Selection and Application Guidelines for Diesel, Gasoline, and Propane Fired Liquid Cooled Engine Pre-Heaters -SAE J1350 DEC81

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PREPRINT

SELECTION AND APPLICATION GUIDELINES FOR DIESEL, GASOLINE, AND PROPANE FIRED LIQUID COOLED ENGINE PRE-HEATERS—SAE J1350 DEC81

SAE Information Report

Report of the Off-Road Machinery Technical Committee, Subcommittee 15, approved December 1981. Rationale statement available.

1. Purpose—The purpose of this information report is to provide selection and application guidelines covering most liquid hydrocarbon fuel burning, engine pre-heating systems. Operating conditions and characteristics of the equipment will determine the design of any successful system, and since these characteristics and conditions vary greatly from one application to another, the application engineer must determine the goals he expects to reach under the conditions encountered. To determine the type and size of heaters will require adherence to several guidelines, some of which are outlined in the following paragraphs.

2. Scope—This information report covers fuel fired pre-heaters which burn gasoline, diesel, or propane fuels. This type of heater must be used in remote areas where 110/220 V, 60 Hz electric power is not available, and is recommended anywhere an on-board self contained system is required. The guidelines in this report are applicable, but not limited to, fuel burning heater installations on the off-road self-propelled work machines described in SAE Recommended Practice J1116.

3. Definitions

3.1 Pre-Heat System—A heating system designed to heat an engine from a cold soaked condition at a selected ambient temperature and wind velocity effect, to an acceptable start temperature.

3.2 Standby Heat System—A heating system designed to prevent engine heat from dropping below an acceptable start temperature. This heating system must also be designed for a selected ambient temperature and wind velocity effect.

4. Heater Types

4.1 Gasoline and Diesel Fired—A typical gasoline or diesel fuel fired heater consists of a burner unit, a combination combustion chamber and heat exchanger, a 12 or 24 V DC motor driven combustion air blower, and controls to regulate the temperature, meter the fuel, and start/stop the heater. A gasoline or diesel burning heater is usually selected to operate on the same fuel as the engine it is heating.

4.2 Propane Fired—A typical propane fuel fired heater consists of a burner nozzle, a tank or coil type heat exchanger, and controls to regulate the temperature, meter the fuel, start/stop the heater, and provide a shut-off in case of flame or burner failure. The burner may be lit manually or may be equipped with an electric igniter powered from the machine electrical system. A propane fired heater requires auxiliary equipment consisting of a propane tank (from 2.7–18 kg (6–40 lb)) capacity dependant on heater size), a pressure regulator, and connection tubing and hose. See Fig. 1 for typical configuration and size data.

4.3 Gravity Circulation Type—In the gravity circulation or thermosiphon system, the heater must be installed so that there is a rise upward from the heater to the engine block and a fall or downward slope in the connecting hose to the heater return. An automatic back flow shut-off to prevent by-passing coolant flow during normal engine operation should be installed between the engine and the heater. High/low temperature, fuel and oil resistant (silicone or equivalent) connecting hoses are recommended. See Fig. 2 for a typical propane fired heater installation and Fig. 3 for typical gasoline and diesel fired heater installation.

4.4 Forced Circulation Type—This system includes a coolant circulating pump which is usually installed in the coolant return hose line. The forced circulation system is required when locations available for the mounting of the heater will not permit the use of the gravity circulation system. An automatic back flow shut-off and high/low temperature fuel and oil resistant (silicone or equivalent) connecting hoses are recommended. See Fig. 4 for a typical forced circulation heater installation.

5. Selection Criteria

5.1 Heater Size—Gasoline and diesel fuel heaters are available in output capacities from approximately 3 kW (10 000 Btu/h) to 26.5 kW (90 000 Btu/h). Propane fired heaters are available in input capacities from 1 kW (3400 Btu/h) to 7.6 kW (26 000 Btu/h).

5.2 Selection—There are many variables such as lowest expected ambient temperature, wind velocity effect, time allowable for heating, etc. which must be considered by the application engineer when selecting a heater and designing a specific heating system. These factors are not considered within the scope of this report. However, two simple methods are recommended for the initial selection of heater size for the pre-heat and standby heat systems.

