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**Laboratory Testing of
Vehicle and Industrial
Heat Exchangers for
Thermal Cycle
Durability**

SAE Recommended Practice
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LABORATORY TESTING OF
VEHICLE AND INDUSTRIAL HEAT EXCHANGERS FOR
THERMAL CYCLE DURABILITY

1. PURPOSE:

This recommended practice is to provide a test guideline for determining the durability of a heat exchanger under thermal cycle conditions.

2. SCOPE:

This 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. This document outlines the tests to determine durability characteristics of the heat exchanger under thermal cycling.

3. OBJECTIVE:

To verify compliance with established criteria that insures durability in a specific application. This document describes a system to thermally induce stresses into a heat exchanger at specified rates and temperatures. The process is accomplished by heating and cooling the unit in a specified manner.

4. FACILITY REQUIREMENT:

The facility should provide the following as required:

- 4.1 Source of "HOT" fluid capable of delivering the fluid to the test unit at specified temperature and pressure.
- 4.2 Source of "COLD" fluid capable of delivering the fluid to the test unit at specified temperature and pressure.
- 4.3 Compressed air at specified pressure and temperature.
 - 4.3.1 Charge air cooler test media

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- 4.3.2 Determination of product integrity
- 4.3.3 Evacuation of steam condensate after heating cycle if required
- 4.4 Means of moving these fluids to and from the test unit in a specified manner.
- 4.5 Means of checking heat exchanger integrity.
- 4.6 A control system adequate to control the thermal cycle as specified. It may include the following:

Flow measuring devices
 Pressure gauges
 Pressure switches
 Fluid filters
 Temperature indicators
 Pressure regulators for each fluid
 Relief and back pressure regulators
 Automatic emergency shut-downs
 Electrical relays, timers, switches, indicator lights, and related items as required
 Thermal cycle counters
 Safety features as specified by regulatory codes and common practices
 Heaters and controls
 Automatic data logging equipment

(See Fig. 1 for typical control system for reference.)

5. TESTING:

- 5.1 Check heat exchanger for integrity.
- 5.2 Install test unit as specified (orientation as in service, if possible) in a safe manner.
- 5.3 Set up control system to obtain specified cycle (see Fig. 2 for typical thermal cycle).

5.3.1 Typical Thermal Cycle Test Temperature Differential:

<u>Type of Heat Exchanger</u>	<u>Temperature Differential</u>
Radiator (Liquid-to-Air)	80°C (144°F)
Air Cooled Oil Cooler (Oil-to-Air)	110°C (198°F)
Liquid Cooled Oil Cooler (Oil-to-Liquid)	110°C (198°F)
Air Cooled Charge Air Cooler (Air-to-Air)	140°C (252°F)
Liquid Cooled Charge Air Cooler (Air-to-Liquid)	140°C (252°F)

