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SURFACE VEHICLE RECOMMENDED PRACTICE

An American National Standard

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Application Testing of Oil-to-Air Oil Coolers for Heat Transfer Performance

1. ***Scope***—This SAE Recommended Practice is applicable to oil-to-air oil coolers installed on mobile or stationary equipment. Such oil coolers may be used for the purpose of cooling automatic transmission fluid, hydraulic system oil, retarder system fluid, etc. This document outlines the methods of procuring the test data to determine the operating characteristics of the oil cooling system and the interpretation of the results. For information regarding application testing of oil-to-water oil coolers for heat transfer performance, see SAE J2414.

1.1 **Purpose—**The purpose of this document is to provide a procedure for determining the cooling performance characteristics of an oil-to-air oil cooler under specified operating conditions.

2. References

2.1 **Applicable Publication—**The following publication forms a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

SAE J2414—Application Testing of Oil-to-Water Oil Coolers for Heat Transfer Performance

2.2 **Related Publications—**The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J631—Radiator Nomenclature
SAE J1004—Glossary of Engine Cooling System Terms
SAE J1244—Oil Cooler Nomenclature and Glossary
SAE J1994—Laboratory Testing of Vehicular and Industrial Heat Exchangers for Heat Transfer Performance

3. ***Objective (of the test)***—Typically one of the following: to verify compliance with established criteria, set new criteria, or guide a desired change of either the cooler or the system of which it is a part. Usually the criteria cover the mass flows of cooling air and oil, the temperature difference between them, the maximum allowable temperatures, and the system oil and air restrictions imposed by the heat exchanger.

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4. ***Facility Requirements***—The facility should provide the following features:

4.1 The facility must be capable of duplicating the most severe-duty cycles and operating conditions specified. It is seldom practical to duplicate the most severe operating conditions unless the use of a dynamometer and wind tunnel are available.

4.2 If cooling air is not controlled, the effects of wind direction and velocity must be considered when establishing vehicle orientation and interpretation of test results.

4.3 The accurate measurement of oil flow and oil pressures plus oil and air temperatures is essential to obtaining a good test result. Measurement devices should be calibrated before and after testing to assure accurate data measurement and repeatability.

4.4 Use of automatic data logging equipment is preferred as it minimizes human error in dealing with the number of points necessary to accumulate for a reliable data base and the establishment of a steady-state operating condition.

4.5 See Figure 1 for schematic of typical oil cooler system.

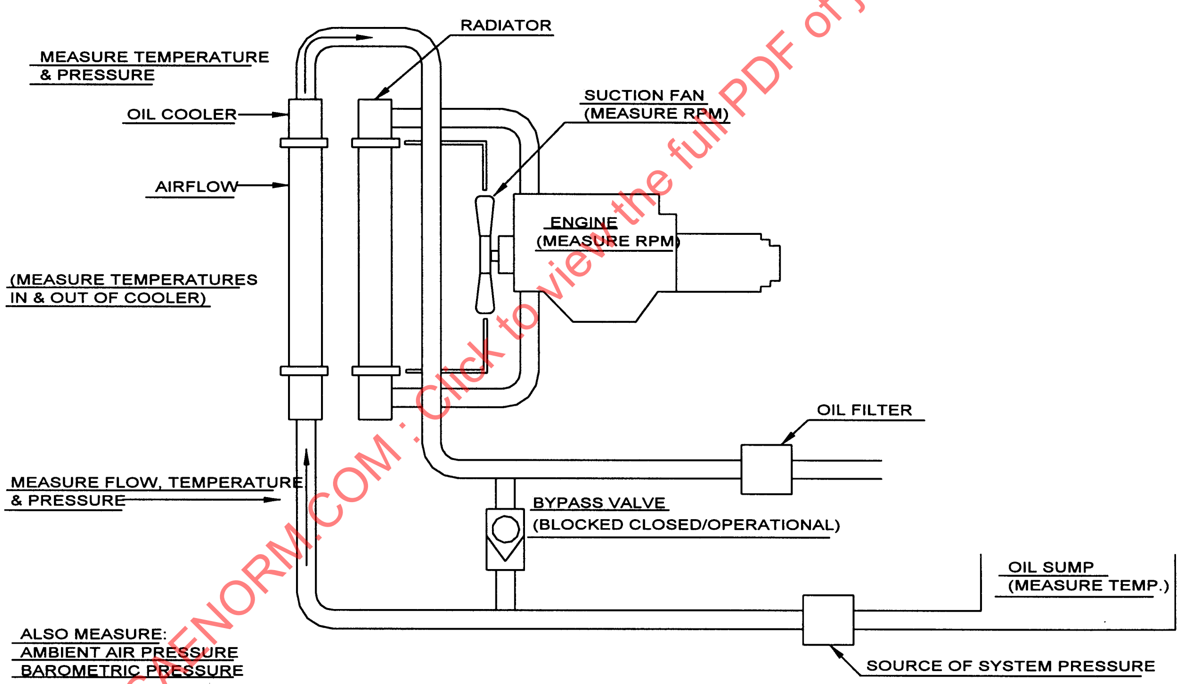

FIGURE 1—SCHEMATIC OF TYPICAL OIL COOLER SYSTEM AND TEST DATA REQUIRED

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5. ***Test Preparation***

5.1 For component testing, any air or oil system bypass should be blocked closed to insure full measured flow of the fluids through the heat exchanger. For system testing, the bypass should be left in the normal operating condition.