5.3 Pre-Heat System—The tables shown in Fig. 5 are recommended to determine the heater size required to heat a diesel engine from a cold soaked condition to a start condition in a specific time. The heat output requirements are based on the dry weight of the engine block and the approximate coolant temperature obtainable after 1 h of heating. Table 1 shows the requirements in SI units (W). Table 2 shows the requirements in BGS Inch/Pound units (Btu/h).

5.4 Standby Heat System—A fuel burning pre-heater may also be

HEIGHT (A)	9	10	15-1/2
DIAMETER (B)	2-1/2	4-1/2	6
BASE TO INLET (C)	2-3/4	2	2-3/4
BASE TO OUTLET (D)	7-1/2	8-1/2	13-1/2
MINIMUM CLEARANCE REQUIRED ABOVE (E)	7	12	20
HOSE SIZE, INLET/OUTLET	5/8	3/4	1
FEMALE NPT SIZE, INLET/ OUTLET	NONE	3/8	1/2
INPUT CAPACITY, BTU/HR	3600	6700	20600
PROPANE USAGE, OZ/HR	2.65	4.94	15.21
RECOMMENDED COOLANT CAPACITY U.S. GALLONS (SEE NOTE 1)	1-6	7-12	13-28
APPROX. HEAT TRANSFERRED TO 50 50 WATER/GLYCOL COOLANT BTU/HR (SEE NOTE 2)	2100	4300	13000

NOTE 1 – CONFIGURATION OF ENGINE, WIND PROTECTION, LOWEST AMBIENT, ETC., WILL AFFECT THESE DATA.

NOTE 2 – HOSE ROUTING, PLACEMENT OF HEATER, WIND CHILL, LOWEST AMBIENT, ETC., WILL AFFECT THESE DATA.

