SAE International™ SURFACE VEHICLE STANDARD

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

1. Scope

This SAE Recommended Practice is applicable to oil-to-water 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-air oil coolers for heat transfer performance, see SAE J1468.

1.1 Purpose

The purpose of this document is to provide a procedure for determining the heat transfer performance characteristics of an oil-to-water oil cooler under specified application operating conditions.

1.2 Rationale

To provide updated language for clarity and to include the latest technology and manufacturing methods.

2. References

2.1 Applicable Publications

The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 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 J1468—Application Testing of Oil-to-Air Oil Coolers for Heat Transfer Performance
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 water and oil, the temperature difference between them, the maximum allowable temperatures, and the system oil and water restrictions imposed by the heat exchanger.

4. *Facility Requirements*

The test facility should provide the following features:

4.1 The facility must be capable of duplicating the most severe duty cycles and operating conditions specified. The best simulation of actual operating conditions is usually obtained by operating the application equipment (such as a portable engine-driven compressor or generator set) in a test cell or, in the case of a vehicle, running the vehicle in a dynamometer facility with ambient controlled wind tunnel. However, testing of an oil cooler mounted in a radiator outlet tank under these conditions can only provide limited results because of the difficulty, if not the impossibility, of determining the temperature of the inlet cooling water to the oil cooler. In spite of this, such testing can be used to determine the heat load transferred by the oil cooler and the value of the stabilized maximum oil temperature under operating conditions.

Fortunately, oil-to-water oil coolers do lend themselves well to testing in a test apparatus which reproduces actual operating inlet fluid temperatures. Using such an apparatus, the inlet cooling water temperature may be determined, along with other temperature values. Provided that the in-tank oil cooler is mounted in the radiator, or in an outlet tank with the baffling which will be used in service, the test can be considered a true application test of the in-tank oil cooler, as opposed to a laboratory test in which the oil cooler might be mounted in some standardized tank or fixture.

4.2 The accurate measurement of oil flow and oil pressures plus oil and water temperatures is essential to obtaining a good test result. Due to the differences in heat capacity and flow rate between the oil and water, the oil side temperature difference is generally considerably higher than the coolant. If a very low coolant side temperature differential exists at specified test conditions it will be difficult to measure the coolant side temperatures with enough accuracy to calculate a heat rate on this side to cross check against the oil side heat rate. Measurement devices should be calibrated before and after testing to assure accurate data measurement and repeatability.

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

4.4 See Figure 1 for an example of the installation of an oil-to-water oil cooler in the bottom tank of a downflow radiator. Such oil coolers may be of the concentric tube type or multiple plate type in automobile and light truck radiators but may also be of the multiple plate type or the tube bundle type in heavier duty radiators, which may be of bolt-up construction (see Figure 2). Modern radiator construction, which typically utilizes a plastic tank mechanically crimped to an aluminum header, limits the number of plates which may be packaged in the tank. These applications may utilize the tank cooler (whether side or bottom tank) in series with an auxilliary cooler to achieve the required capacity. If a bottom tank oil cooler is used in a heavy-duty application, the radiator bottom tank is usually baffled to direct the cooling water flow to the oil cooler in the most advantageous manner. Very heavy-duty applications such as mining trucks, usually use remote mounted oil coolers (4.8).

4.5 See Figure 3 for an example of the installation of an oil-to-water oil cooler in the outlet tank of a crossflow radiator. Such oil coolers are usually of the concentric tube type in automobile and light truck radiators but may also be of the multiple plate type or the tube bundle type in heavier duty radiators, which may be of bolt-up construction (see Figure 2). If an in-tank oil cooler is used in heavy-duty applications, the radiator tank is usually baffled to direct the cooling water flow to the oil cooler in the most advantageous manner.

4.6 See Figure 4 for a schematic of a typical oil-to-water oil cooler system where the oil cooler is incorporated into the radiator bottom or outlet tank. The test data required are noted on this schematic.

