

	SURFACE VEHICLE RECOMMENDED PRACTICE	
	SAE	J1994 AUG2008
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Superseding J1994 OCT2004		
Laboratory Testing of Vehicle and Industrial Heat Exchangers for Heat Transfer and Pressure Drop Performance		

RATIONALE

To correct formula errors and eliminate content not related to Cooling System Committee scope.

1. SCOPE

This SAE Recommended Practice is applicable to all heat exchangers used in vehicle and industrial cooling systems. This document outlines the tests to determine the heat transfer and pressure drop performance under specified conditions.

1.1 Purpose

This document is to provide a test guideline for determining the heat transfer and pressure drop performance of a heat exchanger under specified testing conditions.

1.2 Objective

To determine and document the heat transfer and pressure drop characteristics of a heat exchanger. This document describes a system to flow fluids through the heat exchanger at specified rates and temperatures, and describes and recommends the instrumentation and the procedure for documenting the results. The procedure may be varied to match existing equipment and methods.

2. REFERENCES

2.1 Applicable Publications

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

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2.1.1 SAE Publications

Available from SAE International, 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 J1393	Heavy Duty Vehicle Cooling Test Code R
SAE J1468	Application Testing of Oil-to-Air Oil Coolers for Heat Transfer Performance
SAE J2414	Application Testing of Oil-to-Water Oil Coolers for Heat Transfer Performance
SAE Paper 890227	Prediction of Heat Transfer Performance of a Heat Exchanger

3. FACILITY REQUIREMENT

The facility should provide the following as required:

- 3.1 Source capable of delivering the fluids to the test unit at a specified temperature, pressure, and flow.
- 3.2 Means of moving these fluids to and from the test unit in a specified manner.
- 3.3 A test system adequate to contain the test unit and control the flow and temperatures of the fluids as specified. In addition to the proposed instrumentation, the instrument accuracy for specific flow domain and operating temperature should be specified. Instrumentation and equipment may include, but not be limited to, the following:
 - a. Air flow rate instrumentation
 - b. Automatic data logging equipment
 - c. Fluid flow rate meters
 - d. Heater and controls
 - e. Humidity measuring equipment
 - f. Pressure measuring instrumentation
 - g. Pump and motor with controls
 - h. Reservoir
 - i. Safety features as specified by regulatory codes and common practices
 - j. Temperature indicators
 - k. Thermocouples
 - l. Valves as required
 - m. Various ducting, piping, hoses, and fittings

4. TESTING (NOT NECESSARILY IN THE FOLLOWING ORDER)

- 4.1 Install test unit as specified.
- 4.2 Start heaters and heat fluids to specified temperature.

- 4.3 Start pumps and adjust flows and pressures as specified.
- 4.4 Insure conditions are stable before recording data.
- 4.5 Read and record inlet and outlet temperatures and mass flow rates for fluids. Calculate the differences in temperature, multiply the differences by the mass flow rates (taking into account corrections for relative humidity if necessary), and specific heats of each to obtain heat transfer capacity. Air flow rates should be calculated or corrected using an air density of .075 lbm/ft³ or its metric equivalent. All fluid densities should be corrected to standard temperature conditions.
- 4.6 If the heat transfer capacity of the fluids are within 3% of each other, record the data and continue. (This may be difficult to obtain when one fluid has a small temperature change.)
- 4.7 Read and record pressure drop of each fluid.
- 4.8 Change test parameters and repeat steps 4.5, 4.6, and 4.7 as specified.

5. TEST PROCEDURES (SEE APPENDIX A FOR SPECIFIC PROCEDURES)

- 5.1 Liquid-to-Gas (e.g., radiator) (See Figures A1A and A1B.)
- 5.2 Liquid-to-Liquid (e.g., shell/tube) (See Figures A2A and A2B.)
- 5.3 Gas-to-Liquid (e.g., jacket water aftercooler) (See Figures A3A and A3B.)
- 5.4 Gas-to-Gas (e.g., air-to-air aftercooler) (See Figures A4A and A4B.)

6. This document is valid for laboratory performance testing and comparison.

It is recommended that a full-size heat exchanger be tested, if possible. If this is not possible, then it is recommended that the test results from the test heat exchanger be extrapolated to the full-size heat exchanger as recommended in SAE Paper 890227 and the results be reported for the full size.

Any correlation to field results must be developed on an individual basis (see SAE J1393, J1468 and J2414 for details of field and application testing).

