	26	27	30	155	167					-3.8

LEGEND L, LB LEFT BANK; R, RB RIGHT BANK; F - ENGINE FRONT AT NO 1 CYLINDER; R - ENGINE REAR, FLYWHEEL END (WHEN VIEWED FROM FLYWHEEL END)

TURBOCHARGER MAKE & MODEL LF EL RF EL LR EL RR EL

OPERATOR D. CLINE G. LEVERING DATE 4/20/76
ENGINEER ____ LOG 2 B
WITNESS R. ADAMS JOB NO 2803



Form D-4281 (Diesel) (R-1) 6/76

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 1 A

CUSTOMER SO. CALIF. EDISON — MODEL DSRV-20-4 — TEST STAND 23 — JOB NO. 2804 — ENGINE NO 75042

FULL LOAD RATING 8349 BHP @ 450 RPM 154 BMEP

Line	Date	Wall clock time On Load	Off Load	Load (%)	Dyna RPM	Scale (Dyna Const)	BHP (Corr)	BMEP	Gov Load Limit
1	8/19	0530	0795	25	220	24358	1006	38	3.1
2	8/19	1814	1915	25	220	24356	1006	38	3.1
3	8/19	1930	2030	25	370	24358	1692	38	4.5
4	8/19	2300	2400	50	370	43727	3428	77	4.4
5	8/20	0535	0635	50	450	48727	4175	77	4.6
6	8/20	0640	0740	75	450	73084	6262	116	5.3
7	8/20	1605	1705	75	450	73084	6262	116	5.3
8	8/20	1715	1815	100	450	97442	8349	154	5.9
9	8/20	1815	1915	100	450	97442	8349	154	5.9
10	8/20	1920	2020	25	450	24358	2087	39	4.5

Fuel pump rack position (mm)

Line	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R
1	16.0										16.5									
2	16.0										16.0									
3	12.0										17.0									
4	22.0										22.0									
5	23.0	22.5	22.5	23.0	23.0	22.5	23.0	22.0	23.0	22.5	22.5	22.5	22.6	23.0	22.5	23.0	23.0	23.0	23.0	
6	26.5	26.0	26.5	26.5	26.5	26.0	26.0	26.0	26.0	26.0	26.5	26.5	26.5	26.5	26.0	26.0	26.0	26.0	26.0	
7	26.0										26.0									
8	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	
9	29.0										29.0									
10	18.0										18.0									

Turbocharger pressures

Line	Blower inlet (in. H_2O) LF	RF	LR	RR	Blower discharge LF	RF	LR	RR	Air manifold LB	RB
1					0.3	0.3	0.3	0.3	0	0
2		1.7		2.1	0.7	0.7	0.7	0.7	0.7	0.7
3		4.7		4.1	3.1	3.2	3.2	3.2	3.0	3.1
4		7.4		9.9	8.1	8.1	8.2	8.2	8.0	8.0
5		11.3		15.1	12.9	12.9	12.9	12.9	12.6	12.7
6		17.8		23.2	21.1	21.1	21.1	21.2	20.7	20.8
7					21.5	21.5	21.5	21.5	21.1	21.1
8					31	31	31	31	30.5	30.5
9					31.3	31.3	31.2	31.2	30.8	30.0
10					5.9	6.0	6.0	6.0	5.7	5.7

Turbocharger temperatures, air flow and ambient

Line	Blower inlet (°F) LF	RF	LR	RR	Blower discharge (°F) LF	RF	LR	RR	Air manifold (°F) LB	RB	Nozzle ΔP (in. H_2O) LF	RF	LR	RR	Air flow SCFM total	Ambient baro (corr)	Air (°F)
1	68		68		76	75	78	77	74	74						29.80	68
2	74		74		85	87	90	90	86	85		.9		.9	5504	29.79	74
3	73		73		103	107	108	106	104	101		2.2		2.7	9078	29.79	73
4	69		69		125	130	135	138	113	111		4.3		4.4	12160	29.80	69
5	69		69		141	155	155	158	125	125		6.5		6.7	14979	29.80	69
6	68		68		185	197	198	201	125	125		10.0		10.3	18587	29.78	68
7	77		77		195	206	215	217	124	124							77
8	74		74		217	246	255	256	127	127						29.76	74
9	73		73			246	256	257	125	125							73
10	73		73		114	120	126	128	124	125						29.76	73

Fuel oil data / Diesel BSFC

Line	[illegible]	API gravity as read	@ °F	API corrected to 60°F	LHV (Btu/lb)	LBS meas	Time (sec)	lb/hr	lb/bhp-hr	(Corr) lb/bhp-hr
1	410									
2	4..0									
3	340									
4	4:0									
5	4·0	39.0	79	37.6	18455	1280	2805	1643		.399
6	35.5	39.6	86	37.6	18455	1510	2351	2312		.375
7	42.0	40.2	93	37.6	18455	1660	2592	2305		.373
8	41.5	40.2	94	37.7	18460	1810	2220	2935		.357
9	41.0	40.2	94	37.7	18460	1460	1800	2920		.355
10	42.0	39.8	90	37.6	18455	810	3055	955		.464

REMARKS: 1745 TO 1800 - 15 MINUTE HEAT CHECK

INJECTION/IGNITION TIMING °BTDC 24° LB 23° RB

FUEL OIL SPEC F 10

LUBE OIL SPEC L-21

[illegible] 8/74

AIR FLOW NOZZLE COEFFICIENT LF 12283 RF ______ LR 12283 RR ______ (FLYWHEEL END)

OPERATOR B. VITAL, G. MEIR, J. POPPENK — DATE 8-20-76

ENGINEER D. REID, G. BISONETT — LOG NO 1 A

WITNESS ______ — JOB NO 2804

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 1 B

CUSTOMER SO. CALIF. EDISON — MODEL DSRV-20 — TYPE SERVICE NUCLEAR — JOB NO. 2804 — ENGINE NO 75042

DIRECTION OF ROTATION (AS VIEWED FROM FLYWHEEL END) C.W.

Exhaust temperatures – °F (Turbine inlet (T - Top, B - Bottom) LFTL, LFTR, LFB, RFT, RFB, LRT, LRB, RRTL, RRTR, RRB: no entries)

Line	Turbine exhaust LF	RF	LR	RR
1				
2				
3				
4				
5	664		657	
6	734		718	
7		714	721	744
8		753	756	774
9		751	747	765
10		529	538	541

Exhaust elbow

Line	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R	AVG
1	346	370	360	371	381	411	380	362	376	406	400	437	415	403	394	414	416	419	429	448	397
2	378	401	397	411	424	440	420	397	395	419	414	437	429	419	418	434	430	426	444	440	419
3	510	523	526	545	542	563	529	520	517	546	521	539	539	526	543	551	523	552	551	559	552
4	648	661	654	681	683	647	660	675	687	678	648	659	662	648	678	675	645	696	683	685	669
5	734	756	750	780	763	704	768	764	795	772	726	735	735	735	748	752	735	764	785	774	754
6	841	857	839	861	849	783	845	850	875	871	809	828	809	813	834	827	801	852	873	868	839
7	827	839	818	849	829	835	825	835	865	855	816	807	800	806	818	805	801	836	893	897	828
8	907	919	883	898	877	879	875	899	932	922	886	875	850	850	873	846	837	893	901	923	886
9	896	908	875	891	873	873	871	891	920	911	878	866	857	854	864	839	850	884	889	898	879
10	590	597	588	625	623	619	622	610	647	589	604	602	615	616	610	607	630	617	607	601	611

Line	Engine water PSIG to engine	To engine (°F)	From engine (°F)	Turbocharger water outlet (°F) LF	RF	LR	RR	Aftercooler water inlet (°F) F	R	Outlet (°F) F	R
1	9.5	119	120	111	121	122	122				
2	10.0	153	154	134	155	156	156		74		75
3	16.0	157	161	141	161	160	162		75		92
4	14.0	158	168	161	165	165	167		107		109
5	17.0	157	166	161	163	164	166		127		129
6	16.0	157	170	179	165	166	169		125		128
7	16.0	159	172	177	168	170	171		124		128
8	16.0	164	179	185	177	177	179		126		131
9	16.0	174	180	216	241	256	258		125		131
10	17.0	154	169	150	153	152	154				

Firing pressures – PSIG

Line	1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R	AVG
1																					
2																					
3																					
4																					
5	630	640	636	656	650	620	640	630	640	650	650	630	630	656	660	630	640	640	660	650	642
6	880	900	900	900	920	890	900	920	900	910	900	920	920	920	910	930	890	920	910	900	907
7	900	900	900	910	890	900	910	890	880	900	900	880	910	900	920	880	880	880	870	870	894
8	1150	1100	1140	1140	1160	1120	1110	1120	1110	1100	1140	1140	1140	1160	1130	1120	1150	1120	1080	1080	1126
9																					
10	540	550	540	540	550	540	530	540	530	540	540	540	540	550	540	540	550	540	530	530	540

Line	Lube oil pressure (PSIG) From pump	To engine	Cam header	To turbocharger LF	RF	LR	RR	Lube oil temp (°F) To engine	From engine	Crankcase press (in. H_2O)
1			50.0	34.5	34.5	31.5	21.0	73	113	0.5
2	62.0		52.0	38.0	38.0	36.0	26.0	141	142	-1.8
3	57.0		47.0	33.0	34.0	33.0	22.5	157	168	-2.4
4	58.0	54.0	48.0	32.5	33.0	32.5	22.0	157	170	-2.4
5	60.0	55.0	49.0	33.0	33.0	32.0	28.0	155	172	-2.1
6	60.0	56.0	49.0	33.0	32.5	31.5	27.5	154	174	-2.0
7	59.5	55.0	48.0	32.5	32.0	31.0	27.5	155	175	-2.4
8	57.5	53.5	46.0	32.0	31.5	24.5	27.0	160	182	-2.2
9	57.5	53.5	46.0	32.0	31.5	24.0	27.0	162	184	-2.0
10	59.0	56.0	48.5	34.0	34.0	33.0	29.0	154	169	-2.8

LEGEND L, LB = LEFT BANK; R, RB = RIGHT BANK (WHEN VIEWED FROM FLYWHEEL END); F = ENGINE FRONT AT NO 1 CYLINDER; R = ENGINE REAR, FLYWHEEL END

Form D4174 (R 1) 8/74

TURBOCHARGER MAKE & MODEL: LF EL, RF EL, LR EL, RR EL (BB = Brown Boveri, OE = Osmond, EL = Elliott)

OPERATOR B. VITAL, G. MEIR, J. POPPENK — DATE 8-20-76

ENGINEER D. REID, G. BISONETT — LOG 1 B

WITNESS ______ — JOB NO 2804

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 2 A

CUSTOMER SO. CALIF. EDISON MODEL DSRV-20-4 TEST STAND 23 JOB NO. 2804 ENGINE NO. 75042 FULL LOAD RATING 8349 BHP @ 450 RPM 154 BMEP

LINE	DATE	WALL CLOCK TIME ON LOAD	WALL CLOCK TIME THIS LOG	% LOAD	DYNAMOMETER LOAD DATA RPM	SCALE	BHP	BMEP	A.C. GENERATOR LOAD DATA DISC REVS	TIME	POWER FACTOR	A.C. VOLTS	A.C. AMPS	KW	GEN. EFF.	BHP	BMEP	GOV. LOAD LIMIT	FUEL PUMP RACK POSITION (MM) 1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R
1	8/20	2035	2135	110	450	07187	9184	170										6.2	30.0										30.0									
2	8/20	2040	2110	⊖	450	⊖	⊖	⊖										1.8	12.0										12.0									
3			2120						SET OVERSPEED TRIP AT 5.7 RPM																													

LINE	TURBOCHARGER PRESSURES: BLOWER INLET (in. H_2O) LF	RF	LR	RR	BLOWER DISCHARGE (in. Hg) LF	RF	LR	RR	AIR MANIF. LB	RB	TURBINE INLET (in. Hg) LF	RF	LR	RR	TURBINE EXHAUST (in. H_2O) LF	RF	LR	RR	TURBOCHARGER TEMPERATURES: BLOWER INLET (°F) LF	RF	LR	RR	BLOWER DISCHARGE (°F) LF	RF	LR	RR	AIR MANIF. (°F) LB	RB	AIR FLOW NOZZLE SIZE — TURBOCHARGER RPM LF	RF	LR	RR	NOZZLE ΔP (in. H_2O) LF	RF	LR	RR	AIR FLOW SCFM TOTAL	AMBIENT BARO. (in. Hg)	AIR (°F)
1					35.2	35.2	35.2	35.2	34.8	34.8									71		71		220	259	268	269	129	128										29.78	71
2					2.1	2.1	2.1	2.1	2.0	2.0									71		71		97	97	103	104	104	104										29.78	71

LINE	FUEL OIL DATA: MANIF. (mm)	API GRAVITY AS READ	@ °F	API Corrected To 60°F	LHV (Btu/lb)	DIESEL BSFC: LBS MEAS	TIME (sec)	lb/hr	Btu/bhp-hr	(Corr.) lb/bhp-hr	FUEL GAS DATA: MANIF.	LHV Btu/ft³	COR METER		CORR. FACTOR	GAS BSFC: ft³ MEAS	TIME (sec)	ft³/hr (Corr.)	Btu/bhp-hr	DUAL FUEL BSFC: PILOT Btu/bhp-hr	GAS Btu/bhp-hr	TOTAL Btu/bhp-hr	REMARKS
1	41.5	40.0	90	37.7	18460	1980	2098	3226		.356													
2	42.0	39.8	88	37.8	18465	172	1817	341	—	—													

INJECTION/IGNITION TIMING °BTDC 24° LB 23° RB

FUEL OIL SPEC F 10

LUBE OIL SPEC L-21

Form D-4173 (R-1) 9/74

AIR FLOW NOZZLE COEFFICIENT LF 12283 RF ____ LR 12283 RR ____ (FLYWHEEL END)

OPERATOR B. VITAL, G. MEIR, J. POPPENK DATE 8-20-76

ENGINEER D. REID, G. BISONETT LOG NO. 2 A

WITNESS ____ JOB NO. 2804

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 2 B

CUSTOMER SO. CALIF. EDISON MODEL DSRV-20 TYPE SERVICE NUCLEAR JOB NO. 2804 ENGINE NO. 75042 DIRECTION OF ROTATION (AS VIEWED FROM FLYWHEEL END) C.W.

EXHAUST TEMPERATURES – °F

LINE	TURBINE INLET (T = TOP, B = BOTTOM) LFTL	LFTR	LFB	RFT	RFB	LRT	LRB	RRTL	RRTR	RRB	TURBINE EXHAUST LF	RF	LR	RR	EXHAUST ELBOWS 1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R	AVG
1												760	758	784	925	946	896	914	876	886	885	919	955	945	907	910	873	869	879	855	850	907	918	932	902
2												311	318	311	358	358	357	361	371	353	373	346	359	341	373	378	384	371	355	370	393	363	361	354	364

LINE	ENGINE WATER PSIG TO ENGINE	TO ENGINE (°F)	FROM ENGINE (°F)	TURBOCHARGER WATER OUTLET (°F) LF	RF	LR	RR	AFTERCOOLER WATER INLET (°F) F	R	OUTLET (°F) F	R	FIRING PRESSURES – PSIG 1L	2L	3L	4L	5L	6L	7L	8L	9L	10L	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R	AVG
1	15.0	160	175	187	172	173	176	127		135		1250	1220	1260	1240	1250	1220	1220	1230	1210	1220	1240	1240	1240	1250	1220	1220	1240	1220	1180	1190	1227
2	15.0	150	153	129	152	152	152	104		104																						

LINE	LUBRICATING OIL PRESSURE – PSIG FROM PUMP	TO ENGINE	CAM HEADER	TO TURBOCHARGER LF	RF	LR	RR	LUBRICATING OIL TEMPERATURE °F TO ENGINE	FROM ENGINE	TURBOCHARGER DRAIN LF	RF	LR	RR	CRANK-CASE PRESS ± in. H_2O	REMARKS
1	59.0	55.0	47.5	32.0	32.0	30.0	27.0	157	179					-2.0	
2	61.0	56.5	50.0	36.0	36.5	35.0	31.0	155	167					-3.0	

LEGEND: L, LB = LEFT BANK F = ENGINE FRONT AT NO. 1 CYLINDER
R, RB = RIGHT BANK R = ENGINE REAR, FLYWHEEL END
(WHEN VIEWED FROM FLYWHEEL END)

Form D-4174 (R-1) 9/74

TURBOCHARGER MAKE & MODEL LF EL RF EL LR EL RR EL
BB = Brown-Boveri DE = Delaval EL = Elliott

OPERATOR B. VITAL, G. MEIR, J. POPPENK DATE 8-20-76

ENGINEER D. REID, G. BISONETT LOG 2 B.

WITNESS ____ JOB NO 2804

DRAWINGS

The drawings provided in this manual are intended for the customer's use in the installation and operation of the unit. They include installation, foundation (where applicable) and system piping schematic drawings. Control system drawings are also included. Assembly drawings may be found in the Parts Manual, Volume II.

INSTRUCTION MANUAL FOR ENTERPRISE ENGINES	DELAVAL ENGINE AND COMPRESSOR DIVISION 550-85TH AVENUE OAKLAND, CALIF. 94621

PIPING SYMBOLS

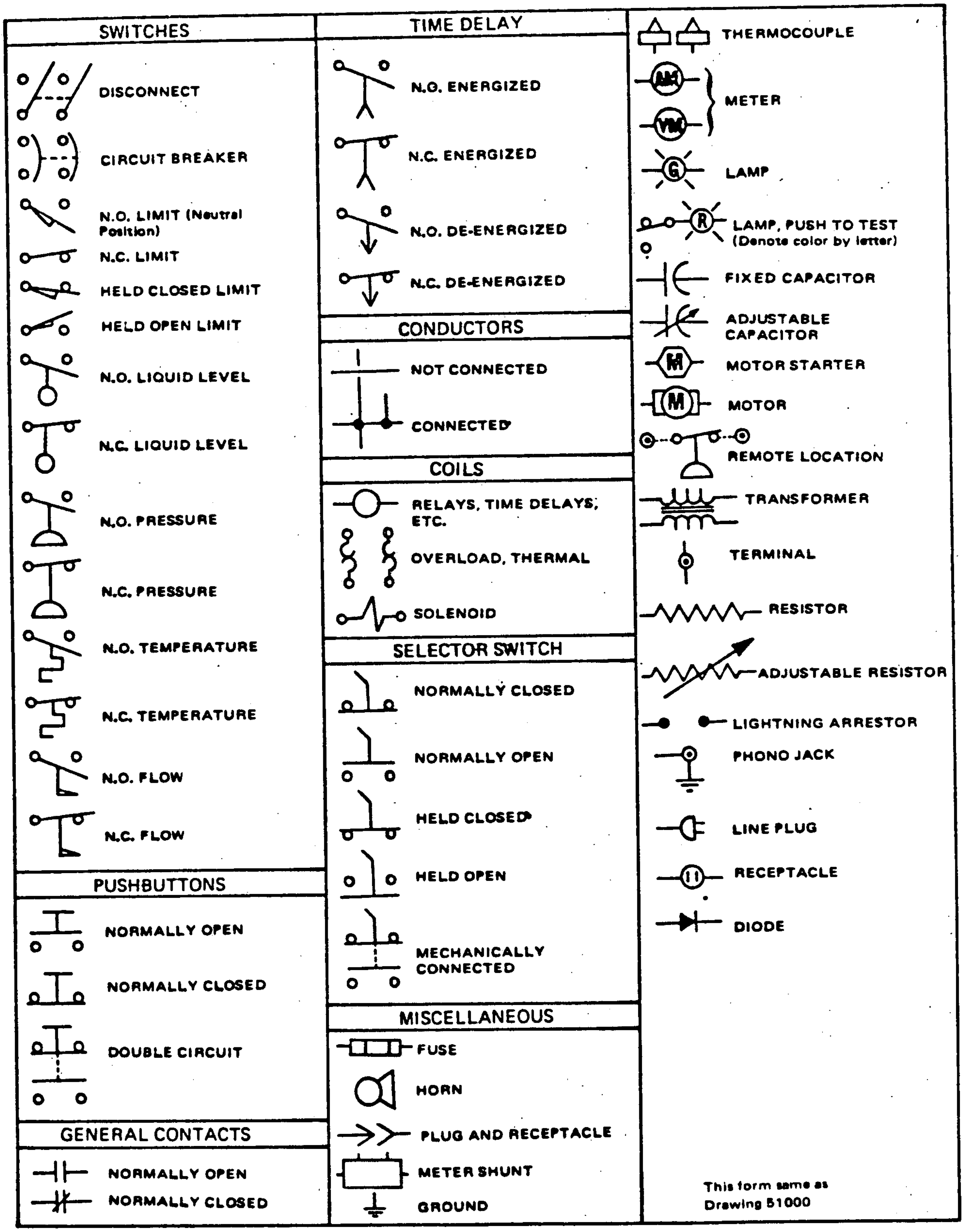
	MANOMETER		PRESSURE REDUCER	L	LEVEL GAUGE
P	PRESSURE SWITCH		GATE VALVE		PLUGGED
T	DIAL THERMOMETER		GLOBE VALVE		STRAINER
T	TEMPERATURE SWITCH		PLUG VALVE		DIRECTION OF FLOW
S	SIGHT FLOW GAUGE		BUTTERFLY VALVE (Tight Sealing Type)		WELD REDUCER
SP	ENGINE SHUT DOWN PRESSURE SWITCH		CHECK VALVE		SCREWED CAP AND NIPPLE
PYR	PYROMETER		STOP COCK		UNION
	PRESSURE SHUT DOWN ELEMENT		SAFETY OR RELIEF VALVE		WELD CAP
	TEMPERATURE CONNECTION — Requires ¾" half coupling for all dial thermometers and separable socket thermometer wells and ½" half couplings for temperature switches, etc. (Field locate as directed by owner.)		PRESSURE CONNECTION — Requires ½" coupling, nipple, stop cock, ½" x ¼" bushing and ¼" plug. (Field locate as directed by owner.)		
	STRAINER "Y"	S	SOLENOID VALVE		
	TEMPERATURE SHUT DOWN ELEMENT		DRESSER COUPLING		
	ELECTRIC WIRING		EXPANSION JOINT		
	CAPILLARY TUBING		ORIFICE		
	BLIND FLANGE	A	ALARM CIRCUIT		
	THERMOMETER	P	PRESSURE GAUGE		
T	TEMPERATURE GAUGE	M	METER		
	FLOAT VALVE	F	FLOAT SWITCH		
	DIAPHRAGM CONTROL VALVE		THERMOSTATIC TEMP. CONTROL VALVE		This form same as Form D-4313

INSTRUCTION MANUAL FOR ENTERPRISE ENGINES

DELAVAL ENGINE AND COMPRESSOR DIVISION
550-85TH AVENUE
OAKLAND, CALIF. 94621

DELAVAL

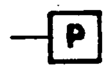
ELECTRICAL SCHEMATIC SYMBOLS



VALVE SYMBOLS

TWO POSITION VALVE (W/O ACTUATOR)	
	Basic two position
	Two way, two position
	Three way, two position
	Four way, two position
	Five way, two position

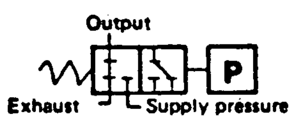
THREE POSITION VALVE (W/O ACTUATOR)	
	Basic three position
	Three way, closed center, three position
	Three way, open center, three position
	Four way, closed center, three position
	Four way, open center, three position
	Five way, open center, three position
	Five way, closed center, three position

ACTUATORS	
	Spring return
	Manual push actuator
	Manual pull actuator
	Detented manual actuator
	Pressure actuator
	Solenoid actuator
	Vibration actuator
	Flow actuator
	Liquid level actuator
	Temperature actuator

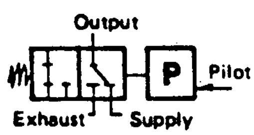
1. Actuators (there may be one or two) are shown attached to either end of valve symbol.
2. Valve symbols are always shown in non-actuated, i.e., "Normal, relaxed" condition.
3. The tube or pipe connections to the valve are considered to be immoveable, while the internal passage blocks are mentally shifted between the external connections to visualize valve action.

EXAMPLES:

Three-way valve, two position, pressure actuated, spring return

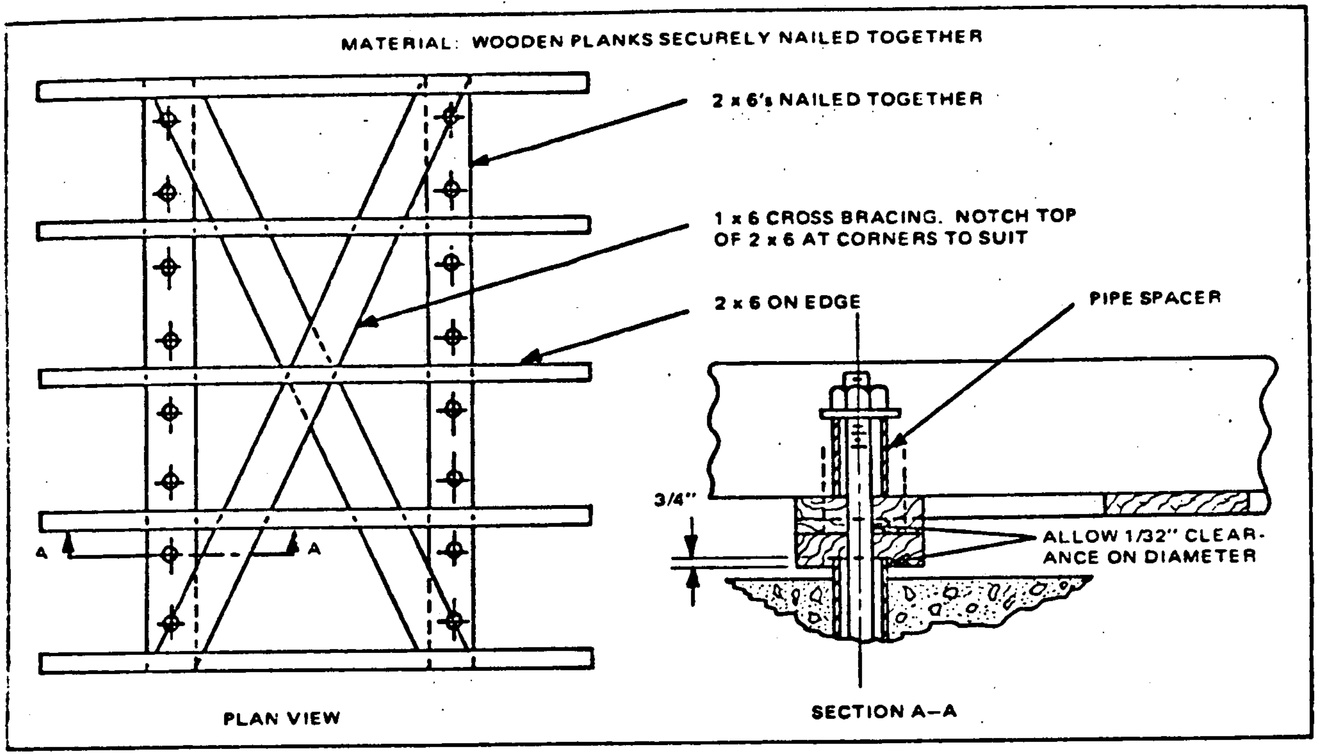


Valve connected normally closed (supply shut off when no pilot pressure exists). Note output is connected to exhaust.



Valve shown with pilot pressure applied (actuated). Supply is now connected to output, and exhaust is blocked. Note that connections have not moved, and valve body is shifted to the left, causing the right passage block to come beneath the connections. Also note, this view will not show up on drawings.

PROCEDURE NOTES FOR MOUNTING ENTERPRISE ENGINES ON CONCRETE FOUNDATIONS



SUGGESTED FOUNDATION BOLT TEMPLATE

OBSERVE THE FOLLOWING SEQUENCE OF OPERATION:

1. Construct a foundation bolt template, using certified foundation drawing to determine positioning of foundation bolt holes. See sketch for a suggested template design. Exercise great care in locating bolt centers.

2. Position and support template from foundation forms, securely anchoring it to prevent movement.

3. Thread foundation bolt into lower nut in shield assembly, being careful not to damage cap at bottom of nut. Insert foundation bolts and shields in holes provided in template, then tighten upper nut. Shields must be securely held in correct position to prevent any movement during pouring of concrete. A suggested method is to use reinforcing rods, welded to each sleeve, or on top of each anchor plate in both rows of bolts running the length of the engine, and then adding "X" bracing between the two rows of bolts. Another method is to tie the bolt assemblies to other reinforcing rods already in the foundation.

4. *Recheck template positioning, alignment and elevation before pouring concrete.* It is recommended that a DELAVAL Engine and Compressor Division Service Representative be present to check bolt layout.

5. Foundation is to be poured monolithic and must suitably reinforced with reinforcing steel. Let concrete set for 10 days before installing equipment and 30 days before running equipment.

6. Top surface of foundation must be roughened wherever grout is to be applied to remove laitance, oil stains, etc., and to provide a rough, dry surface for good bonding of epoxy grout to foundation.

7. Remove engine foundation bolts from shields and set aside where they will not be damaged. Place jacking screw plates in position at each jacking screw location. Plates should either be imbedded in foundation before concrete sets, or grouted in place.

8. Bring engine into position over foundation. If engine is rolled into position, ends of foundation bolt shields must be protected to prevent damage.

9. Insert toe jacks at four corners of engine, just inboard of shipping skids to support engine while skids are being removed. *CAUTION: To avoid damage to base casting, do not locate jacks at center of engine.* Remove shipping skids, clean engine mounting rails and lower engine to grade. Be sure foundation bolt holes in engine base are correctly aligned with foundation bolt sleeves in foundation for easy installation of foundation bolts.

10. Clean sole plates and chocks with a degreasing type solvent. After cleaning, it is recommended that sole plates be primed with a primer recommended by grout manufacturer. Lubricate threads of jacking screws with a mixture of powdered graphite and engine lubricating oil. Lower end of jacking screws should be coated with wax to prevent epoxy grout material from binding to screws.

11. Place sole plates and chocks in position under engine as shown on foundation drawing. Install sole plate retainers on front and rear sole plates, making sure sole plates are forced tightly against shoulder at inner edge of engine

73029-30

mounting rails (The front and rear sole plates at each side of the engine are designed to make contact with the mounting rail shoulder and are intended to restrain side movement of the engine.)

12. Lubricate threads at lower end of foundation bolts with standard mixture of engine oil and powdered graphite, then replace bolts in sleeves and screw firmly into threads at bottom of sleeve. Lubricate upper threads with oil and graphite mixture then place washers and nuts on bolts.

13. Level and align engine, following crankshaft alignment instructions on DELAVAL Engine and Compressor Division Form D-1063 (Revised 12/71). Record deflection readings on form. Insure that all sole plate jacking screws are so adjusted as to distribute the weight evenly on all sole plates. When leveling and alignment is satisfactory, snug down foundation bolts to prevent movement of engine during generator installation and grouting.

14. Attach sole plates to generator and outboard pedestal bearing, using approximately 1/8 inch of shimming material between each sole plate and generator or pedestal. To provide insulation protection against circulating currents, 1/16 inch of the shimming between the sole plates and the pedestal bearing must be insulation material.

15. A DELAVAL Engine and Compressor Division Service Representative *must be present to supervise the alignment of the engine.* See Instruction Manual, Section 2, Page 1, Paragraph B, "Placing and Aligning Engine on the Foundation".

16. If not already installed, attach flywheel to crankshaft. Carefully clean and de-burr all mating surfaces of flywheel, crankshaft coupling flange and driven equipment coupling flange, including bolt holes. Lubricate crankshaft flange and flywheel counter bore with a light coat of anti-seize lubricant such as "Molykote" or "Lubriplate" and mount flywheel on crankshaft flange. Insure one-half inch locating holes are aligned. Make sure no dirt or other foreign matter is present between mating surfaces. Attach three retainer plates to flywheel and draw flywheel up on crankshaft flange until seated.

17. Bring generator and pedestal into position and attach generator shaft to flywheel. Lubricate bore in flywheel and connecting shaft flange with a light coat of anti-seize lubricant. Align half inch locating hole in flange with hole in flywheel and bring connecting shaft into engagement with flywheel. Be sure no dirt is allowed to get between mating surfaces. Insert two long 1 or 1¼ inch diameter bolts through two opposite flywheel bolt holes and draw connecting shaft flange until flange is seated. Check with feeler gauges between face of connecting shaft flange and flywheel to be sure flange is fully seated and square with flywheel. Lubricate two special aligning dowels with a thin coat of anti-seize lubricant (dowels and special flywheel bolt reamers are available from DELAVAL Engine and Compressor Division Service Department), and tap them into two opposite flywheel bolt holes. *Do not drive dowels up hard.* Ream two flywheel bolt holes with the special reamer and measure diameter of reamed hole to the nearest 0.0005 inch. Compare diameter of reamed hole with diameter of bolt. Reamed holes should be approximately 0.0005 inch larger than the bolts to allow for an easy tap fit. Flywheel bolts *must not* be driven with a sledge, jack or "Porto-Power". Fit bolts into two reamed holes, screw nuts on bolts and draw up tight. Use anti-seize lubricant on bolts and powdered graphite and engine oil on threads. Remove two temporary bolts and aligning dowels, ream holes and fit remaining bolts. Torque all bolts to the specified torque.

18. Check crankshaft alignment, then align outboard pedestal bearing. Line stator up with rotor and moderately tighten stator and pedestal foundation bolts with jacking screws in place. Check entire alignment, including crankshaft alignment. Record crankshaft deflections on Form D-1063.

19. Pour and vibrate grout under engine, generator and pedestal bearing. Carter Waters No. 604 or Ceilote No. 648 grout may be used. It is recommended that a representative of the grout supplier be present at the installation to be sure the grout is prepared and place in accordance with manufacturer's specifications. Do not fill bolt shields with grout. If a ramming strap is used, its movement should be slow so as not to entrain excess air in the grout.

20. After grout has cured, back off sole plate jacking screws one turn each and torque foundation bolts to recommended torque value. Snug all bolts in a criss-cross pattern, then apply a light torque to each, using the same criss-cross pattern. Continue applying torque in increments and in the same pattern until final torque value is reached. Foundation bolts should be torqued to the following values:

Engine Model	*Torque (ft-lb)*
G	650
HV, HVA, HA	480
Q, R	1400
RV	3800

21. If foundation bolts are re-tightened at a later date, the nuts must be removed and re-lubricated in order to get accurate torque values. Dry thread torque readings can be as much as 50 percent in error.

22. Recheck entire alignment of equipment and check crankshaft deflections (record readings on Form D-1063). Remove or add shims to pedestal bearing and generator as necessary. Dowel generator and pedestal bearing to sole plates when alignment is necessary.

23. Crankshaft alignment should be rechecked after engine start up when engine and concrete foundation are at their normal operating temperatures. Record deflection on Form D-1063.

ENGINE LUBRICATING OIL PIPING PROCEDURE

1. PRECAUTIONS TO BE OBSERVED DURING CONSTRUCTION OF THE LUBRICATING OIL SYSTEM, AND BEFORE STARTING ENGINE

1.1. Chill rings should not be used in welded pipe joints because of their tendency to retain scale, welding slag and beads which can come loose as the pipe becomes hot during operation of the engine.

1.2. *All* lubricating oil system piping *must* be pickled after fabrication to remove varnish, mill scale, welding debris, dirt and grease. The pickled surfaces of the pipe must be coated with a rust preventive compound immediately after pickling to protect them from rust. The compound must be soluble in the lubricating oil that will be used in the engine, and compatible with it so as not to contaminate the oil. Apply the compound by spraying or flooding the pipes – swabbing with rags or mops will leave lint. Ordinary lubricating oil will not prevent rust in the pipes.

1.3. Mechanical cleaning will not completely clean the pipes, therefore, this method is not acceptable.

1.4. Before the engine is started, the assembled lubricating oil piping system must be thoroughly flushed with oil. Disconnect the pipe at the pressure strainer inlet, (item 168 on installation drawing) and arrange a temporary bypass line from this pipe to the sump tank, or engine base as appropriate. The bypass will permit oil circulation through the piping system without filling the internal lubricating oil system of the engine. Several thicknesses of cloth sack should be secured to the outlet end of the bypass line to catch debris as it is flushed out of the system.

1.5. The piping around the lubricating oil cooler requires special attention to insure that the pipes and the cooler are properly flushed. Precautions must be taken to insure the complete removal of testing fluids, water, or other liquids before attemping to flush the cooler.

1.6. The oil sump tank and engine base must be carefully cleaned before being filled with oil.

1.7. The auxiliary lubricating oil pump, or any continuous duty pump of sufficient capacity, can be used to pump oil during flushing operations. If care was exercised during fabrication of the piping system it should be flushed for at least eight hours. As much as 24 hours of flushing may be required for a dirty system. While the oil is circulating through the system the pipes must be thoroughly pounded several times with a heavy hammer to loosen dirt and debris. Hot flushing oil is recommended as it does a better job of cleaning.

1.8. After flushing is completed, reconnect the piping system for normal operation. Examine all strainers, and filters for cleanliness and for proper assembly.