4.7 See Figure 5 for a schematic of a test apparatus for testing of radiator tank-mounted oil-to-water oil coolers.

4.8 See Figure 6C for examples of remote mounted oil-to-water oil coolers. Such oil coolers may be of a typical shell-and-tube type construction (see Figure 6A), or of a speciality construction designed for surface mounting to a fluid manifold such as on a transmission (see Figure 6B), or in conjunction with an oil filter (see Figure 6C).

4.9 See Figure 7 for a schematic of a typical remote mounted oil cooler system. The test data required are noted on this schematic. See SAE J1994 for information regarding testing of such oil coolers using laboratory apparatus.

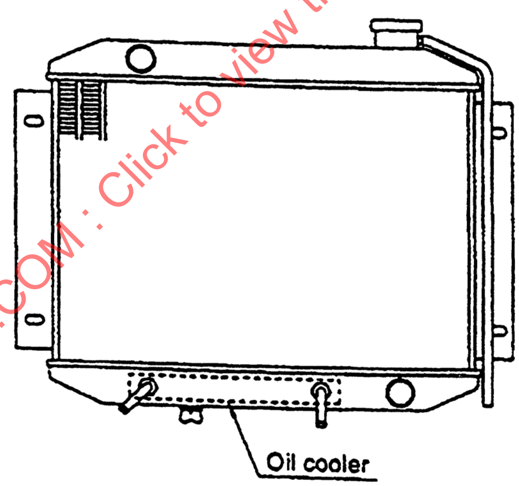

FIGURE 1—EXAMPLE OF OIL COOLER INSTALLATION
(DOWNFLOW TYPE RADIATOR)

