SURFACE VEHICLE RECOMMENDED PRACTICE

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

RATIONALE

This document has been reviewed and revised by adding several clarifying statements to Section 4.

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. This document has been reviewed and revised by adding several clarifying statements to Section 4.

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 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.

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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 +1 724-776-4970 (outside USA), www.sae.org.

SAE J1393 Heavy Duty Vehicle Cooling Test Code

SAE J1468 Oil Cooler Application Testing and Nomenclature

SAE Paper 890227 Prediction of Heat Transfer Performance of a Heat Exchanger Based on Test of a Small Sample

3. FACILITY REQUIREMENTS

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

3.4 Each facility will have a calibration protocol.

3.5 Each facility will have a test start-up protocol that ensures, among other things, that the facility temperature profiles are stable in advance of data collection.

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.

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4.3 Start pumps and adjust flows and pressures as specified.

4.4 Ensure 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 air density at standard 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. It is recommended to use one transducer to determine the pressure drop to reduce instrumentation error.

4.8 Change test parameters and repeat steps 4.4, 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 (l) 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.

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PREPARED BY THE SAE COOLING SYSTEMS STANDARDS COMMITTEE

APPENDIX A

Customer Part Number:

Manufacturer Part Number:

Test Date

Tested By:

Test Number:

Core Type

Core Size:

Core Construction:

ITEM	CRITERIA	UNITS	TEST DATA 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 Inlet and Outlet Temperature	°C (°F)					
R	Average Hot Liquid Specific Heat	kJ/kg°K (Btu/lb°R)					
S	Average Cooling Gas Inlet and Outlet Temperature	°C (°F)					
T	Average Cooling Gas Specific Heat	kJ/kg°K (Btu/lb°R)					
U	Hot Side Heat Transfer (adheres to heat transfer formula: Q = m*Cp*dT)	(A x R x L)					
V	Cooling Side Heat Transfer (adheres to heat transfer formula: Q = m*Cp*dT)	(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/m³ (lb/ft³)					
BB	Face Velocity (at standard conditions)						

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Figure A1A - Liquid-to-gas heat exchanger test data (reference 5.1)

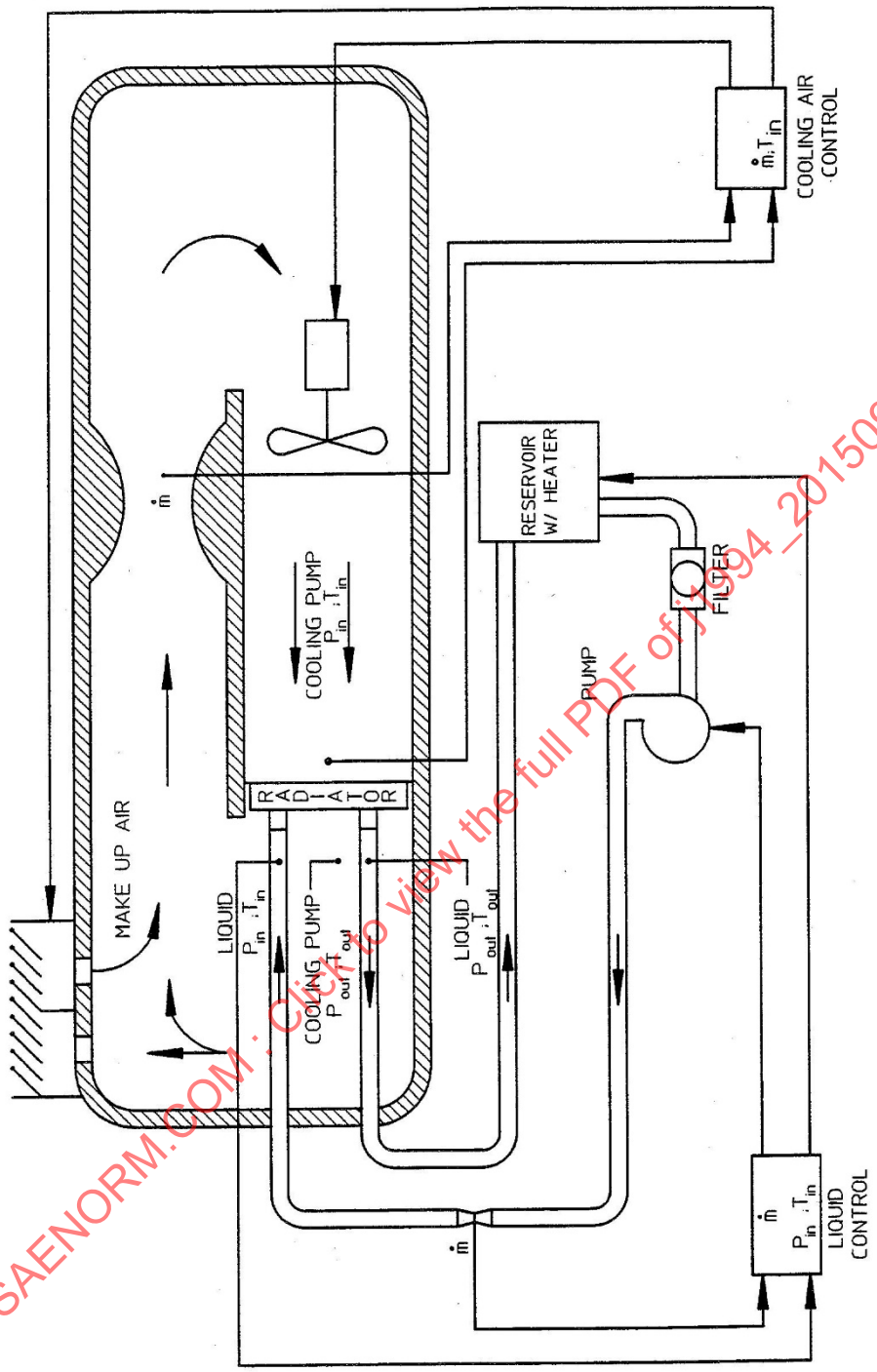

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Figure A1B - Liquid-to-gas (e.g., radiator) heat transfer test loop (reference 5.1)