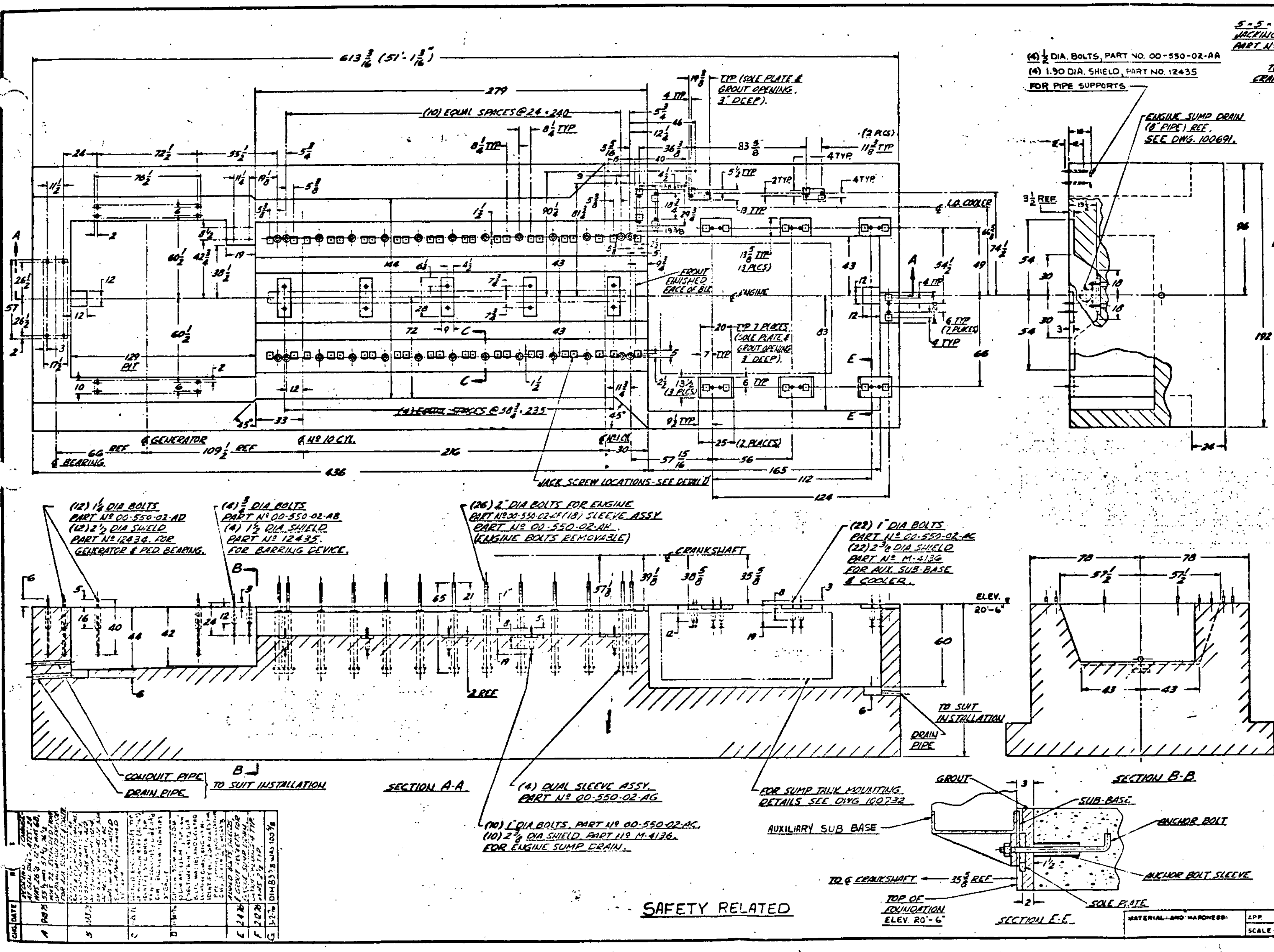
1.9. Disconnect the jumper tubes between the engine lubricating oil header and the main bearings, and between the main headers and the auxiliary headers. Secure a nylon stocking over each main header fitting to catch debris that may pass through the system as it is flushed. Cover the main bearing fittings and the open ends of the auxiliary header feeders to prevent entry of dirt. *Engine oil* should be pumped through the open system for at lease four hours to be sure of removing any foreign material that may have entered the headers during construction.

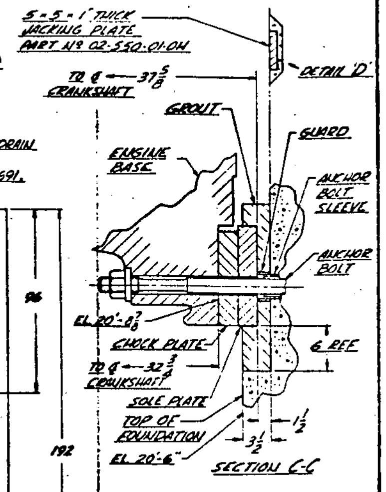
1.10. Reassemble the internal tubes and brackets as required.

1.11. The pressure strainer at the engine oil inlet will catch any debris that may remain in the piping system. It may require several cleanings during the first few hours of engine operation.

1.12. The utmost caution must be observed in the fabrication and preparation of the lubricating oil system for service. Foreign material of any kind can do a great deal of damage to the crankshaft, bearings, pistons, and cylinder liners.

1.13. NOTE, There may be instances where an engine is shipped with the pressure strainer mounted on the engine and connected to the engine lubricating oil header. If it is certain that the pipe connection between the pressure strainer and the engine lubricating oil header has not been disconnected since the engine left the factory, steps 9 and 10 above may be omitted.





11. FOR ENGINE MOUNTING LAYOUT SEE 02-550-…
10. FINAL DIMENSIONS OF ENGINE FOUNDATION MUST BE DETERMINED BY CUSTOMER'S REGISTERED ENGINEER TO SUIT INSTALLATION AND SOIL CONDITIONS.
9. CONCRETE MUST DRY AND CHIPPED CLEAR OF ALL LAITANCE IN AREAS TO BE GROUTED.
8. SEE DWG. Nº 100232 FOR SUGGESTED CONCRETE FOUNDATION AND ENGINE INSTALLATION PROCEDURE.
7. CEILCOTE #648 GROUT OR CARTER-WATERS #604 MAY BE USED. WE RECOMMEND THAT A REPRESENTATIVE OF THE GROUT SUPPLIER BE PRESENT AT INSTALLATION TO BE SURE THAT GROUT IS PREPARED AND PLACED ACCORDING TO SPECIFICATIONS.
6. CLEARANCE OF 6" TO 12" MUST BE MAINTAINED BETWEEN ENGINE FOUNDATION AND ADJOINING BUILDING OR ENGINE FOUNDATION.
5. FOUNDATION MUST BE SUITABLY REINFORCED.
4. 1 1/2" OF GROUT UNDER ENG. SUB-BASE & L.O. COOLER & 1" GROUT UNDER OTHER EQUIPMENT.
3. ALL FOUNDATION BOLTS ARE FURNISHED BY DE LAVAL.
2. FOUNDATION TO BE POURED MONOLITHIC.
1. FOR INSTALLATION SEE DWG. R-3924.

CERTIFIED PRINT MUST BE USED FOR CONSTRUCTION

CERTIFICATION

CUSTOMER: SOUTHERN CALIFORNIA EDISON CO.
CUSTOMER REF.:
JOB NUMBER: 2803 ENGINE NO. 75041
CONTRACT OR ORDER NO.: P.O. # B-0273001
CERTIFIED APPROVED FOR: CONSTRUCTION
BY:
TITLE: MGR. APPL. ENG. DATE:

DELAVAL TURBINE INC
DELAVAL ENGINE AND COMPRESSOR DIVISION
OAKLAND CALIF.

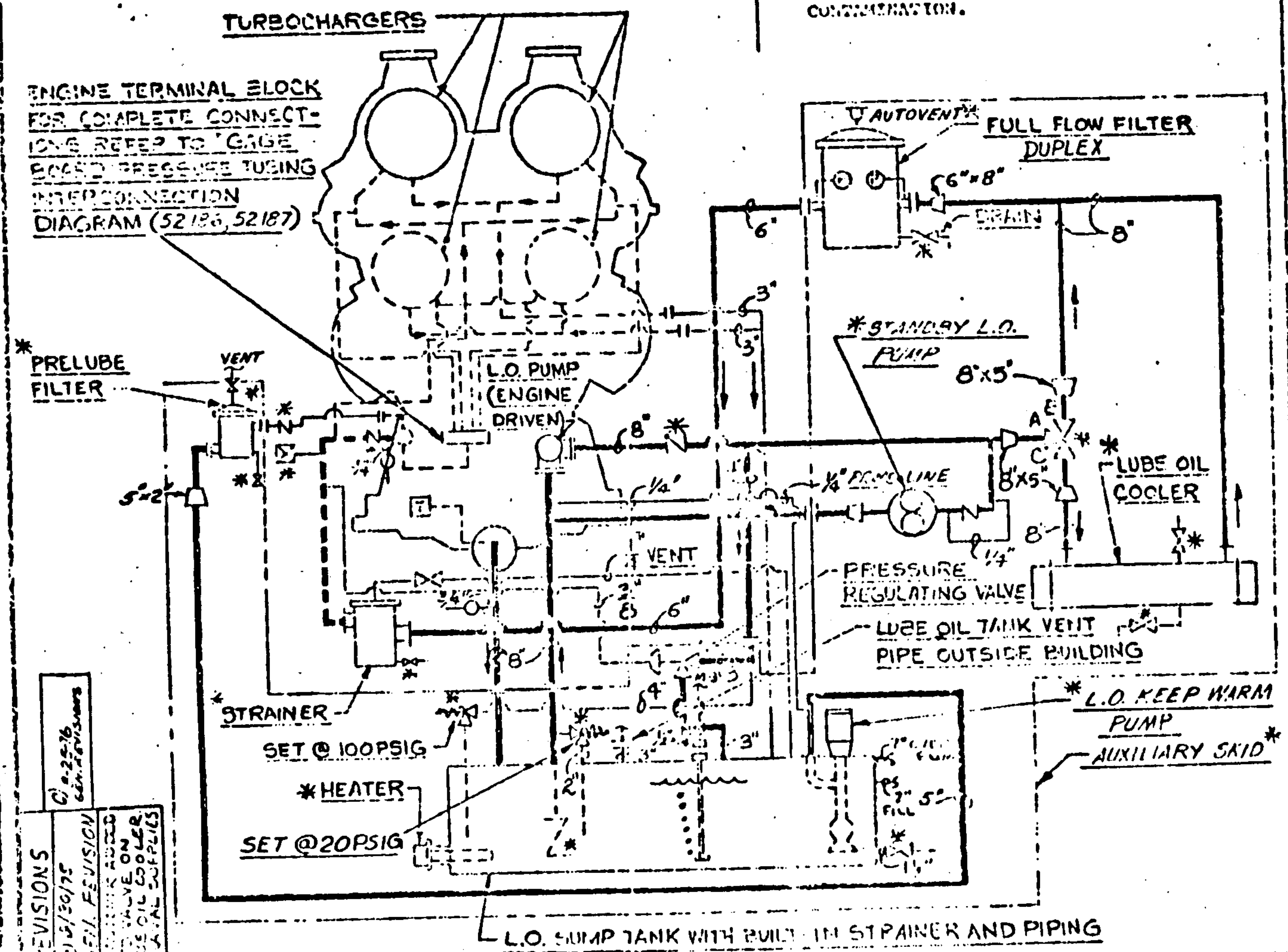
DELAVAL

FOUNDATION DRAWING
UNIT Nº 1 RV-20 (SOUTH)

SCALE 1/4" = 1'-0"

R-3925 G

1. ALL ITEMS MARKED * ARE SUPPLIED BY DELAVAL.
2. ( ) • ( ) SERIES NUMBERS CORRESPOND TO NUMBERED PIPE CONNECTIONS ON INSTALLATION DRAWING.
3. [illegible] ON ENGINE INSIDE OF (100) & (200) [illegible] ENGINE MOUNTED PIPING & FITTINGS SUPPLIED BY DELAVAL EXCEPT AS NOTED.
4. FOR PIPING SYMBOLS SEE DRAWING D-[illegible].
5. FLEXIBLE COUPLINGS ARE NOT RECOMMENDED BECAUSE OF POTENTIAL FAILURE HAZARD DURING OPERATION.
6. ALL PIPING TO BE PROPERLY SUPPORTED TO [illegible] VIBRATION & [illegible] LOADING.
7. TAPPINGS REQUIRED FOR CONTROLS ARE NOT [illegible] SEE CONTROL SCHEMATIC FOR SIZE AND LOCATION.
8. INSTALLATION CONTRACTOR(S) TO SUPPLY ALL OFF-ENGINE PIPING, PIPING FITTINGS, EQUIPMENT & VALVE NOT SUPPLIED WITH ENGINE, & AUXILIARY SKID PIPING SYSTEM.
9. NO [illegible] ARE TO BE USED IN PIPING.
10. PRECAUTIONS FOR LUBE OIL SYSTEM, DELAVAL FORM D-1597 ARE TO BE COMPLIED WITH.
11. INSTALL DRAINS AT ALL LOW POINTS AND VENTS AT ALL HIGH POINTS.
12. DELAVAL RECOMMENDS THAT NO ISOLATING VALVES BE INSTALLED IN THE MAIN LUBE OIL PIPING.
13. ALL PIPE TO BE HOT PICKLED AFTER FABRICATION AND PRESERVED WITH MIL SPECIFICATION C-22411 OR C-16713-0 TO PREVENT RUST. COMMERCIALLY THIS IS MET BY LPS NO. 3 MANUFACTURED BY LPS RESEARCH LABORATORIES, WEST LOS ANGELES, CALIF.
14. OPEN ENDS OF SECTIONS OF PIPE ARE TO BE PROTECTED WITH STEEL BLIND FLANGES AND GASKETS, IN ORDER TO PROTECT AGAINST CONTAMINATION.
15. NO CAST IRON FITTINGS SHALL BE USED IN THE SYSTEM.



REVISIONS
C) 6-25-76 GEN. REVISIONS
1/30/75 GEN. REVISION
ADDED VALVE ON LUBE OIL COOLER

APPL. ENGR.

CUSTOMER SOUTHERN CALIFORNIA EDISON
CUSTOMER REF P.O. NO. B-8273001
ENGINE NO 75041/42

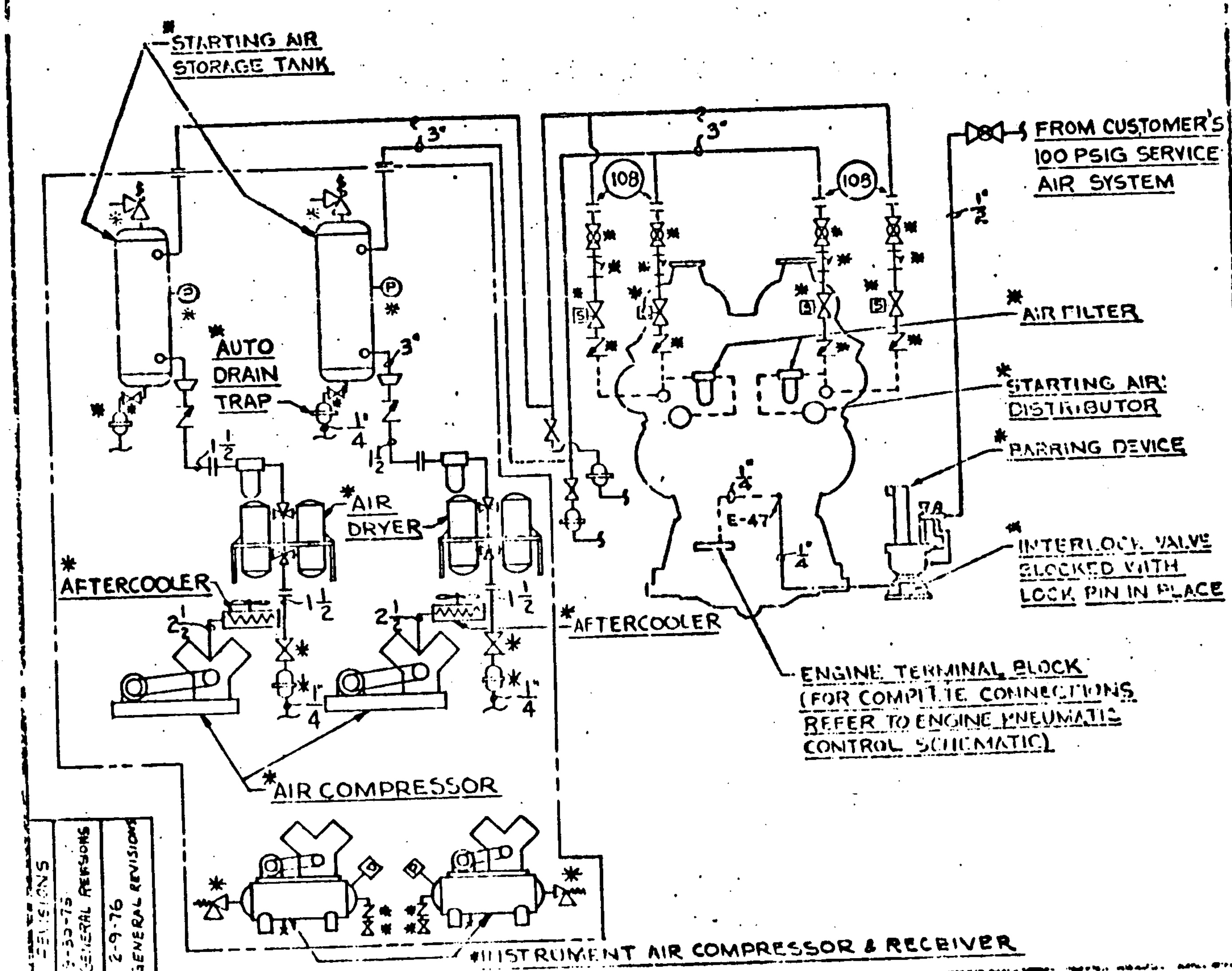
DELAVAL TURBINE INC
OAKLAND CALIF.

LUBE OIL PIPING SCHEMATIC

DRAWN R.L. 6-23-75
CHECKED M.J.
APPROVED G.G.
SCALE NONE

100662 C

11. SYSTEM WORKING PRESSURE 250 PSIG MAXIMUM.



1. ALL ITEMS MARKED * ARE SUPPLIED BY DELAVAL
2. (100) & (200) SERIES NUMBERS CORRESPOND TO NUMBERED PIPE CONNECTIONS ON INSTALLATION DRAWING.
3. LINES ON ENGINE INSIDE OF (100) & (200) SERIES NUMBERED CONNECTIONS [illegible] ENGINE MOUNTED PIPING AND FITTINGS SUPPLIED BY DELAVAL EXCEPT AS NOTED.
4. FOR PIPING SYMBOLS SEE DRAWING D-4313.
5. FLEXIBLE COUPLINGS ARE NOT RECOMMENDED AT CUSTOMER CONNECTIONS BECAUSE OF POTENTIAL FAILURE HAZARD DURING OPERATION.
6. ALL PIPING TO BE PROPERLY SUPPORTED TO MINIMIZE PIPE VIBRATION & FLANGE LOADING.
7. TAPPINGS REQUIRED FOR CONTROLS ARE NOT SHOWN BUT RATHER SEE CONTROL SCHEMATIC FOR SIZE & LOCATION.
8. OWNER TO SUPPLY ALL OFF ENGINE PIPING, PIPING FITTINGS, EQUIPMENT & VALVES NOT SUPPLIED WITH ENGINE & INSTALL ALL OFF ENGINE EQUIPMENT SUPPLIED BY DELAVAL.
9. ALL PIPING TO BE CLEANED INTERNALLY AIR BLOWN CLEAN PRIOR TO START UP.
10. PIPING SHOULD BE RUN AT A LOWER LEVEL THAN ENGINE INLET CONNECTION Nº 108. INSTALL MOISTURE COLLECTORS AND DRAINS IN PIPING, AT LOW POINTS NEAR INLET CONNECTION & ANY OTHER LOW POINT IN THE SYSTEM. START AIR FILTER SHOULD BE LOCATED ADJACENT TO INLET CONNECT Nº 108.

APPL. ENGR. [illegible]

CUSTOMER SOUTHERN CALIFORNIA EDISON

CUSTOMER REF. P.O. NO. B-8273001

ENGINE NO. 75041/42

DELAVAL TURBINE INC.
DELAVAL ENGINE AND COMPRESSOR DIVISION
OAKLAND CALIF. 94621

DELAVAL

STARTING AIR PIPING SCHEMATIC

DRAWN R.L. 6-19-75

CHECKED M.J.

APPROVED E.W.B.

100663 B

REVISIONS
10-30-75 GENERAL REVISIONS
2-9-76 GENERAL REVISIONS

11. PIPE SIZES SHOWN FOR INTAKE & EXHAUST ARE MINIMUM FOR 50 FT. PIPE RUNS

12. LOCATE THE INTAKE & EXHAUST SO THAT EXHAUST HEAT DOES NOT ENTER INTAKE.

13. LOCATE INTAKE AIR SILENCER AS CLOSE AS POSSIBLE TO THE TURBOCHARGER AIR INLET ADAPTER.

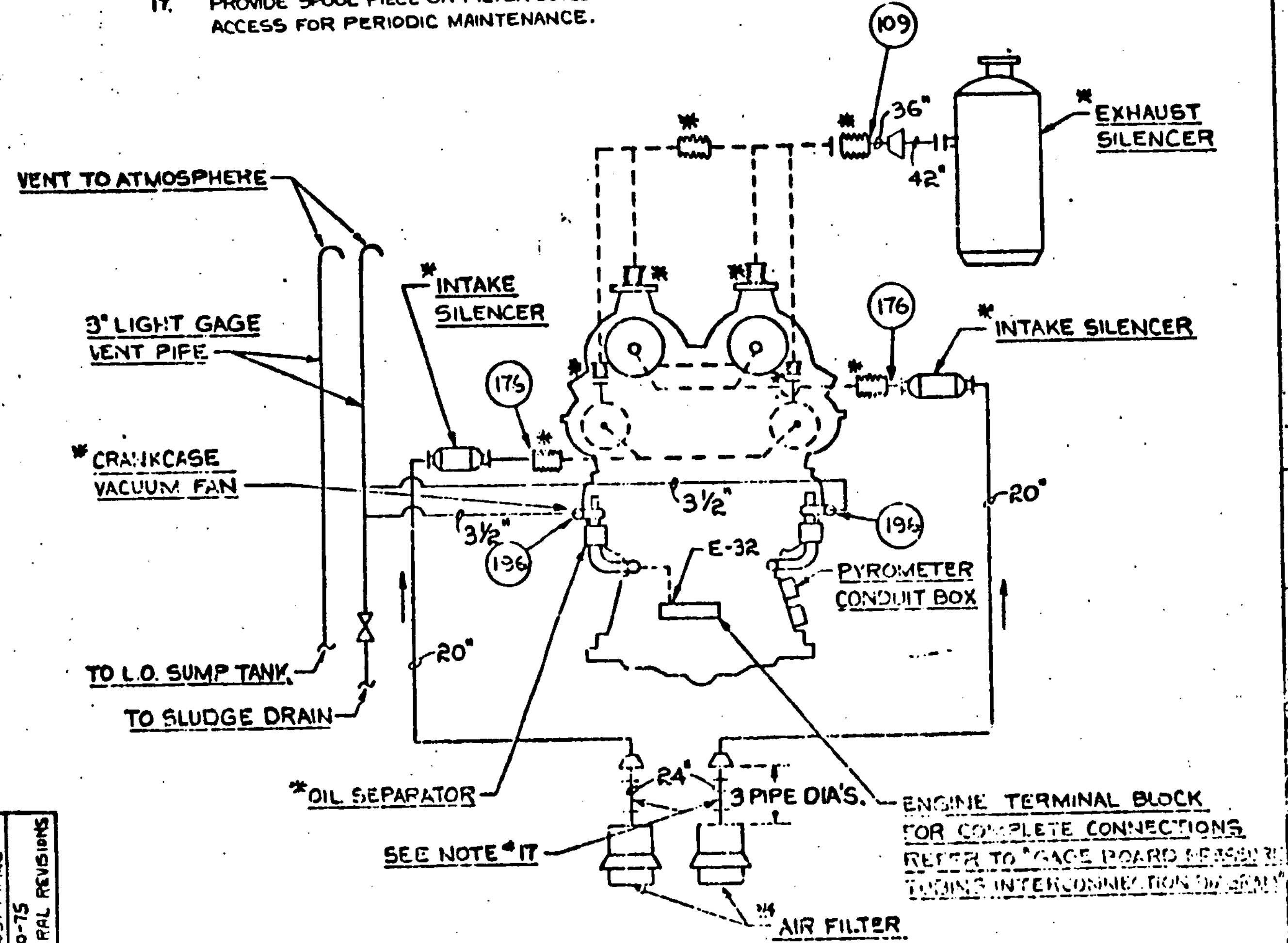
14. SOUND INSULATE PIPE BETWEEN TURBO & INTAKE SILENCER FOR FREQUENCIES BETWEEN 2000 & 8000 HZ.

15. PREPARE & PAINT INSIDE OF INTAKE PIPE WITH RUST-OLEUM OR EQUIVALENT COATING SYSTEM IN ACCORDANCE WITH THEIR DIRECTIONS FOR INTAKE PIPES.

16 EXHAUST MUFFLER TAIL PIPE IS TO BE EXTENDED TO AN OUTLET LEVEL ABOVE EAVES.

17. PROVIDE SPOOL PIECE ON FILTER OUTLET FOR ACCESS FOR PERIODIC MAINTENANCE.

1. ALL ITEMS MARKED * ARE SUPPLIED BY DELAVAL.
2. (100) & (200) SERIES NUMBERS CORRESPOND TO NUMBERED PIPE CONNECTIONS ON INSTALLATION DRAWING.
3. LINES OR ENGINE INSIDE OF (100) & (200) SERIES NUMBERED CONNECTIONS REPRESENTING ENGINE MOUNTED PIPING & FITTINGS SUPPLIED BY DELAVAL EXCEPT AS NOTED.
4. FOR PIPING SYMBOLS SEE DRAWING D-8313
5. FLEXIBLE COUPLINGS ARE NOT RECOMMENDED AT CUSTOMER CONNECTIONS BECAUSE OF POTENTIAL FAILURE HAZARD DURING OPERATION EXCEPT FOR FLEXIBLE CONNECTIONS AT CONNECTIONS 176 & 109
6. ALL PIPING TO BE PROPERLY SUPPORTED TO MINIMIZE PIPE VIBRATION & FLANGE LOADING. INTAKE & EXHAUST PIPES MUST NOT BE SUPPORTED BY THE TURBOCHARGER.
7. TAPPINGS REQUIRED FOR CONTROLS ARE NOT SHOWN BUT RATHER SEE CONTROL SCHEMATIC FOR SIZE & LOCATION.
8. INSTALLATION CONTRACTOR(S) TO SUPPLY ALL OFF ENGINE PIPING, PIPING FITTINGS, EQUIPMENT & VALVES NOT SUPPLIED WITH ENGINE & INSTALL ALL OFF-ENGINE EQUIPMENT.
9. INLET AIR PRESSURE DROP MUST BE NO MORE THAN 12 INCHES H_2O AT CONNECTION 176.
10. EXHAUST GAS BACK PRESSURE MUST BE NO MORE THAN 10 INCHES H_2O AT CONNECTION 109



APPL. ENGR. ____

CUSTOMER SOUTHERN CALIFORNIA EDISON

CUSTOMER REF. P.O. NO. B-8273001

ENGINE NO. 75041/42

DELAVAL TURBINE INC. DELAVAL ENGINE AND COMPRESSOR DIVISION OAKLAND, CALIF. 94621

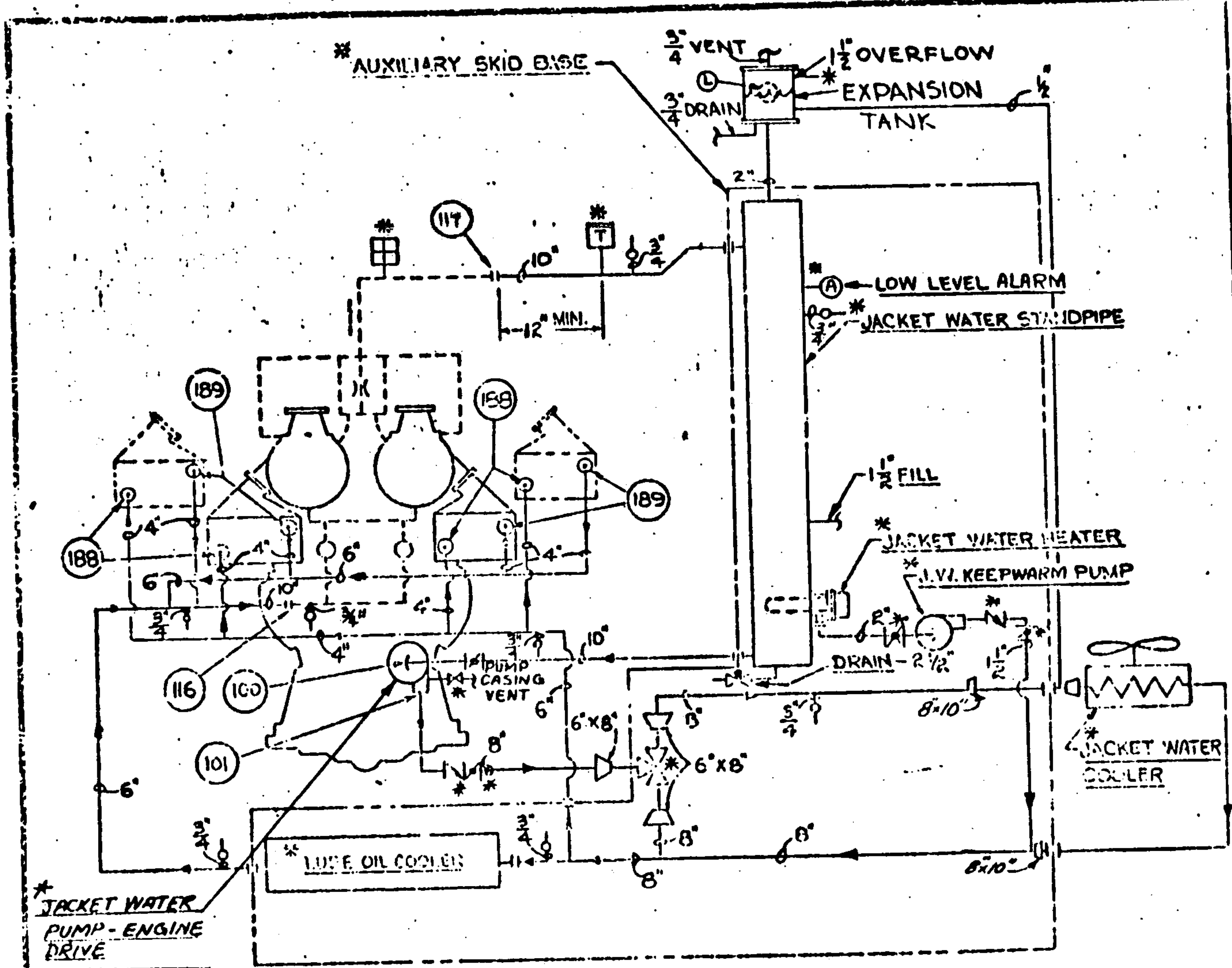
DELAVAL

EXHAUST, INTAKE & CRANKCASE VACUUM PIPING SCHEMATIC

DRAWN R.L. | CHECKED M.J. | APPROVED R.S.

100664 B

REVISIONS
A) 7-10-75 REVISED EXHAUST PIPING
B) 9-30-75 GENERAL REVISIONS



1. ALL ITEMS MARKED * ARE SUPPLIED BY DELAVAL.
2. (100) & (200) NUMBERS CORRESPOND TO NUMBERED PIPE CONNECTIONS ON INSTALLATION DRAWING.
3. LINES ON ENGINE INSIDE OF (100) & (200) SERIES NUMBERED CONNECTIONS REPRESENTING ENGINE MOUNTED PIPING & FITTINGS SUPPLIED BY DELAVAL EXCEPT AS NOTED.
4. FOR PIPING SYMBOLS SEE DRAWING D-4313.
5. FLEXIBLE COUPLINGS ARE NOT RECOMMENDED AT CUSTOMER CONNECTIONS BECAUSE OF POTENTIAL FAILURE HAZARD DURING OPERATION.
6. ALL PIPING TO BE PROPERLY SUPPORTED TO MINIMIZE PIPE VIBRATION & FLANGE LOADING.
7. TAPPINGS REQUIRED FOR CONTROLS ARE NOT SHOWN BUT RATHER SEE CONTROL SCHEMATIC FOR SIZE & LOCATION.
8. INSTALLATION CONTRACTOR(S) TO SUPPLY ALL OFF ENGINE PIPING, PIPING FITTINGS, EQUIPMENT & VALVES NOT SUPPLIED WITH ENGINE & INSTALL ALL OFF ENGINE EQUIPMENT SUPPLIED BY DELAVAL.
9. PROVIDE DRAINS AT ALL LOW POINTS & VENTS AT ALL HIGH POINTS.
10. PIPE SIZES SHOWN ARE MINIMUM FOR MOST INSTALLATIONS BUT MAY VARY WHEN LENGTH OF PIPE, NUMBER OF FITTINGS & VALVES PRODUCE EXCESSIVE PRESSURE DROP.
11. 10 PSI PRESSURE DROP IS AVAILABLE FOR OFF ENGINE PIPING CIRCUIT.

APPL. ENGR. ________

CUSTOMER SOUTHERN CALIFORNIA EDISON

CUSTOMER REF. P.O. NO. B-8273001

ENGINE NO. 75041/42

DELAVAL

JACKET WATER PIPING SCHEMATIC

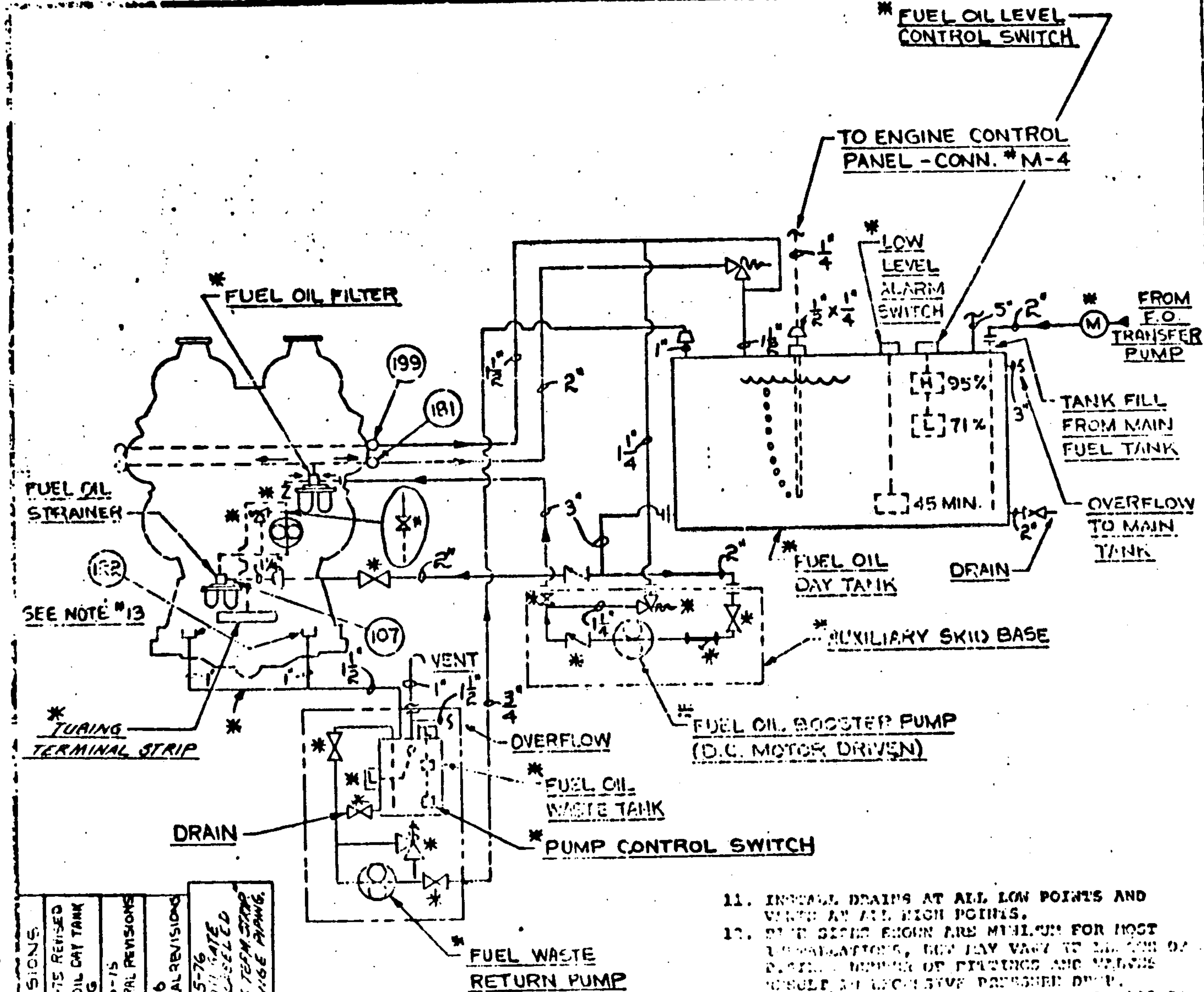
DRAWN R.L. 6-20-75

CHECKED N.J.