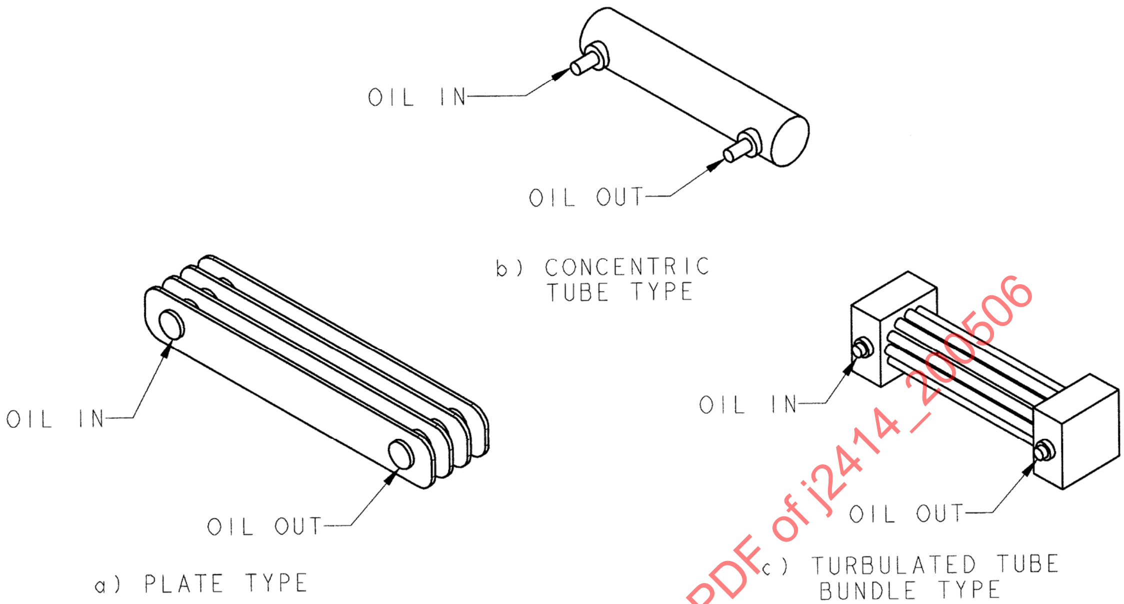

FIGURE 2—OIL COOLERS FOR MOUNTING IN RADIATOR OUTLET OR BOTTOM TANKS

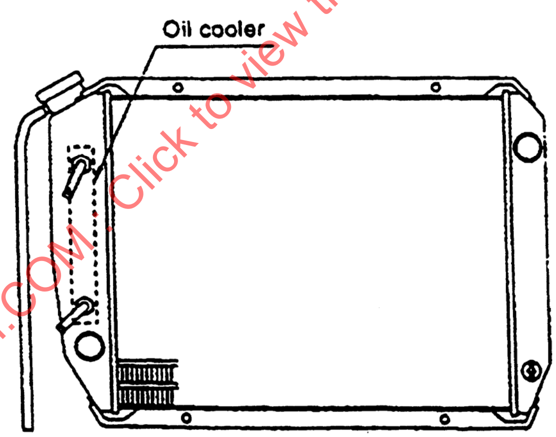

FIGURE 3—EXAMPLE OF OIL COOLER INSTALLATION
(CROSSFLOW TYPE RADIATOR)

