SAE International™ SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) Oil Cooler Application Testing and Nomenclature

RATIONALE

This document has been expanded to include information previously published in SAE J1244, "Oil Cooler Nomenclature and Glossary" and SAE J2414, "Application Testing of Oil-to-Water Oil Coolers for Heat Transfer Performance". This brings all of the SAE Oil Cooler Recommended Practices into one document.

Technical content previously published in SAE J1468 APR2006 is in Sections 3, 4, 5, 6, and 7.

Technical content previously published in SAE J2414 JUN2005 is in Sections 8, 9, 10, 11, and 12.

Technical content previously published in SAE J1244 FEB2008 is in Section 13.

1. SCOPE

This SAE Recommended Practice is applicable to oil-to-air and oil-to-water oil coolers installed on mobile or stationary equipment and provides a glossary of oil cooler nomenclature. 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.

1.1 Purpose

The purpose of this document is to provide a procedure for determining the cooling performance characteristics of oil-to-air and oil-to-water oil coolers under specified operating conditions.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J631 Radiator Nomenclature

SAE J1004 Glossary of Engine Cooling System Terms

SAE J1994 Laboratory Testing of Vehicle and Industrial Heat Exchangers for Heat Transfer and Pressure Drop Performance

3. OBJECTIVE OF OIL-TO-AIR PERFORMANCE 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.

4. FACILITY REQUIREMENTS FOR OIL-TO-AIR PERFORMANCE TEST

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.

5. TEST PREPARATION FOR OIL-TO-AIR PERFORMANCE TEST

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.

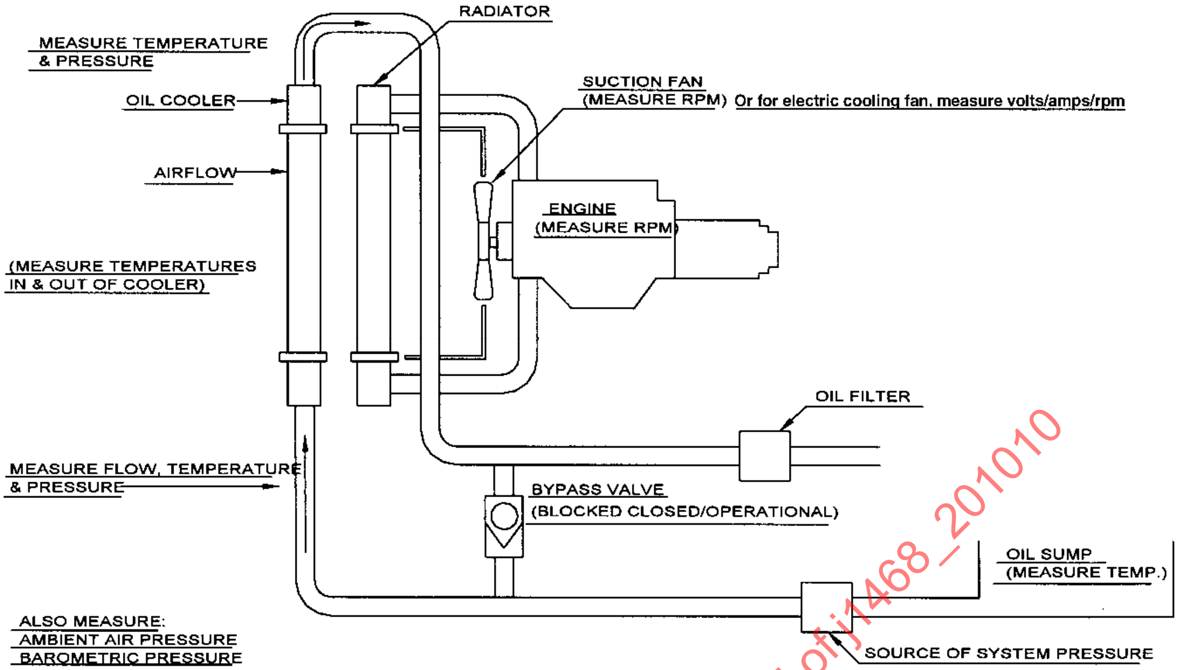

FIGURE 1 - SCHEMATIC OF TYPICAL OIL COOLER SYSTEM AND TEST DATA REQUIRED

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 mass flow measurements are preferred, but equipment to measure mass flow is expensive. Volumetric flow is often measured instead and then converted to mass flow using the fluid density. 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.

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

6. PROCEDURE FOR OIL-TO-AIR PERFORMANCE TEST

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.

7. TEST DATA EVALUATION FOR OIL-TO-AIR PERFORMANCE TEST

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). Oil cooler heat rejection is also known as oil cooler power.

7.1.4.2 Oil cooler heat rejection (BTU/min) = oil specific heat (BTU/(lb_m)(°F) x oil density (lb_m/gal) x oil flow (gal/ min) x oil cooler inlet to outlet temperature differential (°F). Oil cooler heat rejection is also known as oil cooler power.

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 or airflow through the cooler:

7.4.3.1 Does the measured oil flow match the design value?

7.4.3.2 Does the measured air temperature difference across the oil cooler core indicate other than expected air flow?

7.4.3.3 Is the oil cooler core too restrictive to airflow?

7.4.3.4 Is air flowing around the cooler rather than through it?

7.4.4 Estimate oil cooler airflow by performing the following calculation:

7.4.4.1 Air Flow

See Equation 1.

$$\frac{kg}{s} = \frac{\text{oil cooler power (kW)(from 7.1.4.1)}}{1.005 \text{ x oil cooler air } \Delta T(°C)} \quad \text{(Eq. 1)}$$

NOTE: 1.005 is a typcial specific heat value. If more precise information is available for the application in question it can be used. Oil cooler power is another expression for oil cooler heat rejection.

7.4.4.2 Air Flow

See Equation 2.

$$\frac{lb}{min} = \frac{\text{oil cooler BTU / min (from 7.1.4.2)}}{0.240 \text{ x oil cooler air } \Delta T(°F)} \quad \text{(Eq. 2)}$$

NOTE: 0.240 is a typical specific heat value. If more precies information is available for the application in question it can be used. Oil cooler BTU/min is another expression for oil cooler heat rejection

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 or too high. If the test was run substantially below or above the specified ambient temperature, the oil stabilization temperature above ambient may be significantly different than if the test were run at the specified ambient temperature.

7.4.10 When feasible, virtual testing using CFD (Computational Fluid Dynamics) analysis should be performed to get insight into the details of the flow and thermal environment in the oil cooler system. Such analysis can help in identifying the important parameters to look for in a particular test setup and also in evaluating the test data.