APPROVED

100665 B

421



1. ALL ITEMS MARKED * ARE SUPPLIED BY DELAVAL.
2. [illegible] & [illegible] SERIES NUMBERS CORRESPOND TO NUMBERED PIPE CONNECTIONS ON INSTALLATION DRAWING.
3. [illegible] ENGINE [illegible] OF [illegible] & [illegible] SERIES [illegible] CONNECTIONS [illegible] ENGINE MOUNTED PIPING & FITTINGS SUPPLIED BY DELAVAL EXCEPT AS NOTED.
4. FOR PIPING SYMBOLS SEE DRAWING D-4313.
5. FLEXIBLE COUPLINGS ARE NOT RECOMMENDED AT CUSTOMER CONNECTIONS BECAUSE OF POTENTIAL FAILURE HAZARD DURING OPERATION.
6. ALL PIPING TO BE PROPERLY SUPPORTED TO MINIMIZE PIPE VIBRATION & FLANGE LOADING.
7. TAPPINGS REQUIRED FOR CONTROLS ARE NOT SHOWN [illegible] CONTROL SCHEMATIC FOR SIZE AND LOCATION.
8. OWNER TO SUPPLY ALL OFF ENGINE PIPING, PIPING FITTINGS, EQUIPMENT & VALVES NOT SUPPLIED WITH ENGINE & INSTALL ALL OFF ENGINE EQUIPMENT SUPPLIED BY DELAVAL.
9. ALL PIPING TO BE MECHANICALLY CLEANED AND PRESERVED WITH MIL-SPEC C-23411 OR C-15713-D TO PREVENT RUST. COMMERCIALLY THIS IS MET BY LPS NO. 3 MANUFACTURED BY LPS RESEARCH LABORATORIES OF WEST LOS ANGELES, CALIFORNIA.

11. INSTALL DRAINS AT ALL LOW POINTS AND VENTS AT ALL HIGH POINTS.
12. PIPE SIZES SHOWN ARE MINIMUM FOR MOST INSTALLATIONS, BUT MAY VARY [illegible] NUMBER OF FITTINGS AND VALVES [illegible] EXCESSIVE PRESSURE DROP.
13. [illegible]

APPL ENGR.

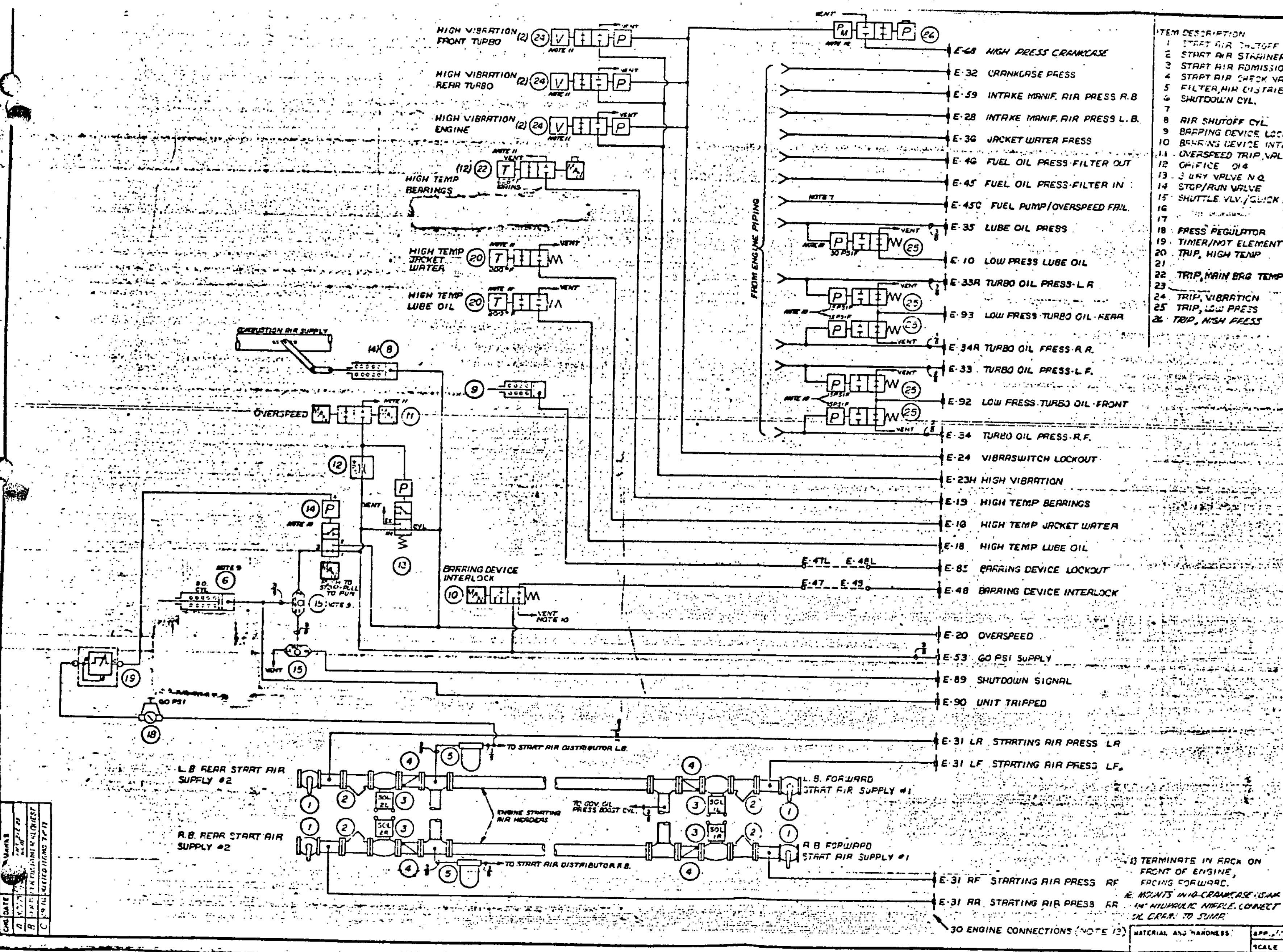
CUSTOMER: SOUTHERN CALIFORNIA EDISON
CUSTOMER REF: P.O. No. B-8273001
ENGINE NO: 75041/42

DELAVAL TURBINE INC. ENGINE AND COMPRESSOR DIVISION OAKLAND CALIF.

FUEL OIL PIPING SCHEMATIC

DRAWN	R.L. [illegible]	100666 D
CHECKED	M.J.	
APPROVED	[illegible]	

REVISIONS
- 10-75 REVISED FUEL OIL DAY TANK PIPING
- 3-30-76 GENERAL REVISIONS
- 2-9-76 GENERAL REVISIONS
- 5-25-76 [illegible] TUBING TERM STRIP [illegible] PIPING



ITEM	DESCRIPTION	PART NO	QTY	P L	MFR
1	START AIR SHUTOFF VALVE	SEE SPEC	4	441	
2	START AIR STRAINER		4		—
3	START AIR ADMISSION VALVE		4		—
4	START AIR CHECK VALVE		4		—
5	FILTER, AIR DISTRIBUTOR		2	442	—
6	SHUTDOWN CYL.		1	413	—
7					
8	AIR SHUTOFF CYL.		4	475	—
9	BARRING DEVICE LOCKOUT CYL.		1	525	—
10	BARRING DEVICE INTERLOCK		1	525	—
11	OVERSPEED TRIP VALVE	F-153-009	1	410	WOODWARD
12	ORIFICE .014	F-573-133	1	695	CALCON
13	3 WAY VALVE N.O.	F-573-132	1		HUMPHREY
14	STOP/RUN VALVE	F-573-212	1		CALCON
15	SHUTTLE VLV./QUICK RELEASE	F-573-126	2		HUMPHREY
16					
17					
18	PRESS REGULATOR	F-579-013	1		NORGREN
19	TIMER/NOT ELEMENT	F-573-307	1		MAC
20	TRIP, HIGH TEMP	F-573-330	2		CALCON
21					
22	TRIP, MAIN BRG TEMP	F-573-271	12		CALCON
23					
24	TRIP, VIBRATION	F-573-171	6		CALCON
25	TRIP, LOW PRESS	F-573-156	5		CALCON
26	TRIP, HIGH PRESS	F-573-359	1		CALCON

1. CONTROL MEDIUM IS AIR
2. ¢ DENOTES TUBE TERMINATION AT ENGINE TERMINAL RACK. IDENTIFY TERMINALS.
3. SYSTEM SHOWN SHUTDOWN & DEPRESSURIZED
4. TUBING IS SEAMLESS STL. 1/4" O.D. EXCEPT AS NOTED. FITTINGS ARE CAD PLATED STEEL.
5. 1/4" O.D. TUBING IS RECOMMENDED FOR CONNECTION TO PANEL EXCEPT AS SHOWN 3/8" ON THIS DWG.
6. SET, TEST, & TAG ALL SAFETY SENSORS DURING SHOP TEST.
7. THIS TUBE CONNECTS BETWEEN FUEL PUMP DISCH & DISCH CHECK VALVE.
8. ALL VENTS MUST FACE DOWN OR BE SPLASH SHIELDED.
9. KEEP TUBES BETWEEN CYLINDERS & FEED DEVICES SHORT.
10. SHOWN IN TRIPPED CONDITION.
11. SHOWN IN NORMAL CONDITION.
12. TERMINATE IN RACK ON FRONT OF ENGINE, FACING FORWARD.
E. MOUNTS IN CRANKCASE [illegible] 1/4" HYDRAULIC NIPPLE. CONNECT OIL DRAIN TO SUMP.

REFERENCE DRAWINGS
52187 PANEL PNEU SCHEM
52189 PANEL ELEC SCHEM
52186 ENGINE ELEC SCHEM
52194 AUX MODE ELEC SCHEM

SAFETY RELATED

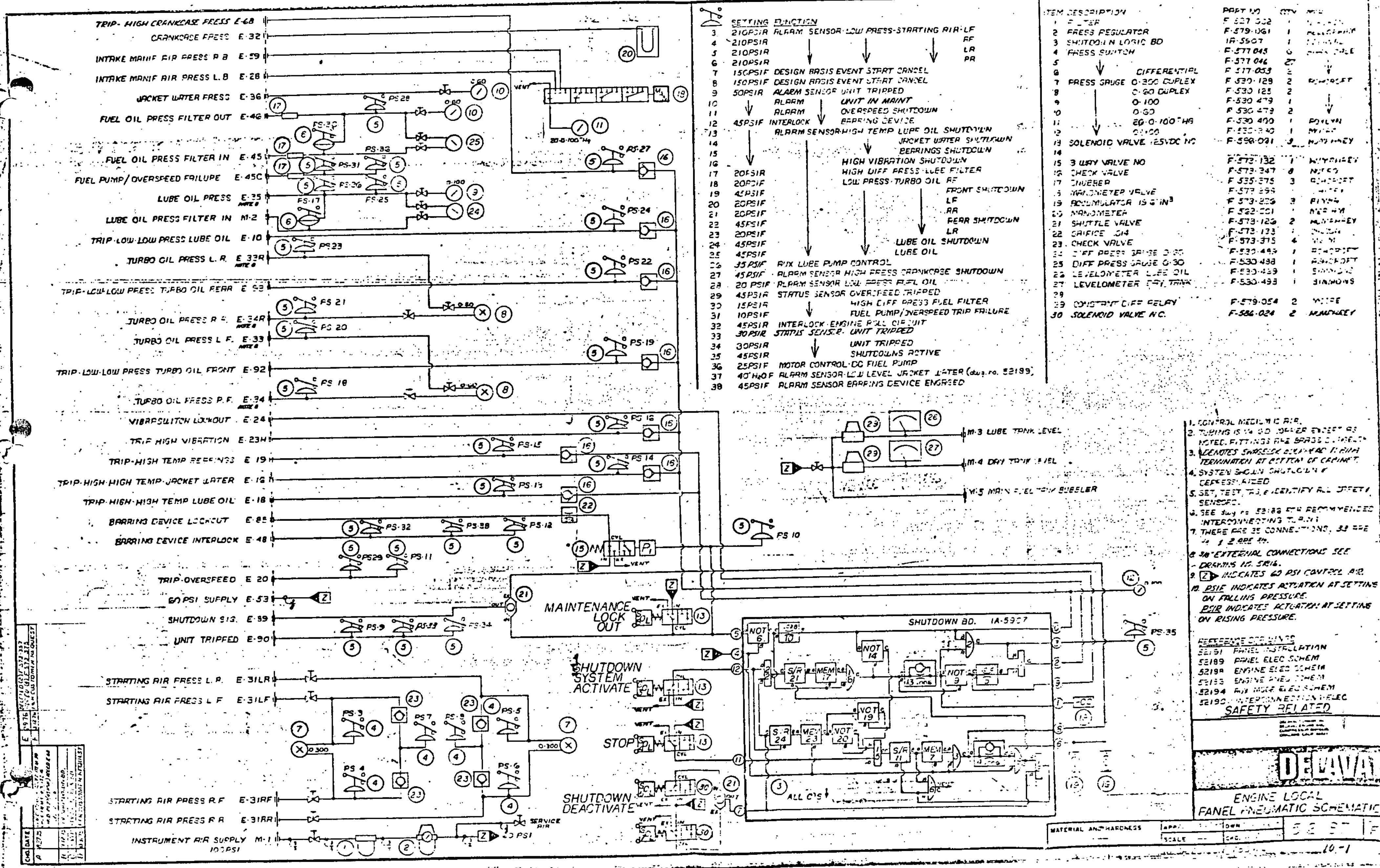
DELAVAL

ENGINE PNEUMATIC SCHEMATIC

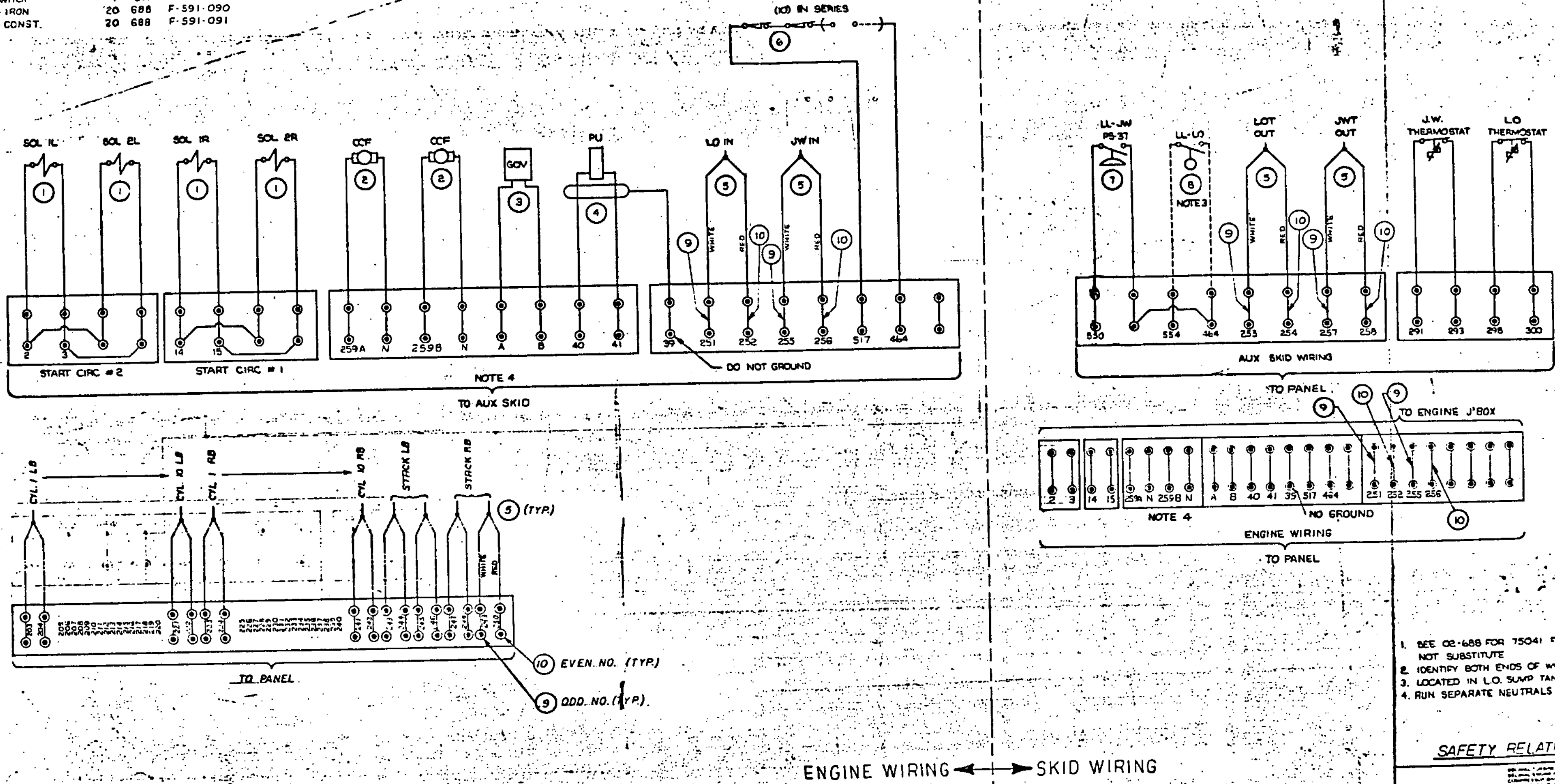
MATERIAL AND HARDNESS | SCALE — | DWN | CKD | 52186

SO. CA. EDISON

10-1


TRIP-HIGH CRANKCASE PRESS E-68
CRANKCASE PRESS E-32
INTAKE MANIF AIR PRESS R.B E-29
INTAKE MANIF AIR PRESS L.B E-28
JACKET WATER PRESS E-36
FUEL OIL PRESS FILTER OUT E-46
FUEL OIL PRESS FILTER IN E-45
FUEL PUMP/OVERSPEED FAILURE E-45C
LUBE OIL PRESS E-35
LUBE OIL PRESS FILTER IN M-2
TRIP-LOW-LOW PRESS LUBE OIL E-10
TURBO OIL PRESS L.R. E-33R
TURBO OIL PRESS R.R. E-34R
TURBO OIL PRESS L.F. E-33
TRIP-LOW-LOW PRESS TURBO OIL FRONT E-92
TURBO OIL PRESS R.F. E-34
VIBRASWITCH LOCKOUT E-24
TRIP HIGH VIBRATION E-23H
TRIP-HIGH TEMP BEARINGS E-19
TRIP-HIGH-HIGH TEMP JACKET WATER E-16
TRIP-HIGH-HIGH TEMP LUBE OIL E-18
BARRING DEVICE LOCKOUT E-85
BARRING DEVICE INTERLOCK E-48
TRIP-OVERSPEED E-20
60 PSI SUPPLY E-53
SHUTDOWN SIG. E-99
UNIT TRIPPED E-90
STARTING AIR PRESS L.R. E-31LR
STARTING AIR PRESS L.F. E-31LF
STARTING AIR PRESS R.F. E-31RF
STARTING AIR PRESS R.R. E-31RR
INSTRUMENT AIR SUPPLY M-1
100PSI
SERVICE AIR
60 PSI
MAINTENANCE LOCK OUT
SHUTDOWN SYSTEM ACTIVATE
STOP
SHUTDOWN DEACTIVATE
SHUTDOWN BD. 1A-5907
ALL O'S
M-3 LUBE TANK LEVEL
M-4 DAY TANK LEVEL
PS 10
PS-35
SETTING FUNCTION
ITEM DESCRIPTION
PART NO.
SOLENOID VALVE N.C.
SAFETY RELATED
ENGINE LOCAL PANEL PNEUMATIC SCHEMATIC
MATERIAL AND HARDNESS
SCALE

ITEM	DESCRIPTION	QTY	PL.	PART NO.
1	STARTING AIR SOLENOID	4	441	SEE SPEC
2	CRANKCASE FAN	2	387	SEE SPEC
3	GOVERNOR CONNECTOR	1	415	SEE SPEC
4	MAGNETIC PICKUP	1	688	EA-004-000
5	THERMOCOUPLE ASSEMBLY	18	690	F-540-050
6	CRANKCASE DOOR SWITCH	10	387	SEE SPEC
7	PRESSURE SWITCH	1	690	F-577-062
[illegible]	LEVEL SWITCH	1	691	F-528-021
[illegible]	TC LUG-IRON	20	688	F-591-090
10	TC LUG-CONST.	20	688	F-591-091



1. SEE 02-688 FOR 75041 FOR WIRE - DO NOT SUBSTITUTE
2. IDENTIFY BOTH ENDS OF WIRES
3. LOCATED IN L.O. SUMP TANK
4. RUN SEPARATE NEUTRALS TO PANEL.

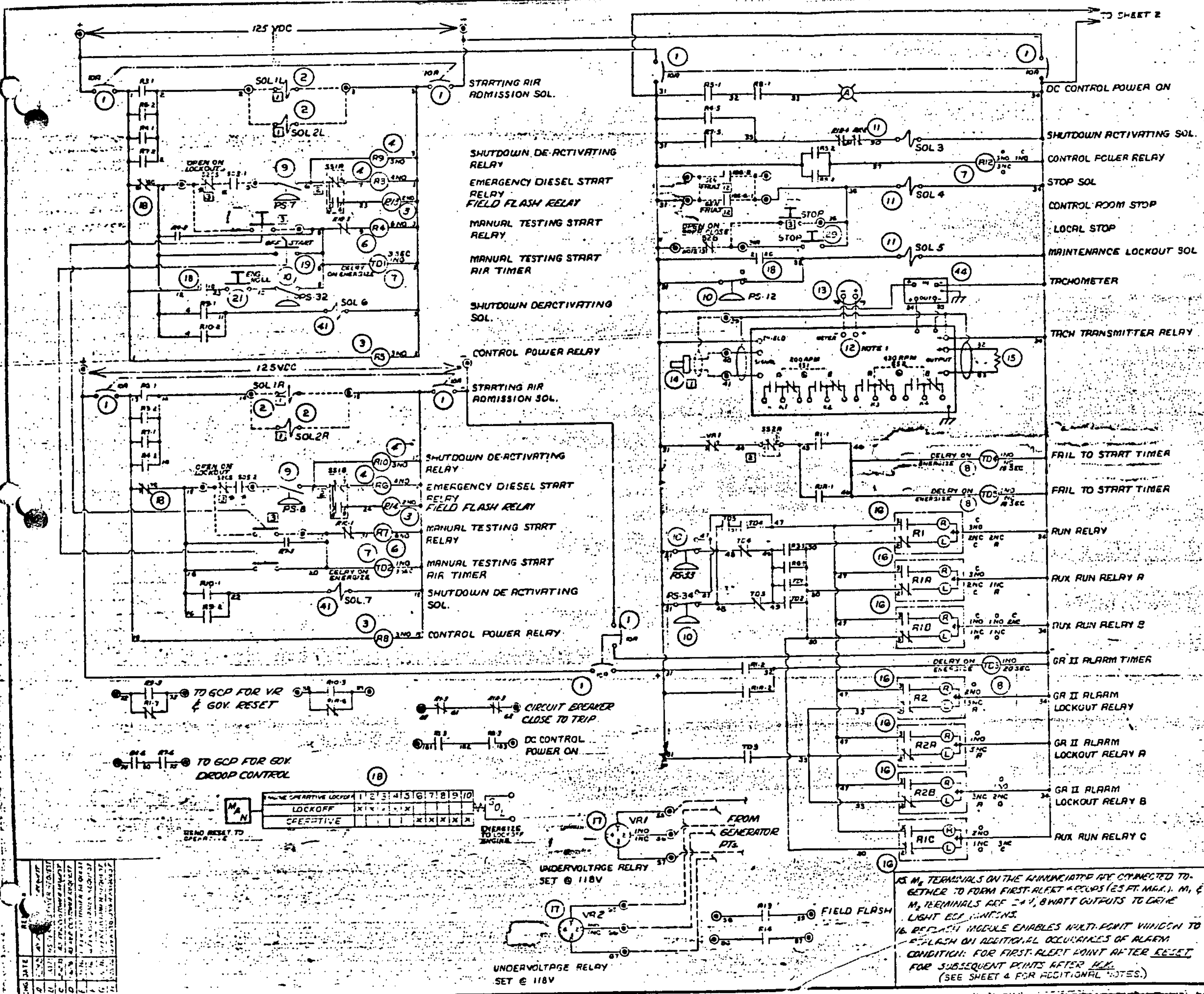
SAFETY RELATED

DELAVAL

ENGINE & AUXILIARY SKID WIRING SCHEMATIC

MATERIAL AND HARDNESS | APP. | SCALE ~ | DWN. | CKD. | 52188

SO CAL. ED 75041



ITEM	DESCRIPTION	PART NO.	F L	QTY	MFR
1	CIRCUIT BREAKER DC	F 511-083	500	10	HEINEMANN
2	AIR START VALVE SOL	SEE SPEC	441	4	CIRCLE SEAL
3	RELAY 2 POLE DC	F 590-072	500	2	ALLEN BRADLEY
4	4	F-580-078		6	
5					
6	7	F-580-081		5	
7	TIME DELAY	F-590-114		2	SYRACUSE
8	TIME DELAY	F-590-110		3	SYRACUSE
9	PRESS SWITCH	F-577 045		6	BARKSDALE
10	PRESS SWITCH	F 577-046		27	BARKSDALE
11	SOLENOID VALVE	F 586-061		3	HUMPHREY
12	TACHOMETER TRANSMITTER	F-594-041		1	[illegible]
13	TACHOMETER	F 594-029		1	DYNALCO
14	MAG PICKUP	EA-004-000	688	1	AIRPAX
15	RESISTOR 50 Ω	F-533-019	500	1	OHMITE
16	RELAY 6 POLE DC L/R	F-580-089		7	ALLEN BRADLEY
17	UNDERVOLTAGE RELAY	F-590-213		2	WILMAR
18	MODE SWITCH	F-585-122		1	GE
19	SEL. SW -KEYED	F-585 121		1	FURNAS
20	CIRCUIT BREAKER AC 15	F-511-085		2	HEINEMANN
21	PUSHBUTTON SW. BLACK	F 576-005		6	FURNAS
22	CIRCUIT BREAKER AC 10	F-511-001		1	HEINEMAN
23	TEMP INDICATOR	F-578-044		1	DORIC
24	THERMOCOUPLE SELECTOR	F-595-120		1	OMEGA
25	CRANKCASE FAN	SEE SPEC	387	2	—
26	HOURMETER	F 581-014	500	1	WESTINGHOUSE
27	TOGGLE SWITCH	F-585-123		1	HUBBELL
28	SEL SW 3 POS	F-585-004		5	FURNAS
29	PUSHBUTTON SW. RED	F-576-006		1	FURNAS
30	HORN	F-536-018		1	FEDERAL
31	ANNUNCIATOR	F-501-053		1	RONAN
32	TC SETPOINT RELAY	F-540-068		1	ACTION PAK
33	TC DUAL SETPOINT RELAY	F-540-098		3	ACTION PAK
34	DUPLEX RECEPTACLE	F-581-024		1	HUBBELL
35	MICRO SWITCH	F-125-003		3	MICRO
36	LAMP ASSY.	F-555-037		1	[illegible]
37	TEMP SWITCH	F-593-004		1	BARKSDALE
38	STRIP HEATER	F-535-395		2	GE
39	DIFF. PRESS SW	F-577-053		2	BARKSDALE
40	SEL SW 2 POS	F-585-003		1	FURNAS
41	SOLENOID VALVE	F-586-024		2	HUMPHREY
42	LEVEL GAUGE	F-561-089		1	METERMASTER
43	RELAY 2 POLE DC	F-580-094		1	ALLEN BRADLEY
44	POWER SUPPLY	F-596-010		1	AIR PAX

* PROVIDED BY OWNER
☐ INDICATES LOCATION
1 ON ENGINE
2 PART OF ITEM 12
3 IN CONTROL ROOM PANEL
4 AUX CONTACT OF ITEM 31
5 ON HEATER
6 IN MCC
7 PART OF DAY TANK LEVEL SW
8 PART OF DC STARTER, AUX SKID
9 PART OF LUBE TANK SW.
10 ON AUX MODULE
11 IN GENERATOR PANEL
12 IN SWITCHGEAR

1. TACH RELAY CONTACTS SHOWN WITH POWER OFF. WHEN POWER IS APPLIED, RELAY CONTACTS REMAIN AS SHOWN.
2. SYSTEM SHOWN DE ENERGIZED.
3. WIRING TO BE [illegible]
4. USE THESE NO CONTACTS TO START AUX. FULL FLOW LUBE OIL PUMP
5. REMOVE JUMPER IF REDUNDANT CONDUIT IS USED IN THIS CIRCUIT.
6. JW-LL SENSOR TO BE 35" BELOW ℄ OF JW INLET FLANGE ON STANDPIPE.
7. THIS CONTACT TO BE CLOSED WHEN LOCKOUT RELAY IS RESET.
8. MODE SW SHOWN LATCHED, OPERATIONAL
9. MOUNT HIGH IN CABINET CENTRALIZED.
10. REMOVE JUMPER IF SPARE IS USED.
11. O, C, A NOTATIONS NEAR RELAYS SHOW CONTACTS FOR OWNER, CONTROL & ALARM RESPECTIVELY
12. NAMEPLATES ON SHT 3 & 4 IN PARENTHESES ARE FOR DIESEL GENERATOR PANEL #2.
13. AUX. CONTACT OF GENERATOR BREAKER. CONTACTS TRANSFER WHEN BREAKER CLOSES
14. ALL ALARM FIELD CONTACTS ARE SHOWN IN A RELAXED OR DE-ENERGIZED STATE. PRESSURE & LEVEL SWITCHES WITH THE EXCEPTION OF PS-11, PS-10 & LS-3 (HIGH LEVEL) ARE SHOWN WITH ALARMING FIELD CONTACTS. ALL OTHER CONTACTS ARE SHOWN NORMAL OR NON-ALARMING.
15. M_1 TERMINALS ON THE ANNUNCIATOR ARE CONNECTED TOGETHER TO FORM FIRST-ALERT GROUPS (25 FT. MAX.). M_1 & M_2 TERMINALS ARE 24V, 8 WATT OUTPUTS TO DRIVE LIGHT ECL WINDOWS.
16. REFLASH MODULE ENABLES MULTI-POINT WINDOW TO REFLASH ON ADDITIONAL OCCURANCES OF ALARM CONDITION: FOR FIRST-ALERT POINT AFTER RESET, FOR SUBSEQUENT POINTS AFTER ACK.
(SEE SHEET 4 FOR ADDITIONAL NOTES.)

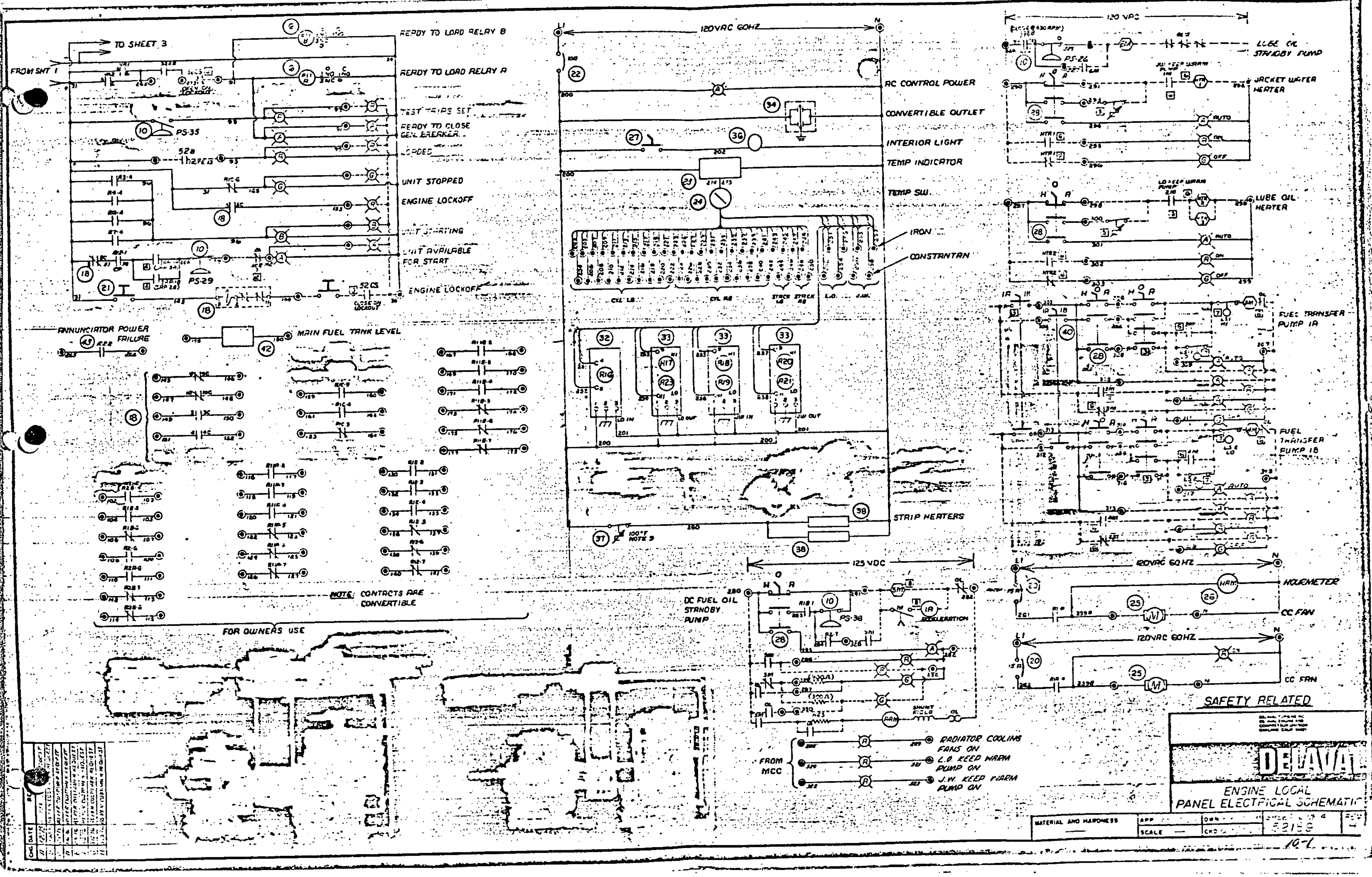
SAFETY RELATED

REFERENCE DRAWINGS
52190 INTERCONNECTIONS
52195 PANEL ELEC SCHEM MCR
52187 PANEL PNEU SCHEM
52186 ENG PNEU. SCHEM.
52194 AUX MOD ELEC
52188 ENG ELEC. SCHEM.
52191 PANEL INSTALLATION

DELAVAL

ENGINE LOCAL PANEL ELECTRICAL SCHEMATIC

MATERIAL AND HARDNESS	APP.	DWN	52[illegible]
—	SCALE —	CKD	



SAFETY RELATED

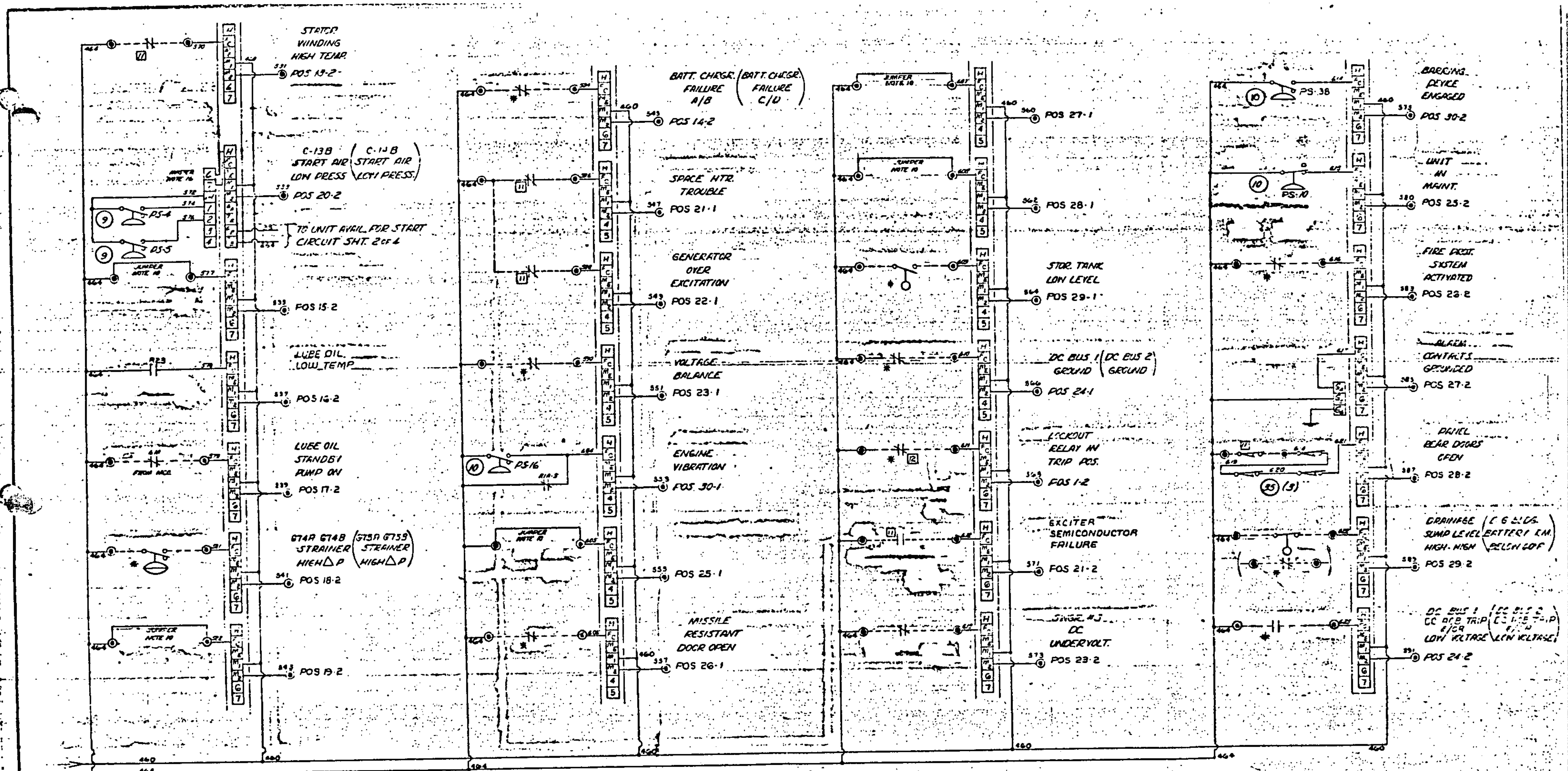
DELAVAL

ENGINE LOCAL PANEL ELECTRICAL SCHEMATIC

MATERIAL AND HARDNESS | APP | DWN | SCALE | CHKD

52198

10-1



NOTES:

17. EACH WIRE TO BE IDENTIFIED ON EACH END. RED MARKERS FOR PANEL 1 & YELLOW FOR PANEL 2.
18. EACH TERMINAL TO BE PERMANTELY IDENTIFIED. RED MARKERS FOR PANEL 1 & YELLOW FOR PANEL 2.
19. APPARATUS MOUNTED INTERNALL SHALL BE IDENTIFIED WITH RED (PANEL 1) OR YELLOW (PANEL 2) MARKERS.
20. SEAL ALL DEVICES ON FRONT FACE OF PANEL WITH GASKET OR RTV.