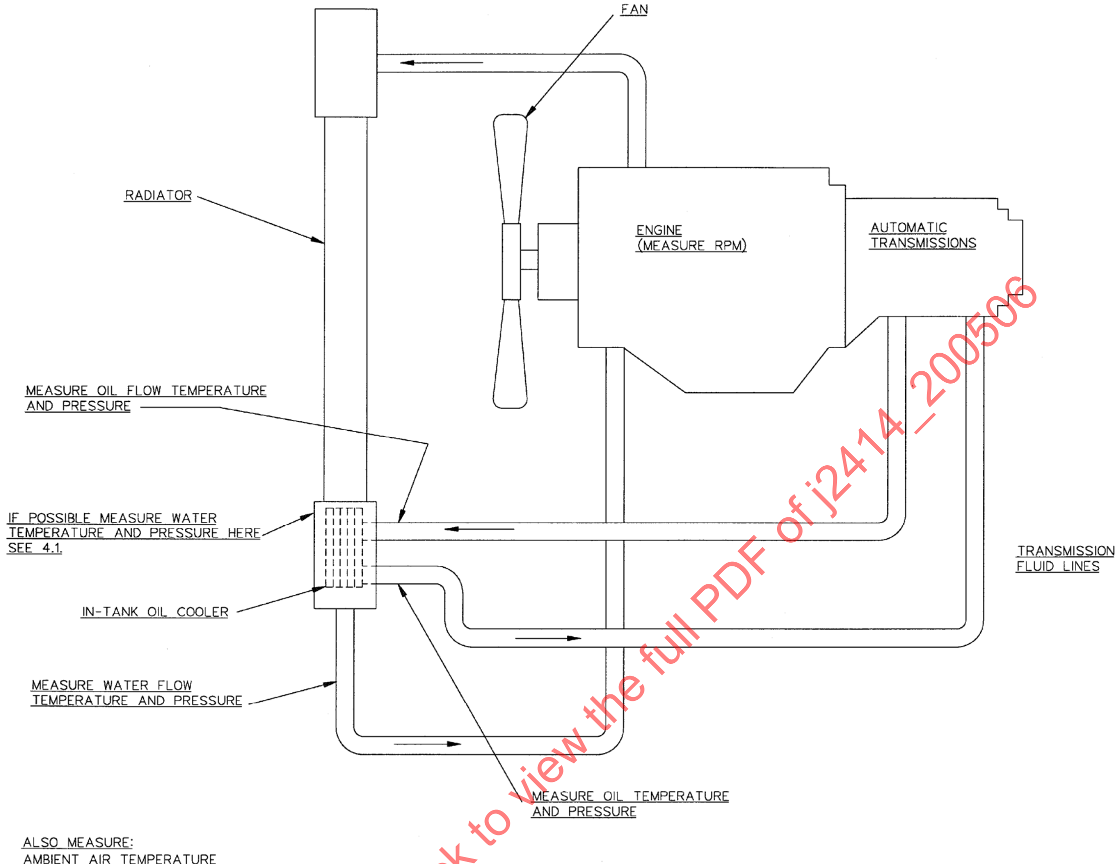

FIGURE 4—SCHEMATIC OF TYPICAL OIL COOLER SYSTEM WITH OIL COOLER INSTALLED IN BOTTOM OR OUTLET TANK OF RADIATOR

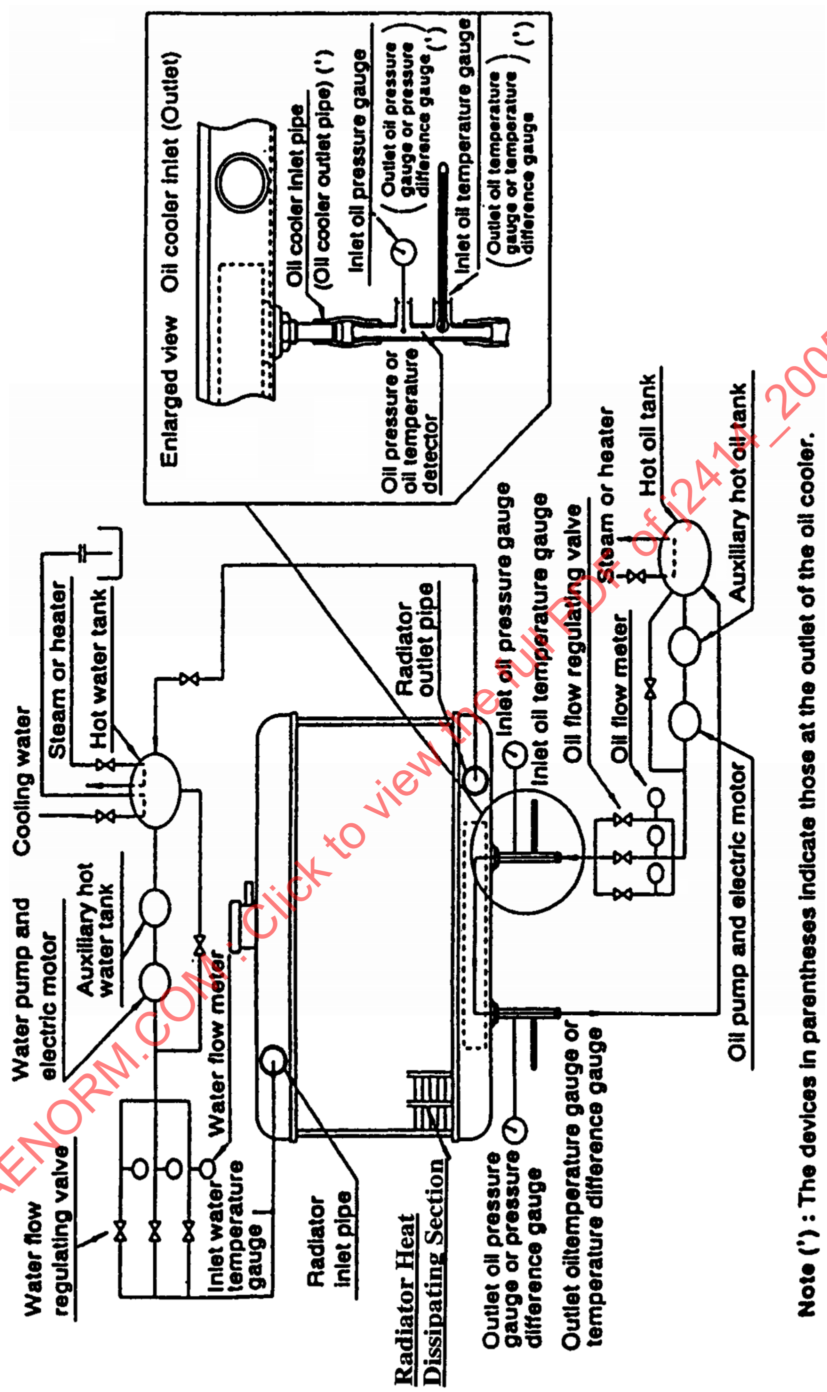

FIGURE 5—SCHEMATIC OF TEST APPARATUS FOR APPLICATION TESTING OF OIL COOLERS INSTALLED IN RADIATOR BOTTOM OR OUTLET TANKS. THIS APPARATUS MAY ALSO BE USED TO TEST AN OIL COOLER MOUNTED IN THE APPLICATION RADIATOR BOTTOM TANK, WITH SUITABLE INLET WATER MANIFOLD OR FIXTURE, WITHOUT THE BALANCE OF THE RADIATOR ASSEMBLY.