7. NOTES

7.1 Marginal Indicia

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

APPENDIX A

Customer Part Number:							
Manufacturer Part Number:							
Test Date							
Tested By:							
Test Number:							
Core Type							
Core Size:							
Core Construction:							
		TEST DATA					
ITEM	CRITERIA	UNITS	1	2	3	4	5
MEASURED VALUES							
A	Hot Liquid Flow Rate	kg/min (lb/min)					
B	Hot Liquid Inlet Temperature	°C (°F)					
C	Hot Liquid Outlet Temperature	°C (°F)					
D	Hot Liquid Inlet Pressure	kPa (psia)					
E	Hot Liquid Outlet Pressure	kPa (psia)					
F	Cooling Gas Flow Rate	kg/min (lb/min)					
G	Cooling Gas Inlet Temperature	°C (°F)					
H	Cooling Gas Outlet Temperature	°C (°F)					
I	Cooling Gas Inlet Pressure (static)	Pa (psia)					
J	Cooling Gas Outlet Pressure (static)	Pa (psia)					
K	Barometric Pressure	kPa (inches Hg)					
CALCULATED VALUES							
L	Hot Liquid Temperature Differential	(B-C)					
M	Hot Liquid Pressure Differential	(D-E)					
N	Cooling Gas Temperature Differential	(H-G)					
O	Cooling Gas Pressure Differential (a differential pressure transducer may be substituted)	(I-J)					
P	Heat Exchanger Effectiveness (Hot Side)	(L/X)					
Q	Average Hot Liquid Temperature						
R	Average Hot Liquid Specific Heat	kJ/kg°K (Btu/lb°R)					
S	Average Cooling Gas Temperature						
T	Average Cooling Gas Specific Heat	kJ/kg°K (Btu/lb°R)					
U	Hot Side Heat Transfer (adheres to heat transfer formula: $Q = m \cdot C_p \cdot \Delta T$)	(A x R x L)					
V	Cooling Side Heat Transfer (adheres to heat transfer formula: $Q = m \cdot C_p \cdot \Delta T$)	(F x T x N)					
W	Heat Transfer Balance	(V/U) x 100					
X	Inlet Temperature Differential	(B-G)					
Y	Average Heat Transfer Per °ITD	((V+U)/2)/X					
Z	Heat Transfer Per Average Temperature	((V+U)/2)/(Q-G)					
AA	Cooling Air Density	kg/m ³ (lb/ft ³)					
BB	Face Velocity (at standard conditions)						

FIGURE A1A - LIQUID-TO-GAS HEAT EXCHANGER TEST DATA (REFERENCE 5.1)

