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**Application Testing
of Oil to Air Oil
Coolers for Cooling
Performance**

SAE Recommended Practice
Issued November 1985

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Submitted for Recognition as
an American National Standard

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RATIONALE:

Not applicable.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

Not applicable.

APPLICATION:

The purpose of this Recommended Practice is to provide a procedure for determining the cooling performance characteristics of an oil to air oil cooler under specified operating conditions.

This Recommended Practice is applicable to oil to air coolers installed on mobile or stationary equipment. This document outlines the method of procuring the test data to determine operating characteristics of the oil cooling system and the interpretation of the test results.

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**APPLICATION TESTING OF OIL TO AIR OIL
COOLERS FOR COOLING PERFORMANCE**

1. **PURPOSE:** The purpose of this Recommended Practice is to provide a procedure for determining the cooling performance characteristics of an oil to air oil cooler under specified operating conditions.
2. **SCOPE:** This Recommended Practice is applicable to oil to air oil coolers installed on mobile or stationary equipment. This document outlines the method of procuring the test data to determine operating characteristics of the oil cooling system and the interpretation of the test results.
3. **OBJECTIVE:** The objective is to verify compliance with established criteria. Usually the criteria covers 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.
4. **FACILITY REQUIREMENTS:** The facility should provide the following features:
 - 4.1 The facility must effectively duplicate 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.
 - 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.

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4.5 See Fig. 1 for schematic of typical oil cooling system.

5. TEST PREPARATION:

5.1 Any air or oil system bypass should be blocked closed to insure full flow of the fluids through the heat exchanger.

5.2 The fan drive, if the unit is so equipped, should be fully engaged during the test using the manufacturer's recommended procedure.

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 normal 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 one of the above).

5.5.3 Oil temperature at oil cooler outlet (if not one of the above).

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.

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 capable of recording millisecond pressure spikes and be installed to eliminate all turbulence possible at the point of measurement.

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 thermal stabilized 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.

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.

7.1.4.1 $\text{Power (kw)} = 1.02 \times \text{specific heat of oil (kJ/kg}\cdot\text{K)} \times \text{oil density (kg/dm}^3\text{)} \times \text{oil flow (dm}^3\text{/s)} \times \text{oil cooler inlet to outlet temperature differential (K)}.$

7.1.4.2 $\text{BTU/min} = \text{oil specific heat (BTU/lb}\cdot\text{°F)} \times \text{oil density (lb/ga)} \times \text{oil flow (ga/min)} \times \text{oil cooler inlet to outlet temperature differential (°F)}.$

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. (Is the oil cooler performing as the manufacturer specified?)

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 $\frac{\text{kg}}{\text{s}} = \frac{\text{oil cooler power (KW) (from paragraph 7.1.4.1)}}{1.02 \times \text{oil cooler air } \Delta T \text{ (K)}}$

7.4.4.2 Air flow $\frac{\text{lbs}}{\text{min}} = \frac{\text{oil cooler BTU/min (from paragraph 7.1.4.2)}}{0.240 \times \text{oil cooler air } \Delta T \text{ (°F)}}$

(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.

7.4.6 Preheating of air into the oil cooler. (Is ambient air being inordinately heated before entering the oil cooler core? Is hot air discharge recirculating into the oil cooler air inlet?)

7.4.7 Other than expected oil pressure differential between oil cooler inlet and outlet. (Is oil cooler pressure drop compatible with the system design? Is excessive pressure causing pumps to create more heat, oil flow to dump over relief valve, etc.?)

7.4.8 Temperature gradient or difference between critical oil temperature and temperature of oil into the cooler. (Are improvements required in system design? Is more oil flow required in a part of the system? Is one part of the system overheating because the hottest oil is not being circulated directly to the oil cooler?)

7.4.9 Ambient temperature too low. If the test was run substantially below the specified ambient temperature, the oil stabilization temperature above ambient may be significantly different than if the test were run at a higher ambient temperature.