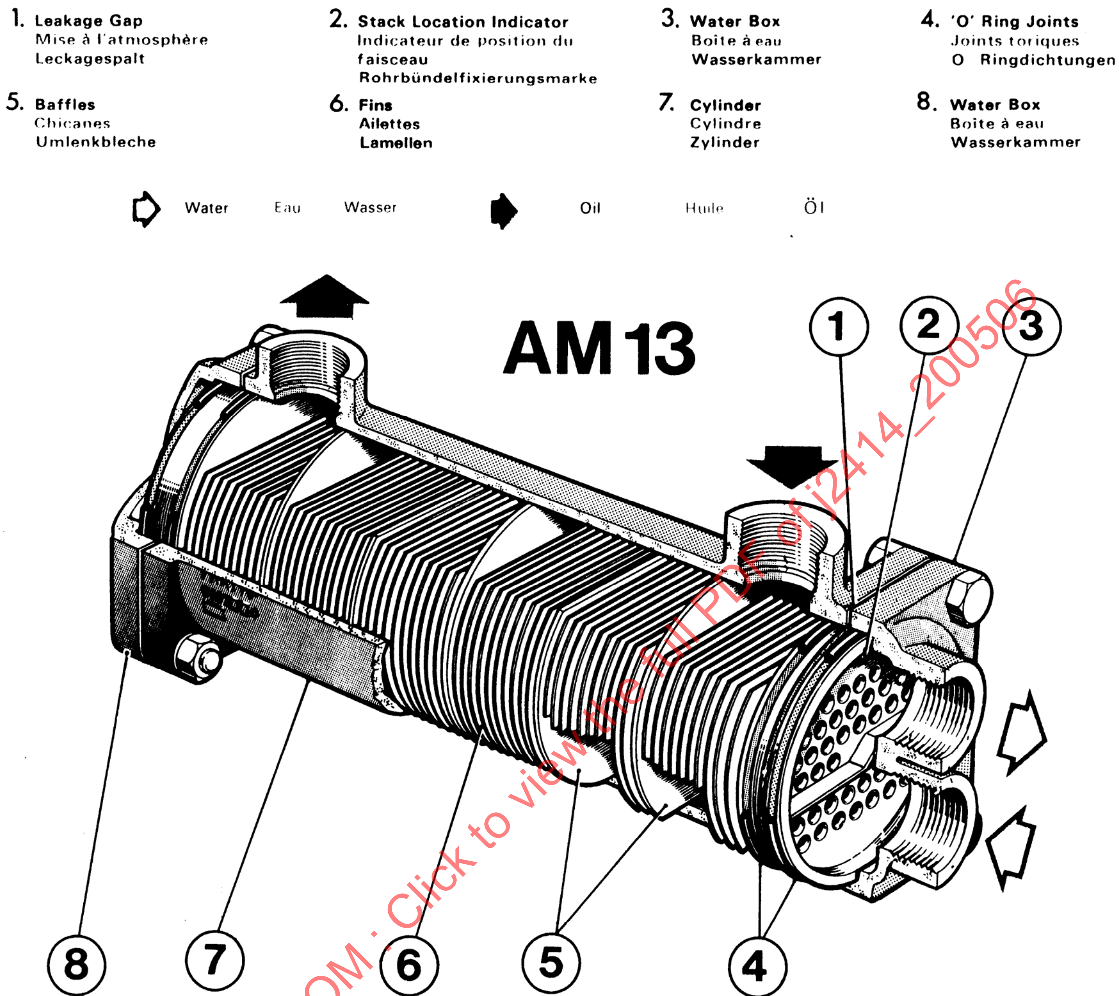

FIGURE 6A—OIL COOLER TEST APPARATUS – TANK MOUNTED

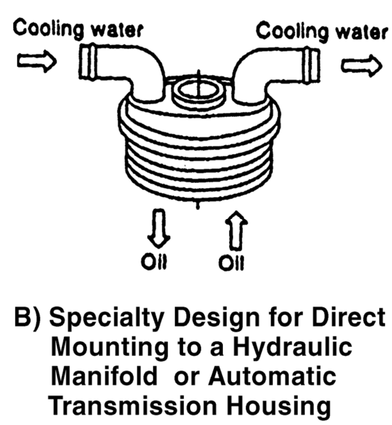

FIGURE 6B—TUBE-IN-SHELL DIRECT MOUNT OIL COOLER

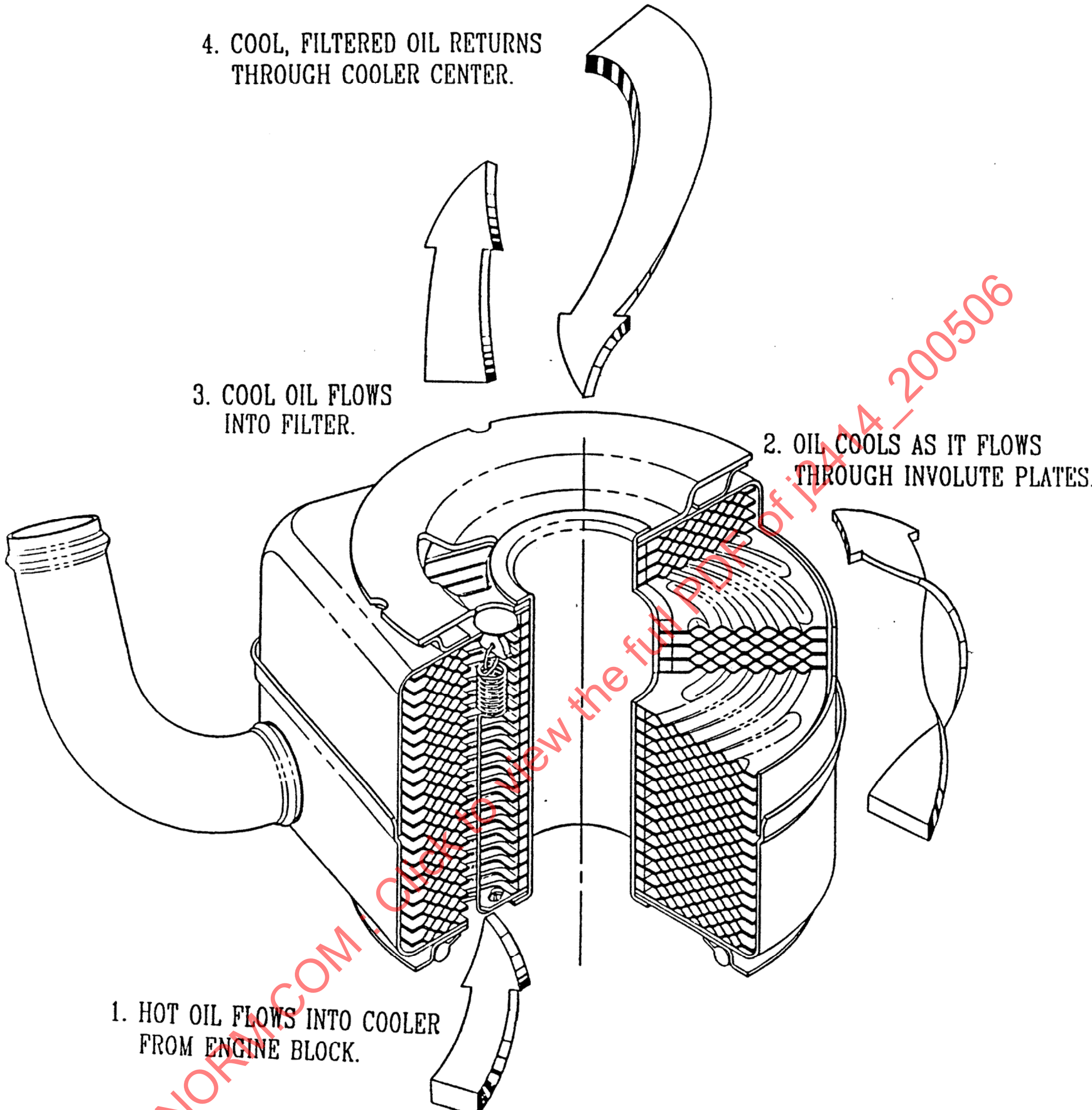

FIGURE 6C—EXAMPLES OF TYPICAL REMOTE-MOUNTED OIL COOLERS

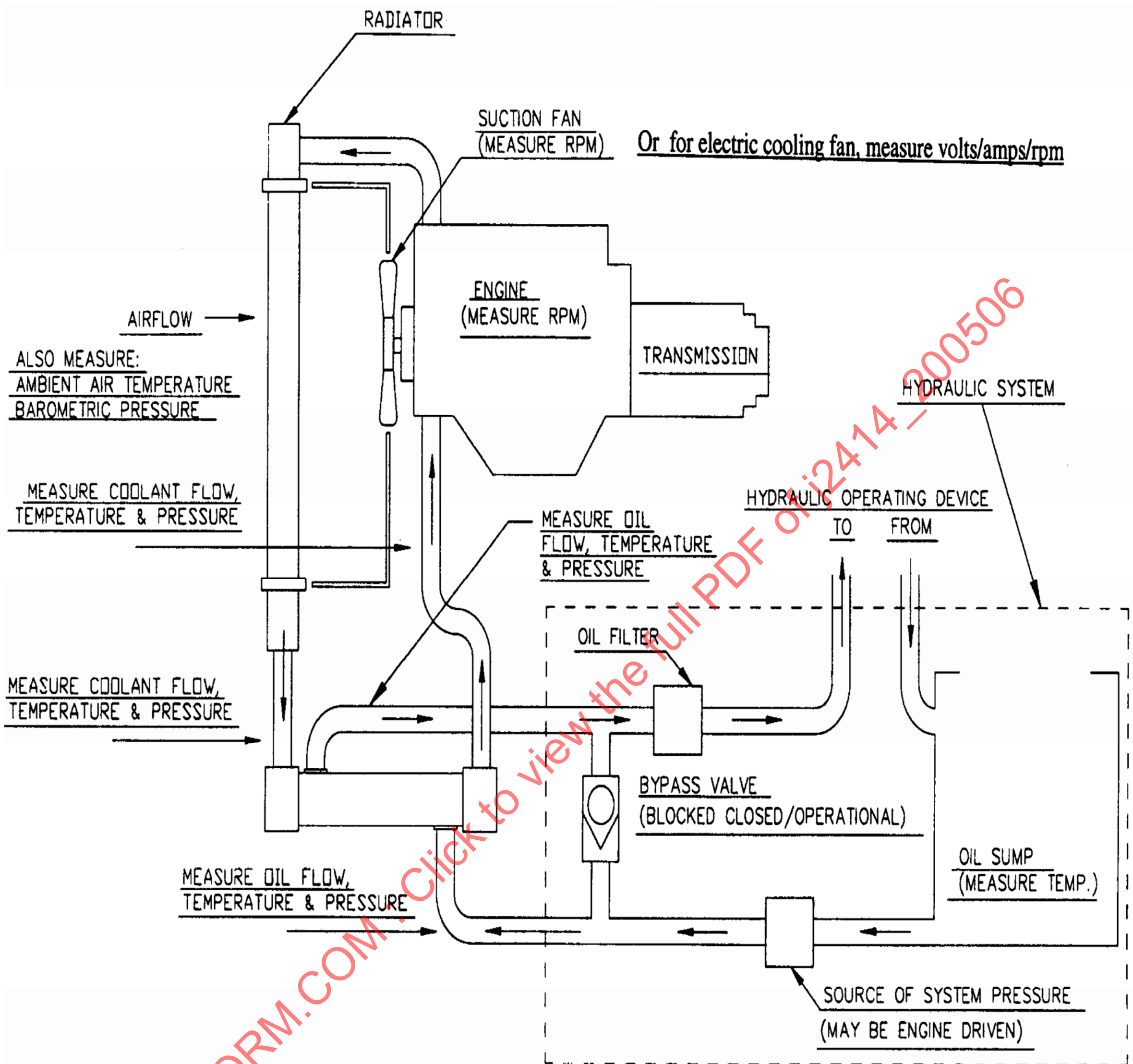

FIGURE 7—SCHEMATIC OF TYPICAL REMOTE-MOUNTED OIL COOLER SYSTEM

5. Test Preparation

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

5.2 For component oil cooler testing in a system application, the fan drive, if the system 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 For component oil cooler testing in a system application, all shutters or other directional air control devices should be fixed in the full open position. For system testing, the devices should be left in the normal operating conditions.

5.4 Instrumentation and data to be recorded includes the following:

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

5.4.2 Oil temperature at oil cooler inlet (if not already specified in 5.4.1).

5.4.3 Oil temperature at oil cooler outlet (if not already specified in 5.4.1).

5.4.4 Water temperature at oil cooler water inlet. For component oil cooler testing of an in-tank oil cooler in a system application, this temperature will be difficult, if not impossible to measure. For testing in a test apparatus of an oil cooler mounted in a complete radiator in the outlet tank of that radiator, the temperature of the water at the inlet to the radiator may be used as the temperature of the water at the inlet to the oil cooler provided that the lines between the point at which the inlet cooling water temperature and the point at which the outlet cooling water temperature is measured are well insulated, and the radiator core itself is well insulated. For testing in a test apparatus of an in-tank oil cooler mounted in the application tank, but without the rest of the radiator assembly, the inlet water temperature may be measured directly. It is important to note that when the radiator core is insulated, the typical drop in temperature through the radiator core will not occur. It will be necessary to obtain the actual performance of the radiator core and expected coolant temperature delivered to the oil cooler in order to evaluate the oil coolers ability to meet the specifications at the most severe-duty cycle.

5.4.5 Water temperature at the oil cooler water outlet.

5.4.6 Oil flow through the oil cooler.

NOTE—The pressure drop across any flow meter must be minimized. If extensive plumbing is required to incorporate a flow meter, the lines to and from the flow meter must be insulated.

5.4.7 Operating pressure at the oil cooler oil inlet.

5.4.8 Operating pressure at the oil cooler oil outlet.

5.4.9 Operating pressure at the oil cooler water inlet.