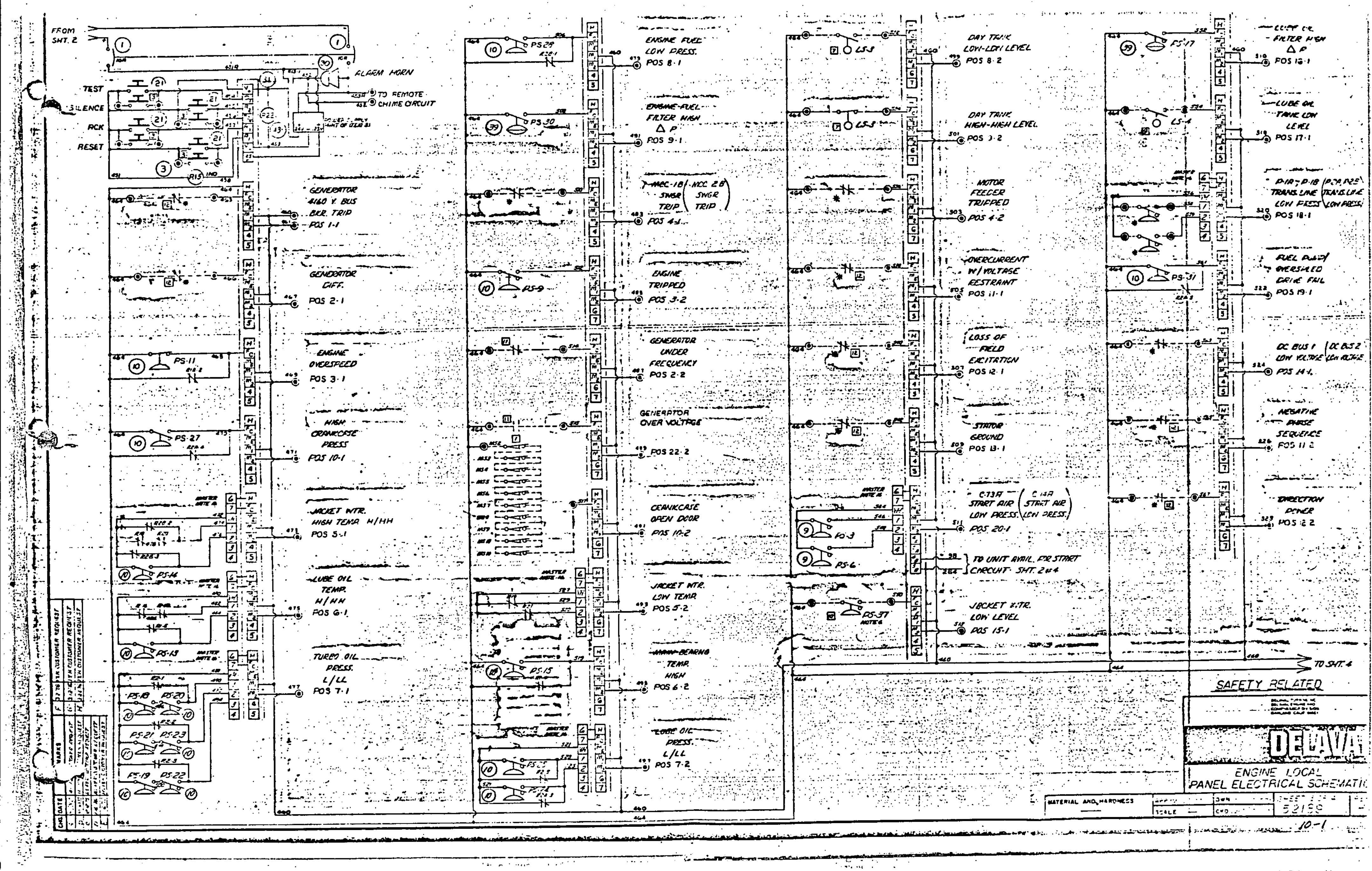
SAFETY RELATED

DELAVAL

ENGINE LOCAL PANEL ELECTRICAL SCHEMATIC

MATERIAL AND HARDNESS | APP. | DWN. | SCALE | CKD.

10-1


FROM SHT. 2
ALARM HORN
TEST
SILENCE
ACK
RESET
TO REMOTE CHIME CIRCUIT
GENERATOR 4160 V. BUS BKR. TRIP POS 1-1
GENERATOR DIFF. POS 2-1
ENGINE OVERSPEED POS 3-1
HIGH CRANKCASE PRESS POS 10-1
JACKET WTR. HIGH TEMP. H/HH POS 5-1
LUBE OIL TEMP. H/HH POS 6-1
TURBO OIL PRESS. L/LL POS 7-1
ENGINE FUEL LOW PRESS. POS 8-1
ENGINE FUEL FILTER HIGH Δ P POS 9-1
MCC-1B SWGR TRIP (MCC 2B SWGR TRIP) POS 4-1
ENGINE TRIPPED POS 3-2
GENERATOR UNDER FREQUENCY POS 2-2
GENERATOR OVER VOLTAGE POS 22-2
CRANKCASE OPEN DOOR POS 10-2
JACKET WTR. LOW TEMP. POS 5-2
MAIN BEARING TEMP. HIGH POS 6-2
LUBE OIL PRESS. L/LL POS 7-2
DAY TANK LOW-LOW LEVEL POS 8-2
DAY TANK HIGH-HIGH LEVEL POS 9-2
MOTOR FEEDER TRIPPED POS 4-2
OVERCURRENT W/VOLTAGE RESTRAINT POS 11-1
LOSS OF FIELD EXCITATION POS 12-1
STATOR GROUND POS 13-1
C-13A START AIR LOW PRESS. (C-14A START AIR LOW PRESS.) POS 20-1
TO UNIT AVAIL. FOR START CIRCUIT SHT. 2 & 4
JACKET WTR. LOW LEVEL POS 15-1
FILTER HIGH Δ P POS 16-1
LUBE OIL TANK LOW LEVEL POS 17-1
P-1A, P-1B TRANS LINE LOW PRESS (P2A, P2B TRANS LINE LOW PRESS) POS 18-1
FUEL PUMP OVERSPEED DRIVE FAIL POS 19-1
DC BUS 1 LOW VOLTAGE (DC BUS 2 LOW VOLTAGE) POS 14-1
NEGATIVE PHASE SEQUENCE POS 11-2
DIRECTION POWER POS 22
TO SHT. 4
SAFETY RELATED
DELAVAL
ENGINE LOCAL PANEL ELECTRICAL SCHEMATIC
MATERIAL AND HARDNESS
SCALE
10-1

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
+A												+DC SUPPLY
-A												-DC SUPPLY
+B												+DC SUPPLY
-B												-DC SUPPLY
2	2											
3	3											
4							299					
							217U					
5										X		SDS-1
8							218U					
14	14											
15	15											
16							300					
							310U					
17										X		SDS-2
20							311U					
21							413					
33A							217V					
34							41A				R1-A	
							296					
36							218V			X		186-2
										X		186-G-1
										X		CR-2
39	39											
40	40											
41	41											
55				A								
56				B								
57				C								
53			B-									
59			3									
60										X		TRIP 52
62										X		TRIP 52
65				A								
66				B								
67				C								
72		143	B+				148			X		52a & Seq.
73		210										
[illegible]		267										

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 1 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
75		148	9									
86				B-								
87				3								
88		148										
89		210										
91							301				R2-B	
93											R1-B	
95										X	R3-B	52a
96											R5-B	
99										X		186
102												
103												
106												
107												
108												
109												
110												
111												
112												
113												
114												
115												
116												
117												
118												
119												
120												
121												
122												
123												
124												
125												
126												
127												
130												
131												
132												
133												
134												

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 2 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
135												
136												
137												
138												
139												
140												
141												
142										X	R6-B	186
144							217W					
145												
146												
147												
148												
149												
150												
151												
152												
153							280D					
154												
159												
160												
161												
162												
163												
164												
165											R4-B	
167												
168												
169												
170												
171												
172												
173												
174												
175												
176												
177												
178												
179		360										SHIELDED

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 3 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
180							196					SHIELDED
181							279D					
183							203					
							337					
200											R7-A	
203 TO 258	28 PR. Fe/Const.											
259A	259A											
259B	259B											
263										X		(IF USED)
265										X		ANNUNCIATOR P.F.
266										X		ANNUNCIATOR P.F.
273							302		X			(IF USED)
280									X			DC PUMP
281									X			DC PUMP
282									X		R8-B	DC PUMP
286									X		R8-A	DC PUMP
287									X			DC PUMP
288									X			RAD. FAN
289									X			RAD. FAN
290									X			J.W. HEATER
291	291								X			J.W. HEATER
292									X			J.W. HEATER
293	293											
295									X			J.W. HEATER
296									X			J.W. HEATER
297									X			L.O. HEATER
298	298								X			L.O. HEATER
299									X			L.O. HEATER
300	300											
302									X			L.O. HEATER
303									X			L.O. HEATER
304							192C		X			FUEL TRANSFER PUMP
							405A					FUEL TRANSFER PUMP
							407C					
							409C					
							407A					
							409A					
							411A					

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 4 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
305							193C					FUEL LEVEL SW.
306							190C					
307							423		X			FUEL TRANSFER PUMP
							389C					
308							319C					
309							186					
							188					
							387C					
310							408A		X			FUEL TRANSFER PUMP
311							410A		X			
							412A					
312							192B		X			FUEL TRANSFER PUMP
							405C					
							411C					
							405B					
							407B					
							409B					
							411B					
313							193B					FUEL LEVEL SW.
314							190B					
315							427		X			FUEL TRANSFER PUMP
							389B					
316							319B					
317							420					
							424					
							387B					
318							408B		X			FUEL TRANSFER PUMP
319							410B		X			FUEL TRANSFER PUMP
							412B					
320									X			L.O. KEEP [illegible] PUMP
321									X			L.O. KEEP [illegible] PUMP
322									X			J.W. KEEP [illegible] PUMP
323									X			J.W. KEEP [illegible] PUMP
324									X			L.O. STAN[illegible] PUMP
325									X			L.O. STAN[illegible] PUMP
327									X			L.O. STAN[illegible] PUMP
328									X			DC PUMP
329									X		R9-A	X
330									X		R10-A	X

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 5 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
332							388C					
334							388B					
339							189					LOW-LOW FUEL SWITCH
340							187					LOW FUEL SW.
341							406A					
342							425					LOW-LOW FUEL SWITCH
343							421					LOW FUEL SW.
344							406B					
345							422					
							408C					
							410C					
346							426					
							406C					
							412C					
451							217P					
							217R					
							217S					
							217T					
							C					
452							352					CHIME
453A							217G					
							392					
							393					
454							218T					
455							218P					
456							218R					
457							218S					
461							125					
464	464	104	56				201	X		X		DAY TANK
		106										
		108										
		130										
		132										
		142										
		145										
		166										
		170										
		172										
		173										

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 6 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
(464)		298										
465										X		4160v BUS ACB
466										X		GEN. DIFF.
467							126					
469							127					
471							134					
473							129					
475							130					
477							131					
479							132					
481							133					
483							128					
485							135					
487							136					
489							137					
491							144					
493							139					
495							382					
497							141					
499							142					
501							143					
503							138					
505							145					
507							364					
509							365					
510										X		MCC SWGR TRIP
511							154					
513							357					
514		177										
515		174										
516							368					
517	517											
518							151					
520							152					
522							153					
524							366					
526							369					
528							370					
531							371					

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 7 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
532												DAY TANK SW.
533							164					
534												DAY TANK SW.
535							394					
536												MOTOR FEEDER TRIP
537							395					
538										X		51-V
539							161					
540										X		FIELD
541							162					
542										X		STATOR GRD.
543							163					
545							372					
547							165					
549							166					
550	550											
551							167					
553							174					
554	554											
555							169					
556												TRANS. LINE PRESS.
557							170					
558												TRANS. LINE PRESS.
559												TRANS. LINE PRESS.
560							171					
562							172					
563												D.C. BUS LOW
564							173					
565										X		NEG. PHASE SEQ.
566							168					
567										X		REV. POWER
568							175					
570		105										
		107										
		131										
		141										
		143										
		147										
571							176					
573							177					

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 8 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
575							184					
577							368					
579									X			L.O. STANDBY PUMP
580							179					
581												STRAINER △ P
582												
583							180					
584												BATT. CHGR.
585							181					
586		129										
		176										
587							182					
588			50									
589							183					
590										X		VOLTAGE BAL.
591							178					
605								X				
606												MISSILE DOOR OPEN
607												
608												
609		297										
610												D.C. BUS GRD.
611										X		186
612			57									
613												D.C.-U.V. SWGR 3
615							350					
616												FIRE SYSTEM
618							335					
622												DRAIN. SUMP (BATT. RM.)
623												
L1-1												120v SUPPLY
L1-2												120v SUPPLY
N-1												120v SUPPLY
N-2												120 v SUPPLY
A	A	178										
B	A	179										
L1												
N											R7-B	120v SUPPLY
		109 (128)				DET. 1-N						

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 9 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
		110				DET. 1-W						
		111				DET. 1-W						
		112				DET. 1-R						
		113				DET. 2-W						
		114				DET. 2-W						
		115				DET. 2-R						
		116				DET. 3-W						
		117				DET. 3-W						
		118				DET. 3-R						
		119				DET. 4-W						
		120				DET. 4-W						
		121				DET. 4-R						
		122				DET. 5-W						
		123				DET. 5-W						
		124				DET. 5-R						
		125				HTR. 1-W						
		126				HTR. 2-W						
		127				HTR. 2-R						
		128 (109)										
		133			CT1-X1							
		135			CT3-X1							
		140					140					
		146	B-				146					
		(270)	38									
			40									
		149										
		150										
		151	42									
		152	41									
		154	43									
		155	37				155					
		157	36				157					
		158	39				158					
		160					160					
		162										120 v SUP
		163										120v SUP
		167										
		171										
		175										

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

	SHT. 10 OF 24	REV.
CKD.		
APP	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
		183										
		185										
		187					201					
		190					305					
		191										
		192										
		193										
		194										
		195										
		196										
		197										
		198										
		199	1				199				X	186-G-1
		200					200				X	N.C. in Seq.
		201					380					
		203										
		204										
		205										
		206										
		207	30									
		208	31									
		212	51									
		215	F-				346					
		216	F+				347					
		217										
		218										
		219	A2									
		220	A1									
		224		CT2-X1								
		268 (269)										
		269 (268)										
		270 (146)										
		272					272					
		275					275					
		277										
		278										
		279										
		280										
		281										

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 11 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
		282										
		283					283					
		284					284					
		286		C								
		287		B								
		288		A								
		289					289					
		290					290					
		291					291					
		292										
		293										
		296										
		300										
		301										
		308A										
		308B										
		308C										
		308D										
		308E										
		308F										
		308G										
		308H										
		309A										
		309B										
		309C										
		309D										
		309E										
		309F										
		309G										
		309H										
		310A										
		310B										
		310C										
		310D										
		310E										
		310F										
		310G										
		310H										
		311A										

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 12 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
		311B										
		311C										
		311D										
		311E										
		311F										
		311G										
		311H										
		312A										
		312B										
		312C										
		312D										
		312E										
		312F										
		312G										
		312H										
		313A										
		313B										
		313C										
		313D										
		313E										
		313F										
		313G										
		313H										
		314A										
		314B										
		314C										
		314D										
		314E										
		314F										
		314G										
		314H										
		315A										
		315B										
		315C										
		315D										
		315E										
		315F										
		315G										
		315H										

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT 12 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
		316A										
		316B										
		316C										
		316E										
		316F										
		317A										
		317B										
		317C										
		317E										
		317F										
		318A										
		318B										
		318C										
		318E										
		318F										
		319A										
		319B										
		319C										
		319E										
		319F										
		320				HTR. 2-R						
		321				HTR. 2-W						
		322				HTR. 2-W						
		323				DET. 6-W						
		324				DET. 6-W						
		325				DET. 6-R						
		326A										
		326B										
		326C										
		326D										
		326E										
		326F										
		326G										
		326H										
		327A										
		327B										
		327C										
		327D										
		327E										

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 14 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
		327F										
		327G										
		327H										
		330A										
		330B										
		330E										
		330F										
		331A										
		331B										
		331E										
		331F										
		333	8									
		337										
		338										
		339										
		340										
		341										
		342										
		343								X		52a
		350										
		351										
		354					354					
		355	53				355					
		356	55				356					
		357	54				357					
		358	52				358					
		361					194					SHIELDED
		CG			CT1, 2, 3 X1							
			7	PARA. CT X2								
			29 (B-1)									
			32	A								
			33	B								
			34	C								
			35	PARA. CT X1								
			44									
			(B+)									
			(BF+)									
			B-									90a DC S[illegible]

DELA[illegible]

ELECTRICAL INTERCONNECT DIAG[illegible]

CKD.	SHT. 15 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
			(BF-)									90v DC SUPPLY
		F+	F+									
		F-	F-									
			X1	POWER CT1								
			X2	POWER CT2								
			X3	POWER CT3								
			2	POWER CT'S								
							191B		X			FUEL TRANSFER PUMP
							191C		X			FUEL TRANSFER PUMP
							197					120v SUPPLY
							204					
							(342)					
							208A					
							208B					
							208D					
							208H					
							209A					
							209B					
							209D					
							209H					
							210A					
							210B					
							210D					
							210H					
							211A					
							211B					
							211D					
							211H					
							212A					
							212B					
							212D					
							212H					
							213A					
							[illegible]					
							213D					
							[illegible]					
							[illegible]					
							[illegible]					
							[illegible]					

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD	SHT. 16 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
							214H					
							215A					
							215B					
							215D					
							215H					
							216A					
							216B					
							216D					
							216H					
							217A					
							217C					
							217H					
							218A					
							218C					
							218G (353)					
							218H (404)					
							218W (307)					
							219C					
							219G					
							219H					
							219P					
							219R					
							219S					
							219T					
							219U					
							219V					
							219W					
							222A					
							222B					
							222C					
							222D					
							223A					
							223B					
							223C					
							223D					
							224A					
							224B					
							224C					
							224D					

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CHD.	SHT. 17 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
							226A					
							226B					
							226C					
							226D					
							227A					
							227B					
							227C					
							227D					
							228A					
							228B					
							228C					
							228D					
							229A					
							229B					
							229C					
							229D					
							230A					
							230B					
							230C					
							230D					
							232					
							233					
							234					
							243			X		BUS P.T.
							246			X		GEN. P.T. –
							247			X		GEN. P.T. [illegible]
							248					CT A
							251					CT B
							252					CT C
							255					GEN. P.T. C
							279A				R2-4	
							279B				R6-4	
							279C (283)				R7-4	
							280A				R4-4	
							280B				R3-4	
							280C				R1-4	
							282A					
							282B					
							282D					

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 18 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
							282H				R5-4	
							285A					
							285B					
							285C					
							285D					
							286A					
							286B					
							286C					
							286D					
							287A					
							287B					
							287C					
							287D					
							288			X		52 CLOSE
							292			X		52 TRIP
							293					
							297			X		52 CLOSE
							303			X		186-G1
							304			X		186-G1
							306					
							307 (218W)					
							310A					
							310C					
							310G					
							310H					
							310P					
							310R					
							310S					
							310T					
							310V					
							310W					
							311A					
							311C					
							311G					
							311H					
							311P					
							311R					
							311S					
							311T					

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 19 OF 24	REV.
APP.	52190	

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
							311V					
							311W					
							312A					
							312C					
							312G					
							312H					
							312P					
							312R					
							312S					
							312T					
							312U					
							312V					
							312W					
							313A					
							313C					
							313G					
							313H					
							313P					
							313R					
							313S					
							313T					
							313U					
							313V					
							313W					
							314A					
							314C					
							314G					
							314H					
							314P					
							314R					
							314S					
							314T					
							314U					
							314V					
							314W					
							315A					
							315C					
							315G					
							315H					

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 20 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
							315P					
							315R					
							315S					
							315T					
							315U					
							315V					
							315W					
							316A					
							316C					
							316G					
							316H					
							316P					
							316R					
							316S					
							316T					
							316U					
							316V					
							316W					
							317A					
							317C					
							317G					
							317H					
							317P					
							317R					
							317S					
							317T					
							317U					
							317V					
							317W					
							318A					
							318C					
							318G					
							318H					
							318P					
							318R					
							318S					
							318T					
							318U					
							318V					

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 21 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
							318W					
							320A					
							320B					
							320C					
							320D					
							320E					
							320F					
							320G					
							320H					
							320J					
							320K					
							320L					
							320M					
							321A					
							321B					
							321C					
							321D					
							321E					
							321F					
							321G					
							321H					
							321J					
							321K					
							321L					
							321M					
							322A					
							322B					
							322C					
							322D					
							322E					
							322F					
							322G					
							322H					
							322J					
							322K					
							322L					
							322M					
							340				R10-4	
							341				R9-4	

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 22 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
							342					
							(204)					
							348					
							349					
							351					52 TRIP
							353					
							(218G)					
							363					
							(279C)					
							373			X		REACTOR SW.
							374			X		REACTOR SW.
							375			X		REACTOR SW.
							376			X		REACTOR SW.
							377			X		REACTOR SW.
							378			X		REACTOR SW.
							379				R8-4	
							381					
							383A					
							383B					
							383C					
							383D					
							390					120v AC (N)
							391					
							396A					
							396B					
							396C					
							396D					
							396E					
							396F					
							396G					
							396H					
							396K					
							396L					
							396M					
							397A					
							397B					
							397C					
							397D					
							397E					

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 23 OF 24	REV.
APP.	52190	2

Diesel Local	Engine	Gen. Local	VR	HV	Neutral	Gen.	Gen. Remote	Air Comp.	MCC	Swgr.	Relay Panel	
							397F					
							397G					
							397H					
							397J					
							397K					
							397L					
							397M					
							401					
							402					BUS PT GRD.
							404 (218G)					
							CG			X		CT COMMON
							L1			B11-U		SPACE HTR.
							L2			B11-X1		SPACE HTR.
							CR1			B11-C11		SPACE HTR.
							CR2			B11-C21		SPACE HTR.
							CR3					
							CR4					
							CR5					
							CR6					
	335								X			F.O. DRIP SW.
	336								X			F.O. DRIP SW.
					CT4X1				X			GEN. DIFF.
					CT5X1				X			GEN. DIFF.
					CT6X1				X			GEN. DIFF.
					CT4, 5, 6 X2				X			GEN. DIFF
					PT X1				X			GRD.
					PT X2				X			GRD. FAULT
			2							X		N.C. [illegible]
										X		136-G1 186-2

DELAVAL

ELECTRICAL INTERCONNECT DIAGRAM

CKD.	SHT. 24 OF 24	REV.
APP.	52190	2

ANNUNCIATOR NAMEPLATES

11-1 OVERCURRENT W/ VOLTAGE RESTRAINT
12-1 LOSS OF FIELD EXCITATION
13-1 STATOR GROUND
14-1 DC BUS 1 LOW VOLT (DC BUS 2 LOW VOLT)
15-1 JACKET WTR. LOW LEVEL
16-1 LUBE OIL FILTER HIGH ΔP
17-1 LUBE OIL TANK LOW LEVEL
18-1 P-1A, P-1B TRANS LINE LOW PRESS. (P2A, P2B TRANS LINE LOW PRESS.)
19-1 FUEL PUMP/ OVERSPEED DRIVE FAIL
20-1 1A START AIR LOW PRESS (2A START AIR LOW PRESS)
11-2 NEGATIVE PHASE SEQUENCE
12-2 DIRECTION POWER
13-2 STATOR WINDING HIGH TEMP.
14-2 BATT CHRGR FAILURE A/B (BATT CHRGR FAILURE C/D)
16-2 LUBE OIL LOW TEMP
17-2 LUBE OIL STANDBY PUMP ON
18-2 P-1A, P-1B STRAINER HIGH ΔP (P2A, P2B STRAINER HIGH ΔP)
19-2 [illegible]
20-2 1B START AIR LOW PRESS (2B START AIR LOW PRESS)

21-1 SPACE HTR. TROUBLE
22-1 GENERATOR OVER EXCITATION
23-1 VOLTAGE BALANCE
24-1 DC BUS 1 GROUND (DC BUS 2 GROUND)
25-1 [illegible]
26-1 MISSILE RESISTANT DOOR OPEN
27-1
28-1
29-1 STOR. TANK LOW LEVEL
30-1 ENGINE VIBRATION
21-2 EXCITER SEMICONDUCTOR FAILURE
22-2 GEN. OVER VOLTAGE
23-2 SWGR #3 DC UNDERVOLT.
24-2 DC BUS 1 DC ACB TRIP &/OR L/V (DC BUS 2 DC ACB TRIP &/OR L/V)
25-2 UNIT IN MAINT.
26-2 FIRE PROT. SYSTEM ACTIVATED
27-2 ALARM CONTACTS GROUNDED
28-2 PANEL REAR DOORS OPEN
29-2 DRAINAGE SUMP LEVEL HIGH-HIGH (D-6 BLDG. BATTERY RM BELOW 60°F)
30-2 BARRING DEVICE ENGAGED

NAMEPLATES

31 TEMPERATURE SELECTOR
32
33
34
35
36 STARTING AIR PRESSURE RED-LEFT FRONT BLACK-RIGHT FRONT
37 STARTING AIR PRESSURE RED-LEFT REAR BLACK-RIGHT REAR
38 LUBE OIL PRESSURE
39 TURBO OIL PRESSURE RED-LEFT FRONT BLACK-RIGHT FRONT
40 TURBO OIL PRESSURE RED-LEFT REAR BLACK-RIGHT REAR
41 FUEL OIL PRESS
42 DIFFERENTIAL PRESSURE FUEL OIL FILTER
43 COMBUSTION AIR PRESSURE LEFT BANK RIGHT BANK
44 DIFFERENTIAL PRESSURE LUBE OIL FILTER
45 JACKET WATER PRESSURE
46 CRANKCASE PRESSURE
47 ENGINE SPEED
48 ENGINE HOURS
49 MANUAL TEST START
50 MAINTENANCE STANDBY
51 MAINTENANCE MODE SELECT
52 MAINTENANCE MODE ONLY
53 DC CONTROL POWER ON
54 AC CONTROL POWER ON
55 UNIT STOPPED
56 UNIT AVAILABLE FOR START
57 UNIT STARTING
58 TEST TRIPS SET
59 READY TO CLOSE GEN. BREAKER
60 UNIT LOADED/READY TO LOAD
61 FUEL TRANSFER PUMP 1A (2A)
62 TRANSFER PUMP SELECT
63 FUEL TRANSFER PUMP 1B (2B)
64 FUEL STANDBY PUMP
65 LUBE OIL HEATER
66 JACKET WATER HEATER
67 MAIN FUEL TANK LEVEL
68 DAY TANK LEVEL
69 LUBE TANK LEVEL
70 L.O. KEEP WARM PUMP ON
71 J.W. KEEP WARM PUMP ON
72 RADIATOR COOLING FANS ON
73 CRANKCASE FANS ON

a OFF START
b STOP
c MAINT.
d ENGINE ROLL
e SILENCE
f ACKNOWLEDGE
g RESET
h TEST
j OFF
k ON
l AUTO
m HAND OFF AUTO
n P-1A P-1B (P-2A P-2B)

1. ALL ANNUNCIATOR LENSES ARE WHITE TRANSLUCENT & ENGRAVED WITH 1/4" BLACK UPPER CASE LETTERING AS SHOWN. SEE DRAWING NO. 52193 FOR DETAILED ENGRAVING DATA.
2. a-n ARE STANDARD BLACK FURNAS NAMEPLATES AS SHOWN.
3. NAMEPLATES 36-72 ARE STANDARD DELAVAL: 1/16" LAMINATED PHENOL, BLACK FACE WITH WHITE BACKING. ENGRAVE WITH CUTTER .016 WIDE TO A DEPTH OF .016. EDGES OF PLATES ARE BEVEL. ALL LETTERING IS 1/8" UPPERCASE. NAMEPLATES 53-60 ARE 3/4" X 1 1/4". ALL OTHERS ARE 3/4" X 2 1/4".
4. NAMEPLATES SHOWN IN PARENTHESES ARE FOR DIESEL GENERATOR PANEL #2.

REFERENCE DRAWINGS
52187 PANEL PNEUMATIC SCHEMATIC
52189 PANEL ELECTRICAL SCHEMATIC

SAFETY RELATED

DO NOT SCALE DRAWING

PAINT SPECIFICATION:
PANEL EXTERIOR TO BE A HIGH GLOSS FINISH, ASA #61 GRAY. INTERIOR TO BE NON-REFLECTIVE WHITE, F-096-107.

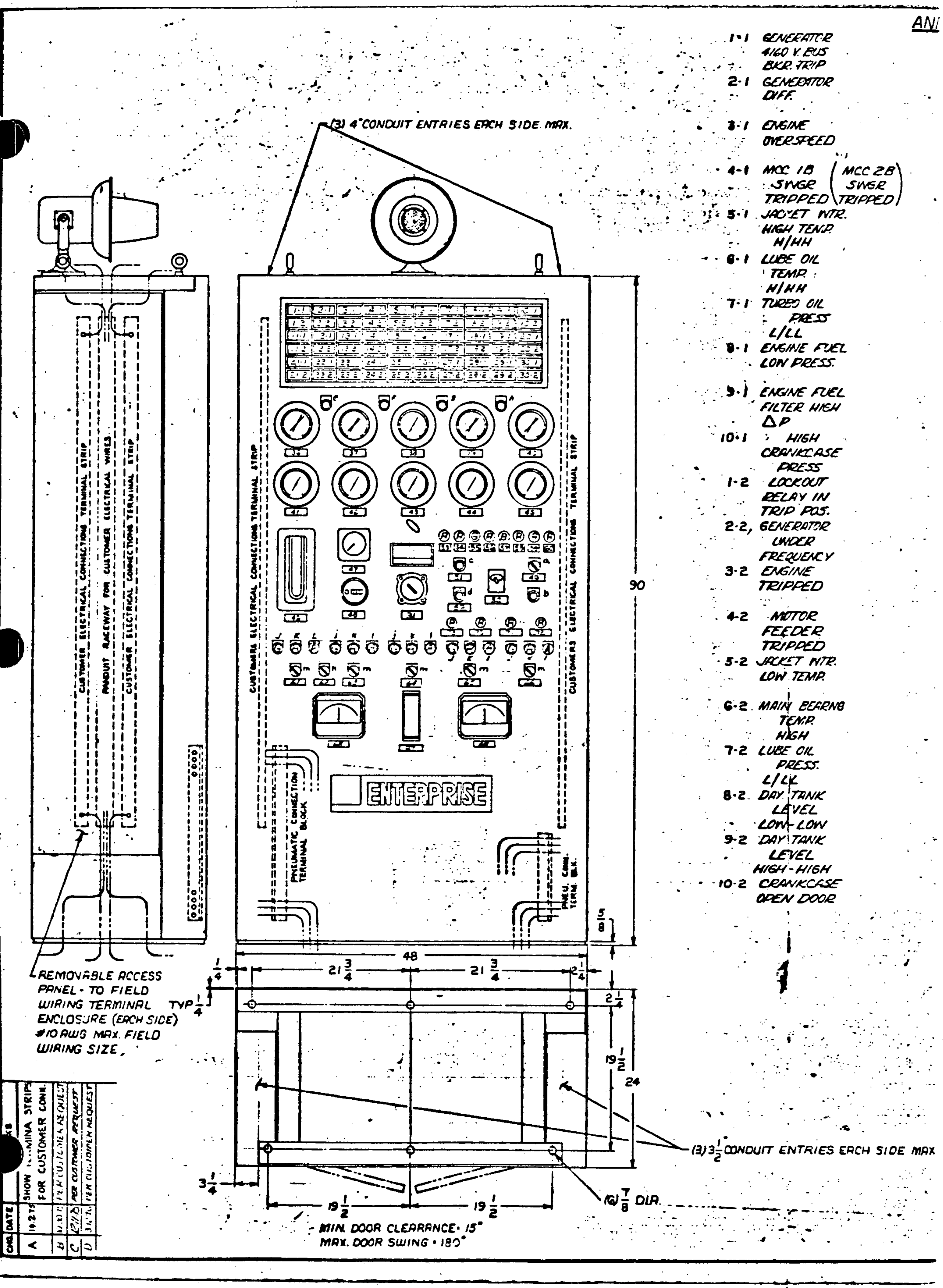
SEE D-4849 FOR GENERAL CONTROL CABINET SPEC.

DELAVAL

ENGINE CONTROL PANEL INSTALLATION

MATERIAL AND HARDNESS	APP.	DWN.	52191
—	SCALE	CKD.	

SO. CALIF. EDISON [illegible]



ANI
1-1 GENERATOR 4160 V. BUS BKR. TRIP
2-1 GENERATOR DIFF.
3-1 ENGINE OVERSPEED
4-1 MCC 1B SWGR TRIPPED (MCC 2B SWGR TRIPPED)
5-1 JACKET WTR. HIGH TEMP. H/HH
6-1 LUBE OIL TEMP. H/HH
7-1 TURBO OIL PRESS L/LL
8-1 ENGINE FUEL LOW PRESS.
9-1 ENGINE FUEL FILTER HIGH ΔP
10-1 HIGH CRANKCASE PRESS
1-2 LOCKOUT RELAY IN TRIP POS.
2-2 GENERATOR UNDER FREQUENCY
3-2 ENGINE TRIPPED
4-2 MOTOR FEEDER TRIPPED
5-2 JACKET WTR. LOW TEMP.
6-2 MAIN BEARNG TEMP. HIGH
7-2 LUBE OIL PRESS. L/LL
8-2 DAY TANK LEVEL LOW-LOW
9-2 DAY TANK LEVEL HIGH-HIGH
10-2 CRANKCASE OPEN DOOR
(3) 4" CONDUIT ENTRIES EACH SIDE MAX.
CUSTOMER ELECTRICAL CONNECTIONS TERMINAL STRIP
PANDUIT RACEWAY FOR CUSTOMER ELECTRICAL WIRES
CUSTOMERS ELECTRICAL CONNECTIONS TERMINAL STRIP
PNEUMATIC CONNECTION TERMINAL BLOCK
PNEU. CONN. TERM. BLK.
ENTERPRISE
90
5/8
48
21 3/4
21 3/4
2 1/4
1/4
TYP 1/4
2 1/4
19 1/2
24
3 1/4
19 1/2
19 1/2
REMOVABLE ACCESS PANEL - TO FIELD WIRING TERMINAL ENCLOSURE (EACH SIDE) #10 AWG MAX. FIELD WIRING SIZE.
(3) 3 1/2 CONDUIT ENTRIES EACH SIDE MAX
(6) 7/8 DIA.
MIN. DOOR CLEARANCE: 15"
MAX. DOOR SWING: 180°
CHG DATE
A 10.2.75 SHOW TERMINA STRIPS FOR CUSTOMER CONN.
B PER CUSTOMER REQUEST
C PER CUSTOMER REQUEST
D PER CUSTOMER REQUEST

ANNUNCIATOR ENGRAVING DRAWING #52193

FOR: F-501-053

DIESEL GENERATOR PANEL #2

1-1	2-1	3-1	4-1	5-1	6-1	7-1	8-1	9-1	10-1
1-2	2-2	3-2	4-2	5-2	6-2	7-2	8-2	9-2	10-2
11-1	12-1	13-1	14-1	15-1	16-1	17-1	18-1	19-1	20-1
11-2	12-2	13-2	14-2	15-2	16-2	17-2	18-2	19-2	20-2
21-1	22-1	23-1	24-1	25-1	26-1	27-1	28-1	29-1	30-1
21-2	22-2	23-2	24-2	25-2	26-2	27-2	28-2	29-2	30-2

ANNUNCIATOR NAMEPLATES

-1 GENERATOR 4160 V. BUS BKR. TRIP

-1 GENERATOR DIFF.

-1 ENGINE OVERSPEED

-1 MCC 2B SWGR TRIPPED

-1 JACKET WTR. HIGH TEMP H/H H

-1 LUBE OIL TEMP H/H H

TURBO OIL PRESS. L/L L

-1 ENGINE FUEL LOW PRESS

-1 ENGINE FUEL FILTER HIGH Δ P

-1 HIGH CRANKCASE PRESS.

-2 LOCKOUT RELAY IN TRIP POS.

-2 GENERATOR UNDER FREQUENCY

-2

-2 MOTOR FEEDER TRIPPED

-2 JACKET WTR. LOW TEMP.

