



<b>SURFACE VEHICLE RECOMMENDED PRACTICE</b>	<b>J1542™</b>	<b>DEC2020</b>
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Superseding J1542 FEB2016		
(R) Laboratory Testing of Vehicle and Industrial Heat Exchangers for Thermal Cycle Durability		

## RATIONALE

This document includes both technical and editorial revisions with several sections reworded for clarity.

### 1. SCOPE

This SAE Recommended Practice is applicable to all liquid-to-air, liquid-to-liquid, air-to-liquid, and air-to-air heat exchangers used in vehicle and industrial cooling systems.

### 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 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](http://www.sae.org).

- SAE J1597 Laboratory Testing of Vehicle and Industrial Heat Exchangers for Pressure-Cycle Durability
- SAE J1598 Laboratory Testing of Vehicle and Industrial Heat Exchangers for Durability Under Vibration-Induced Loading
- SAE J1726 Charge Air Cooler Internal Cleanliness, Leakage, and Nomenclature
- SAE J2914 Exhaust Gas Recirculation (EGR) Cooler Nomenclature and Application

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### 3. OBJECTIVE

The objective of this document is to establish a guideline for the thermal cycle durability testing of heat exchangers. The thermal cycle durability test is intended to simulate thermal expansion and contraction that occurs during the typical duty cycle of a heat exchanger and is accomplished by alternating the flow of hot and cold fluid through the heat exchanger. The cycling is designed to induce a high but reasonable level of thermal strain damage to the heat exchanger, and the target number of cycles may be historically or empirically correlated back to a vehicle level durability target. Thermal cycling can result in fatigue fractures in the fluid-carrying components (tube, plates, etc.) of the heat exchanger, resulting in leaks. The likelihood of thermal fatigue fractures resulting in leaks is affected by material thickness, material strength, high temperature, magnitude of temperature differentials, and number of cycles. The pass/fail criteria should be “no leaks,” but may also include other undesirable damage associated with the testing. The test temperatures, pressures, flow rates, number of cycles, and pass/fail criteria may be different for each type of heat exchanger and application; therefore, the test specification is determined and agreed between the heat exchanger manufacturer and their customer.

### 4. FACILITY REQUIREMENT

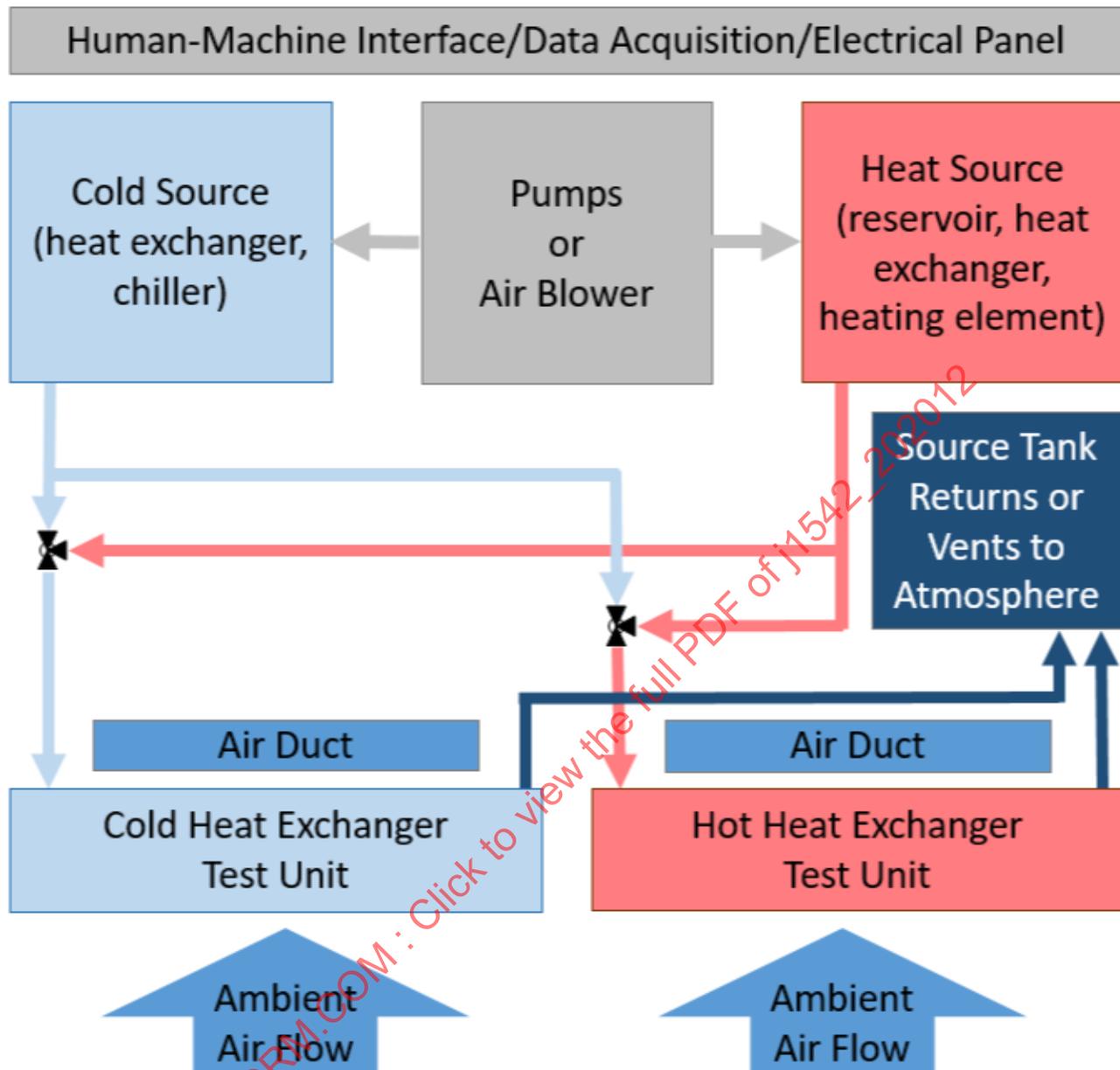
The test facility should provide a system that provides a source of “hot” and “cold” process fluids that are:

- 4.1 Of the type used in the application, or acceptable substitute.
- 4.2 Supplied at the specified temperature(s) and pressure(s), as agreed.
- 4.3 Supplied at the specified fluid flow rate range, as agreed.

The system may include:

- 4.4 Safety features as specified by regulatory codes and common practices, such as pressure relief, automatic shutdown in case of fluid leaks, and an enclosure to contain fluids.
- 4.5 Automated data logging and cycle counting.
- 4.6 Filters to maintain fluid quality.

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**Figure 1 - Typical thermal cycle test system**

## 5. TESTING

- 5.1 Prior to starting test, check heat exchanger for integrity. This is generally a leak test. For charge air coolers, use the methods described in SAE J1726 to verify that leakage does not exceed acceptable levels.
- 5.2 Install test heat exchanger(s) as specified by the vehicle manufacturer and the heat exchanger supplier (orientation and support as in service, if possible) in a safe manner. It is very important that the heat exchanger mounting hardware and method replicate that intended to be used in the production application. A test setup that does not constrain the heat exchanger as installed can result in unintended stresses that may lead to a non-representative and possibly premature failure.

- 5.3 Set up control system to obtain specified cycle (see Figure 2 for typical thermal cycle for reference).
- 5.3.1 Hot temperature is specified based on specific application and is to be at least equal to normal operating conditions. The system shall be capable of maintaining this temperature.
- 5.3.2 Temperature differential (hot cycle temperature minus cold cycle temperature) is based on the specific application. Temperature differentials in Table 1 are expressed in ranges to include the various applications and OEM specifications, are typically agreed to in accordance with the customer's reliability targets, and should be maintained within  $\pm 6$  °C by controlling either hot or cold source.

**Table 1 - Typical thermal cycle test temperature differential**

Type of Heat Exchanger	Temperature Differential
Radiator (Liquid-to-Air)	80 to 100 °C
Air-Cooled Oil Cooler (Oil-to-Air)	100 to 125 °C
Liquid-Cooled Oil Cooler (Oil-to-Liquid)	50 to 80 °C
Air-Cooled Charge Air Cooler (Air-to-Air)	150 to 250 °C
Liquid-Cooled Charge Air Cooler (Air-to-Liquid)	140 to 200 °C
Exhaust Gas Recirculation Cooler (Air-to-Liquid)	500 to 800 °C

- 5.3.3 Cold temperature is hot temperature minus temperature differential.
- 5.3.4 The test cycle and its segments are based on specific application and are typically measured in seconds. One cycle consists of a heating segment and a cooling segment. A segment includes the ramp time to reach a specified temperature and the hold time at that temperature; see Figure 2. Ramp rates will vary depending on test media, test equipment, flow rates, and test method. Test specifications should include tolerances allowed for hold times, hold temperatures, and ramp rates.
- 5.3.5 Test ambient temperature is to be specified based on the application. Test specifications may or may not require circulation of the cold media (air for an air-cooled heat exchanger, or liquid on a liquid-cooled heat exchanger, etc.) to simulate specific operating conditions such as grille shutters or driving through a tunnel, maximize thermal loading, expedite testing, and/or to ensure compliance with outlet temperature targets.
- 5.3.6 Nominal pressures and pressure ranges observed during the test should be recorded and maintained.
- 5.4 Test duration cycle count varies widely, depending on application and heat exchanger type. At minimum, the thermal cycle test should be run to a target number of cycles based either on a pre-determined specification or the life of an existing, comparable heat exchanger. Testing to failure beyond the target cycle count can add value to the results by providing data to estimate life of the heat exchanger in the application, correlate to simulation (FEA), and identify potential design improvements to further extend life. Instrumenting and measuring temperatures, pressures, flows, etc., of heat exchangers in application during a typical duty cycle combined with expected product life in the vehicle/machine can provide the means to determine test duration cycle count. The typical duty cycle should incorporate vehicle/machine loading and operating conditions in both hot summer and cold winter operating environments. Typical on-highway vehicle duty cycle can include cold startup, city traffic, highway, hill climb, rolling hills, idling, hot soak, and cool down. Typical off-highway machine duty cycle incorporating conditions for a typical workday covering all primary working modes can include traveling, digging, plowing, grading, truck loading, etc. Test duration cycle count can be determined by extrapolating out the resulting cycle peak amplitudes and frequency over the expected product life, applying safety factors as desired.
- 5.5 Remove and check heat exchanger(s) for leaks and structural damage.