8. OBJECTIVE OF OIL-TO-WATER PERFORMANCE 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.

9. FACILITY REQUIREMENTS FOR OIL-TO-WATER PERFORMANCE TEST

The test facility should provide the following features:

9.1 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.

9.2 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.

9.3 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.

9.4 See Figure 2 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 3). 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.

9.5 See Figure 4 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 3). 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.

9.6 See Figure 5 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.

9.7 See Figure 6 for a schematic of a test apparatus for testing of radiator tank-mounted oil-to-water oil coolers.

9.8 See Figure 9 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 7), or of a speciality construction designed for surface mounting to a fluid manifold such as on a transmission (see Figure 8), or in conjunction with an oil filter (see Figure 9).

9.9 See Figure 10 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.

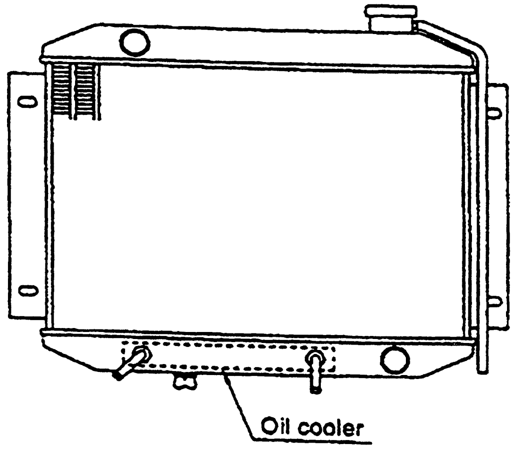

FIGURE 2 - EXAMPLE OF OIL COOLER INSTALLATION
(DOWNFLOW TYPE RADIATOR)

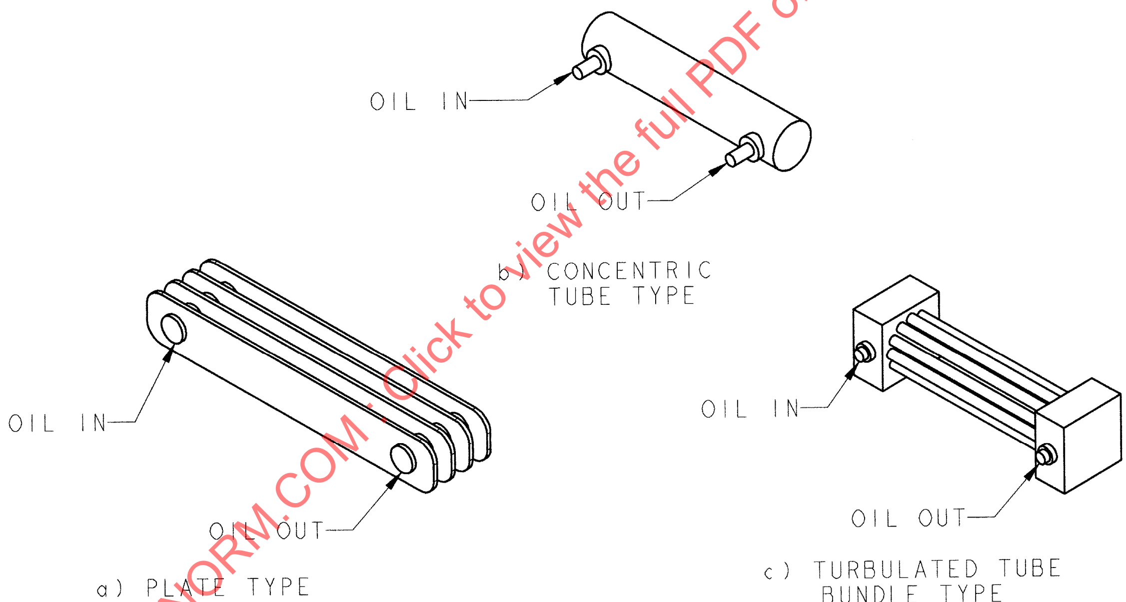

FIGURE 3 - OIL COOLERS FOR MOUNTING IN RADIATOR OUTLET OR BOTTOM TANKS

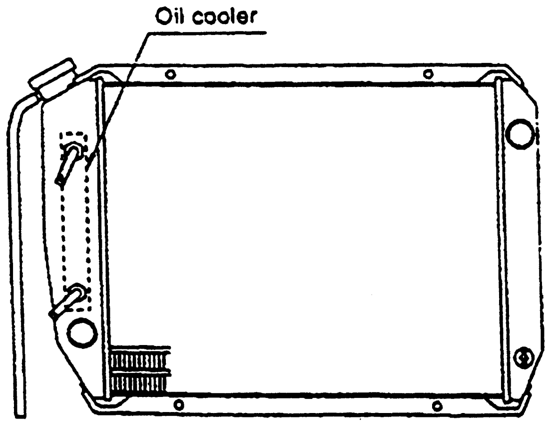

FIGURE 4 - EXAMPLE OF OIL COOLER INSTALLATION
(CROSSFLOW TYPE RADIATOR)