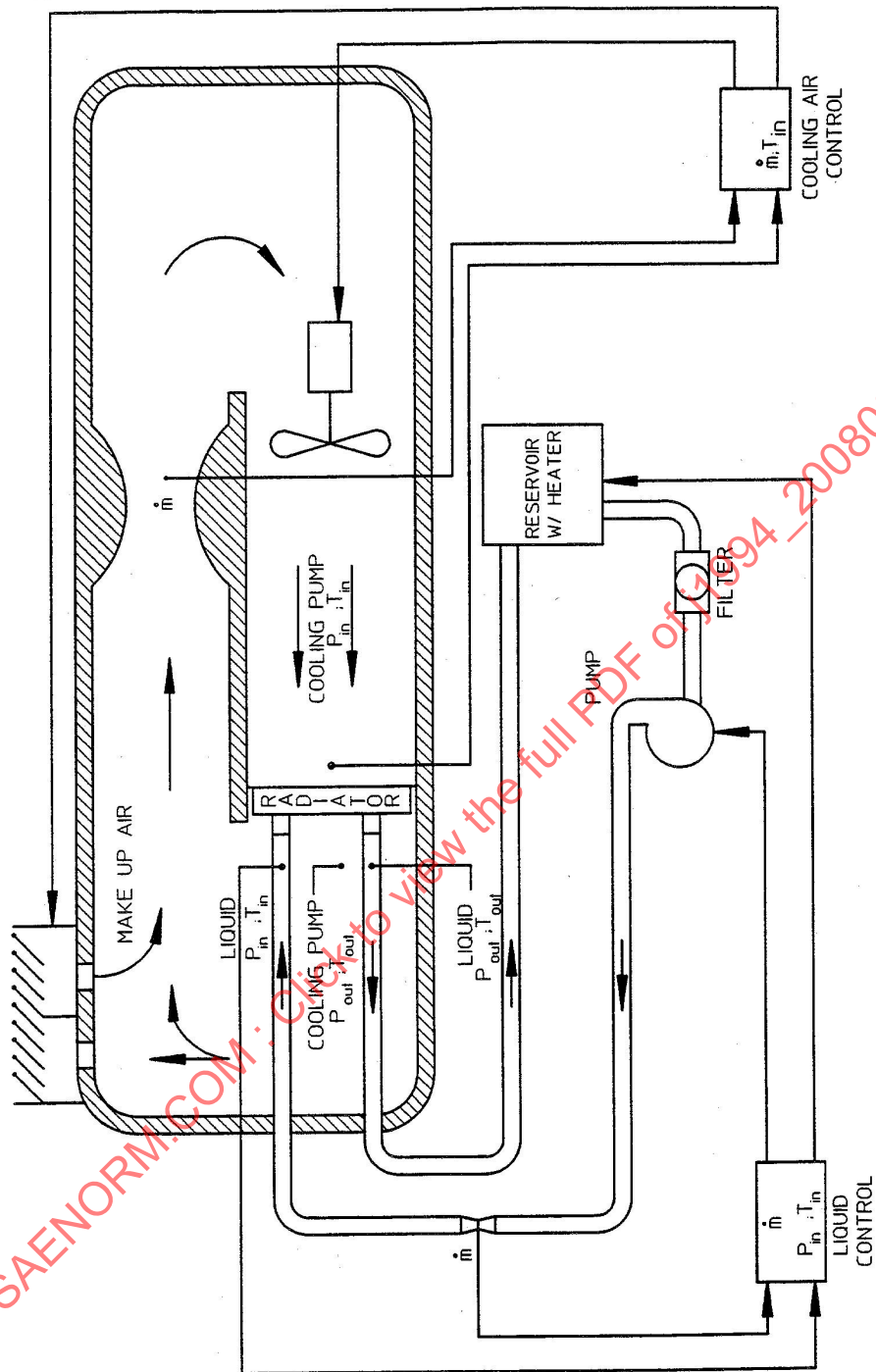


FIGURE A1B - LIQUID-TO-GAS (E.G., RADIATOR) HEAT TRANSFER TEST LOOP
(REFERENCE 5.1)

Customer Part Number:

Manufacturer Part Number:

Test Date

Tested By:

Test Number:

Core Type

Core Size:

Core Construction:

TEST DATA

ITEM	CRITERIA	UNITS	1	2	3	4	5
MEASURED VALUES							
A	Hot Liquid Flow Rate	kg/min (lb/min)					
B	Hot Liquid Inlet Temperature	°C (°F)					
C	Hot Liquid Outlet Temperature	°C (°F)					
D	Hot Liquid Inlet Pressure	kPa (psia)					
E	Hot Liquid Outlet Pressure	kPa (psia)					
F	Cooling Liquid Flow Rate	kg/min (lb/min)					
G	Cooling Liquid Inlet Temperature	°C (°F)					
H	Cooling Liquid Outlet Temperature	°C (°F)					
I	Cooling Liquid Inlet Pressure	kPa (psia)					
J	Cooling Liquid Outlet Pressure	kPa (psia)					
CALCULATED VALUES							
K	Hot Liquid Temperature Differential	(B-C)					
L	Hot Liquid Pressure Differential	(D-E)					
M	Cooling Liquid Temperature Differential	(H-G)					
N	Cooling Liquid Pressure Differential	(I-J)					
O	Heat Exchanger Effectiveness (Hot Side)	(K/W)					
P	Average Hot Liquid Temperature						
Q	Average Hot Liquid Specific Heat	kJ/kg°K (Btu/lb°R)					
R	Average Cooling Liquid Temperature						
S	Average Cooling Liquid Specific Heat	kJ/kg°K (Btu/lb°R)					
T	Hot Side Heat Transfer (adheres to heat transfer formula: $Q = m \cdot C_p \cdot \Delta T$)	(A x Q x K)					
U	Cooling Side Heat Transfer (adheres to heat transfer formula: $Q = m \cdot C_p \cdot \Delta T$)	(F x S x M)					
V	Heat Transfer Balance	(U/T) x 100					
W	Inlet Temperature Differential	(B-G)					
X	Average Heat Transfer Per °ITD	((U+T)/2)/W					
Y	Heat Transfer Per Average Temperature	((U+T)/2) / (P-G)					

FIGURE A2A - LIQUID-TO-LIQUID HEAT EXCHANGER TEST DATA (REFERENCE 5.2)