-2 MAIN BEARING TEMP. HIGH

7-2 LUBE OIL PRESS. L/L L

8-2 DAY TANK LEVEL LOW-LOW

9-2 DAY TANK LEVEL HIGH-HIGH

10-2 CRANKCASE OPEN DOOR

11-1 OVERCURRENT W/VOLTAGE RESTRAINT

12-1 LOSS OF FIELD EXCITATION

13-1 STATOR GROUND

14-1 DC BUS 2 LOW VOLT

15-1 JACKET WTR. LOW LEVEL

16-1 LUBE OIL FILTER HIGH Δ P

17-1 LUBE OIL TANK LOW LEVEL

18-1 P-2A, P-2B TRANS. LINE LOW PRESS.

19-1 FUEL PUMP/ OVERSPEED DRIVE FAIL

20-1 C-14A START AIR LOW PRESS.

11-2 NEGATIVE PHASE SEQUENCE

12-2 DIRECTION POWER

13-2 STATOR WINDING HIGH TEMP.

14-2 BATT CHRGR FAILURE C/D

15-2 SPARE

16-2 LUBE OIL LOW TEMP

17-2 LUBE OIL STANDBY PUMP ON

18-2 G75A, G75B STRAINER HIGH Δ P

19-2 SPARE

20-2 C-14B START AIR LOW PRESS.

21-1 SPACE HTR. TROUBLE

22-1 GENERATOR OVER EXCITATION

23-1 VOLTAGE BALANCE

24-1 DC BUS 2 GROUND

25-1 SPARE

26-1 MISSILE RESISTANT DOOR OPEN

27-1 SPARE

28-1 SPARE

29-1 STOR. TANK LOW LEVEL

30-1 ENGINE VIBRATION

21-2 EXCITER SEMICONDUCTOR FAILURE

22-2 GENERATOR OVERVOLTAGE

23-2 SWGR #3 DC UNDERVOLT

24-2 DC BUS 2 DC ACB TRIP &/OR L/V

25-2 UNIT IN MAINT.

26-2 FIRE PROT. SYSTEM ACTIVATED

27-2 ALARM CONTACTS GROUNDED

28-2 PANEL REAR DOORS OPEN

29-2 D-G BLDG. BATTERY RM BELOW 60°F

30-2 BARRING DEVICE ENGAGED

POS. 5-1, 6-1, 7-1, 5-2, 7-2, 18-1, 20-1, 20-2 REFLASH MODULES

POS. 27-2, GROUND DETECTION MODULE

POS. 20-1 & 20-2, AUX. CONTACT MODULE

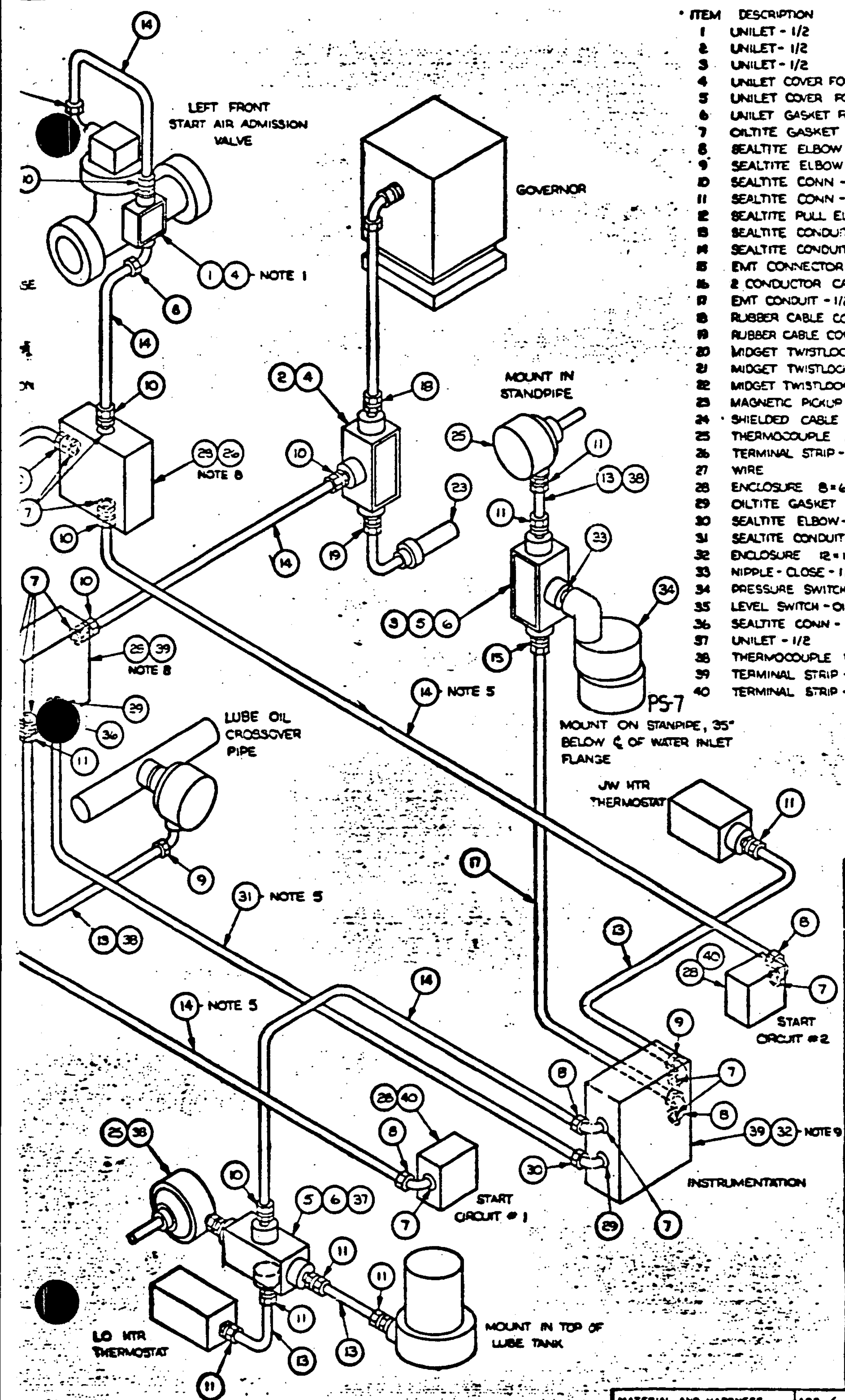
OUTHERN CALIFORNIA EDISON
ERIAL NUMBER: 75041/42

52193

REV. B) 3-15-76
REV. A) 12-18-75
REL.) 8-11-75

1-5

ITEM	DESCRIPTION	PART NO	QTY
1	UNILET - 1/2	F-509-089	4
2	UNILET - 1/2	F-509-294	1
3	UNILET - 1/2	F-509-021	13
4	UNILET COVER FOR ITEM 1&2	F-509-090	5
5	UNILET COVER FOR ITEM 3	F-509-037	14
6	UNILET GASKET FOR ITEM 3	F-509-041	14
7	OILTITE GASKET ASSY - 1/2	F-509-078	32
8	SEALTITE ELBOW - 1/2 x 1/2	F-509-124	8
9	SEALTITE ELBOW - 3/8 x 1/2	F-509-123	3
10	SEALTITE CONN - 1/2 x 1/2	F-509-119	14
11	SEALTITE CONN - 3/8 x 1/2	F-509-118	6
12	SEALTITE PULL ELBOW - 1/2 x 1/2	F-509-139	9
13	SEALTITE CONDUIT - 3/8	F-509-113	AR
14	SEALTITE CONDUIT - 1/2	F-509-114	AR
15	EMT CONNECTOR - 1/2 x 1/2	F-509-049	28
16	2 CONDUCTOR CABLE	F-509-338	AR
17	EMT CONDUIT - 1/2	F-509-001	AR
18	RUBBER CABLE CONNECTOR	F-509-178	10
19	RUBBER CABLE CONNECTOR - 1/8 x 3/16	F-509-331	1
20	MIDGET TWISTLOCK - FEMALE	F-509-099	10
21	MIDGET TWISTLOCK - MALE	F-509-100	10
22	MIDGET TWISTLOCK - SLEEVE	F-509-101	20
23	MAGNETIC PICKUP ASSY	EA-004-000	1
24	SHIELDED CABLE	F-509-231	AR
25	THERMOCOUPLE ASSY	F-540-050	4
26	TERMINAL STRIP - 4 CIRCUIT	F-591-007	2
27	WIRE	F-509-337	AR
28	ENCLOSURE 8x6x3	F-510-018	5
29	OILTITE GASKET	F-509-080	2
30	SEALTITE ELBOW - 1"	F-509-126	1
31	SEALTITE CONDUIT - 1"	F-509-116	AR
32	ENCLOSURE 12x10x5	F-510-072	1
33	NIPPLE - CLOSE - 1/2	F-509-013	1
34	PRESSURE SWITCH - JWL	F-577-062	1
35	LEVEL SWITCH - OIL	F-528-021	1
36	SEALTITE CONN - 1"	F-509-121	1
37	UNILET - 1/2	F-509-156	1
38	THERMOCOUPLE WIRE	F-509-333	AR
39	TERMINAL STRIP - 8 CIRCUIT	F-591-011	6
40	TERMINAL STRIP - 2 CIRCUIT	F-591-005	2



1. USE BRACKET 52235 TO HOLD ITEM TO VALVE
2. THIS CONDUIT RUNS UNDER CAMSHA[illegible] GALLERY
3. THIS CONDUIT RUNS IN THE VEE
4. ALLOW CONDUIT & WIRE TO REACH SUMP TANK
5. ALLOW CONDUIT & WIRE TO REACH ENGINE J'BOX. DISCONNECT AT ENG J'BOX FOR SHIPMENT.
6. USE RING TONGUE TERMINATIONS O[illegible] ALL TERMINAL BLOCKS
7. IDENTIFY BOTH ENDS OF WIRE
8. MOUNT J'BOX ON FRONT OF ENGIN[illegible]
9. MOUNT J'BOX ON FRONT OF AUX. SKID ON ℄

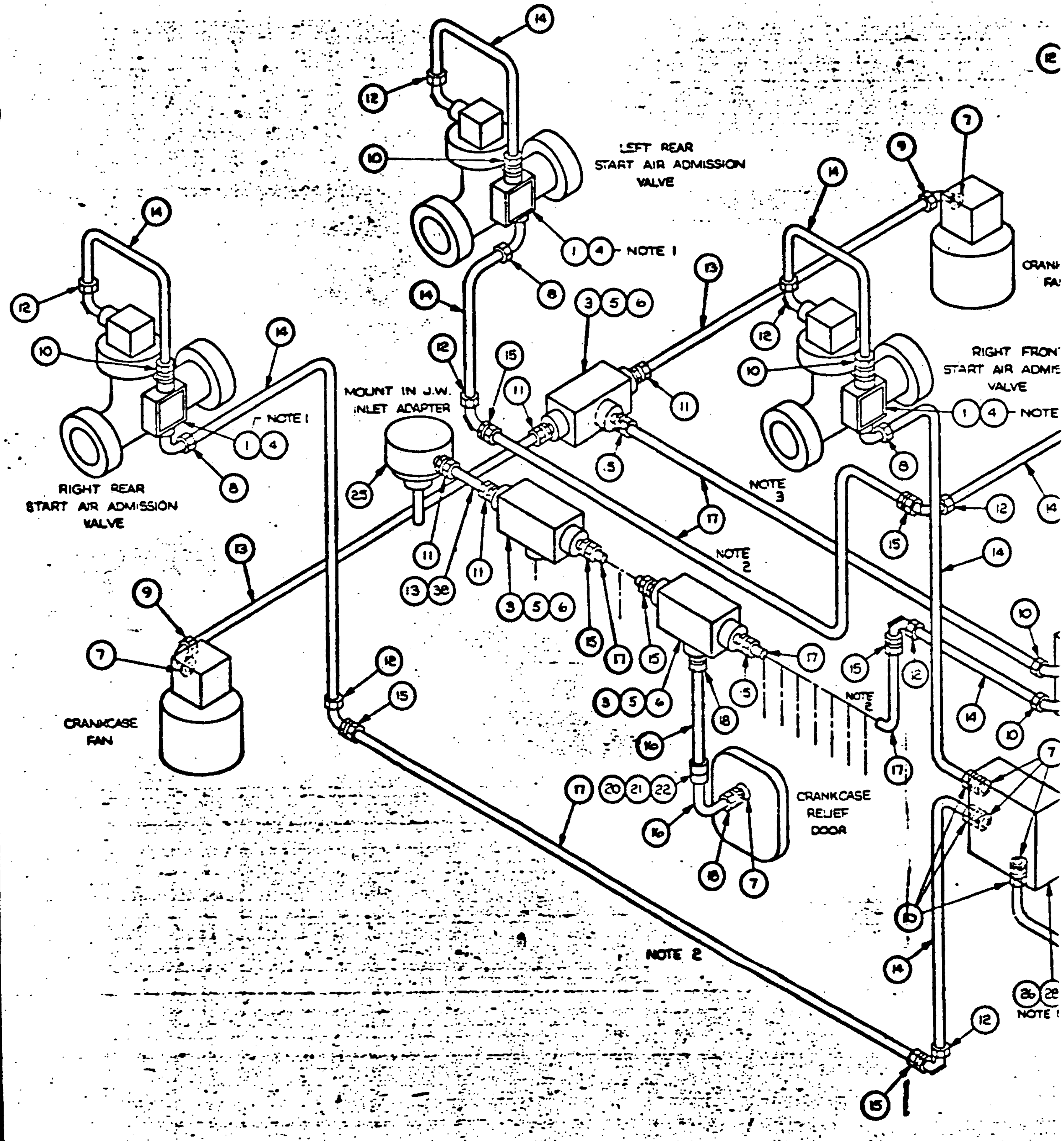
DELAVA[illegible]

ENGINE & AUXILIARY SKID
CONDUIT LAYOUT

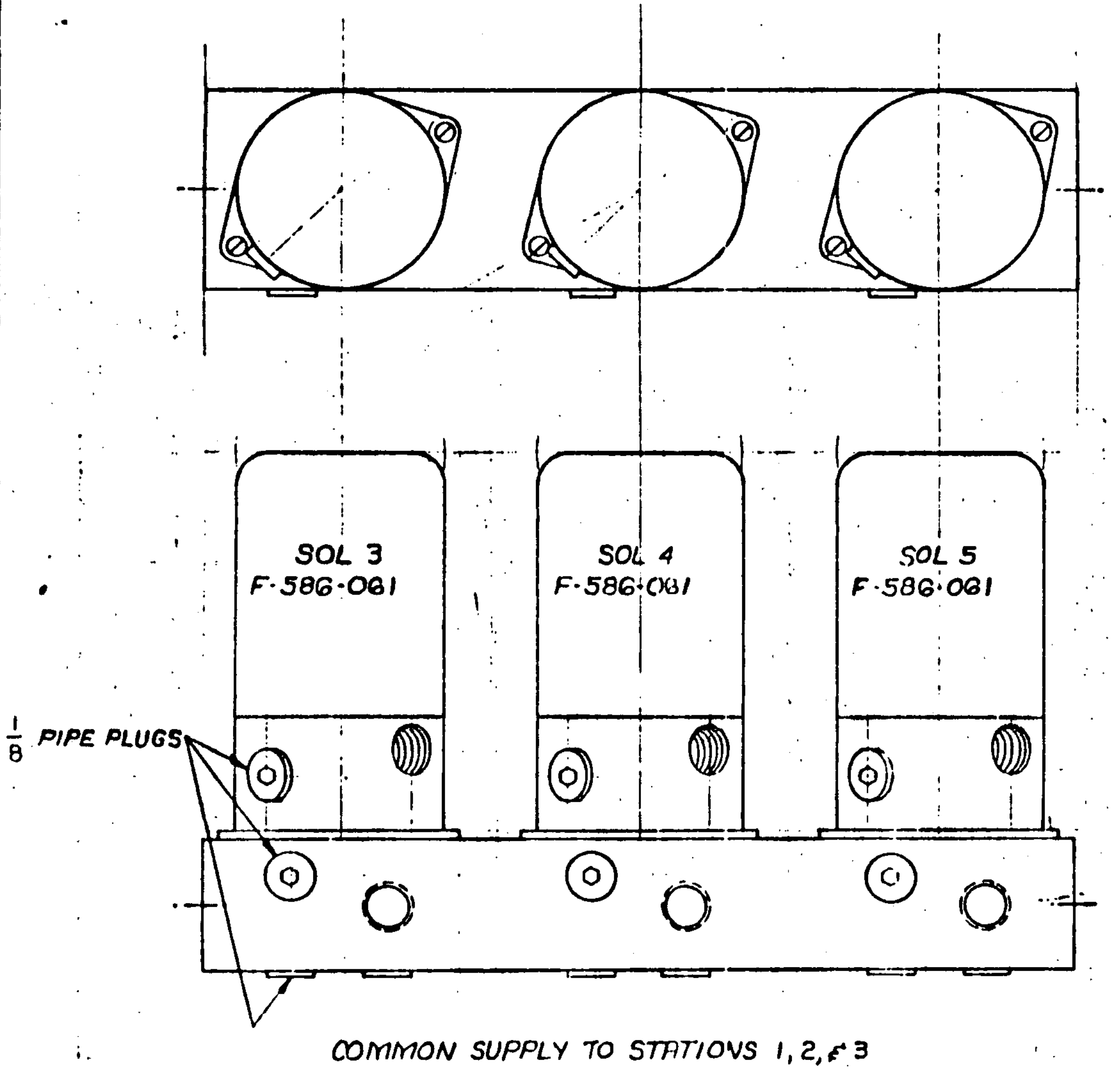
MATERIAL AND HARDNESS	APP.	DWN.	52194
	SCALE	CKD	

SO. CAL. ED 75241

9-30



CHG	DATE	REMARKS
B	11-9-73	REVISED & REDRAWN
C	12-75	ITEM 25 WAS F.309.030
D	1-2-76	ITEM 34 WAS F-317.042



4. ✓ SURFACE FINISH SYMBOL WITH NUMBER INDICATING MU. IN RMS.
3. ALL MACHINING DIMENSIONS ± .010 UNLESS OTHERWISE SPECIFIED.
2. REMOVE ALL BURRS AND SHARP CORNERS.
1. DO NOT SCALE DRAWING.

ENTERPRISE DIVISION
DE LAVAL TURBINE INC.
OAKLAND CALIFORNIA

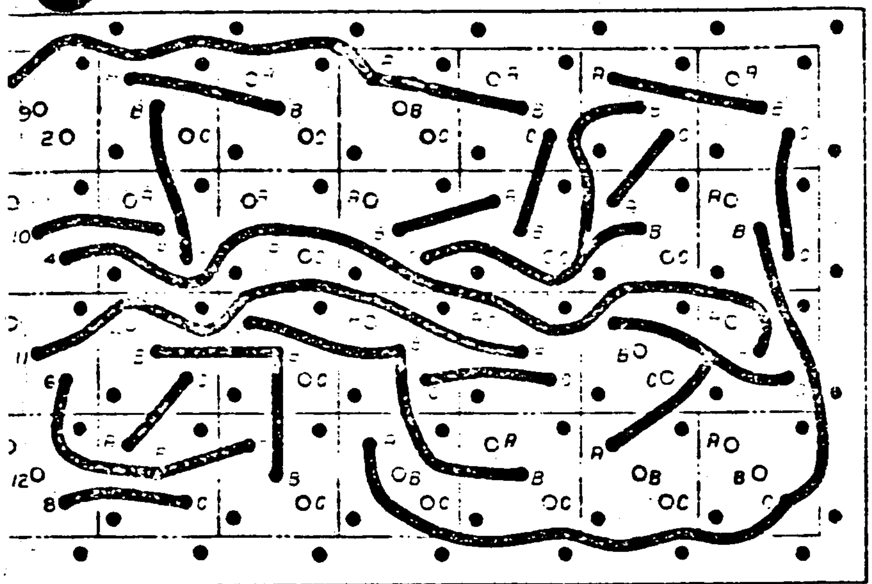
MATERIAL AND HARDNESS
——

SOLENOID MANIFOLD

PATT NO. --- | APPROVED | DRAWN

MATERIAL LIST

ITEM	QTY	DESCRIPTION	
1	1	CONNECTOR - 12 PORT	[illegible]
2	24	O-RING	[illegible]
3	1	CIRCUIT MODULE GASKET	[illegible]
4			
5	1	CIRCUIT MODULE GASKET	AS REQ'D
6	2	CIRCUIT BASE PLATE	[illegible]
7	1	CIRCUIT COVER PLATE	[illegible]
8	10	SCREW, ALLEN HEAD # 6-32 x 2 LG.	[illegible]
9	27	NUT, HEX LIGHT # 6-32 UNC-2B	[illegible]
10 *	25	SCREW, ALLEN HEAD # 6-32 x 5/8 LG.	[illegible]
OR	4	OR LOGIC ELEMENT	[illegible]
AND	5	AND LOGIC ELEMENT	[illegible]
NOT	5	NOT LOGIC ELEMENT	[illegible]
MEM	3	MEMORY LOGIC ELEMENT	[illegible]
S/R	3	SET/RESET LOGIC ELEMENT	[illegible]
POC	2	PARALLEL ORIFICE CHECK .006	[illegible]
ORIFICE	2	ORIFICE .028	F-573-22[illegible]

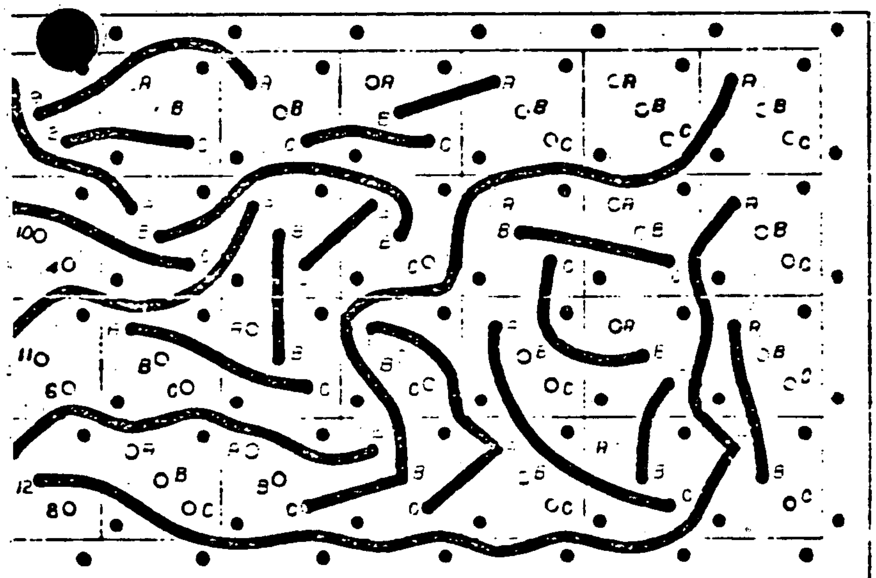


* ITEM 10 TO BE USED TO MOUNT ORIFICE PAC TO LOGIC BOARD

(5) CUTOUT AS SHOWN - 1/8" WIDE CHANNELS

CIRCUIT MODULE GASKETS USE F-573-291

(3) CLEAR GASKET HOLES AND ADJACENT CUTS BY 1/8"



FUNCTION: TO PROVIDE NECESSARY SHUTDOWN SIGNALS TO ENGINE.

TEST PROCEDURE:

1. ALL INPUTS & OUTPUTS TO BE 60 PSI.
2. INPUTS TO BE VENTED WHEN NOT PRESSURIZED.
3. ATTACH (1) F-573-326 ACCUMULATOR TO PORT 1 & (2) F-573-326 ACCUMULATOR TO PORT 6.
4. GAUGE OUTPUTS AT PORTS 2, 3, 8, 9, & 10.
5. PRESSURIZE PORT 4 & MAINTAIN THROUGHOUT REMAINDER OF TEST. NOTE OUTPUT AT PORT 10. MOMENTARILY PRESSURIZE PORT 12, NOTE OUTPUTS AT PORTS 2 & 9. WAIT APPROX 90 SEC. NOTE LOSS OF OUTPUTS AT PORTS 2, 3, & 9, VENT PORT 10, NOTE OUTPUT AT PORT 8. AFTER APPROX. 3 MIN NOTE LOSS OF OUTPUT AT PORT 8.
6. NOTE OUTPUT AT PORT 10. MOMENTARILY PRESSURIZE PORT 11 NOTE OUTPUT AT PORT 8. IMMEDIATELY PRESSURIZE PORT 7 NOTE OUTPUT AT PORTS 2 & 3 AND LOSS OF OUTPUT AT PORT 8 VENT PORT 10, NOTE LOSS OF OUTPUT AT PORTS 2 & 3 AND NO OUTPUT AT PORT 2. PRESSURIZE PORT 5, NOTE LOSS OF OUTPUT AT PORT 10.

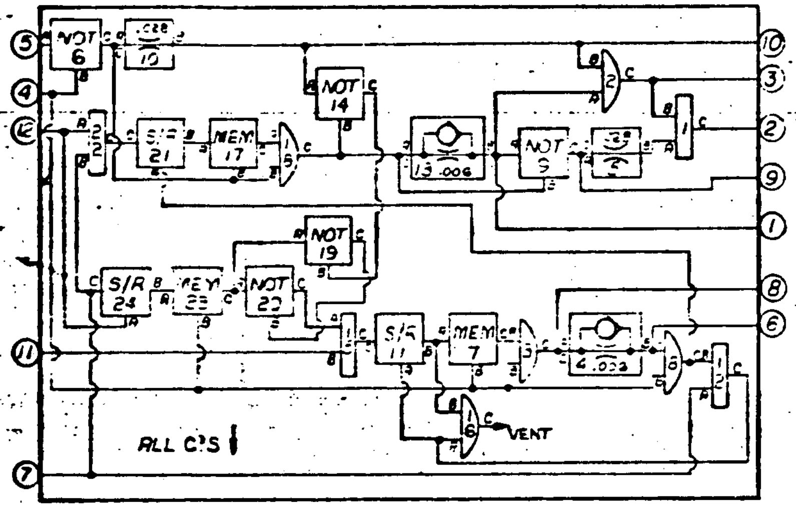
DO NOT SCALE DRAWING

DELAVAN

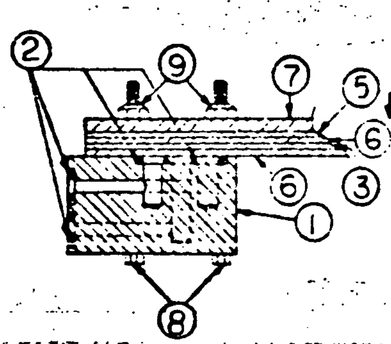
SHUTDOWN PNEUMATIC LOGIC BOARD AS[illegible]

MATERIAL AND HARDNESS	APR	DWN	
	SCALE FULL	CKD	61-560-5907

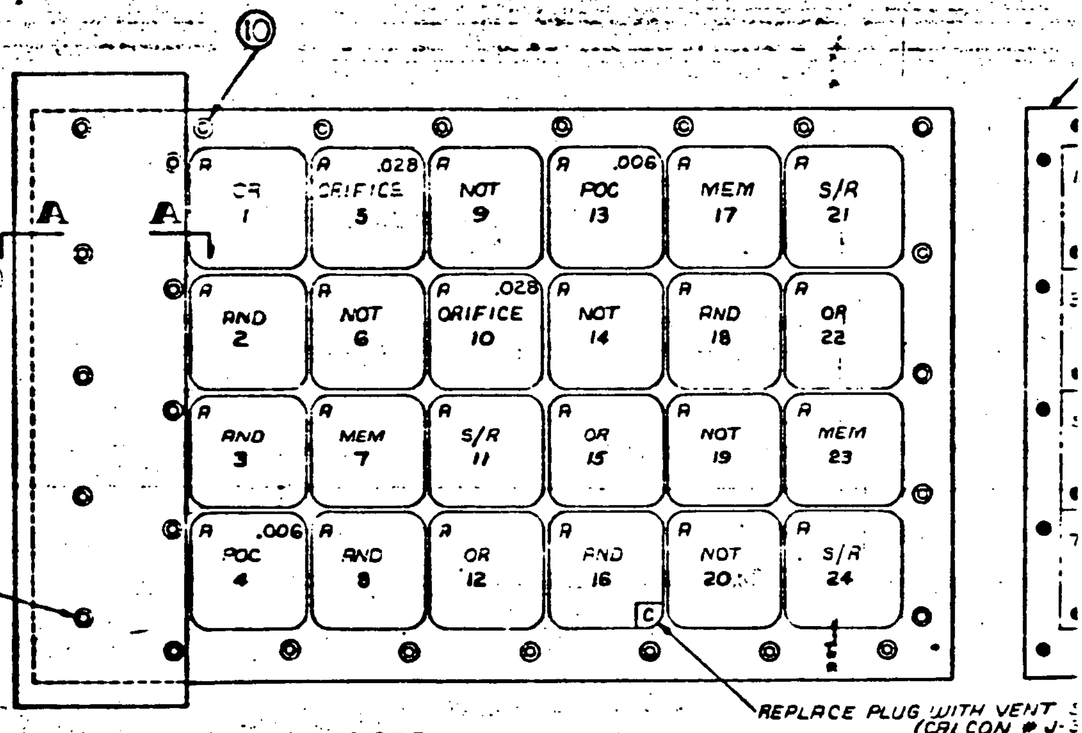
LILCO 74010



CIRCUIT DIAGRAM



SECTION A A



NOTE: PORT DESIGNATIONS MATCH LOGIC ELEMENTS TO POSITION SHOWN

LOGIC BOARD ASSEMBLY

E&C INTERNAL TRANSMITTAL

Southern California Edison Company

DATE ISSUED 1-25-77

MAILED BY OFFICE SERVICES ON

REFERENCE NUMBER 01190

DATE COMMENTS DUE

PROJECT NAME SONGS 1 SPA

DESIGNER/VENDOR Delavel

	TYPE OF ISSUE		DISCIPLINE
	FOR REVIEW AND COMMENT		MECHANICAL
	FOR APPROVAL	X	ELECTRICAL
X	FOR INFORMATION		CIVIL/STRUCTURAL
			CONTROLS
			ARCHITECTURAL
			NUCLEAR

DRAWING NUMBERS	DESCRIPTION
CE01-HMA	Instruction Manual, Volume 1 - (engine) Model - DSRV-20-4 - Serial No. 75041-2803, 75042-2804 - (Date: November 9, 1976)

Note: These two items wree inadvertently left out of our transmittal package no. 11237 dated 11-23-76.

REVIEWERS COMMENTS

☐ DRAWING ACCEPTABLE WITHOUT CHANGE

☐ CHANGE AS FOLLOWS:

☐ COMMENTS ARE INDICATED ON ATTACHED DRAWINGS

Sylvia/Fred
Please file this in
De Laval Manual
Thy.

SIGNATURE

DATE

RETURN TO EDM, ATTENTION: Caren Garcia ROCM: 184 PAX: 22696

DISTRIBUTION vc

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H. Richter
J. Ketzbeck
P. Portonova
C. Stoddart
J. Dunn
A. Marr
D. Gorg

H. Richter
Project Engineer

SCE 21-125 REV 11/75

20WS100 SERIES
3 PHASE, 3 WIRE

CE01-HMA
80-1

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

. Designed for Utility Requirements
. Measures Reverse and Forward Power Flow
. Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100K	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	250 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-0???

20WS100 SERIES
3 PHASE, 3 WIRE

WATT TRANSDUCERS

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- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS	20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT	120 VOLTS		
NOMINAL CURRENT INPUT	5 AMPS		
FULL SCALE CALIBRATING WATTS	1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)	100MV	1MA	1MA
OUTPUT LOAD REQUIRED	100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C	±0.5% OF FULL SCALE		
POWER FACTOR RANGE	UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE	-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)	±1%		
FREQUENCY RANGE	50-62Hz(1)		
A.C. COMPONENT (PEAK)	100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE	<1MS	<200MS	<200MS
VOLTAGE RANGE	0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS — POTENTIAL	150 VOLTS		
INPUT OVERLOAD LIMITS — CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN — MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN — MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED	NONE	NONE	85-135V 60Hz [illegible]
CALIBRATION ADJUSTMENT	±10%(3)		
ZERO ADJUSTMENT	NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND	1500V RMS		
PACKAGING AND CONNECTIONS	DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-6891

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Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

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SPECIFICATIONS

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NOMINAL POTENTIAL INPUT	120 VOLTS		
NOMINAL CURRENT INPUT	5 AMPS		
FULL SCALE CALIBRATING WATTS	1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)	100MV	1MA	1MA
OUTPUT LOAD REQUIRED	100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C	±0.5% OF FULL SCALE		
POWER FACTOR RANGE	UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE	-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)	±1%		
FREQUENCY RANGE	50-62Hz(1)		
A.C. COMPONENT (PEAK)	100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE	<1MS	<200MS	<200MS
VOLTAGE RANGE	0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS — POTENTIAL	150 VOLTS		
INPUT OVERLOAD LIMITS — CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN — MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN — MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED	NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT	±10%(3)		
ZERO ADJUSTMENT	NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND	1500V RMS		
PACKAGING AND CONNECTIONS	DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.
6510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 885-[illegible]

20WS100 SERIES
3 PHASE, 3 WIRE

WATT TRANSDUCERS

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SPECIFICATIONS

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NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	2VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	3VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	95-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-0831

20WS100 SERIES
3 PHASE, 3 WIRE

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 895-0691

20WS100 SERIES
3 PHASE, 3 WIRE

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS	20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT	120 VOLTS		
NOMINAL CURRENT INPUT	5 AMPS		
FULL SCALE CALIBRATING WATTS	1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)	100MV	1MA	1MA
OUTPUT LOAD REQUIRED	100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C	±0.5% OF FULL SCALE		
POWER FACTOR RANGE	UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE	-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)	±1%		
FREQUENCY RANGE	50-62Hz(1)		
A.C. COMPONENT (PEAK)	100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE	<1MS	<200MS	<200MS
VOLTAGE RANGE	0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS — POTENTIAL	150 VOLTS		
INPUT OVERLOAD LIMITS — CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN (MAXIMUM PER ELEMENT)	2VA	4VA	2VA
CURRENT BURDEN (MAXIMUM PER ELEMENT)	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED	NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT	±10%(3)		
ZERO ADJUSTMENT	NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND	1500V RMS		
PACKAGING AND CONNECTIONS	DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS, OHIO 430[illegible] • (614) [illegible]

20WS100 SERIES
3 PHASE, 3 WIRE

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 885-0001

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

8510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 895-0391

20WS100 SERIES
3 PHASE, 3 WIRE

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.
6510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-0621

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-0801

20WS100 SERIES
3 PHASE, 3 WIRE

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6810 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 846-8091

20WS100 SERIES
3 PHASE, 3 WIRE

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100KΩ	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +50°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz, 2W
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.
6810 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-8081

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

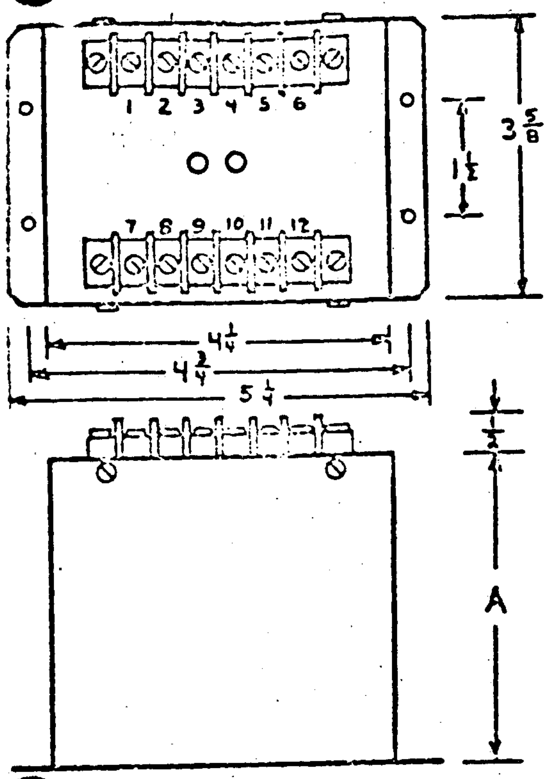
Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

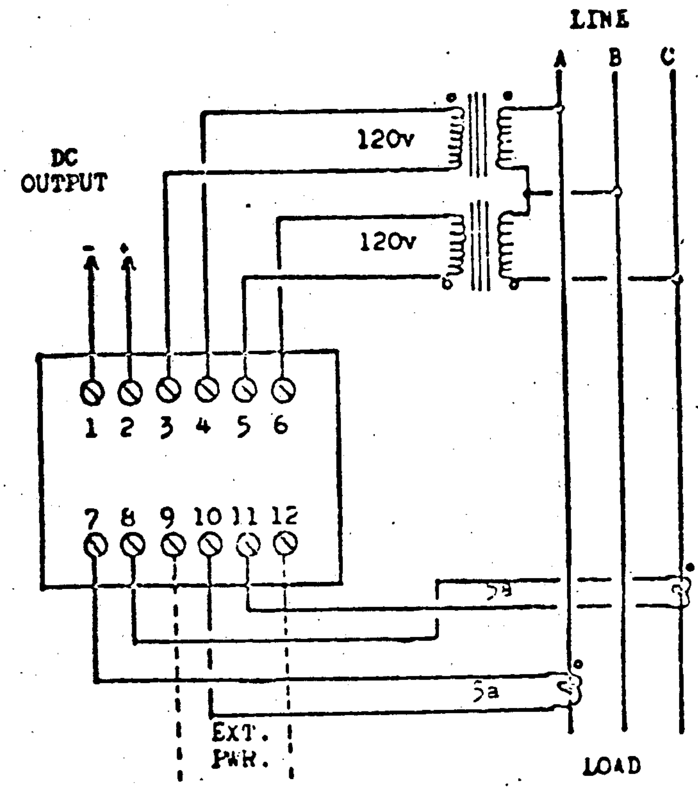
- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +[illegible]°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	65-135V 60Hz [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE





Dimension A

20WS100	....	3 1/4
20WS101	....	4
20WS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

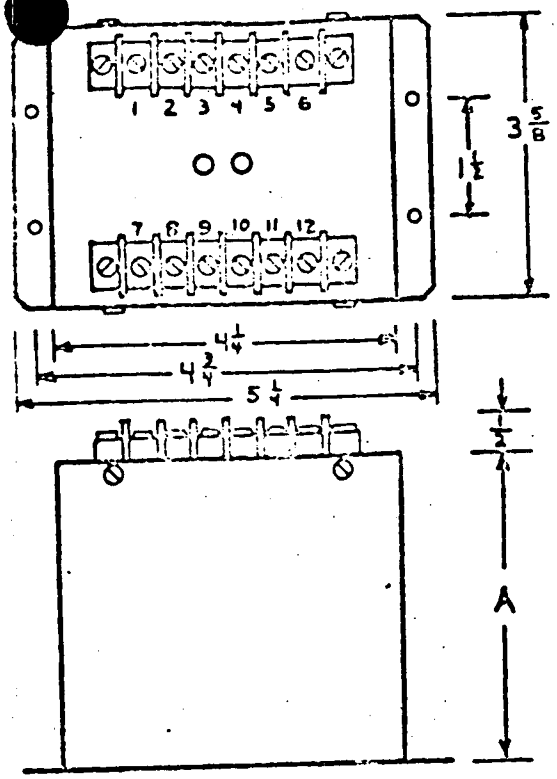
Terminal screws are 8-32 binding head.

Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity.



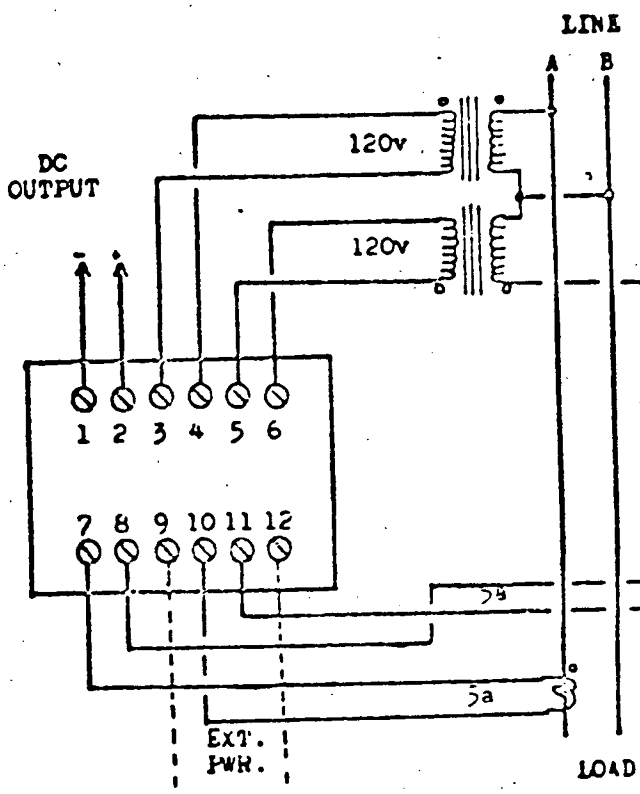
Dimension A

20WS100	....	3 1/4
20WS101	....	4
20WS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

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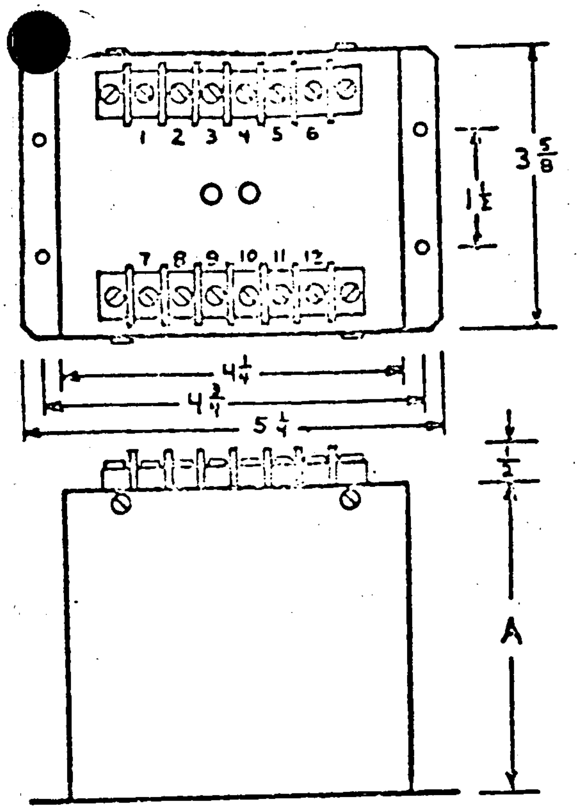


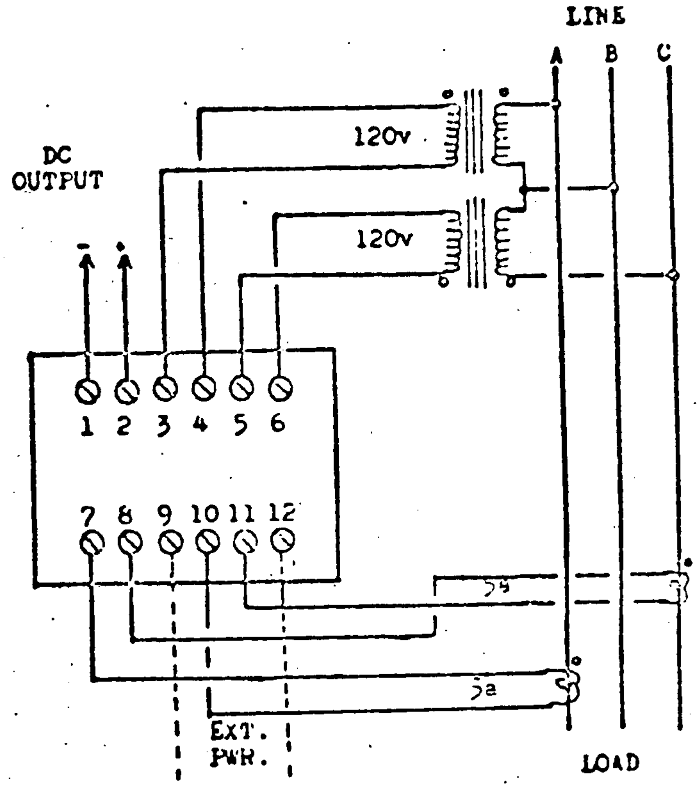
Dimension A

20WS100	....	3 1/4
20WS101	....	4
20WS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

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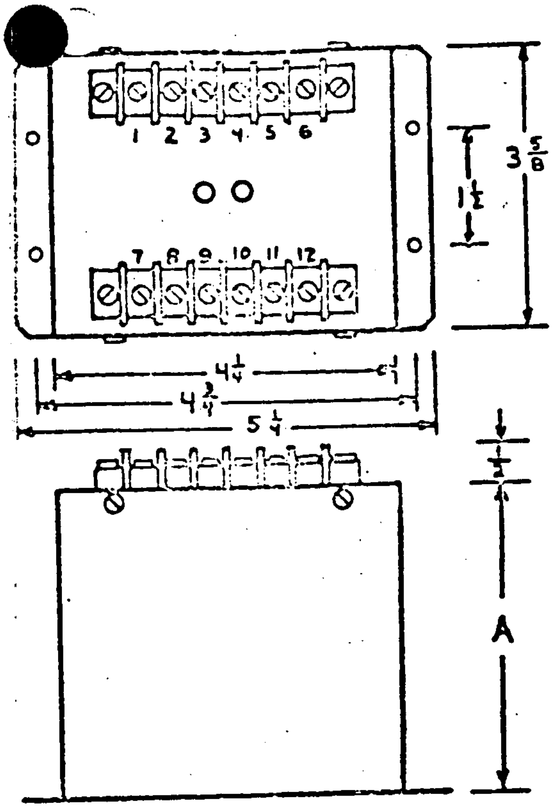

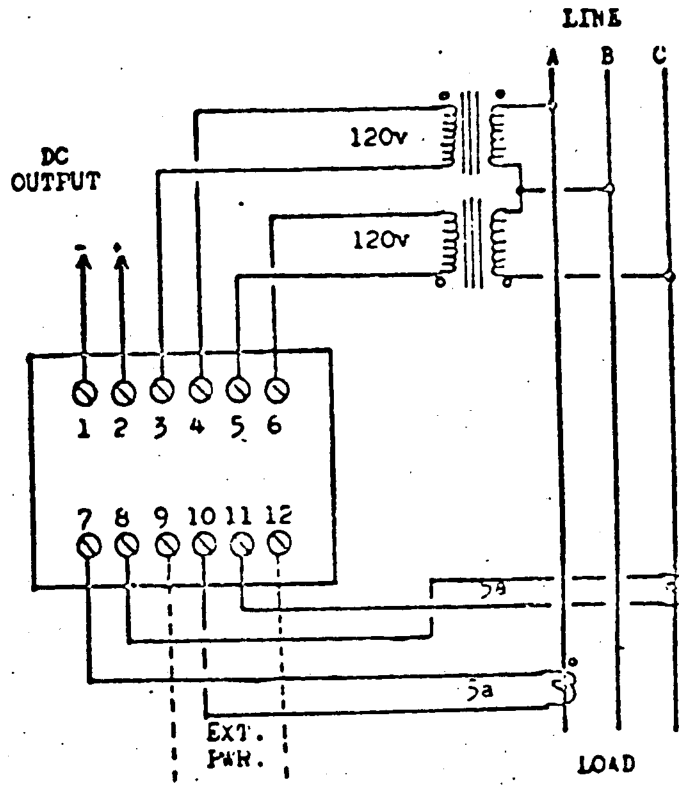

Dimension A

20WS100	....	3 1/4
20WS101	....	4
20WS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

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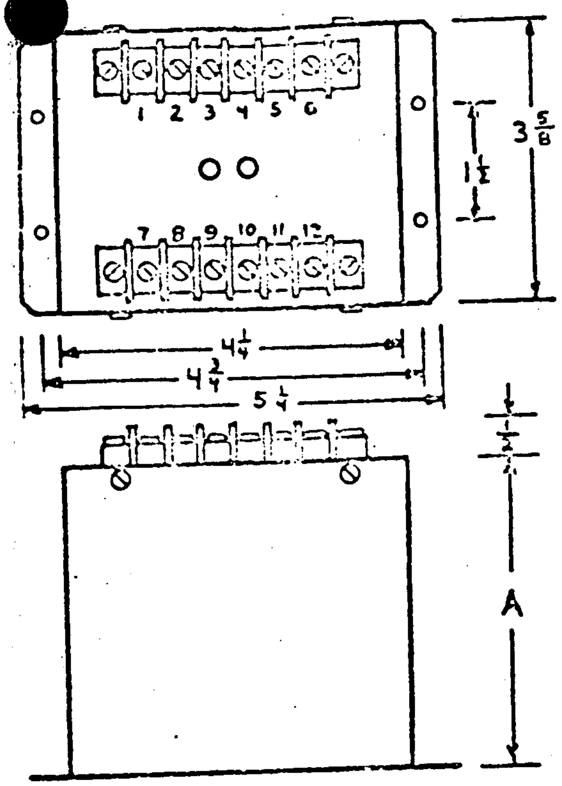


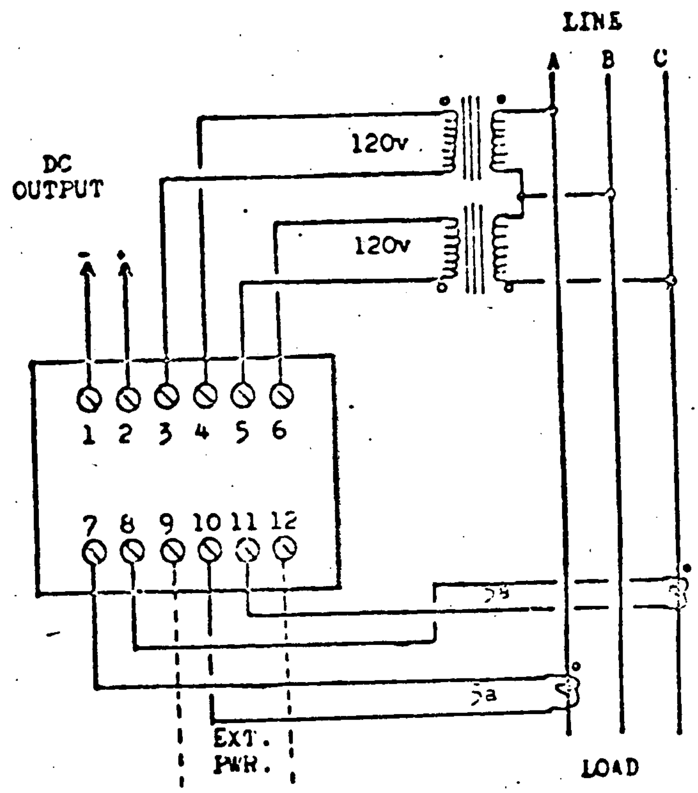
Dimension A

20WS100	.... 3 1/4
20WS101	 4
20WS101 E	 4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

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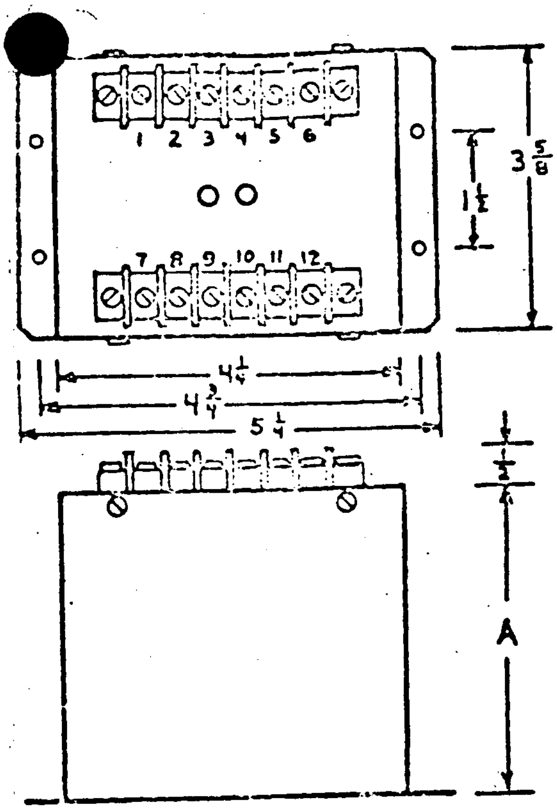

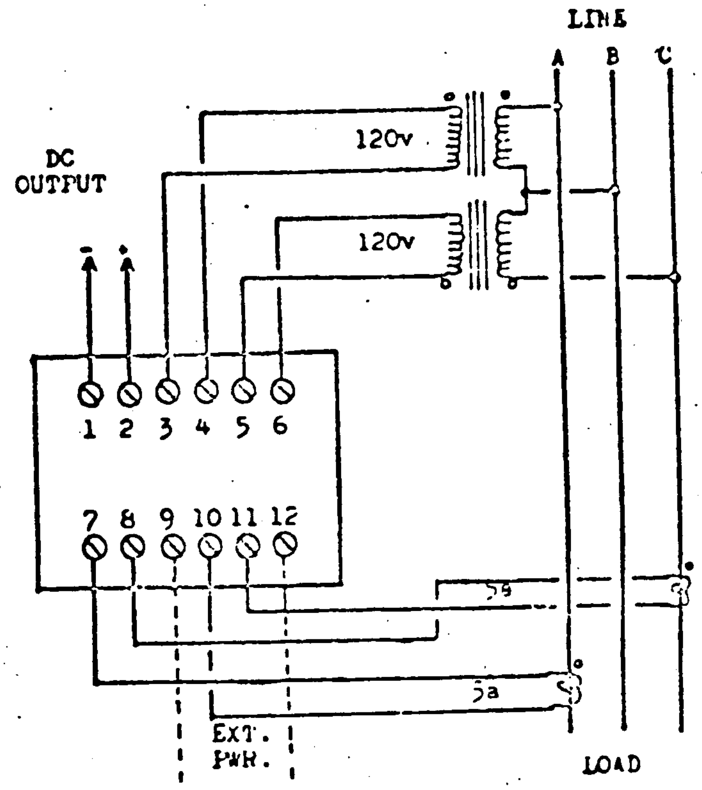

Dimension A

20WS100	3 1/4
20WS101	4
20WS101 E	4

Mounting holes (4).. 3/16 Dia.

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Connection diagram to a three phase three wire line using current and potential transformers.

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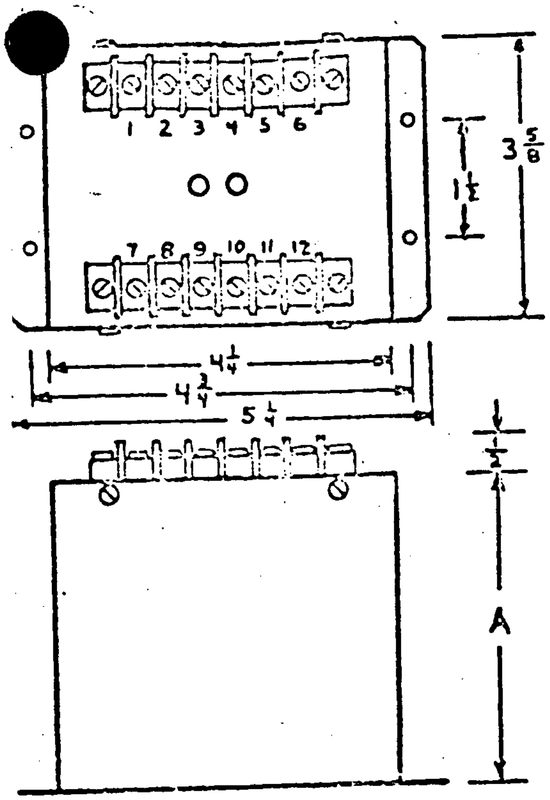

Dimension A

20WS100	....	3 1/4
20WS101	....	4
20WS101 E	....	4

Mounting holes (4).. 3/16 Dia.

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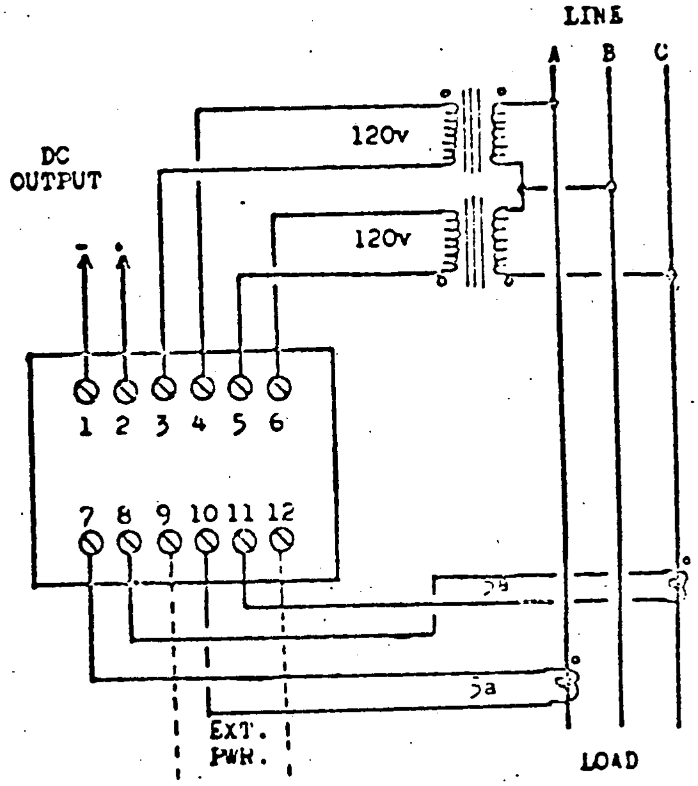
Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

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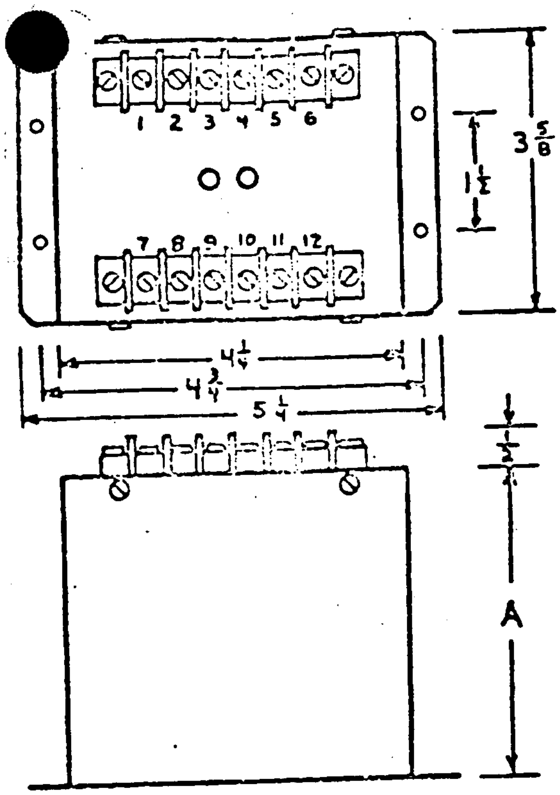

Dimension A

20WS100	....	3 1/4
20WS101	....	4
20WS101 E	....	4

Mounting holes (4).. 3/16 Dia.

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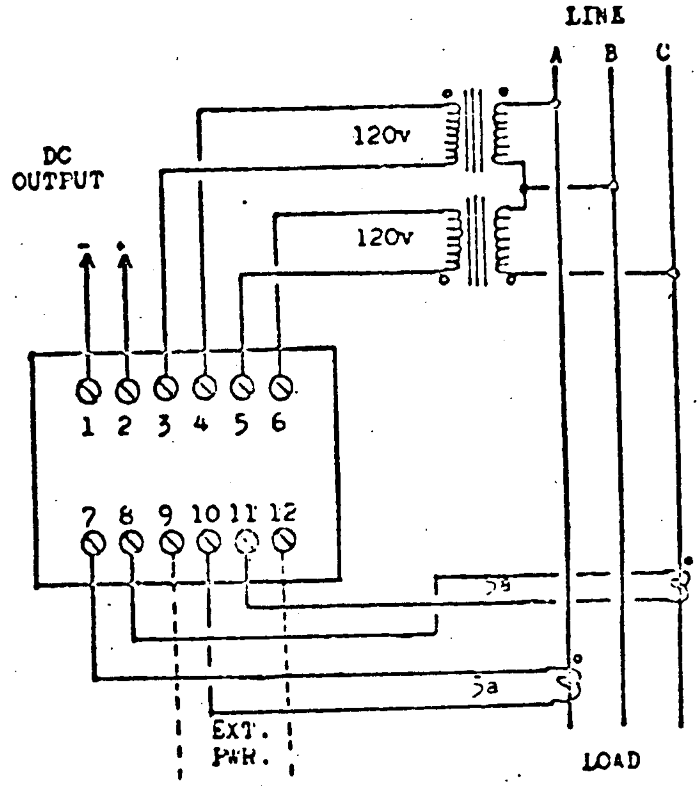

Connection diagram to a three phase three wire line using current and potential transformers.

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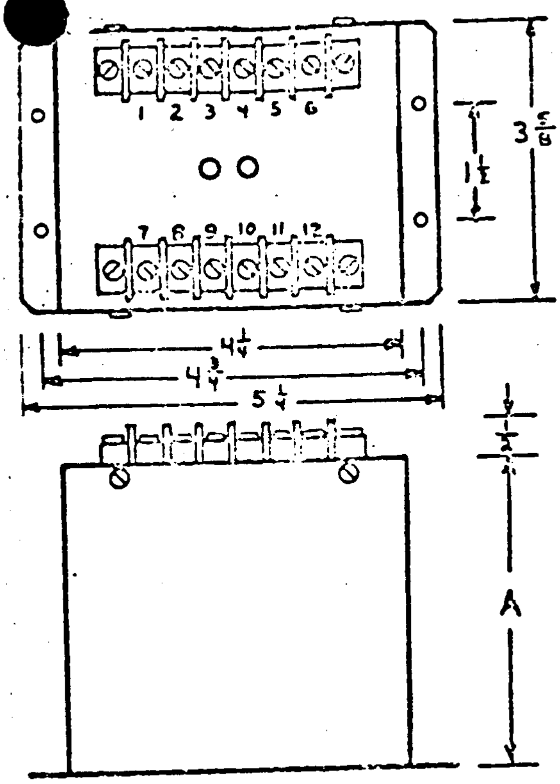

Dimension A

20WS100	....	3 1/4
20WS101	....	4
20WS101 E	....	4

Mounting holes (4).. 3/16 Dia.

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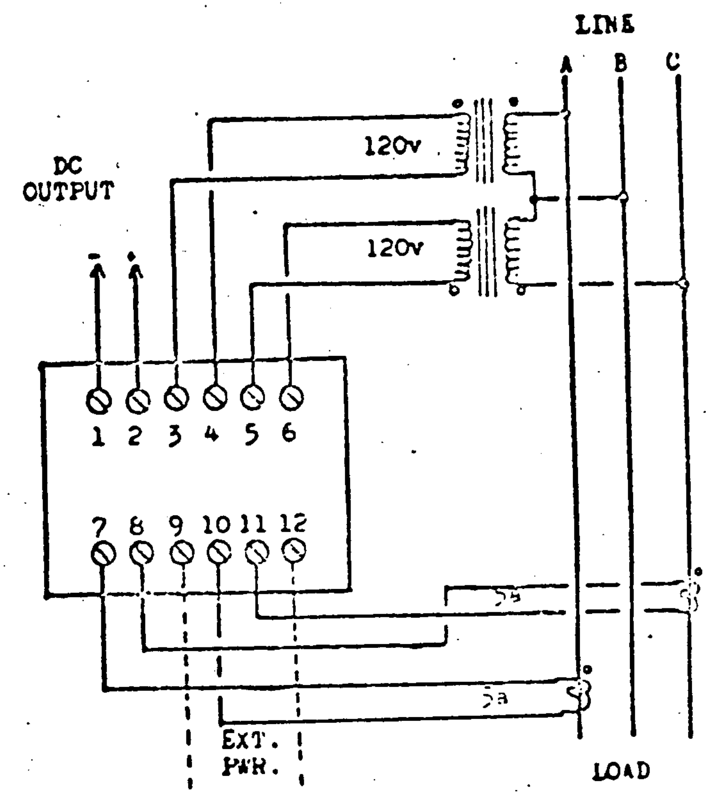
Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

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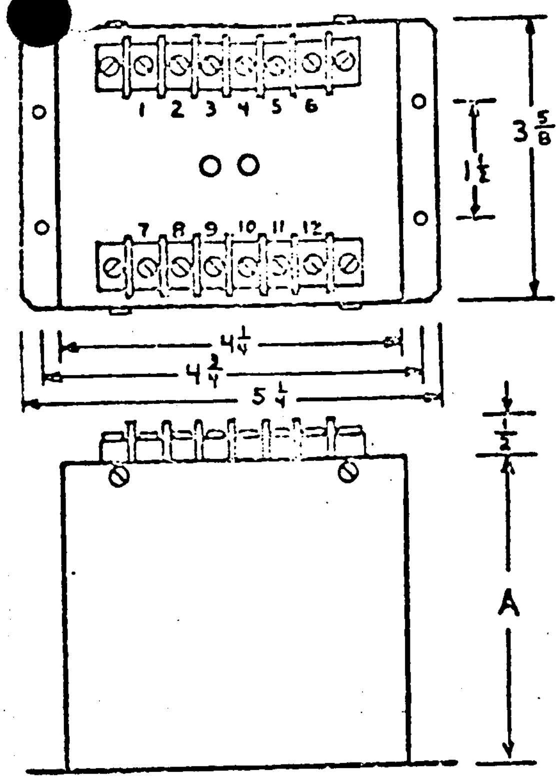

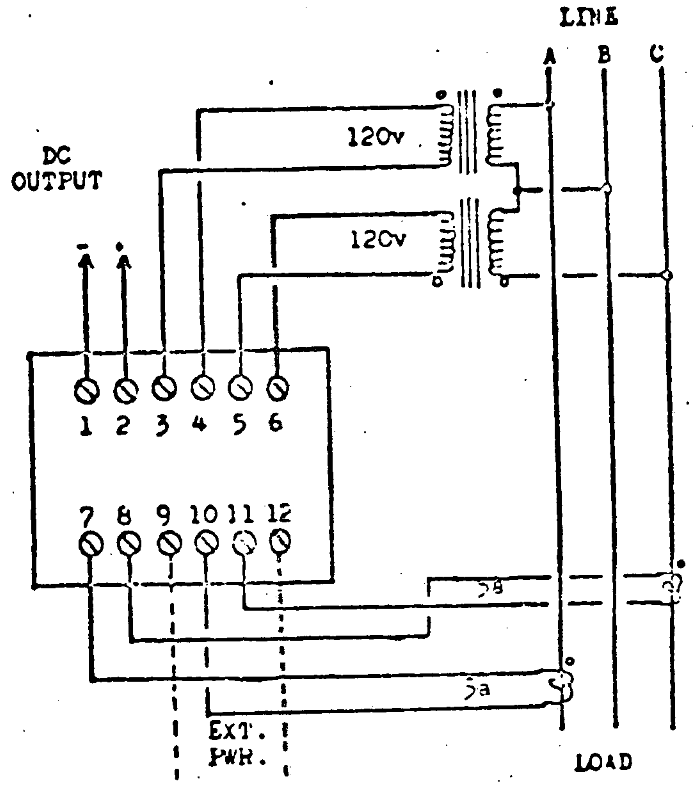

Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20WS100	3 1/4
20WS101	4
20WS101 E	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

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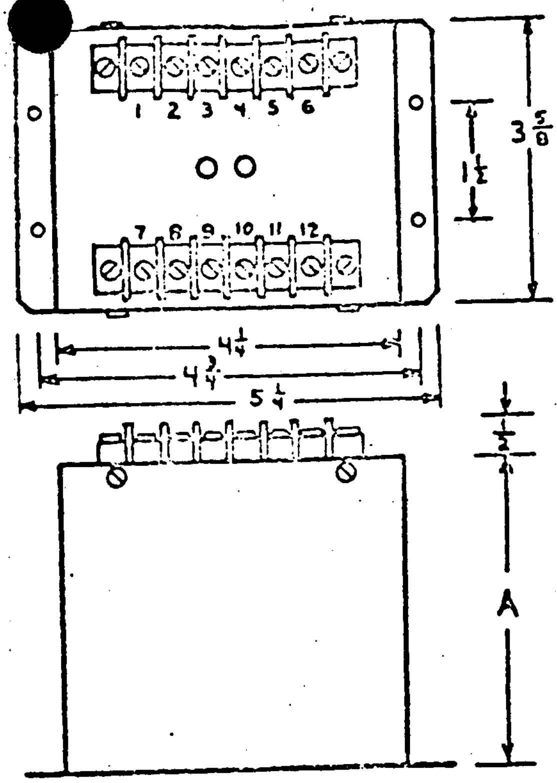

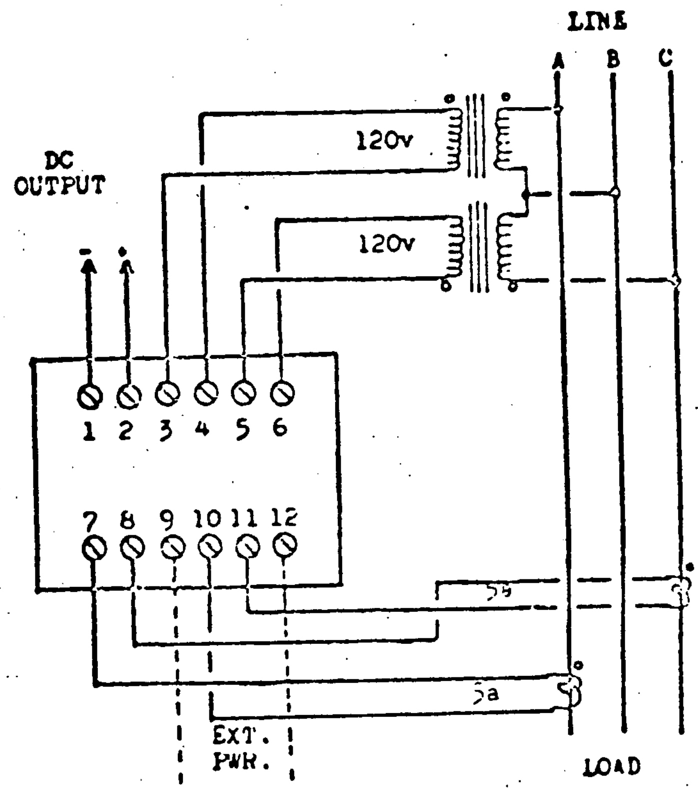

Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20WS100	3 1/4
20WS101	4
20WS101 E	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

The external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

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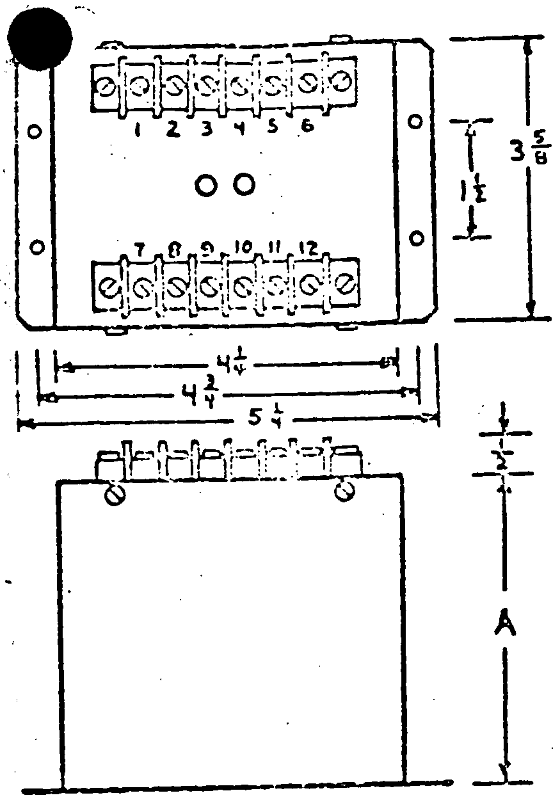


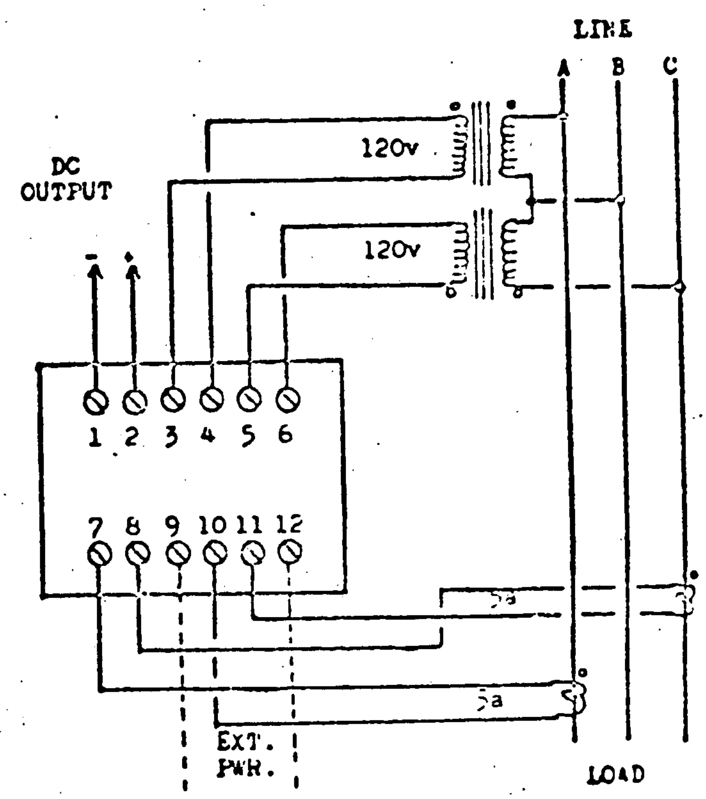
Dimension A

20WS100	....	3 1/4
20WS101	....	4
20WS101 E	....	4

Mounting holes (4)., 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

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20 RS 100 SERIES

3 PHASE, 3 WIRE

C EO1-HMA
SO-1

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a verying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- . Designed for Utility Requirements
- . Measures Leading and Lagging Reactive Power
- . Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

2510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 885 9891

20 RS 100 SERIES
3 PHASE, 3 WIRE

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 895-3591

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz (1)		
A.C. COMPONENT (PEAK)		100% (2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10% (3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-9391

20 RS 100 SERIES

3 PHASE, 3 WIRE

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

8510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (214) 885 8881

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz (1)		
A.C. COMPONENT (PEAK)		100% (2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10% (3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

8510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-9591

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz (1)		
A.C. COMPONENT (PEAK)		100% (2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN		2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz [illegible]
CALIBRATION ADJUSTMENT		±10% (3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.
8510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 885-8881

20 RS 100 SERIES

3 PHASE, 3 WIRE

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	[illegible]
CURRENT BURDEN		2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 885-8891

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		200%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN		2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-8861

20 RS 100 SERIES

3 PHASE, 3 WIRE

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. There are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	[illegible]	2VA
CURRENT BURDEN		2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES

(2) FILTERED OUTPUT AVAILABLE

(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 885-8891

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load. resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

. Designed for Utility Requirements
. Measures Leading and Lagging Reactive Power
. Calibrated Output

SPECIFICATIONS

MODEL NUMBERS	20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT	120 VOLTS		
NOMINAL CURRENT INPUT	5 AMPS		
FULL SCALE CALIBRATING VARS	1000 VARS		
OUTPUT AT FULL SCALE (d.c.)	100MV	1MA	1MA
OUTPUT LOAD REQUIRED	100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C	±0.5% OF FULL SCALE		
POWER FACTOR RANGE	UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE	-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)	±1%		
FREQUENCY RANGE	60Hz(1)		
A.C. COMPONENT (PEAK)	100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE	<1MS	<200MS	<200MS
VOLTAGE RANGE	0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS — POTENTIAL	150 VOLTS		
INPUT OVERLOAD LIMITS — CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN — MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN — MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED	NONE	NONE	85-135V 60Hz [illegible]
CALIBRATION ADJUSTMENT	±10%(3)		
ZERO ADJUSTMENT	NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND	1500V RMS		
PACKAGING AND CONNECTIONS	DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 846-8891

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100K	0 to 10K	0 to 10K
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	[illegible]	[illegible]
CURRENT BURDEN		2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V [illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.
6510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 885-9801

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6810 PROPRIETORS ROAD • COLUMBUS, OHIO 43085 • (614) 885-8891

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

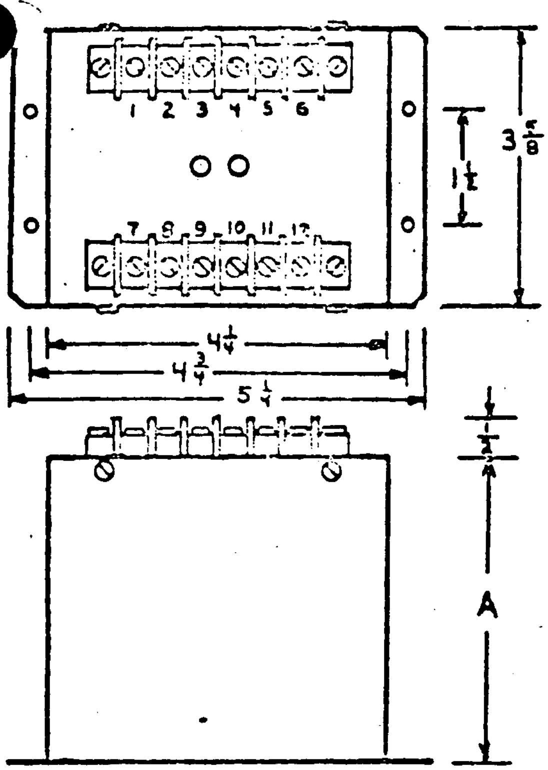
- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

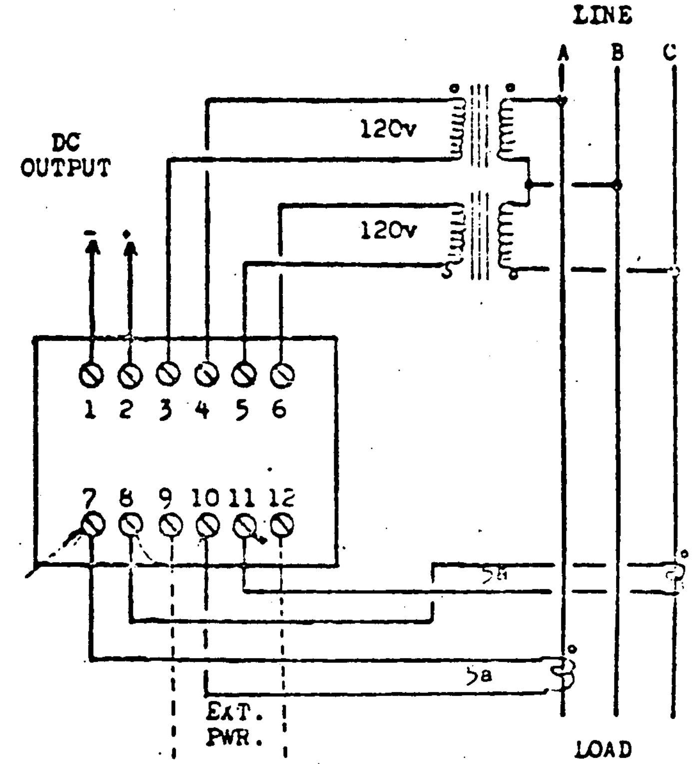
SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		[illegible]	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-145V	85-145V	0-145V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	[illegible]	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	[illegible]		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	[illegible]
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.
8510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 885-8881





Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20RS100	3 1/4
20RS101	4
20RS101 E	4

Mounting holes (4).. 3/16 Dia.