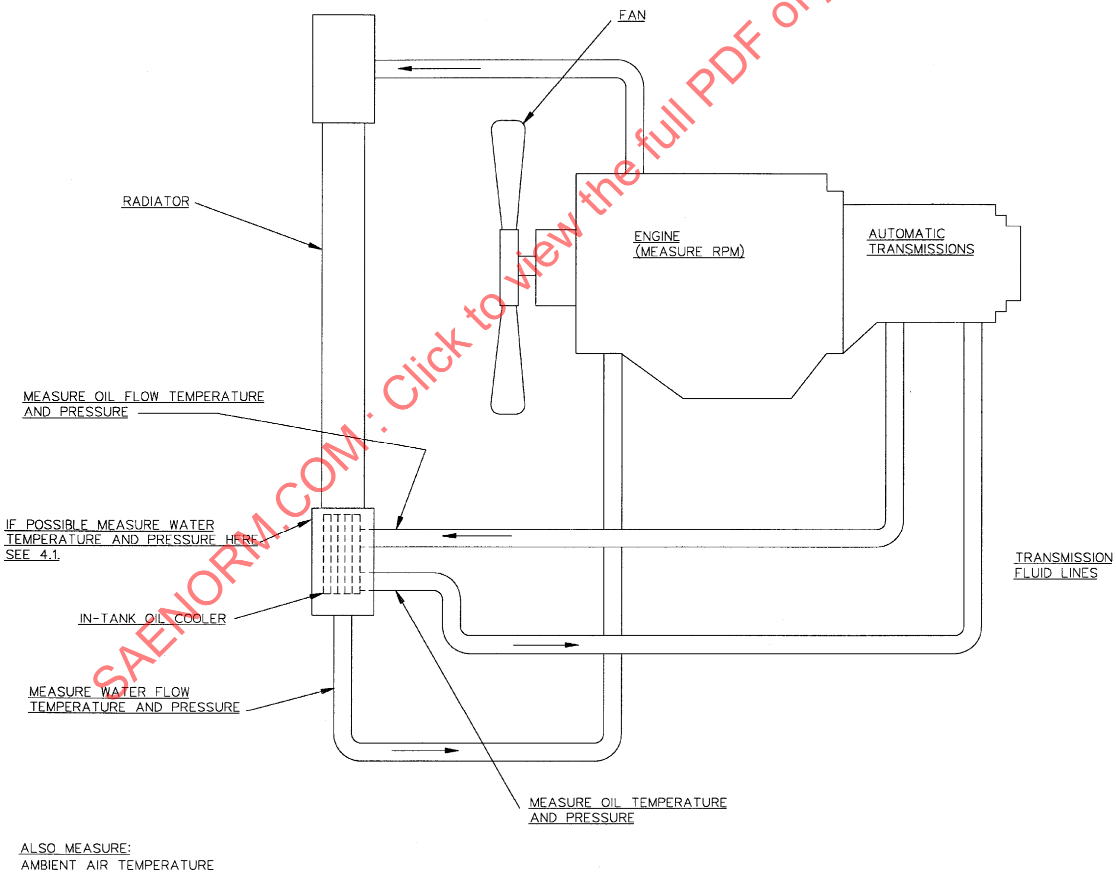

FIGURE 5 - SCHEMATIC OF TYPICAL OIL COOLER SYSTEM WITH OIL COOLER
INSTALLED IN BOTTOM OR OUTLET TANK OF RADIATOR

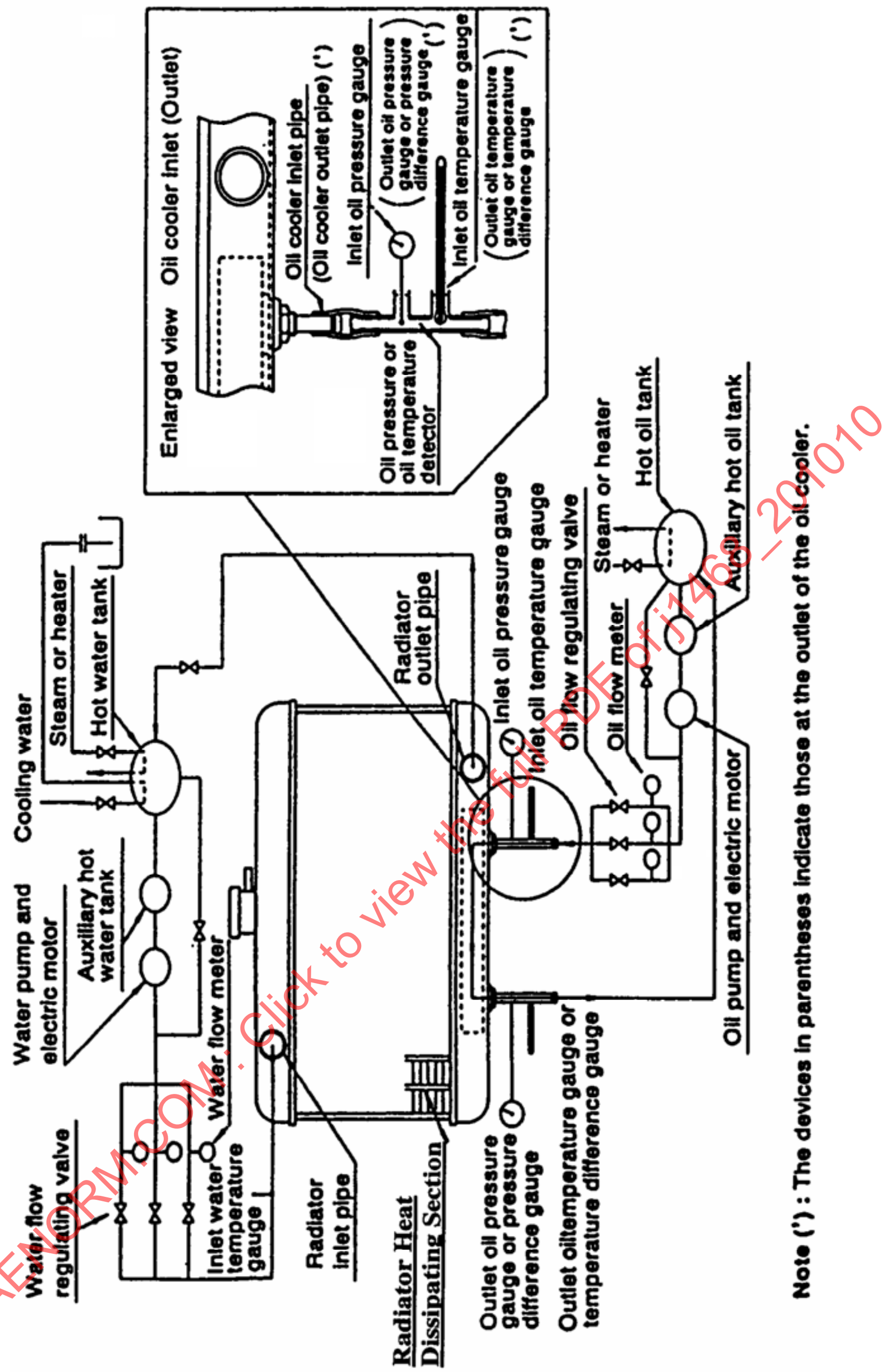

FIGURE 6 - SCHEMATIC OF TEST APPARATUS FOR APPLICATION TESTING OF OIL COOLERS INSTALLED IN RADIATOR BOTTOM OR OUTLET TANKS. THIS APPARATUS MAY ALSO BE USED TO TEST AN OIL COOLER MOUNTED IN THE APPLICATION RADIATOR BOTTOM TANK, WITH SUITABLE INLET WATER MANIFOLD OR FIXTURE, WITHOUT THE BALANCE OF THE RADIATOR ASSEMBLY.