5.2 For component testing, the fan drive, if the unit is so equipped, should be fully engaged using the manufacturer's recommended procedure. For system testing, the drive should be left in the normal operating condition.

5.3 All shutters or other air directional control devices should be fixed for the test in the full open position.

5.4 All other heat-producing equipment that may adversely affect the air temperature to the oil cooler and fan should be operated during the test in a specified manner.

5.5 Instrumentation and data to be recorded includes the following:

5.5.1 Oil temperatures at designer-specified critical locations, for example, inlet to the cooler, reservoir, etc.

5.5.2 Oil temperature at oil cooler inlet (if not already specified in 5.5.1).

5.5.3 Oil temperature at oil cooler outlet (if not already specified in 5.5.1).

5.5.4 Average air temperature at oil cooler air inlet (multipoint grid normally required).

5.5.5 Average air temperature at oil cooler air outlet (multipoint grid normally required).

5.5.6 Oil flow (net through the cooler).

NOTE—Pressure drop across flow meter should be kept to a minimum. If extensive plumbing is required to incorporate flow meter, lines to and from meter should be insulated.

5.5.7 Barometric pressure at test site.

5.5.8 Test fluid shall be as specified.

5.5.9 Operating pressure at oil cooler inlet.

5.5.10 Operating pressure at oil cooler outlet.

NOTE—Pressure measurement devices should be installed to eliminate any possible source of error due to turbulence at the point of measurement. Direct massflow measurements are preferred. For structural information, these devices should be capable of measuring millisecond pressure spikes.

5.5.11 Engine or motor operating speeds.

5.5.12 Ambient air temperature.

5.5.13 Actual fan speed and/or vehicle velocity.

5.6 Verify that the oil cooler is mounted in its designated location with proper inlet and outlet connections.

6. Procedure

6.1 Operate test unit in its specified and verified work cycle until practical stabilized thermal conditions have been achieved.

6.2 Collect data for a total of 10 complete work cycles, or for a time span of no less than 10 min.

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7. *Test Data Evaluation*

7.1 Calculate oil cooler heat rejection from the test data.

7.1.1 Oil flow rate.

7.1.2 Oil cooler inlet temperature.

7.1.3 Oil cooler outlet temperature.

7.1.4 Obtain manufacturer's specific heat and density of oil to establish oil thermal characteristics at average oil temperature.

7.1.4.1 Oil cooler heat rejection (kW) = specific heat of oil (kJ/kg · °C) x oil density (kg/L) x oil flow (L/s) x oil cooler inlet to outlet temperature differential (°C).

7.1.4.2 Oil cooler heat rejection (BTU/min) = oil specific heat (BTU/lb/°F) x oil density (lb/gal) x oil flow (gal/min) x oil cooler inlet to outlet temperature differential (°F).

7.2 Determine oil stabilization temperature above ambient at the critical location.

7.2.1 Oil stabilization temperature above ambient = oil temperature measured at critical location minus ambient air temperature.

7.3 Compare oil stabilization temperature above ambient with the specification.

7.4 Analyze the test data. Unsatisfactory results could be due to one or more of the following.

7.4.1 Other than expected oil cooler heat load. (Is the oil system rejecting more or less heat than the cooler was designed for?)

7.4.2 Oil cooler heat rejection performance is not to the manufacturer's specifications.

7.4.3 Other than expected oil flow through the cooler. (Does the measured oil flow match the design value?)

7.4.4 Other than expected airflow through the oil cooler. (Does the measured air temperature difference across the oil cooler core indicate other than expected air flow?) Estimate oil cooler airflow by performing the following calculation:

7.4.4.1 *Air flow*—See Equation 1.

$$\frac{\text{kg}}{\text{s}} = \frac{\text{oil cooler power (kW) (from 7.1.4.1)}}{1.005 \times \text{oil cooler air } \Delta T(^\circ C)} \qquad \text{(Eq. 1)}$$

7.4.4.2 *Air flow*—See Equation 2.

$$\frac{\text{lb}}{\text{min}} = \frac{\text{oil cooler BTU/min (from 7.1.4.2)}}{0.240 \times \text{oil cooler air } \Delta T(^\circ F)} \qquad \text{(Eq. 2)}$$

(Is the oil cooler core too restrictive to airflow? Is air flowing around the cooler rather than through it?)

7.4.5 Poor airflow distribution across the oil cooler core. (Are upstream or downstream obstructions causing poor airflow through portions of the oil cooler core?) Detect by performing anemometer survey or similar technique.

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