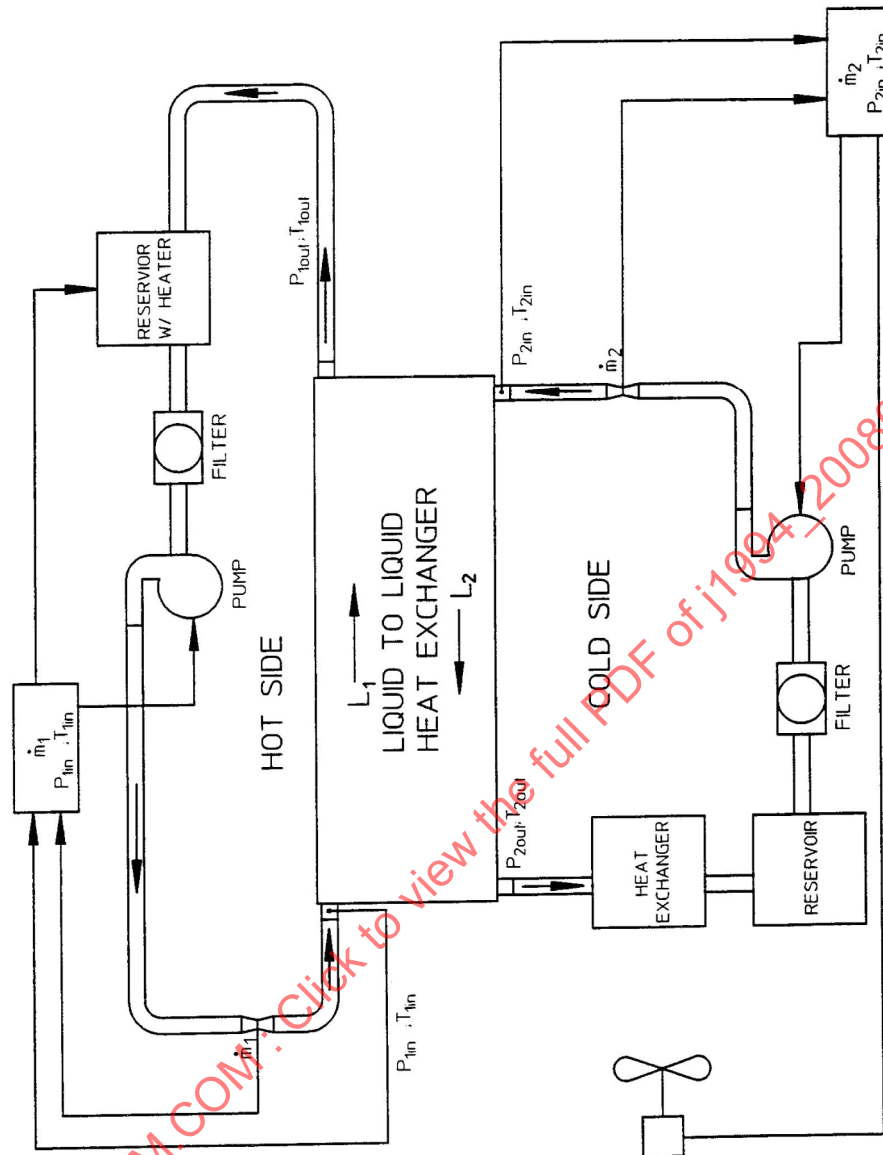


FIGURE A2B - LIQUID-TO-LIQUID (E.G., SHELL/TUBE) HEAT TRANSFER TEST LOOP
(REFERENCE 5.2)

Customer Part Number:							
Manufacturer Part Number:							
Test Date							
Tested By:							
Test Number:							
Core Type							
Core Size:							
Core Construction:							
			TEST DATA				
ITEM	CRITERIA	UNITS	1	2	3	4	5
MEASURED VALUES							
A	Hot Gas Flow Rate	kg/min (lb/min)					
B	Hot Gas Inlet Temperature	°C (°F)					
C	Hot Gas Outlet Temperature	°C (°F)					
D	Hot Gas Inlet Pressure (static)	Pa (psia)					
E	Hot Gas Outlet Pressure (static)	Pa (psia)					
F	Cooling Liquid Flow Rate	kg/min (lb/min)					
G	Cooling Liquid Inlet Temperature	°C (°F)					
H	Cooling Liquid Outlet Temperature	°C (°F)					
I	Cooling Liquid Inlet Pressure	kPa (psia)					
J	Cooling Liquid Outlet Pressure	kPa (psia)					
CALCULATED VALUES							
K	Hot Gas Temperature Differential	(B-C)					
L	Hot Gas Pressure Differential (may substitute pressure differential transducer)	(D-E)					
M	Cooling Liquid Temperature Differential	(H-G)					
N	Cooling Liquid Pressure Differential	(I-J)					
O	Heat Exchanger Effectiveness (Hot Side)	(K/U)					
P	Average Hot Gas Specific Heat	kJ/kg°K (Btu/lb°R)					
Q	Average Coolant Specific Heat	kJ/kg°K (Btu/lb°R)					
R	Hot Side Heat Transfer (adheres to heat transfer formula: $Q = m \cdot C_p \cdot dT$)	(A x P x K)					
S	Cooling Side Heat Transfer (adheres to heat transfer formula: $Q = m \cdot C_p \cdot dT$)	(F x Q x M)					
T	Gas Density Recovery Efficiency	((D-L)/D) x (G/C)					
NOTE-D, G, and C are all absolute terms							
U	Inlet Temperature Differential	(B-G)					

FIGURE A3A - GAS-TO-LIQUID HEAT EXCHANGER TEST DATA (REFERENCE 5.3)