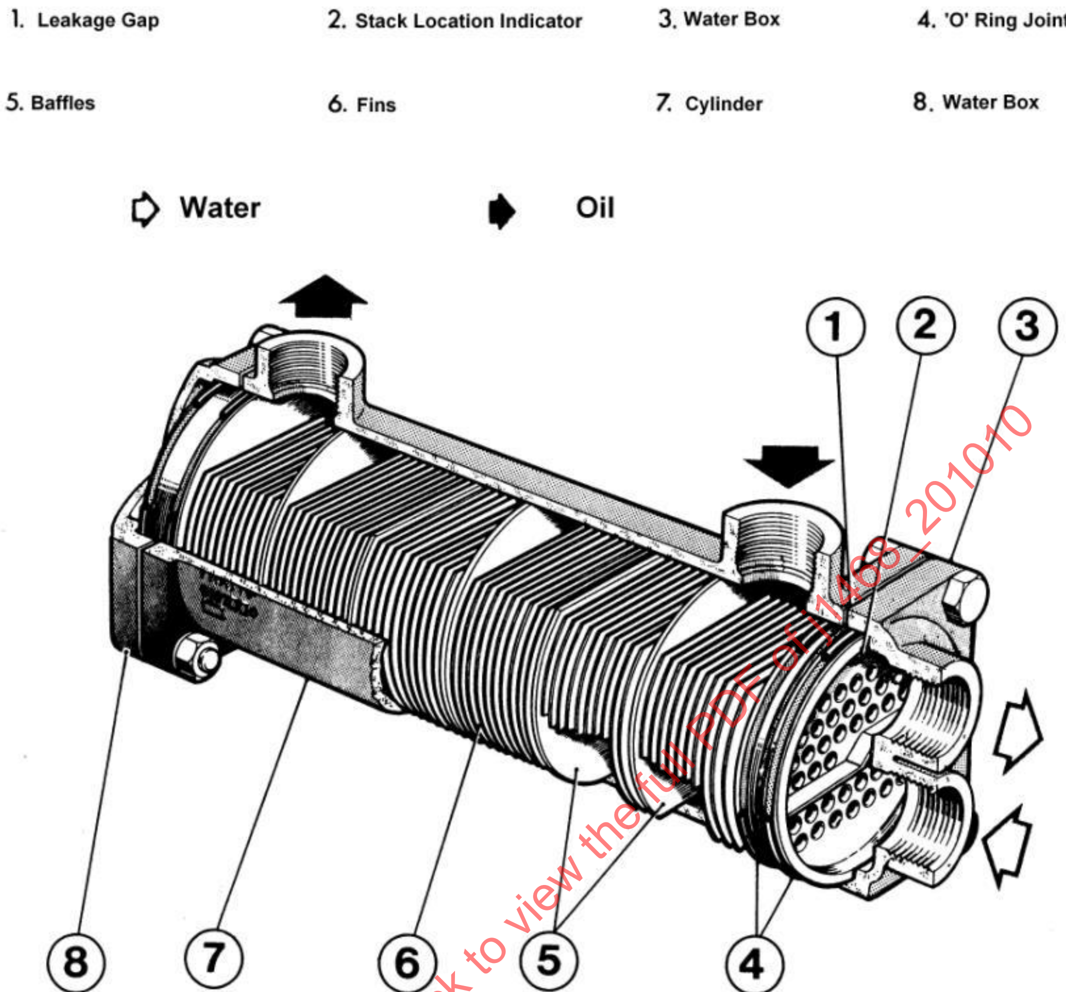

FIGURE 7 - OIL COOLER TEST APPARATUS - TANK MOUNTED

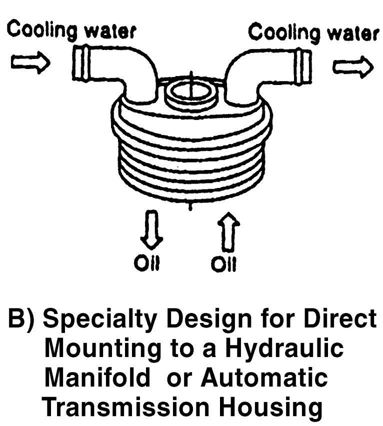

FIGURE 8 - TUBE-IN-SHELL DIRECT MOUNT OIL COOLER

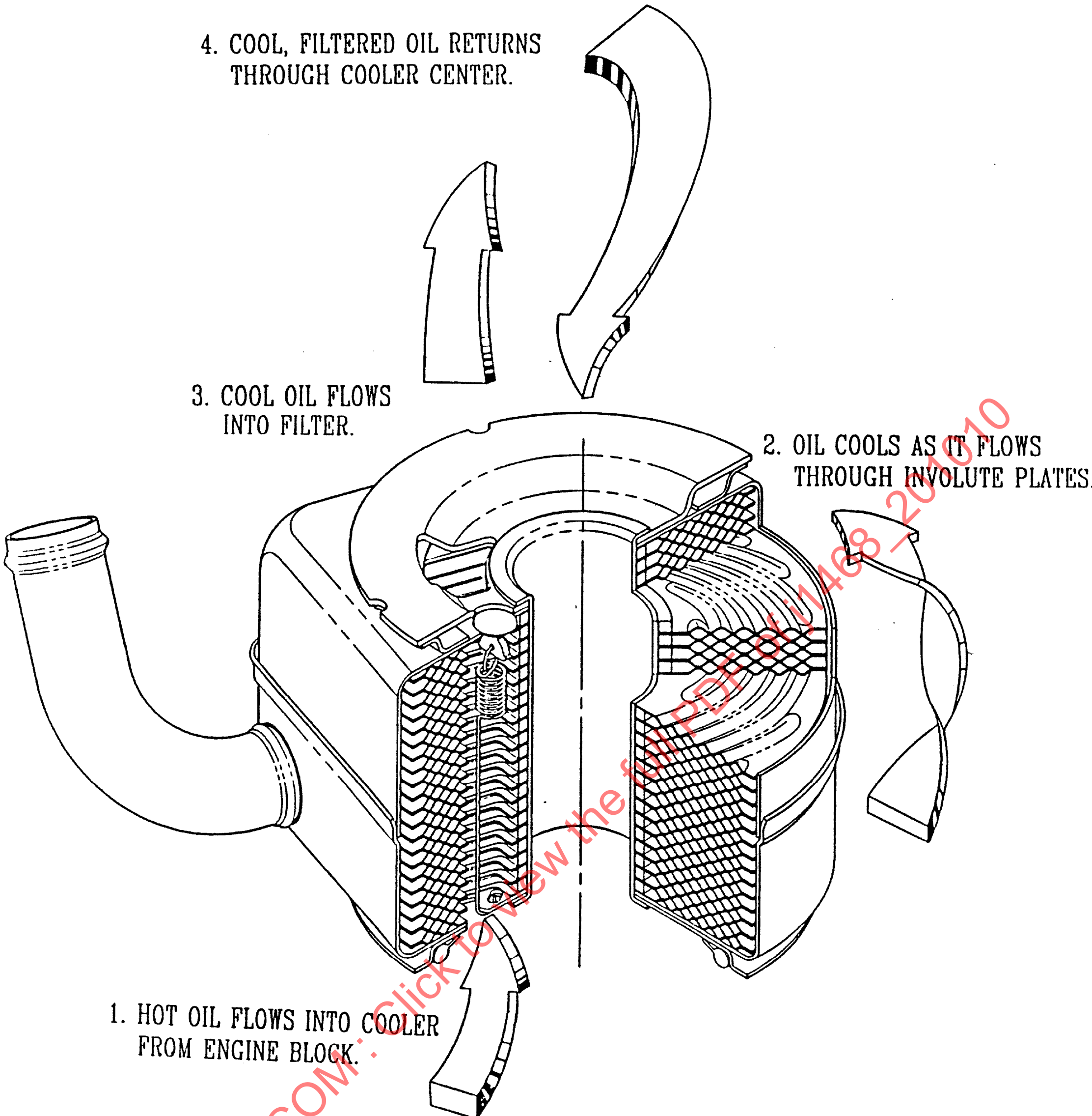

FIGURE 9 - EXAMPLES OF TYPICAL REMOTE-MOUNTED OIL COOLERS

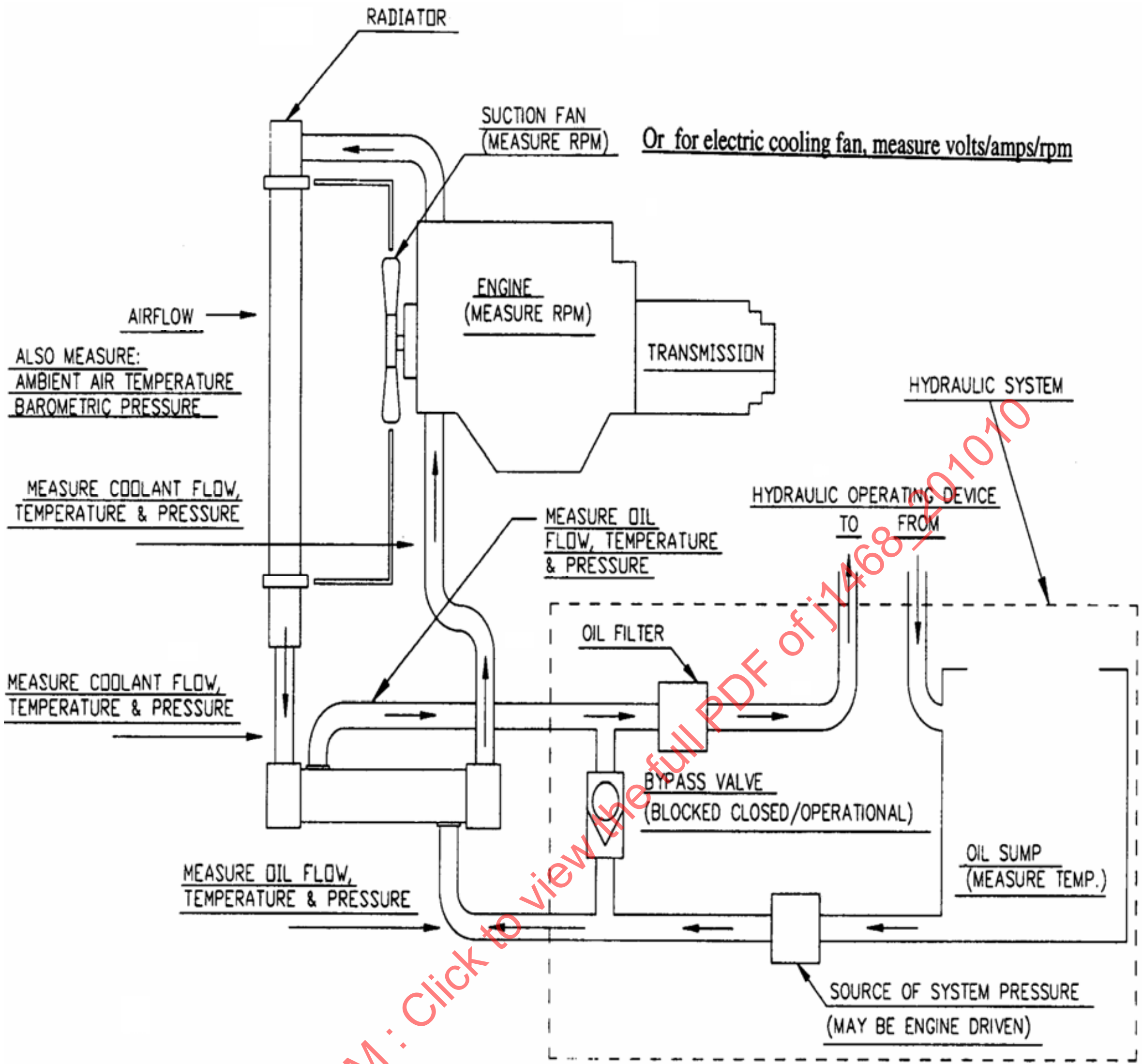

FIGURE 10 - SCHEMATIC OF TYPICAL REMOTE-MOUNTED OIL COOLER SYSTEM

10. TEST PREPARATION FOR OIL-TO-WATER PERFORMANCE TEST

10.1 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.

10.2 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.

10.3 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.

10.4 Instrumentation and data to be recorded includes the following:

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

10.4.2 Oil temperature at oil cooler inlet (if not already specified in 10.4.1).

10.4.3 Oil temperature at oil cooler outlet (if not already specified in 10.4.1).

10.4.4 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.

10.4.5 Water temperature at the oil cooler water outlet.

10.4.6 Water flow rate through the cooler.

10.4.7 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.

10.4.8 Operating pressure at the oil cooler oil inlet.

10.4.9 Operating pressure at the oil cooler oil outlet.

10.4.10 Operating pressure at the oil cooler water inlet.

10.4.11 Operating pressure at the oil cooler water outlet.

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

10.4.12 Engine or motor operating speeds.

10.4.13 Ambient air temperature, especially important if not testing at the most severe ambient conditions.

10.4.14 Type of oil or hot fluid. This oil or fluid shall be as specified for the application system.

10.4.15 Unless otherwise specified, the water used in the water circuit of the oil cooler shall be fresh potable water. When antifreeze mixtures are used, the type of coolant concentrate and the percent mixture by volume of the concentrate with water shall be noted.

10.5 Verify that the oil cooler is mounted in its designated position with proper inlet and outlet connections. An attempt should be made to plumb the oil cooler circuit in a counter flow direction to the coolant flow direction to get the best performance on a single pass cooler.

11. PROCEDURE FOR OIL-TO-WATER PERFORMANCE TEST

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

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

12. TEST DATA EVALUATION FOR OIL-TO-WATER PERFORMANCE TEST

12.1 Calculate oil cooler heat rejection from the test data as follows:

12.1.1 Oil flow rate.

12.1.2 Oil Cooler inlet oil temperature.

12.1.3 Oil Cooler outlet oil temperature.

12.1.4 Obtain manufacturer's specific heat and density of the oil (or fluid) to establish oil thermal characteristics at average oil temperature.