Customer Part Number:

Manufacturer Part Number:

Test Date

Tested By:

Test Number:

Core Type

Core Size:

Core Construction:

ITEM	CRITERIA	UNITS	TEST DATA 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 Inlet and Outlet Temperature	°C (°F)					
Q	Average Hot Liquid Specific Heat	kJ/kg°K (Btu/lb°R)					
R	Average Cooling Liquid Inlet and Outlet Temperature	°C (°F)					
S	Average Cooling Liquid Specific Heat	kJ/kg°K (Btu/lb°R)					
T	Hot Side Heat Transfer (adheres to heat transfer formula: Q = m*Cp*dT)	(A x Q x K)					
U	Cooling Side Heat Transfer (adheres to heat transfer formula: Q = m*Cp*dT)	(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)					

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Figure A2A - Liquid-to-liquid heat exchanger test data (reference 5.2)

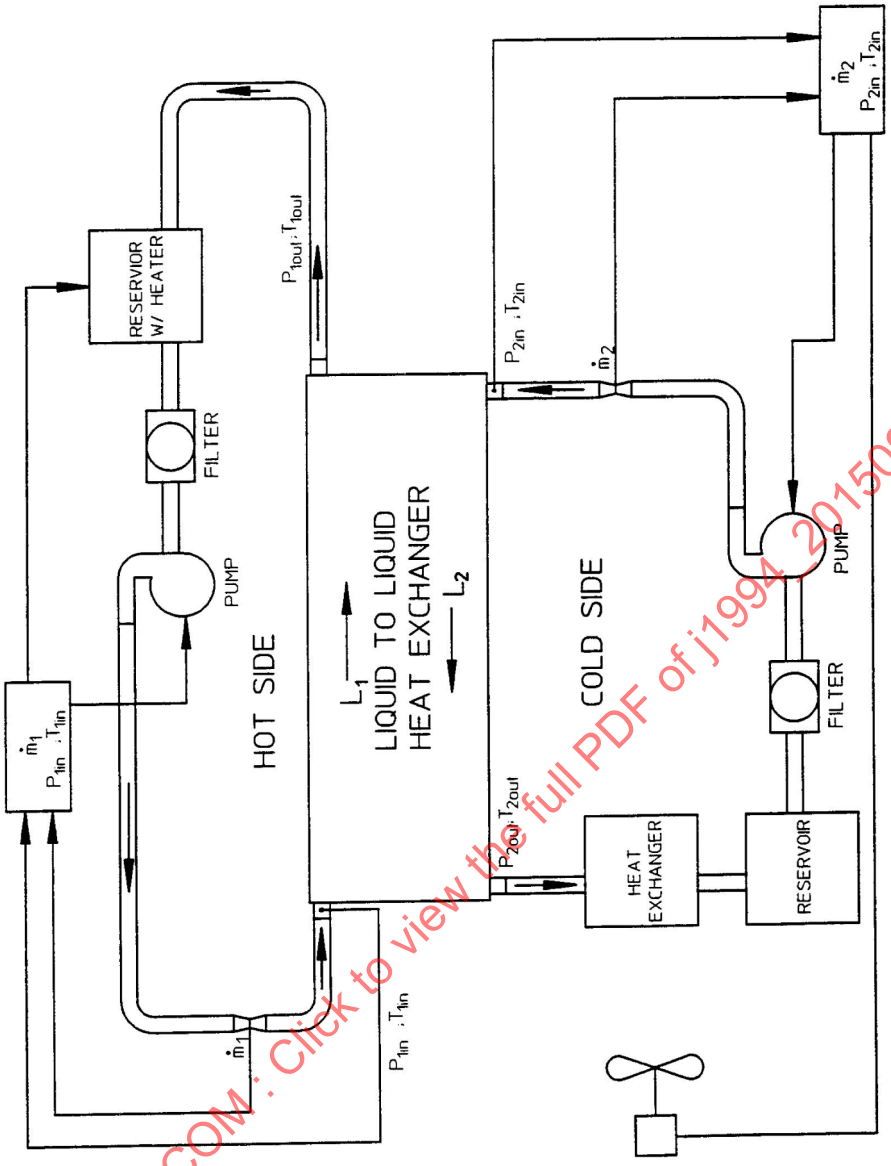

Figure A2B - Liquid-to-liquid (e.g., shell/tube) heat transfer test loop (reference 5.2)

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Customer Part Number:

Manufacturer Part Number:

Test Date

Tested By:

Test Number:

Core Type

Core Size:

Core Construction:

ITEM	CRITERIA	UNITS	TEST DATA 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*Cp*dT)	(A x P x K)					
S	Cooling Side Heat Transfer (adheres to heat transfer formula: Q = m*Cp*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)					

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Figure A3A - Gas-to-liquid heat exchanger test data (reference 5.3)