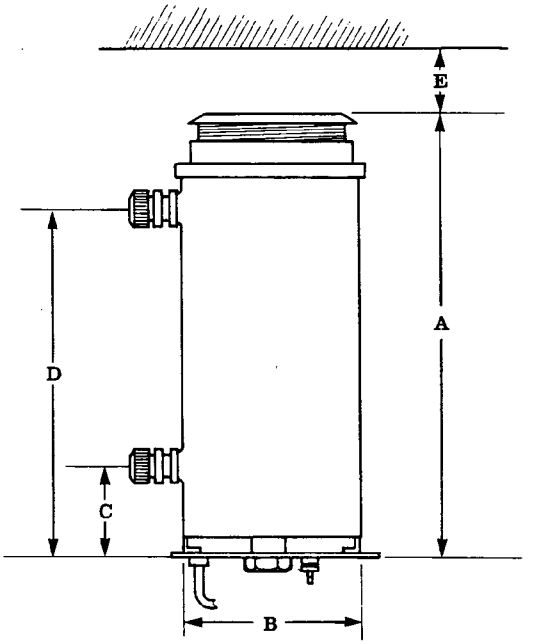

FIG. 1—TYPICAL PROPANE HEATER

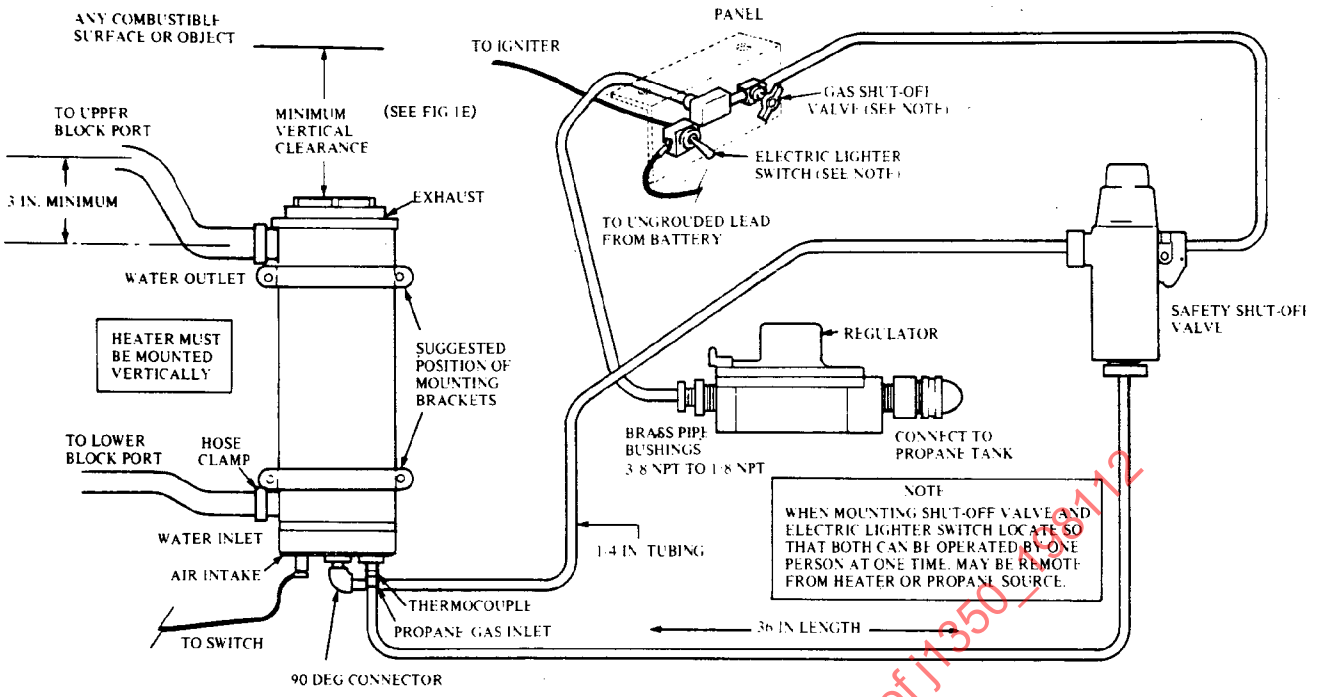

FIG. 2—TYPICAL PROPANE HEATER INSTALLATION

used to provide standby heat. The amount of heat output required to maintain the temperature of an already hot engine is much less than that required for pre-heat. However, when selecting a fuel burning heater for standby heat, the electrical consumption of motors and controls must be considered to ensure the battery capacity will be sufficient for the standby period. The following formula is based on engine displacement and an ambient air temperature of −30°C (−22°F).

SI Units

$$\text{Capacity in kW} = \frac{\text{Engine displacement in cubic centimetres}}{3412}$$

Sample Calculation—To maintain the heat in a 16 387 cm³ displacement engine requires $\frac{16\,387}{3412} = 4.8$ kW heater output.

BGS Inch/Pound Units

Capacity in Btu/h = Engine displacement in cubic inches × 16.5.

Sample Calculation—To maintain the heat in a 1000 in³ displacement engine requires 1000 × 16.5 = 16 500 Btu/h heater output.

6. Installation Guidelines

6.1 Heater Mounting—The heater should be mounted on the machine chassis preferably in the engine compartment as close to the engine