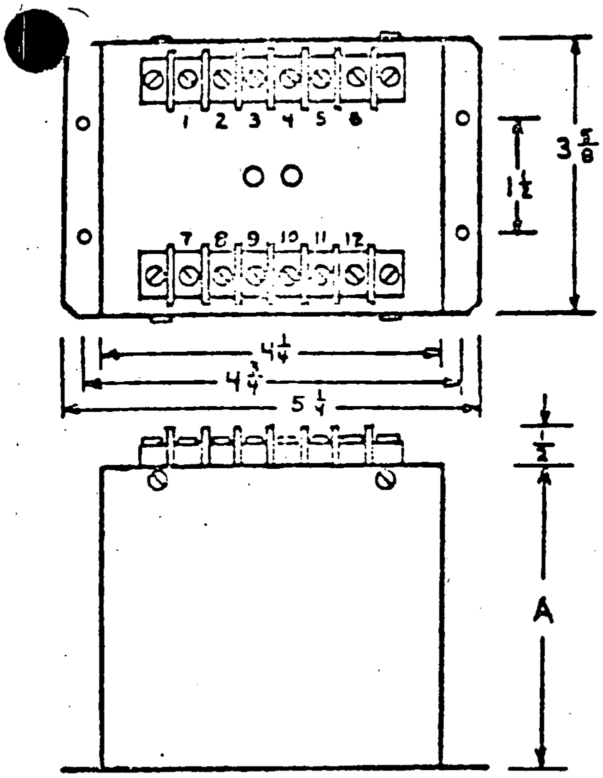
Can is steel with integral mounting flanges.

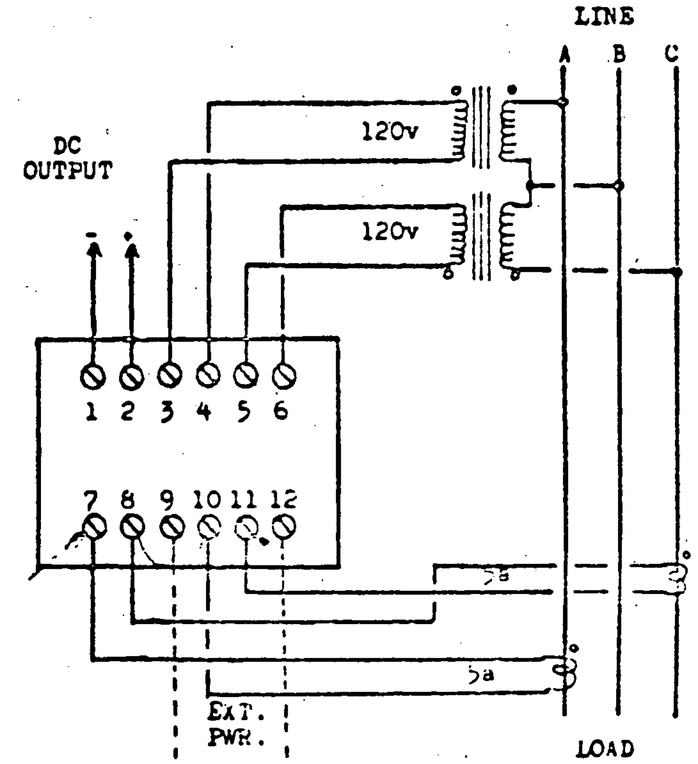
Terminal screws are 8-32 binding head.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity





Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20RS100	3 1/4
20RS101	4
20RS101 E	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

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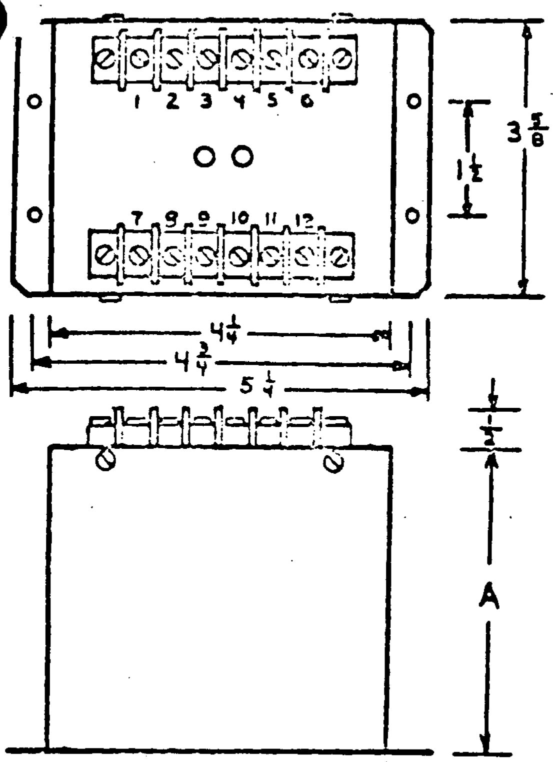

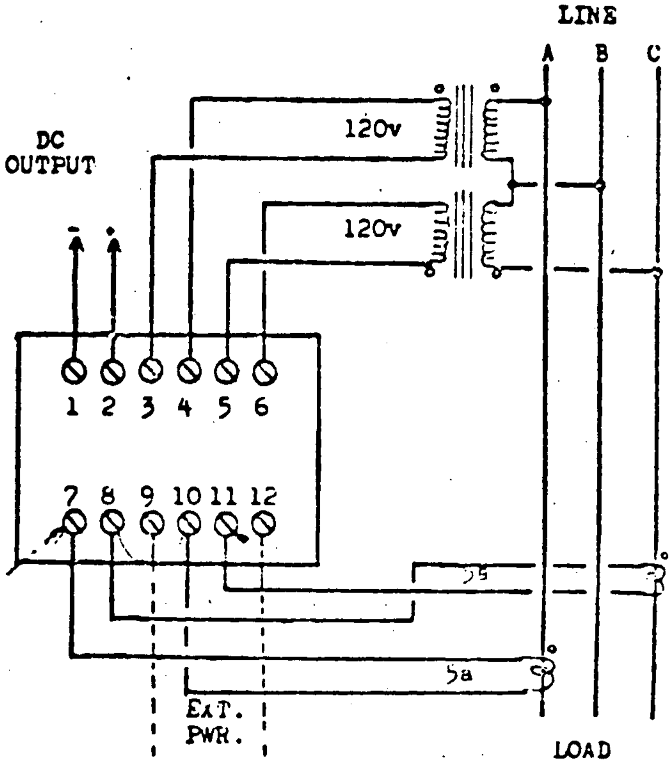

Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20RS100	....	3 1/4
20RS101	....	4
20RS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

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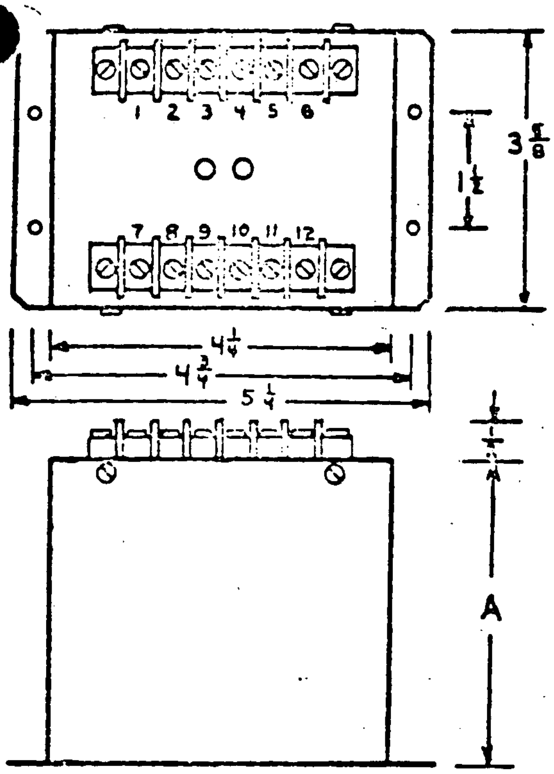

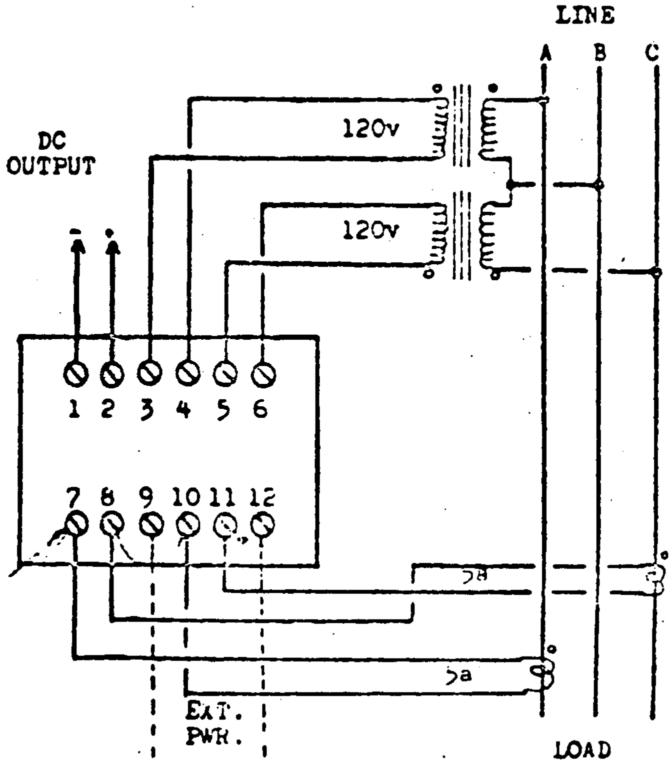

Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20RS100	....	3 1/4
20RS101	....	4
20RS101 E	....	4

Mounting holes (4).. 3/16 Dia.

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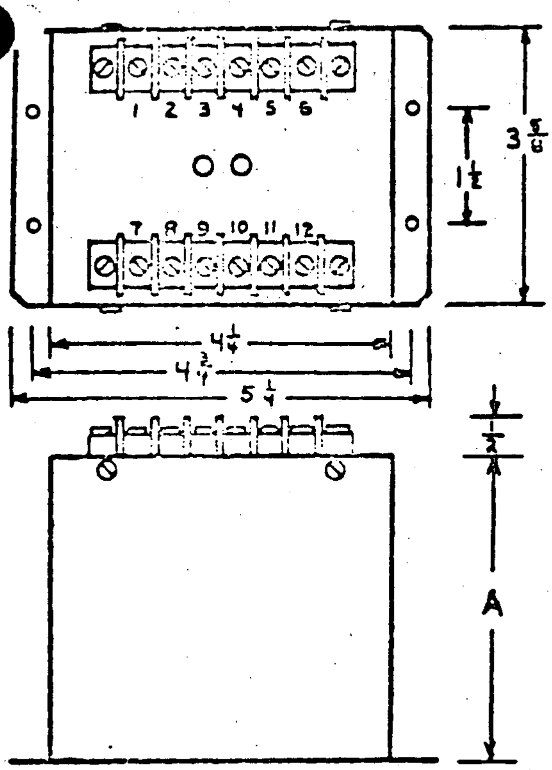

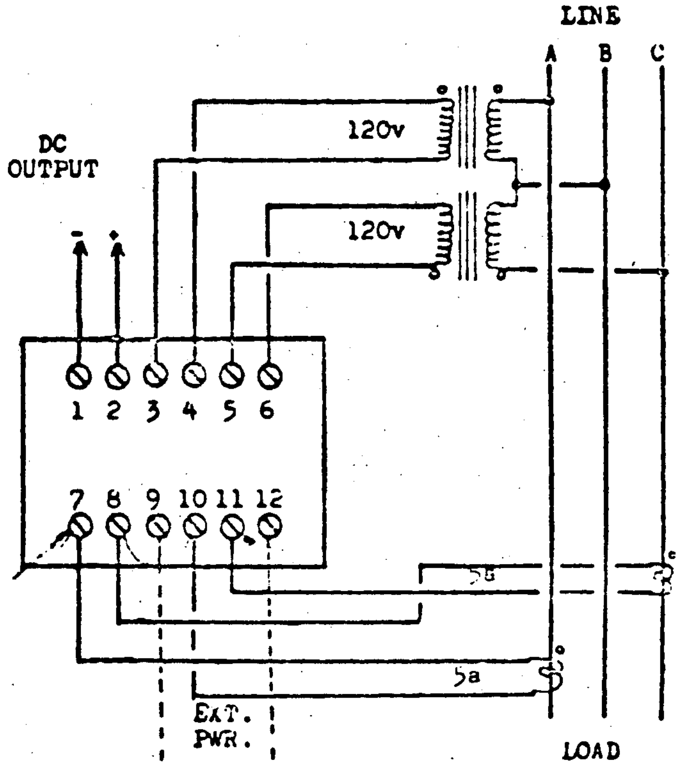

Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20RS100	....	3 1/4
20RS101	....	4
20RS101 E	....	4

Mounting holes (4).. 3/16 Dia.

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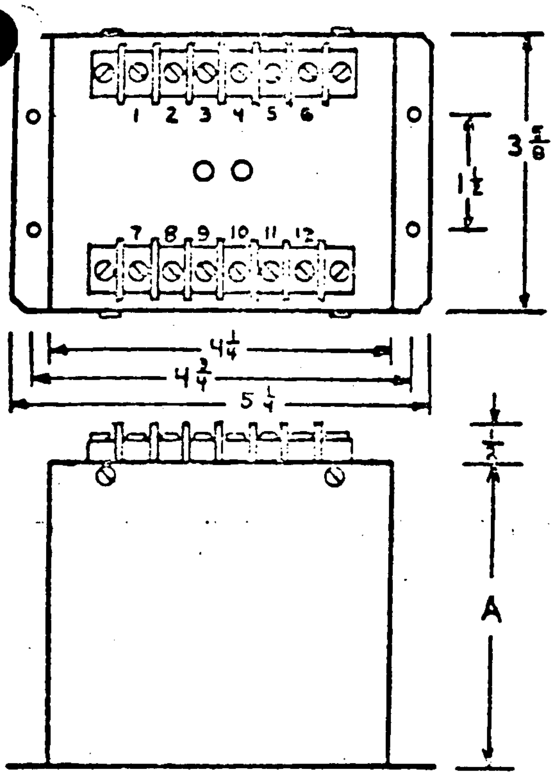

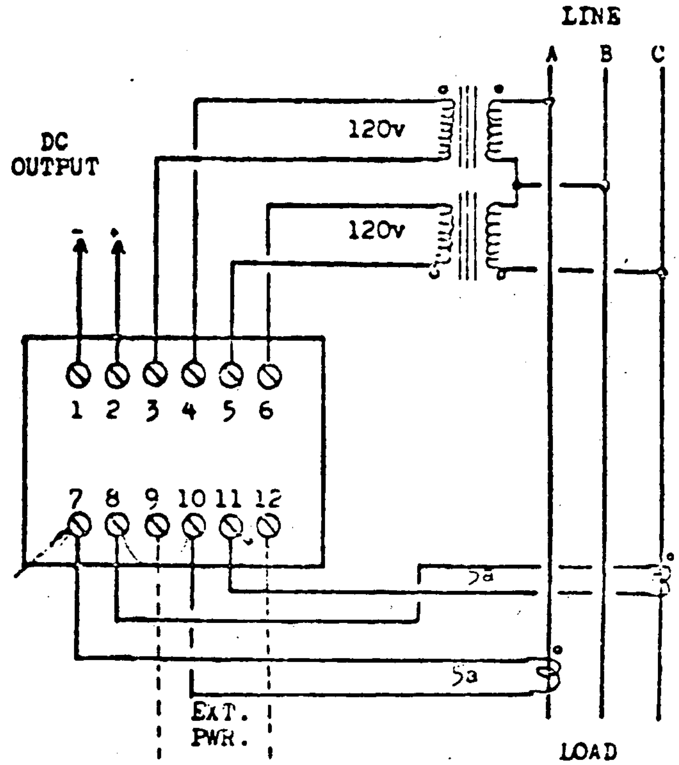

Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20RS100	.... 3 1/4
20RS101	 4
20RS101 E	 4

Mounting holes (4).. 3/16 Dia.

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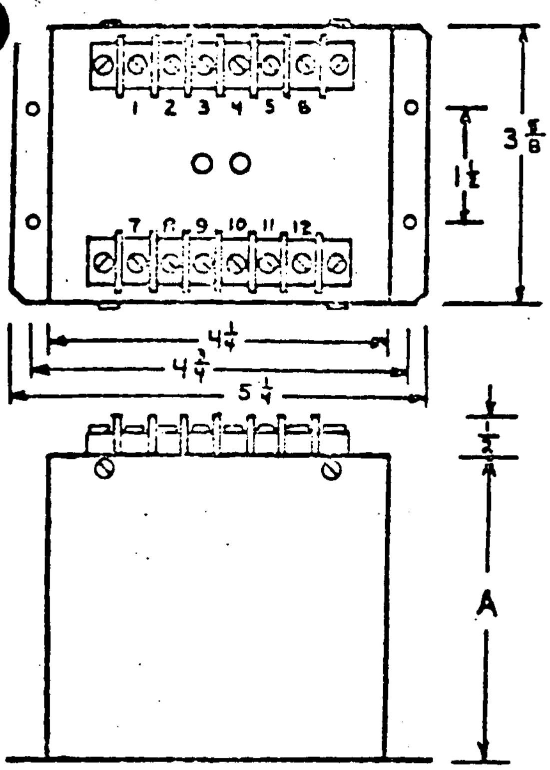

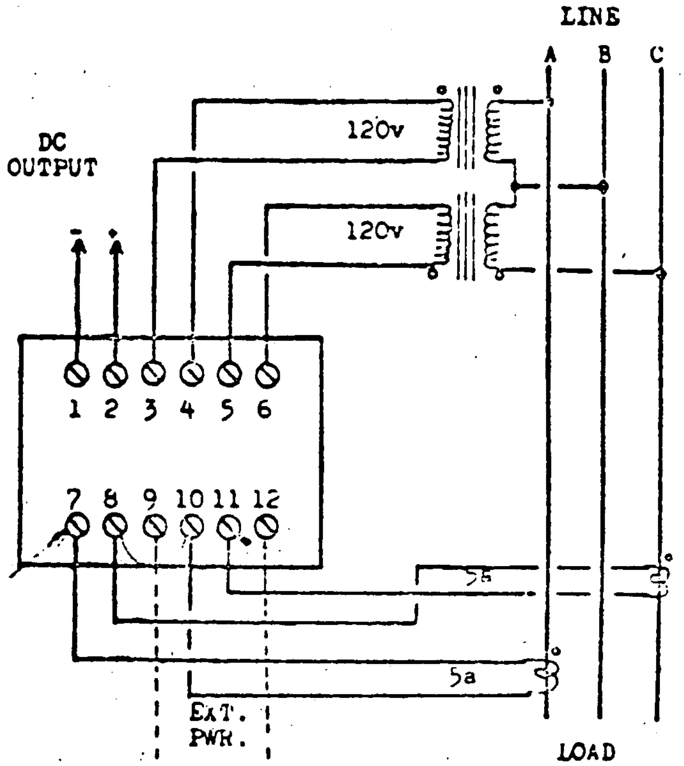

Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

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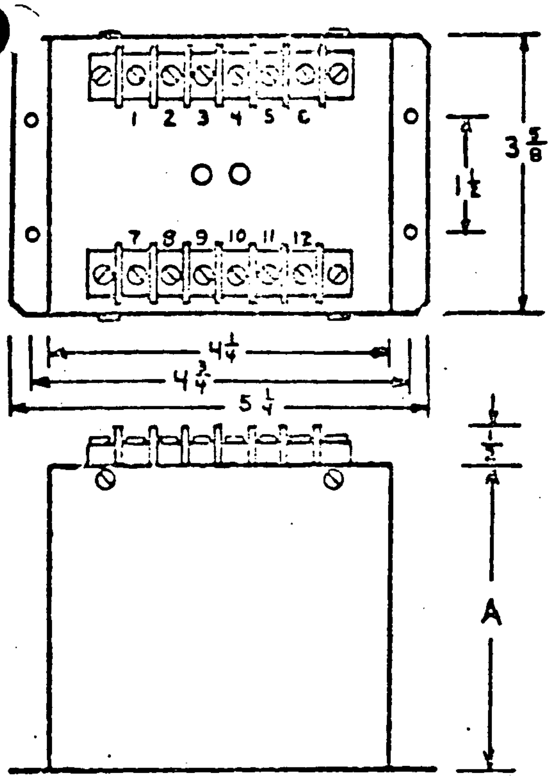
Dimension A

20RS100	....	3 1/4
20RS101	....	4
20RS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



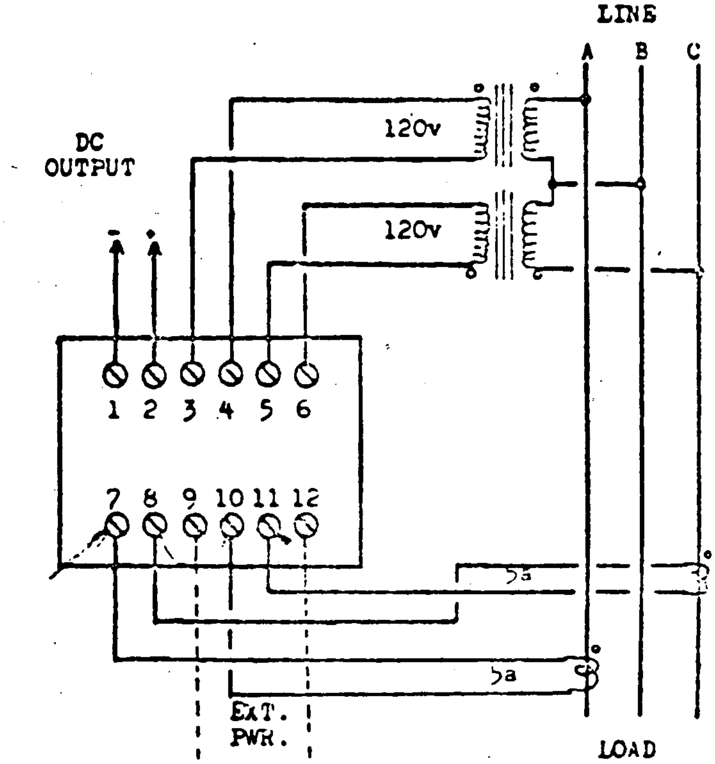
Dimension A

20RS100 .... 3 1/4
20RS101 4
20RS101 E 4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

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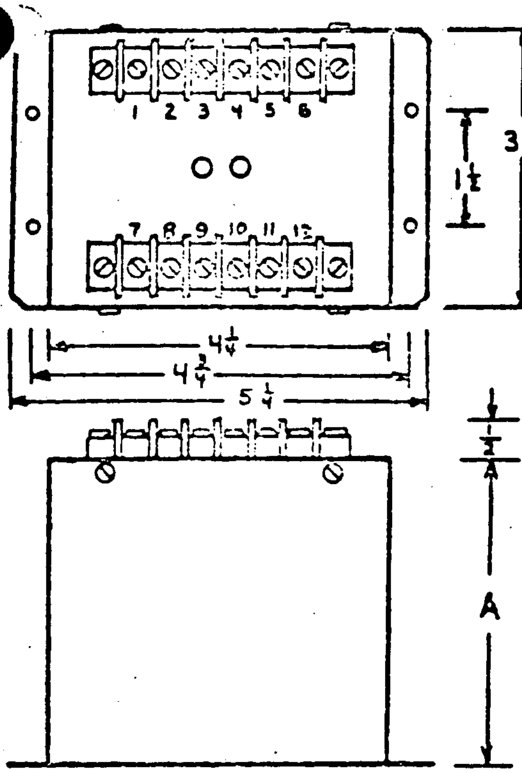


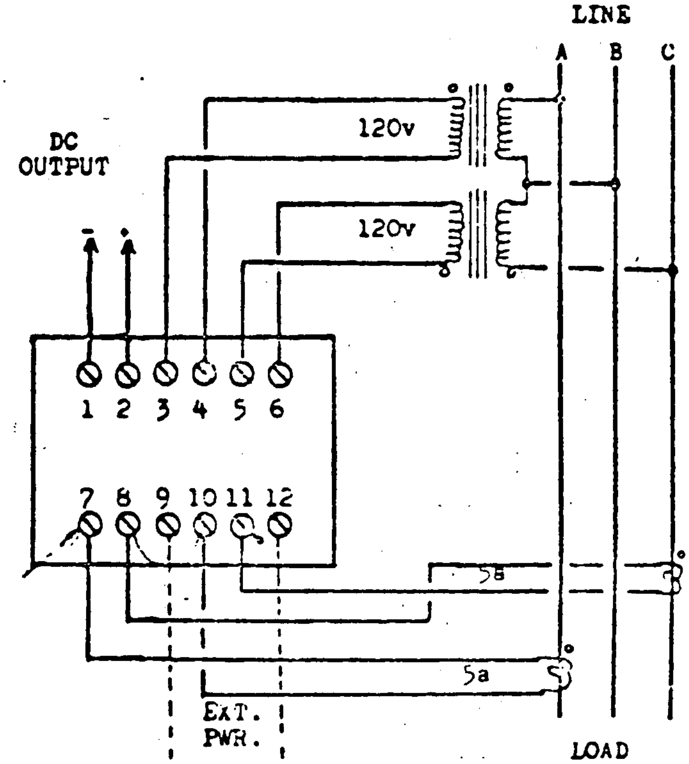
Dimension A

20RS100	....	3 1/4
20RS101	....	4
20RS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

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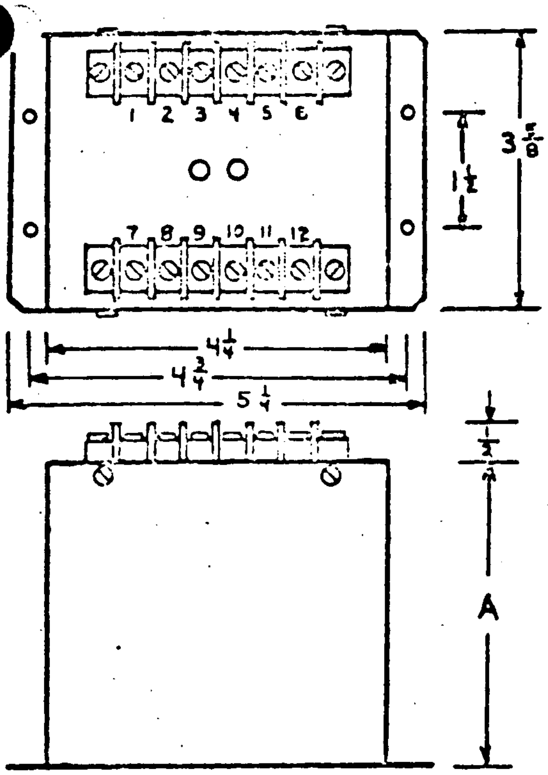


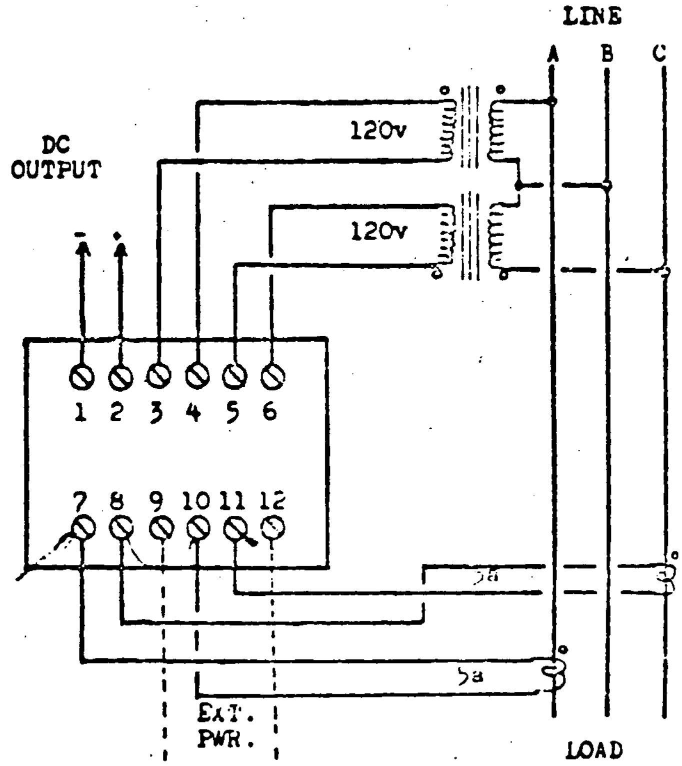
Dimension A

20RS100	....	3 1/4
20RS101	....	4
20RS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

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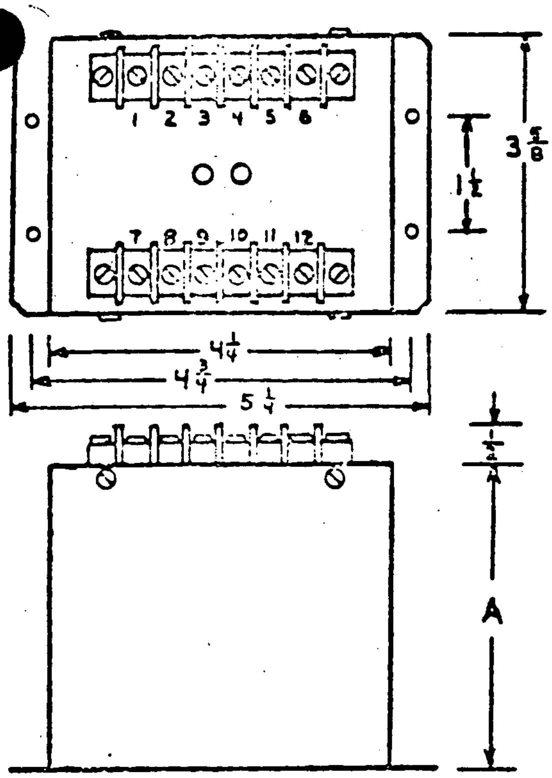
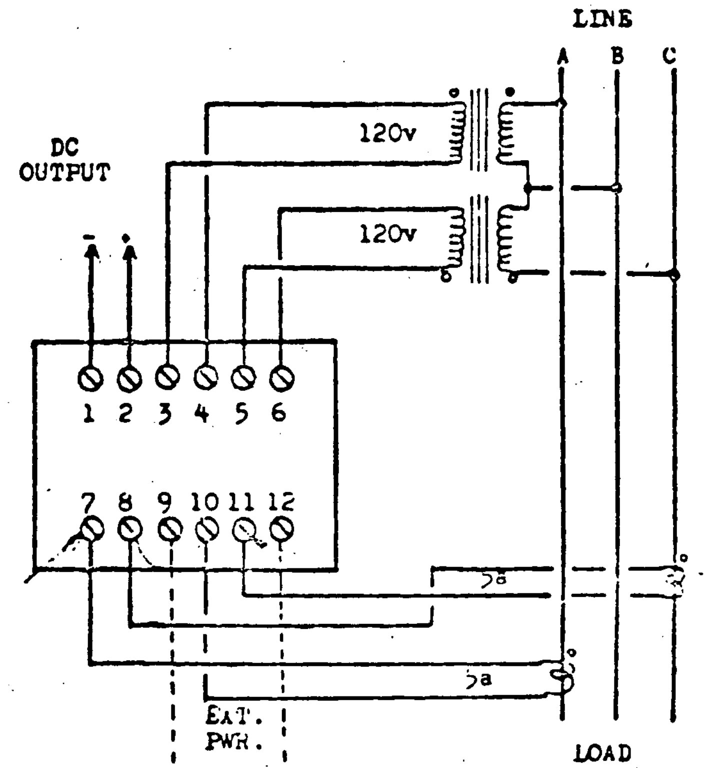




Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20RS100	3 1/4
20RS101	4
20RS101 E	4

Mounting holes (4).. 3/16 Dia.