12.1.5 Calculate the Oil Cooler Heat Rejection Oil Side, as follows:

$$Q_{o/c} = m_{oil} \times c_{\rho_{oil}} \times \rho_{oil} \times (T_{oil_{in}} - T_{oil_{out}}) \quad \text{(Eq. 3)}$$

where:

$Q_{o/c}$ = Heat Rejection kW (Btu/min)
m = Oil Flow Rate L/s (gpm)
C_p = Specific Heat kJ/kg/°C (Btu/(lb_m)(°F)
ρ = Density kg/L (lb/gal)
T = Temperature °C (°F)

12.1.6 Calculate the Oil Cooler Heat Rejection Water Side, as follows:

$$Q_{H_2O} = m_{H_2O} \times c_{\rho_{H_2O}} \times \rho_{H_2O} \times (T_{H_2O_{in}} - T_{H_2O_{out}}) \quad \text{(Eq. 4)}$$

12.2 Determine the test Initial Temperature Difference at stabilized temperatures above coolant inlet at the critical location (maximum oil-to-coolant temperature), as follows:

$$ITD_{Test} = T_{Oil_{in}} - T_{H_2O_{in}} \quad \text{(Eq. 5)}$$

12.3 Determine the oil cooler performance based on an Initial Temperature Difference of 33.3 °C (60 °F) between the entering oil and the entering coolant, as follows:

$$Q_{ITD_{33.3\,°C}} = Q_{Test} \times \left(\frac{33.3\,°C}{ITD_{Test}} \right) \quad \text{(Eq. 6)}$$

NOTE: Calculation of oil cooler Initial Temperature Difference may not be possible in the case of testing a complete system. See 9.1.

12.4 Using the heat capacity of the oil cooler as derived in 12.3, calculate the actual heat rejection of the oil cooler at the most severe-duty cycle to required specifications, as follows:

$$Q_{Actual} = Q_{ITD_{33.3\,°C}} \times \left(\frac{T_{Oil_{inMax}} - T_{H_2O_{inMax}}}{33.3\,°C} \right) \quad \text{(Eq. 7)}$$

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

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

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

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

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

12.5.5 Poor water flow distribution to the oil cooler. (In the case of tank-mounted oil coolers, is the baffling design adequate?)

12.5.6 Other than expected oil pressure differential between oil cooler oil inlet and outlet. Due to viscosity affects the oil pressure drop may have to be corrected when the test pressure drop is based on a much lower average oil temperature than that expected in the most severe-duty cycle. (Is oil cooler pressure drop compatible with system design? Is excessive pressure causing pumps to create more heat, oil flow to dump over relief value, etc.)

12.5.7 Other than expected water pressure differential between oil cooler water inlet and outlet. (Does high pressure drop cause reduced cooling water flow?)

12.5.8 Temperature gradient or difference between critical oil temperature and temperature of oil into the oil 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?)

12.5.9 Ambient temperature too low or too high. If the test was run at ambient temperatures substantially different from the specified ambient temperature, the oil stabilization temperature above ambient may be significantly different from what it would be at specified ambient temperature.

13. GLOSSARY OF OIL COOLER NOMENCLATURE

13.1 Baffle

A partition, which directs flow of fluids across the core. See Figure 12.

13.2 Baffle Spacing

Distance between adjacent baffles.

13.3 Bonnet

Collector or manifold on end of shell and tube heat exchanger, which directs flow of tube-side fluid.

13.4 Core

That section of an oil cooler assembly that is comprised of the heat transfer surfaces.

13.5 End Zone

Space between first or last baffle and adjacent tube sheet or header of a shell and tube oil cooler.

13.6 Face Area

Area defined by the core width multiplied by the core height. (Oil to air coolers.)

13.7 Face Velocity

The average velocity of air approaching the core.

NOTE: Volume per unit time divided by face area.

13.8 Fin

Extended Heat Transfer Surface.

See Figure 11, Figure 14, Figure 16, and Figure 17.

NOTE: Shell and tube oil coolers may have fins or other extended surfaces.

13.9 Fixed Bundle Oil Cooler

A shell and tube heat exchanger with the tube bundle permanently installed in the shell. See Figure 13.

13.10 Fouling Factor

See Fouling Resistance.

13.11 Fouling Resistance

The resistance to heat transfer resulting from accumulation of foreign material on the heat transfer surfaces of an oil cooler.

13.12 Header

This term has a dual meaning. It is sometimes used synonymously with tube sheet or tank. See Figure 12, Figure 13, Figure 16, and Figure 17.

13.13 Heat Dissipation

The quantity of heat, usually expressed in kilowatts (British Thermal Units per minute), that an oil cooler can dissipate under specified conditions.

13.14 Inlet Temperature Differential

The difference in temperature between the fluid being cooled and the cooling medium at the point each enters the heat exchanger.

13.15 Manifold

See Tank or Bonnet. Refer to Figure 11, Figure 16, Figure 17, Figure 18, and Figure 19.

13.16 Multi-Pass Oil Cooler

An oil cooler that is so circuited that either fluid passes across or through the core more than once.

13.17 Oil Cooler Pressure Relief Valve

A pressure differential activated device, which allows oil to bypass the oil cooler.

NOTE: Commonly used for protection under low temperature, high viscosity conditions, or any pressure surge condition where inlet pressure can become excessive.

13.18 Oil Cooler Thermostat

A temperature-activated device in the oil cooler circuit, which can either by-pass oil around or modulate oil flow through the cooler.

NOTE: This device regulates oil cooler heat transfer to allow rapid heating of oil at start up or prevent excessive cooling under light load conditions.

13.19 Operating Pressure

The fluid pressure to which the oil cooler is normally exposed during operation.

13.20 Partition

A device that is installed in a manifold, header, bonnet, or tank to create multiple pass of fluids through the core.

13.21 Peak Pressure

The highest pressure to which the oil cooler is intermittently subjected.

13.22 Pressure Drop

The pressure differential between inlet and outlet at a specified fluid flow rate and viscosity.

a. Air side is measured in Pa (inches of water).

b. Oil side is measured in kPa (psi).

c. Water side is measured in kPa (psi).

13.23 Removable Tube Bundle Oil Cooler

A shell and tube heat exchanger utilizing seals between the shell and tube fluids allowing the tube bundle to be removed from the shell.

NOTE: Normally used to provide for disassembly and/or thermal expansion. See Figure 12.

13.24 Tank

An enclosure located at the inlet and/or outlet of an oil cooler that is sealed against the tube sheet or individual tubes and distributes the tube side fluid into the tubes or collects the tube side fluid as it exits the tubes. See Figure 16 and Figure 17.

13.25 Tube Sheet

See Figure 12 and Figure 13.