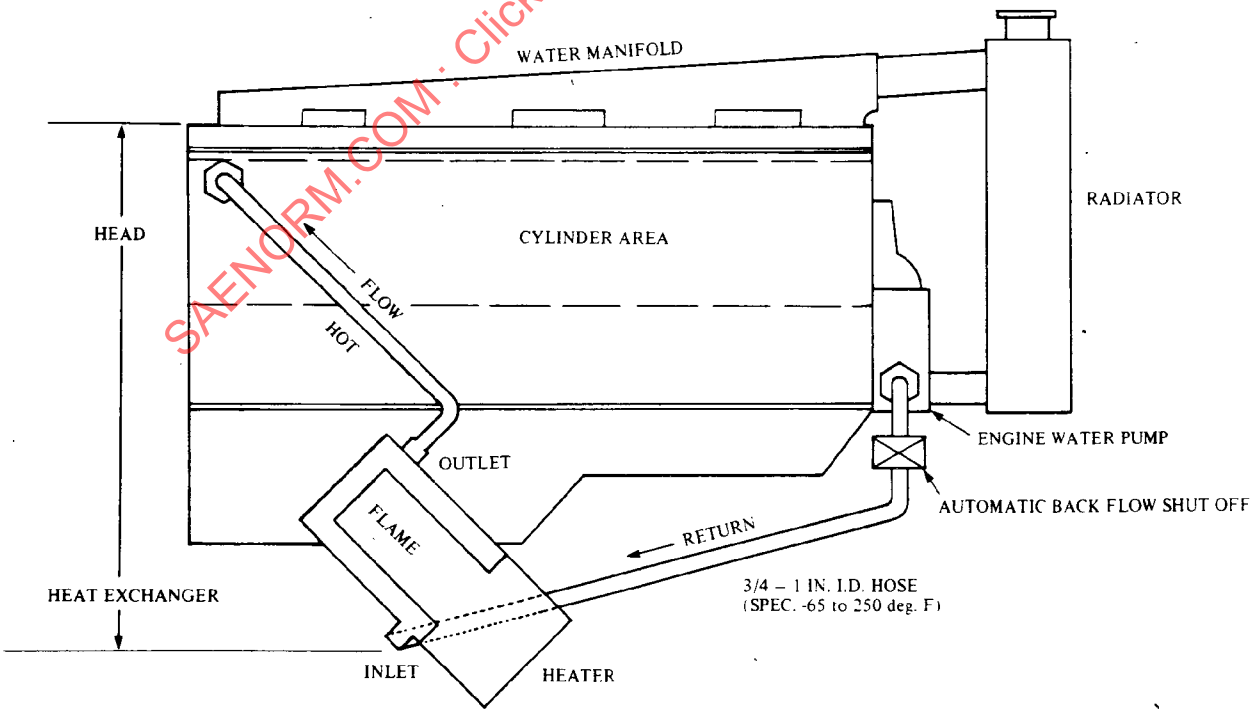

FIG. 3—TYPICAL THERMOSYPHON GASOLINE OR DIESEL HEATER INSTALLATION

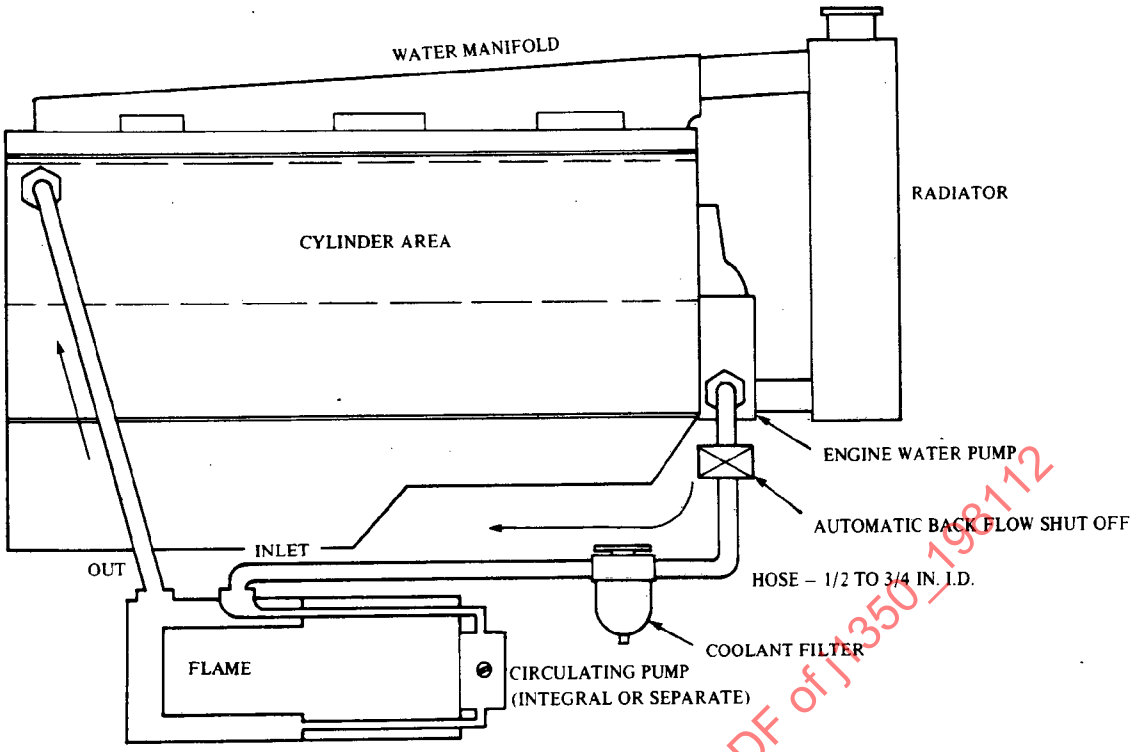

FIG. 4—TYPICAL FORCED CIRCULATION HEATER INSTALLATION

block as possible to prevent heat loss. To prevent vibration problems, the heater must not be mounted on the engine. If mounted outside the engine compartment, suitable protection must be provided from wind and blowing snow. The location selection must provide clearance to prevent combustion of adjacent materials and to provide sufficient air supply for efficient operation. The heater mounting system must be designed to isolate the heater from the vibration and shock inherent in off-road work machines, especially track mounted. On gravity circulation type heaters, the mounting location must be as low as possible relative to the engine block to provide proper coolant flow. The location of the connections into the engine block are critical. The engine manufacturer should be consulted regarding the coolant connecting points.

6.2 Fuel System—Gasoline and diesel fuel should be filtered to protect the heater fuel metering devices. When the heater system does not have a fuel filtering device, it is good practice to flush the line with filtered fuel before connecting it to the heater. Low temperature hose compatible with the fuel supply is recommended. Avoid all dips and loops which could cause water traps with consequent blockage due to freezing. On propane heater systems, the fuel tank should be mounted on the chassis away from the engine compartment in a well ventilated and protected location. Under extreme low ambient temperatures (below −30°C), it may be necessary to keep the propane tank in a warm storage area to ensure there is sufficient vapor pressure to fire the burner when the heater is required. Leaky fuel lines are a dangerous fire hazard. To minimize the danger, the fuel systems, especially gasoline and propane, must be inspected regularly.