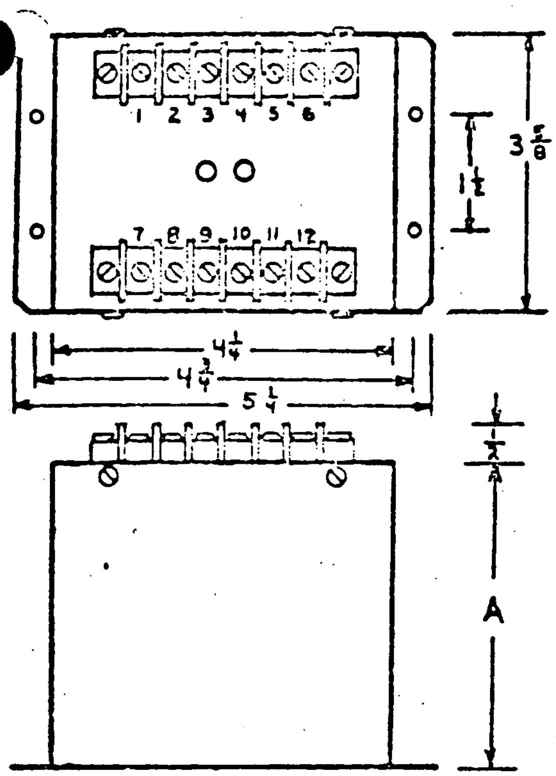
Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity



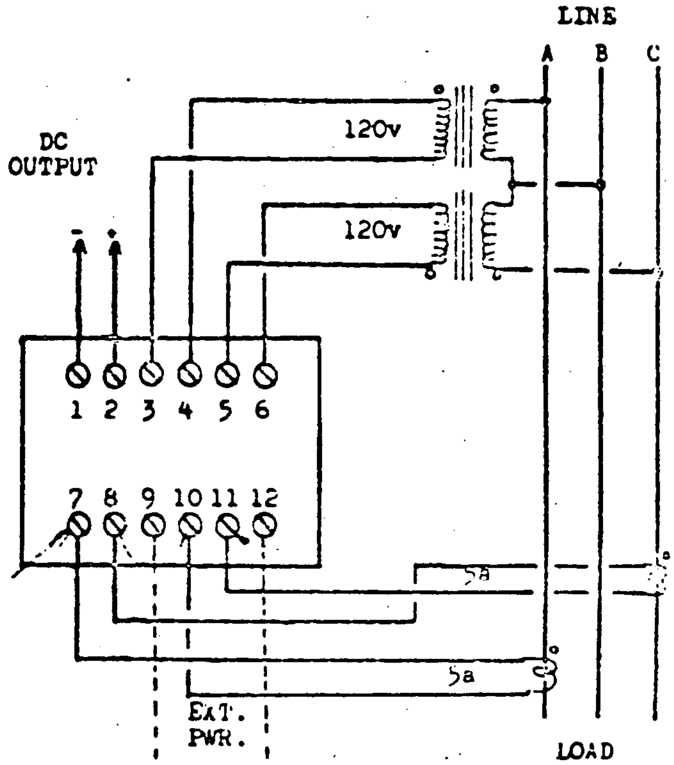
Dimension A

20RS100 .... 3 1/4
20RS101 4
20RS101 E 4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

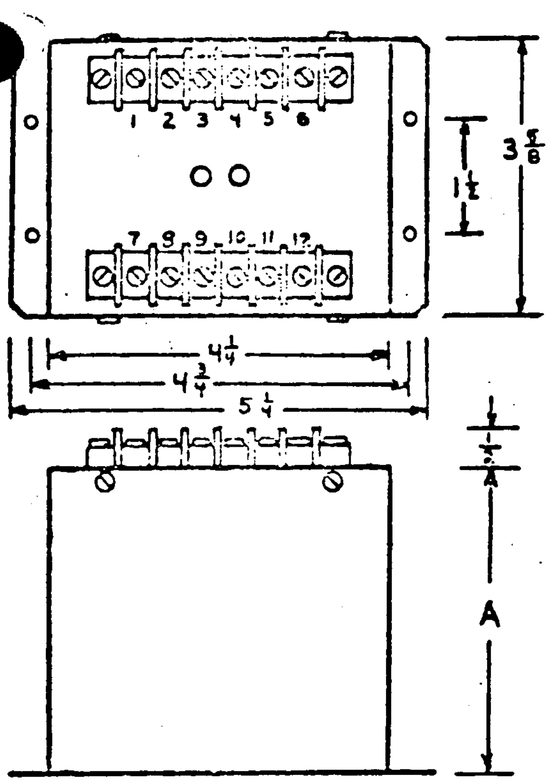


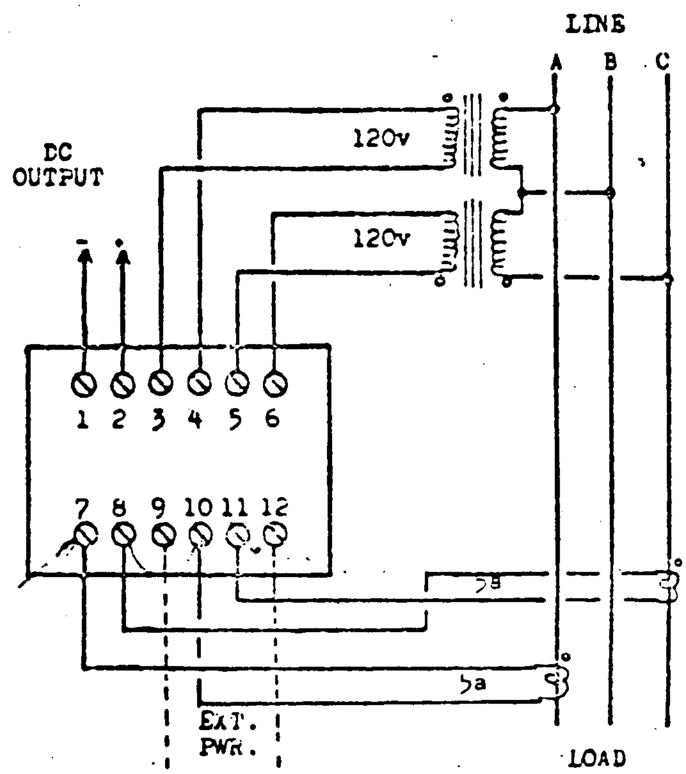
Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity





Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20RS100	3 1/4
20RS101	4
20RS101 E	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

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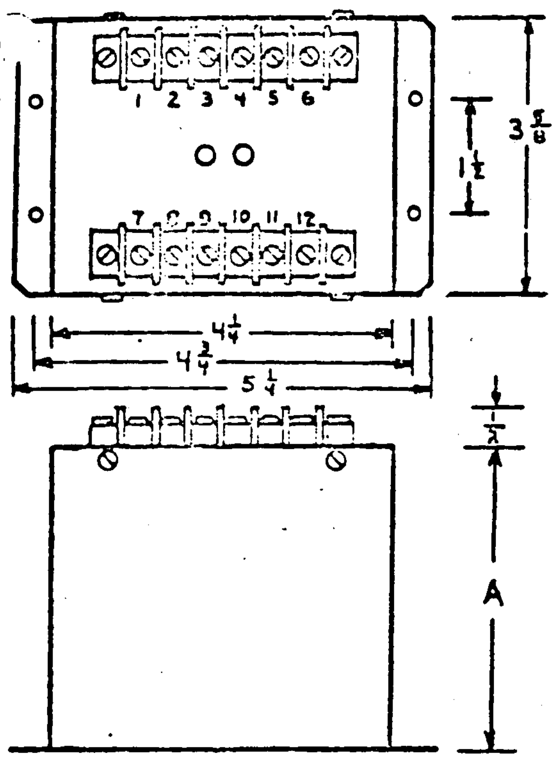

Dimension A

20RS100	....	3 1/4
20RS101	....	4
20RS101 E	....	4

Mounting holes (4).. 3/16 Dia.

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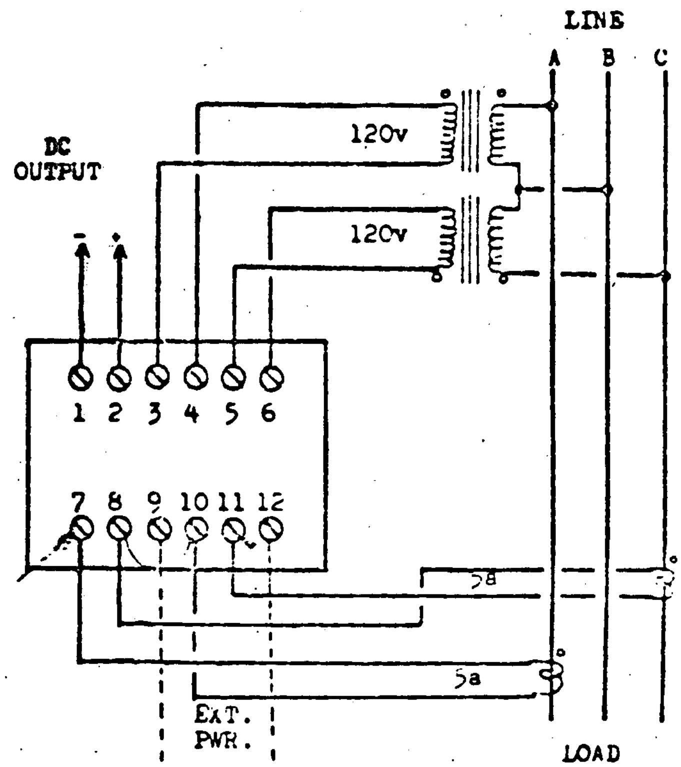

Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

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Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity

20 RS 100 SERIES

3 PHASE, 3 WIRE

CE01-HMA
SO-1

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100K	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

6510 PROPRIETORS ROAD • COLUMBUS OHIO 43085 • (614) 885-9881

20 RS 100 SERIES

3 PHASE, 3 WIRE

VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

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The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING VARS		1000 VARS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10K..	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		±1%		
FREQUENCY RANGE		60hz (1)		
A.C. COMPONENT (PEAK)		100% (2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	2VA	2VA
CURRENT BURDEN		2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10% (3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

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VAR TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect VAR transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20RS100 series is comprised of two element Hall Effect VAR transducers. there are three basic models in the series, with options of filtered outputs and 0 to 110% calibration adjustments, thereby offering a complete line of transducers for utility and industrial applications.

Model 20RS100 has a full scale output of 100 mV. The 20RS101 and 20RS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at zero p.f. This a.c. component is considerably lower than the stated value for balanced three phase operation.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current and power factor. For current output models, variation of output load impedance is included.

Standard VAR transducers are calibrated for 60Hz. For applications other than 60Hz the specific frequency must be specified when ordering.

- Designed for Utility Requirements
- Measures Leading and Lagging Reactive Power
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS	20RS100	20RS101	20RS101E
NOMINAL POTENTIAL INPUT	120 VOLTS		
NOMINAL CURRENT INPUT	5 AMPS		
FULL SCALE CALIBRATING VARS	1000 VARS		
OUTPUT AT FULL SCALE (d.c.)	100MV	1MA	1MA
OUTPUT LOAD REQUIRED	100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C	±0.5% OF FULL SCALE		
POWER FACTOR RANGE	UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE	-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)	±1%		
FREQUENCY RANGE	60Hz(1)		
A.C. COMPONENT (PEAK)	100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE	<1MS	<200MS	<200MS
VOLTAGE RANGE	0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS — POTENTIAL	150 VOLTS		
INPUT OVERLOAD LIMITS — CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN — MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN — MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED	NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT	±10%(3)		
ZERO ADJUSTMENT	NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND	1500V RMS		
PACKAGING AND CONNECTIONS	DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 50Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

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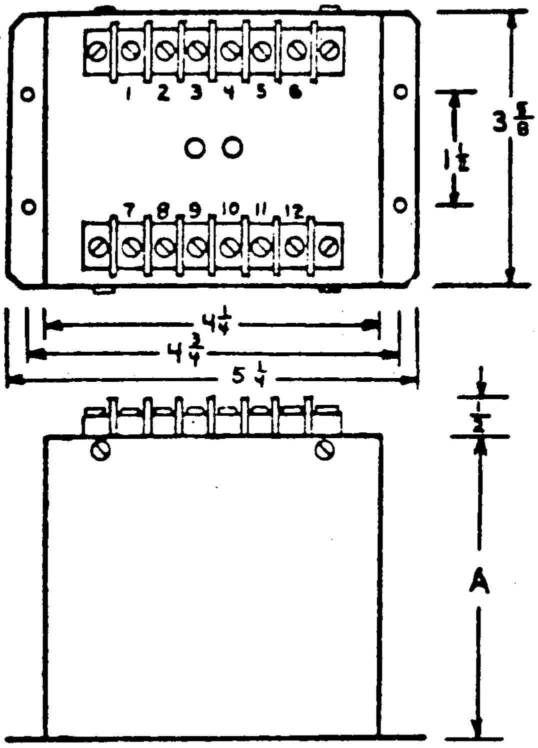


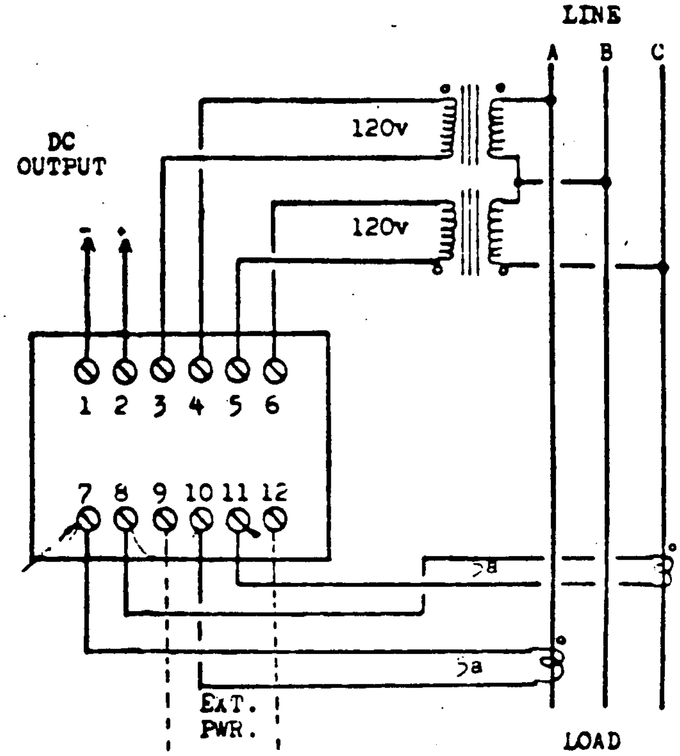
Dimension A

20RS100	.... 3 1/4
20RS101	 4
20RS101 E	 4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

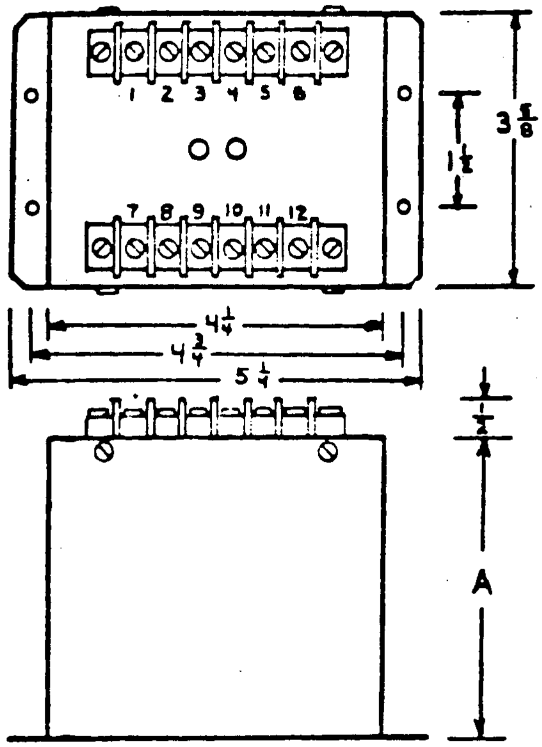


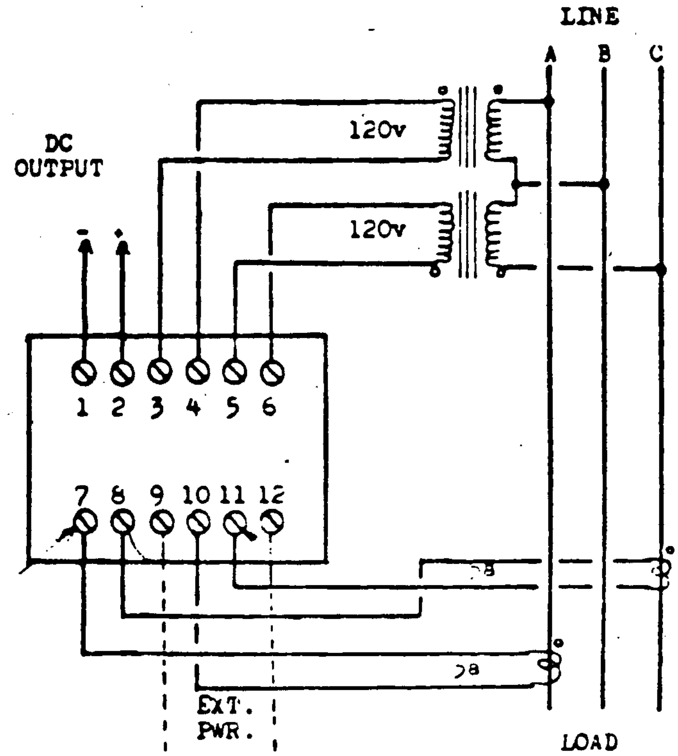
Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity





Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity

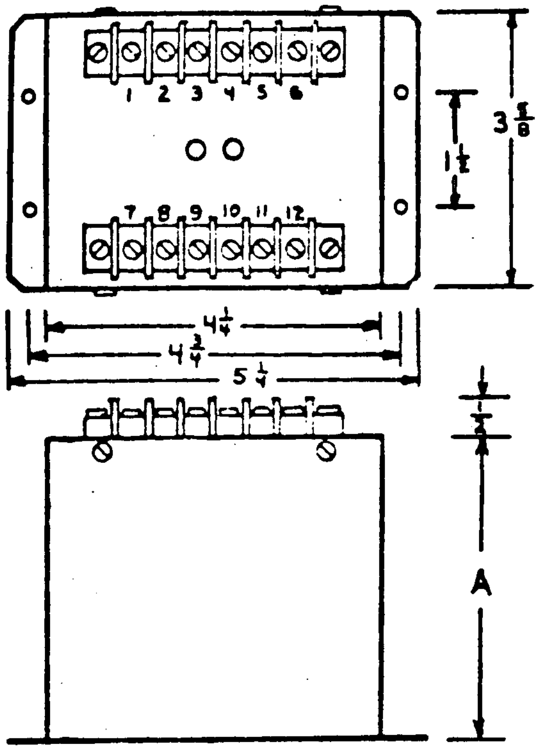
Dimension A

20RS100	.... 3 1/4
20RS101	 4
20RS101 E	 4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



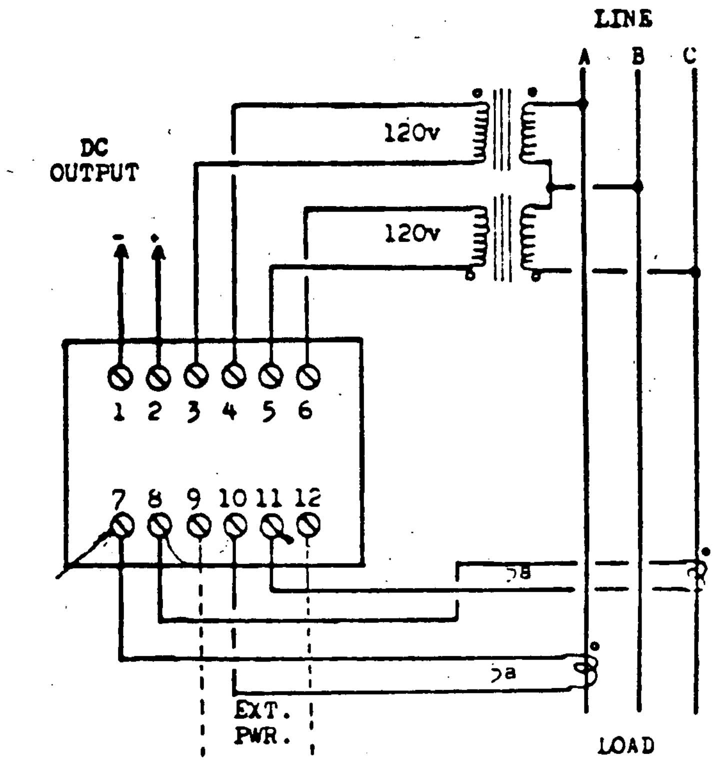
Dimension A

20RS100	....	3 1/4
20RS101	....	4
20RS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20RS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity

WATT TRANSDUCERS

DESCRIPTION

TransData, Inc., offers a complete selection of Hall Effect watt transducers. These models are available with such features as voltage or current outputs, calibration adjustment and filtered or unfiltered outputs. TransData transducers are also noted for their small physical size, high reliability and applicational flexibility.

The 20WS100 series is comprised of two element Hall Effect watt transducers. These models are for use on three phase, three wire systems. There are three basic models in this series, with options of filtered outputs and 0 to 110% calibration adjustment, thereby offering a complete line of transducers for utility and industrial applications.

Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS	20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT	120 VOLTS		
NOMINAL CURRENT INPUT	5 AMPS		
FULL SCALE CALIBRATING WATTS	1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)	100MV	1MA	1MA
OUTPUT LOAD REQUIRED	100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C	±0.5% OF FULL SCALE		
POWER FACTOR RANGE	UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE	-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)	±1%		
FREQUENCY RANGE	50-62Hz(1)		
A.C. COMPONENT (PEAK)	100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE	<1MS	<200MS	<200MS
VOLTAGE RANGE	0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS — POTENTIAL	150 VOLTS		
INPUT OVERLOAD LIMITS — CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN — MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN — MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED	NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT	±10%(3)		
ZERO ADJUSTMENT	NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND	1500V RMS		
PACKAGING AND CONNECTIONS	DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

TRANSDATA, inc.

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WATT TRANSDUCERS

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Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS		20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT		120 VOLTS		
NOMINAL CURRENT INPUT		5 AMPS		
FULL SCALE CALIBRATING WATTS		1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)		100MV	1MA	1MA
OUTPUT LOAD REQUIRED		100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C		±0.5% OF FULL SCALE		
POWER FACTOR RANGE		UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE		-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)		[illegible]		
FREQUENCY RANGE		50-62Hz(1)		
A.C. COMPONENT (PEAK)		100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE		<1MS	<200MS	<200MS
VOLTAGE RANGE		0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS	•POTENTIAL	150 VOLTS		
	CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN	MAXIMUM PER ELEMENT	2VA	4VA	2VA
CURRENT BURDEN	MAXIMUM PER ELEMENT	2VA		
EXTERNAL AMPLIFIER POWER REQUIRED		NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT		±10%(3)		
ZERO ADJUSTMENT		NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND		1500V RMS		
PACKAGING AND CONNECTIONS		DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

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20WS100 SERIES

3 PHASE, 3 WIRE

WATT TRANSDUCERS

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Model 20WS100 has a full scale output of 100 mV. The 20WS101 and 20WS101E have a full scale output of 1mA, operable into a varying loop or load resistance of 0 to 10K ohms, with no loss of stated accuracy.

The a.c. component is stated for worst case (single phase) operation at unity p.f. This a.c. component is considerably lower than the stated value for balanced three phase operations.

Accuracy/linearity specification of ±0.5% includes influences of variations in voltage, current, power factor, waveform and frequency. For current output models, variation of output load impedance is included.

- Designed for Utility Requirements
- Measures Reverse and Forward Power Flow
- Calibrated Output

SPECIFICATIONS

MODEL NUMBERS	20WS100	20WS101	20WS101E
NOMINAL POTENTIAL INPUT	120 VOLTS		
NOMINAL CURRENT INPUT	5 AMPS		
FULL SCALE CALIBRATING WATTS	1000 WATTS		
OUTPUT AT FULL SCALE (d.c.)	100MV	1MA	1MA
OUTPUT LOAD REQUIRED	100Ω	0 to 10KΩ	0 to 10KΩ
ACCURACY/LINEARITY @ 25°C	±0.5% OF FULL SCALE		
POWER FACTOR RANGE	UNITY TO LEAD OR LAG ZERO		
TEMPERATURE RANGE	-20°C to +60°C		
TEMPERATURE EFFECTS ON ACCURACY (MAX.)	±1%		
FREQUENCY RANGE	50-62Hz(1)		
A.C. COMPONENT (PEAK)	100%(2)	<1%	<1%
RESPONSE TIME TO 99% OF FINAL VALUE	<1MS	<200MS	<200MS
VOLTAGE RANGE	0-135V	85-135V	0-135V
INPUT OVERLOAD LIMITS — POTENTIAL	150 VOLTS		
INPUT OVERLOAD LIMITS — CURRENT	10A CONTINUOUS, 250A FOR 1 SEC.		
VOLTAGE BURDEN — MAXIMUM PER ELEMENT	2VA	2VA	2VA
CURRENT BURDEN — MAXIMUM PER ELEMENT	1VA		
EXTERNAL AMPLIFIER POWER REQUIRED	NONE	NONE	85-135V 60Hz 2W
CALIBRATION ADJUSTMENT	±10%(3)		
ZERO ADJUSTMENT	NONE	±2%	±2%
DIELECTRIC TEST-INPUT TO OUTPUT TO GROUND	1500V RMS		
PACKAGING AND CONNECTIONS	DIAGRAMS ON REVERSE SIDE		

(1) AVAILABLE AT 25Hz, 400Hz AND HIGHER FREQUENCY RANGES
(2) FILTERED OUTPUT AVAILABLE
(3) 0-110% CALIBRATION ADJUSTMENT AVAILABLE

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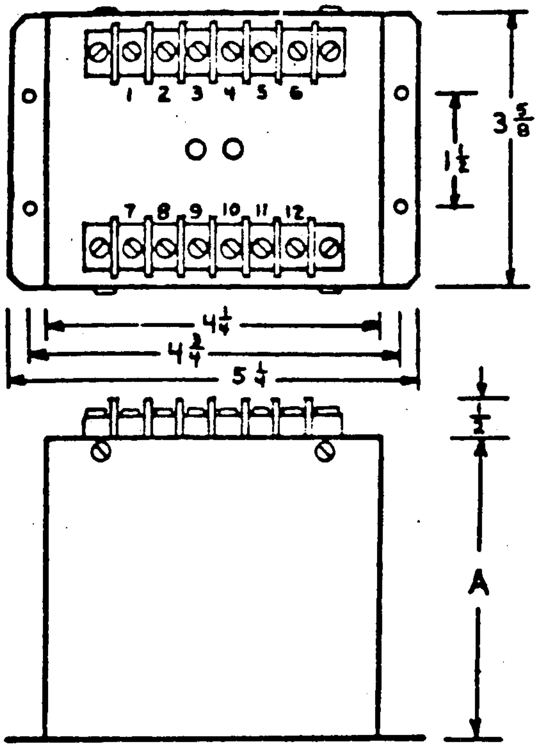
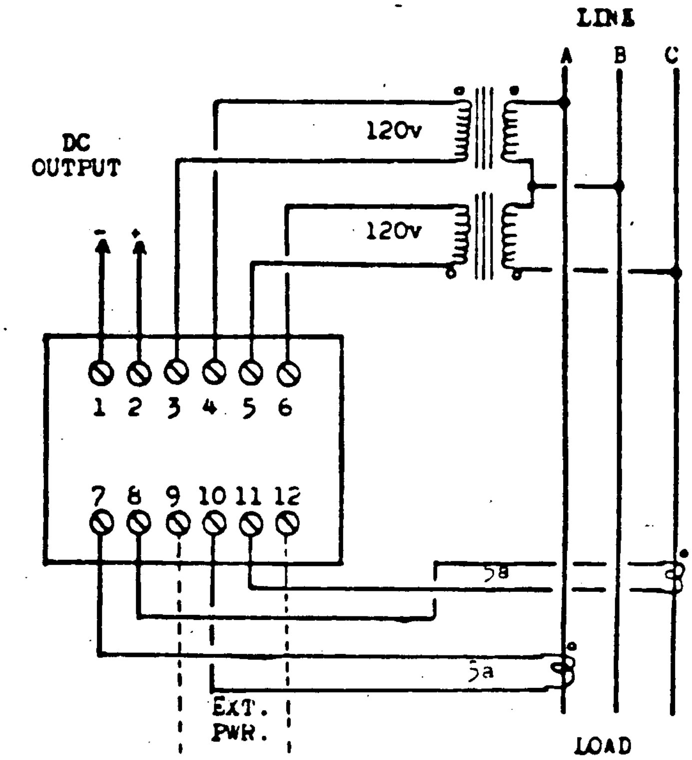




Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20WS100	.... 3 1/4
20WS101	 4
20WS101 E	 4

Mounting holes (4).. 3/16 Dia.

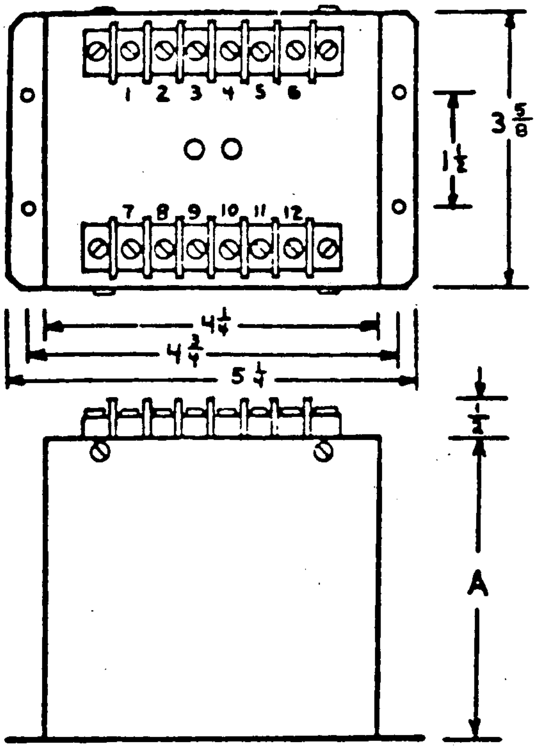
Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

The external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity.



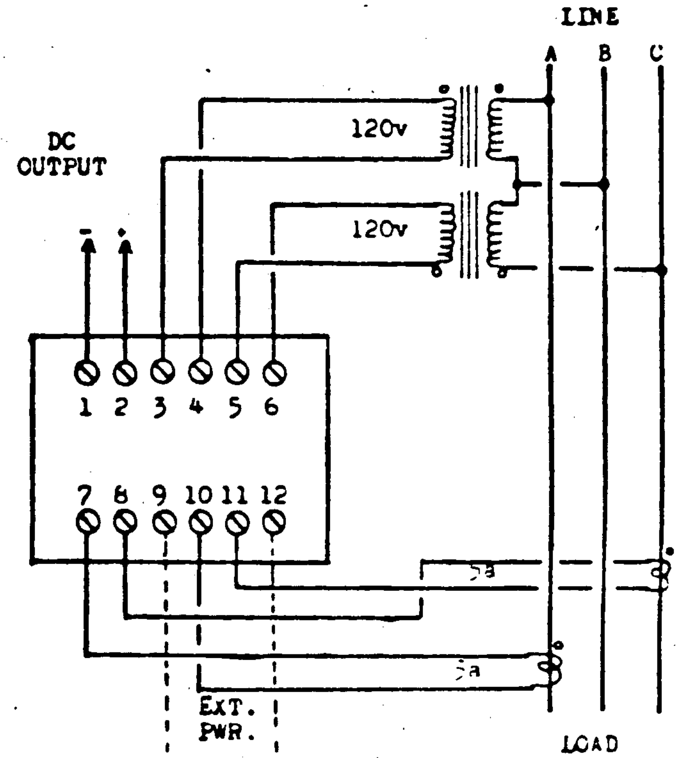
Dimension A

20WS100	....	3 1/4
20WS101	....	4
20WS101 E	....	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

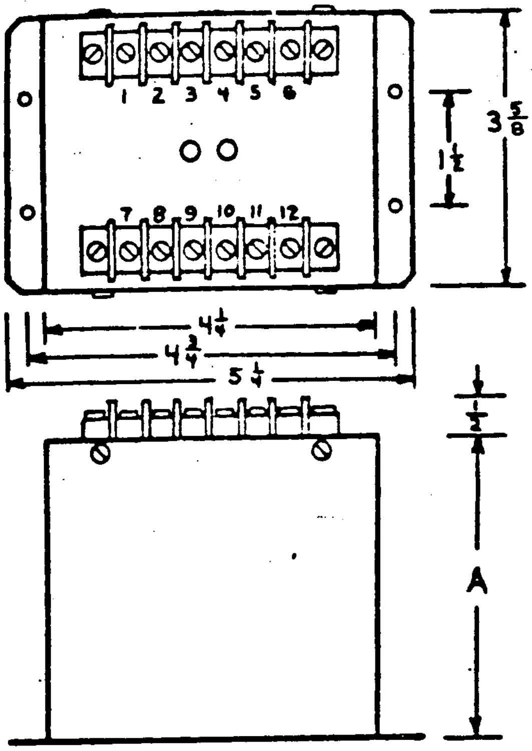


Connection diagram to a three phase three wire line using current and potential transformers.

The -external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

Grounding considerations may dictate connecting the primary opposite from the way shown. This is permissible if the secondary is also reversed, maintaining the same relative polarity.



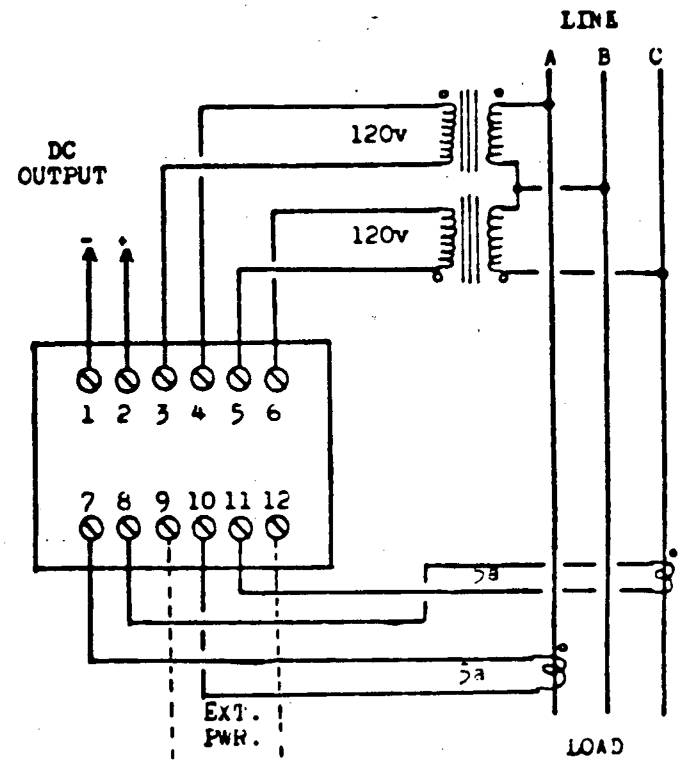
Dimension A

20WS100	3 1/4
20WS101	4
20WS101 E	4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.



Connection diagram to a three phase three wire line using current and potential transformers.

The external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

The dots shown on the transformers are relative polarity markings and show the proper connection polarity. Instrument transformer terminals are marked with a dot, a ± symbol or other identifiable mark on both primary and secondary. Failure to observe the proper polarity may result in erroneous readings.

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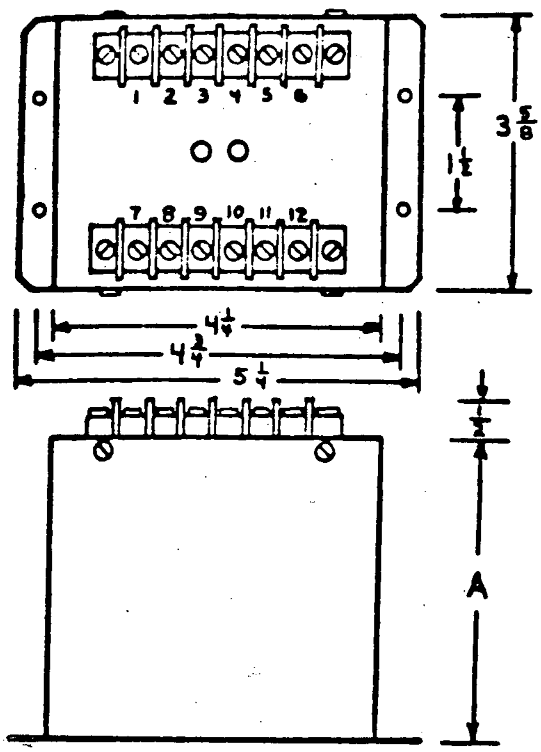

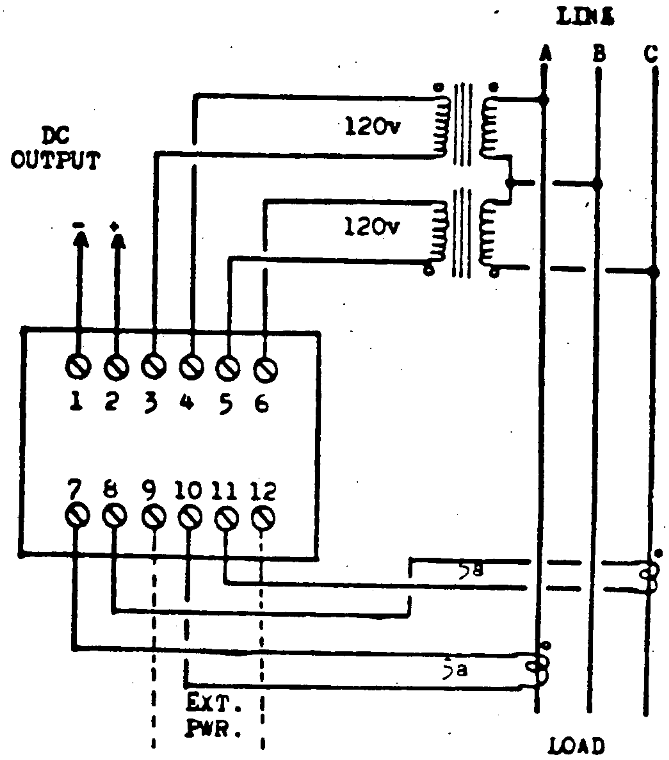

Connection diagram to a three phase three wire line using current and potential transformers.

Dimension A

20WS100	.... 3 1/4
20WS101	 4
20WS101 E	 4

Mounting holes (4).. 3/16 Dia.

Can is steel with integral mounting flanges.

Terminal screws are 8-32 binding head.

The external power for the amplifier for model 20WS101 E is connected to terminals 9 and 12. On the other models these terminals are unused.

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