13.26 Turbulator

A device that increases fluid turbulence for the purpose of increasing heat transfer. For typical turbulator configurations, see Figure 11, Figure 15, Figure 16, Figure 17, and Figure 19.

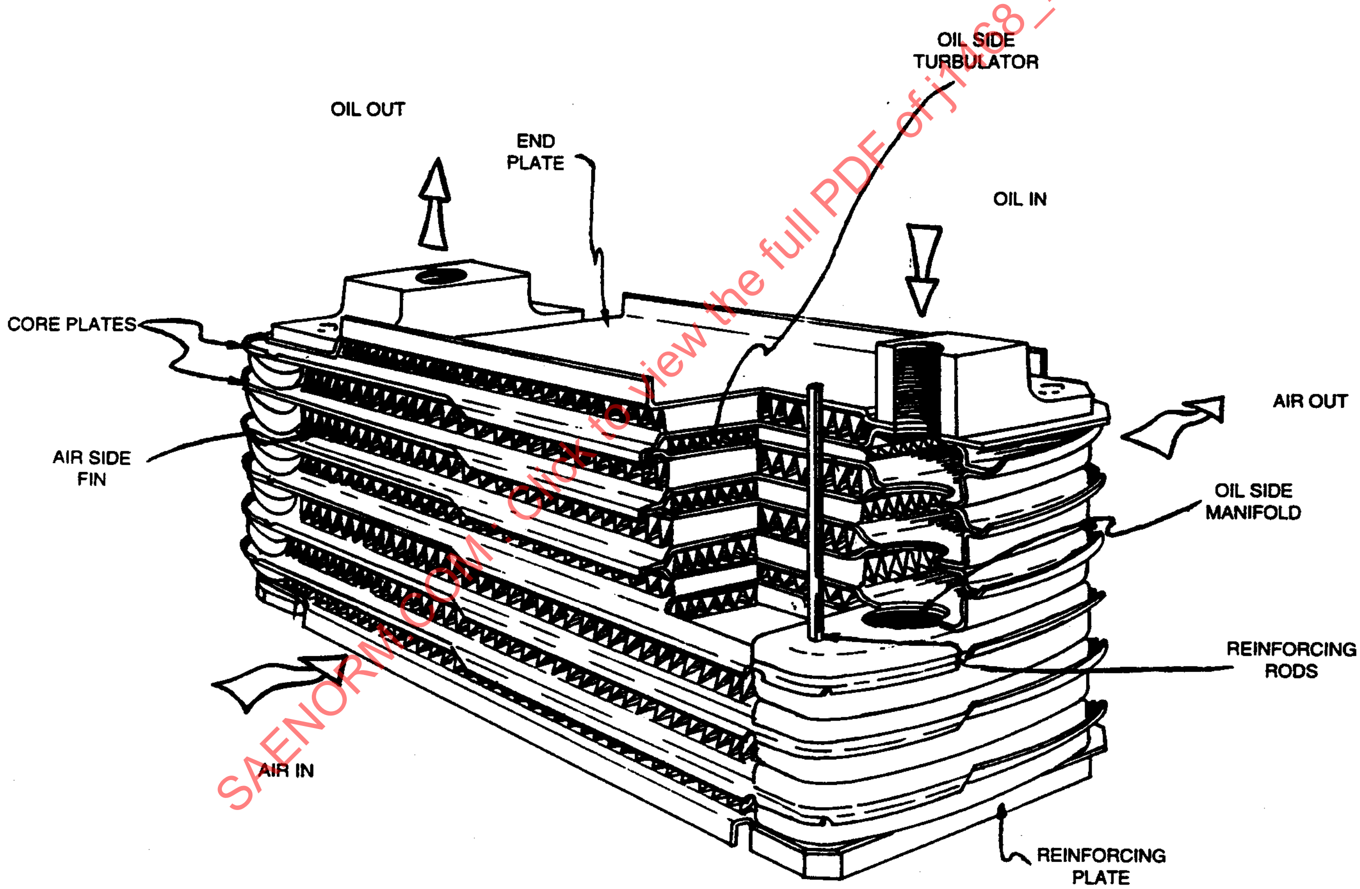

FIGURE 11 - PLATE FIN SEPARATOR OIL TO AIR COOLER