6.3 Exhaust System—Connections between the heater and the exhaust line must be secure and have minimum leakage to protect operating, maintenance, and other personnel. Ensure that the exhaust line is isolated from combustible materials and that exposed lines which can be contacted by personnel while operating or maintaining the machine or heater system are adequately insulated. The exhaust discharge must be isolated from the cab air intake and heater air intake. The engine heater exhaust has been used to heat areas such as oil sumps, transmission housings, battery compartments, etc. This practice is not recommended because of the danger to operators from lethal gases, the corrosive effects of the exhaust residue, and the possibility of the moisture in the exhaust condensing, freezing, and blocking the exhaust line. However, if exhaust heating is used, corrosion resistant ducts and housings must be used and since combustion air blowers are not normally designed for the high pressures necessary for long exhaust lines, the heater manufacturer must be consulted for the design limits on the specific exhaust system.

6.4 Antifreeze—The engine cooling system should be filled with an antifreeze solution. Refer to SAE Information Report J814 and SAE Recommended Practice J1034 for information on the selection of antifreeze solutions and the water/antifreeze percentages required for specific ambient temperatures.

7. *Battery Heating*—The battery is adversely affected by cold. The en-

TABLE 1—ENGINE HEAT REQUIREMENTS IN WATTS FOR A GIVEN TEMPERATURE RISE—BASED ON DRY BLOCK WEIGHT

Engine Weight (kg)	Engine Coolant Temperature Rise (°C/h)		
	25°	50°	75°
50	100	200	300
100	200	400	600
150	300	600	900
200	400	800	1200
300	600	1200	1800
400	800	1600	2400
500	1000	2000	3000
750	1500	3000	4500
1000	2000	4000	6000
2000	4000	8000	12 000
2500	5000	10 000	15 000

TABLE 2—ENGINE HEAT REQUIREMENTS IN Btu/h FOR A GIVEN TEMPERATURE RISE—BASED ON DRY BLOCK WEIGHT

Engine Weight (lb)	Engine Coolant Temperature Rise (°F/h)		
	50°	100°	150°
100	420	680	1000
300	1260	2040	3000
500	2100	3500	5000
750	3150	5100	7500
1000	4200	6800	10 000
1500	6300	10 200	15 000
2000	8400	13 600	20 000
2500	10 500	17 000	25 000
3000	12 600	20 000	30 000
4000	16 800	27 000	40 000
5000	21 000	40 750	50 000

FIG. 5—ENGINE HEAT REQUIREMENT TABLES