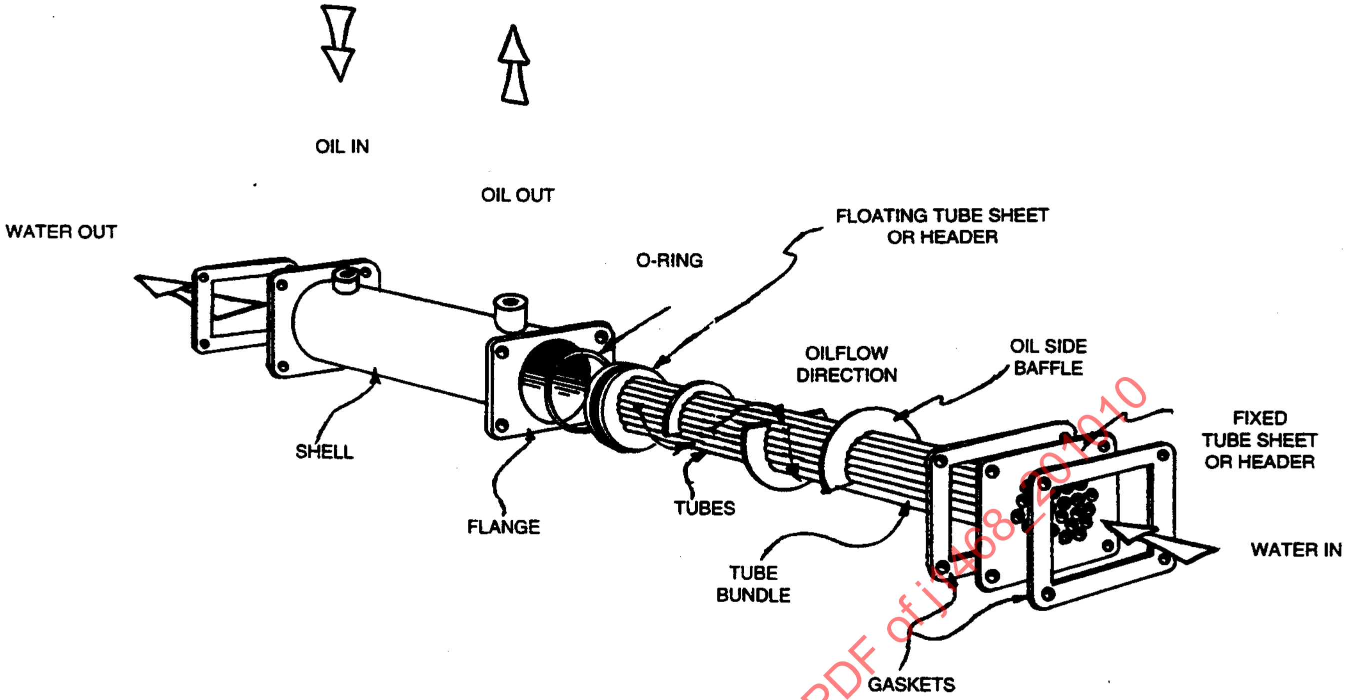

FIGURE 12 - SHELL AND TUBE REMOVABLE BUNDLE OIL TO WATER COOLER

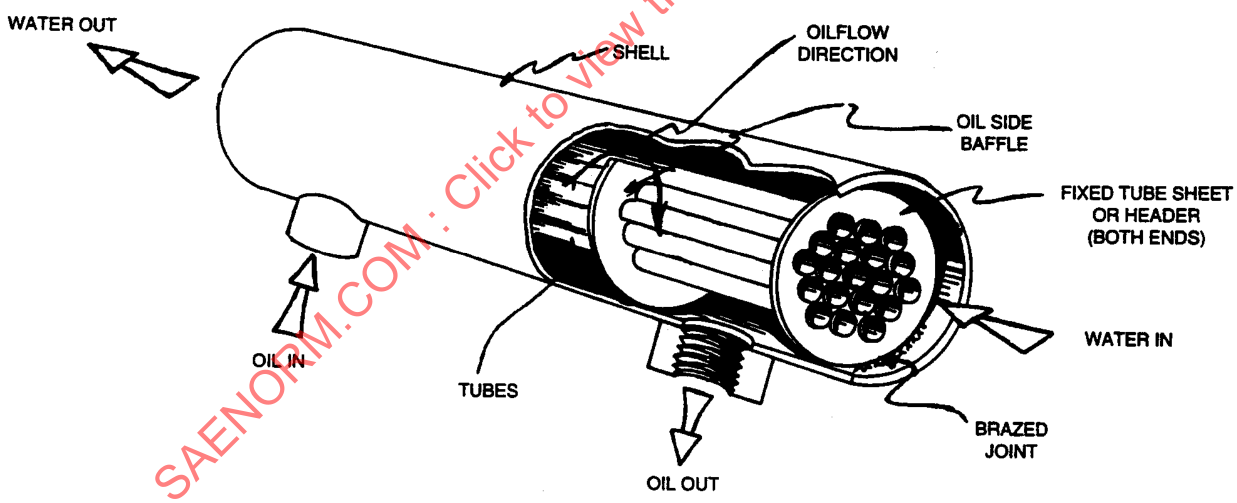

FIGURE 13 - SHELL AND TUBE OIL TO WATER COOLER-FIXED BUNDLE

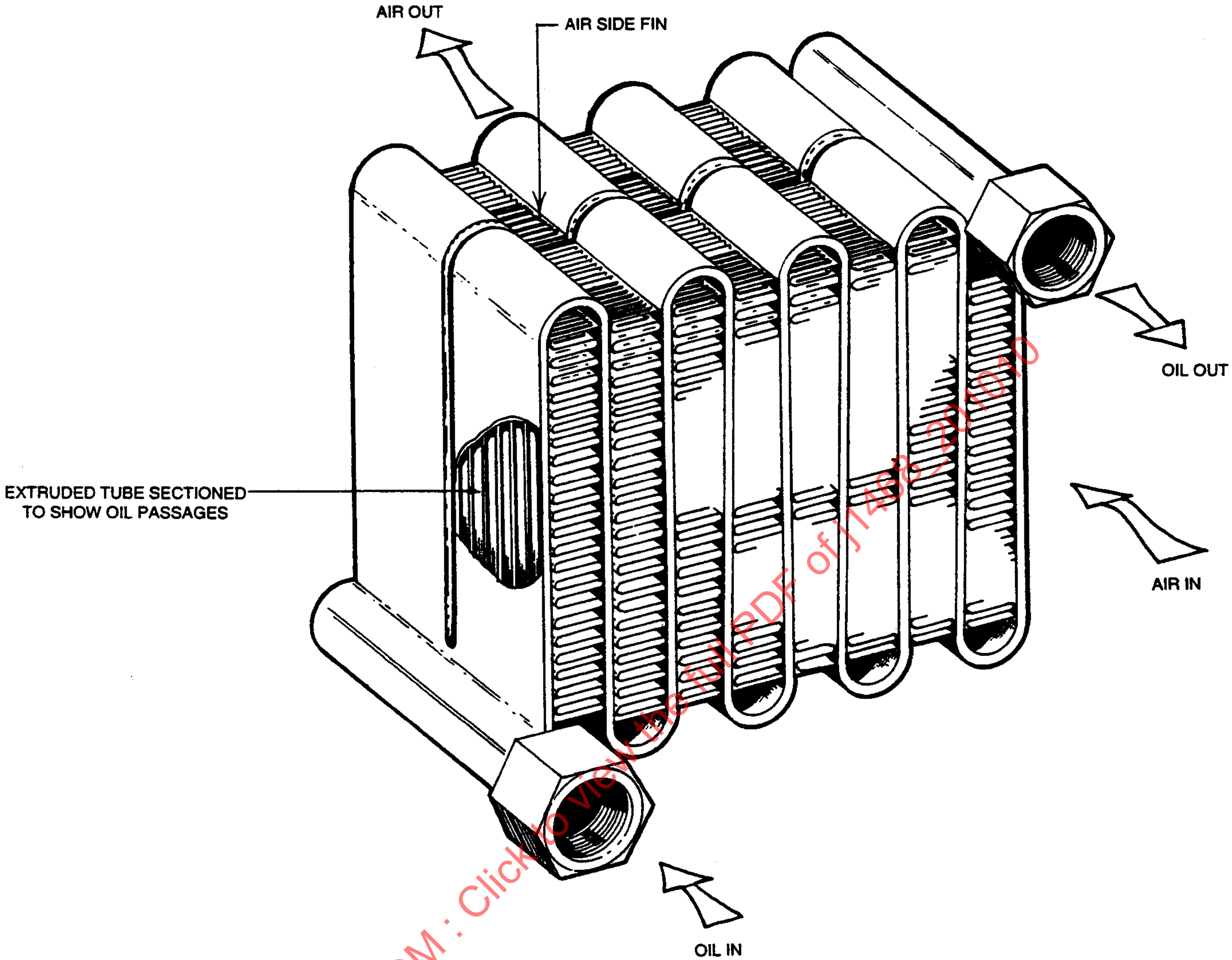

FIGURE 14 - SERPENTINE TUBE AND FIN OIL TO AIR COOLER