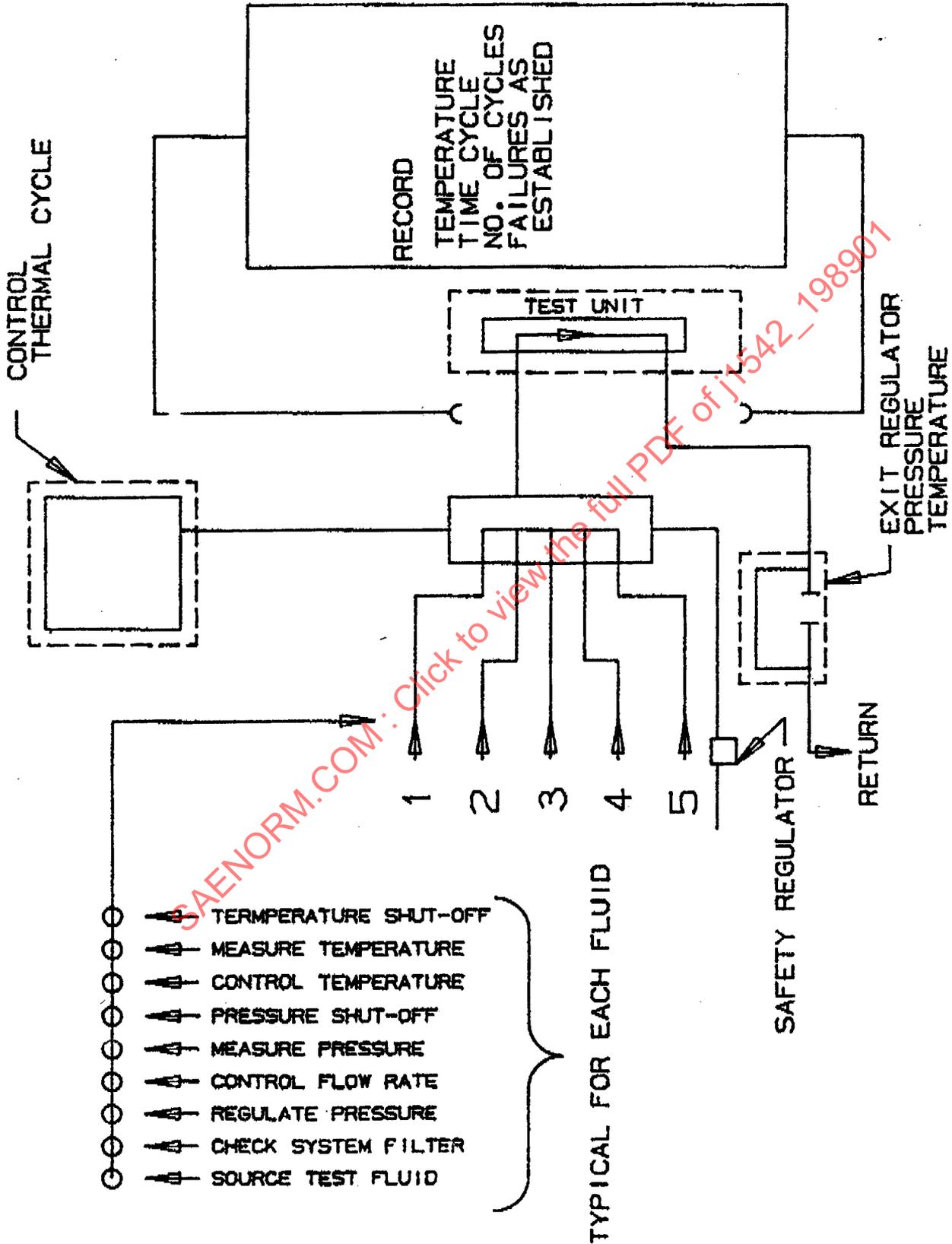
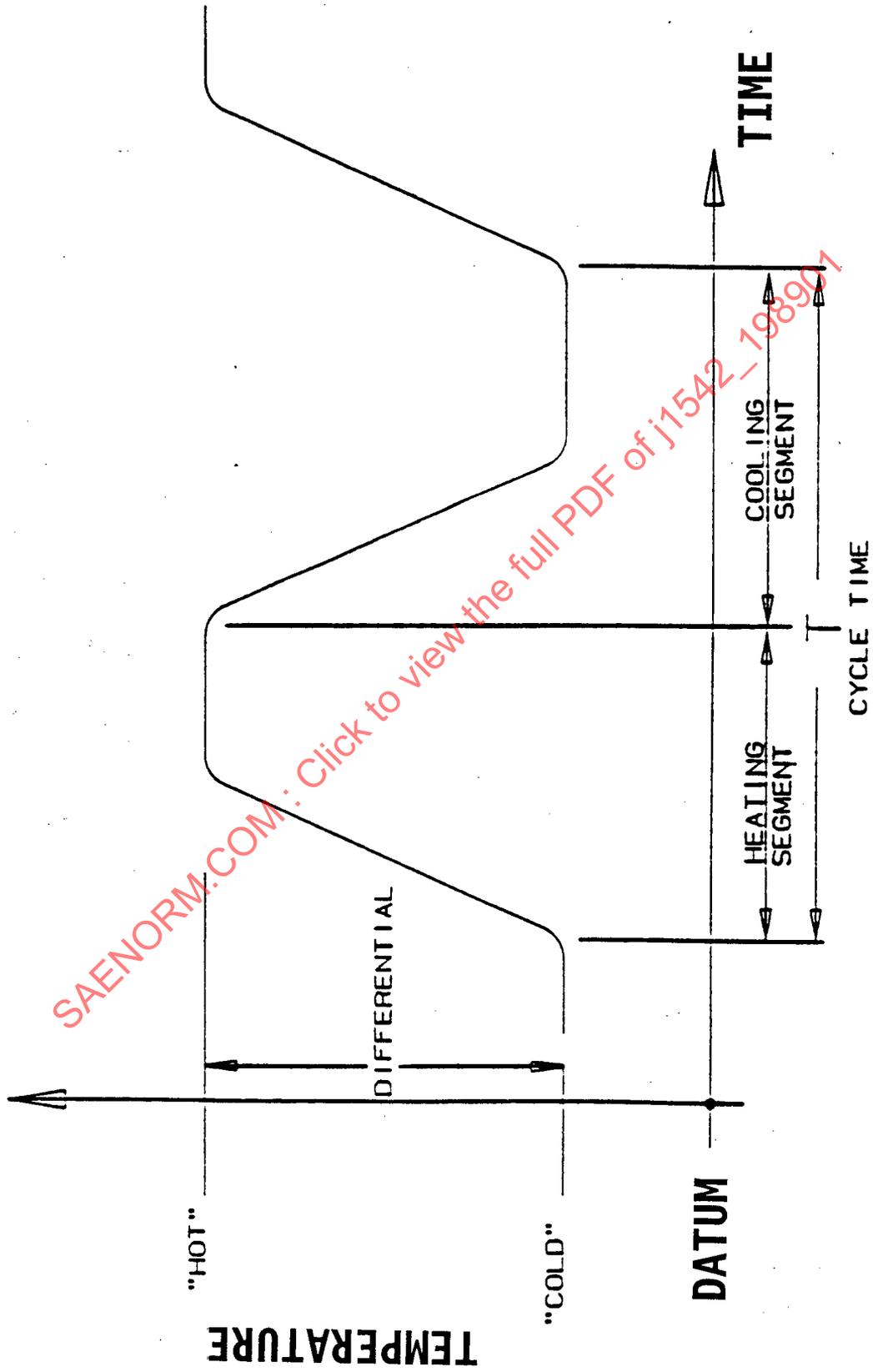


FIGURE 1 - Typical Control System



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FIGURE 2 - Typical Thermal Cycle

- 5.3.2 "HOT" temperature is specified based on specific application. This temperature to be at least equal to normal operating conditions. The system shall be capable of maintaining this temperature.
- 5.3.3 "HOT-COLD" test temperature differential is based on individual application. A controlled temperature should be maintained within $\pm 6^{\circ}\text{C}$ ($\pm 11^{\circ}\text{F}$) by controlling either hot or cold source to take advantage of available resources.
- 5.3.4 "COLD" temperature is established by test temperature differential.
- 5.3.5 The test cycle and its segments are to be based on specific application and are measured in seconds. The transition time from HOT to COLD will vary depending on test media, test equipment, and test method. One cycle consists of a heating segment and a cooling segment. A segment is that time required to bring the outlet temperature to within 5% of inlet temperature. It is desirable to minimize segment duration in order to expedite testing and maximize thermal cycle loading. To this end, and to insure compliance with outlet temperature goals, it may be required to circulate ambient media.
- 5.3.6 Test ambient temperature is to be specified based on specific application.
- 5.3.7 Nominal pressures and pressure ranges observed within the test should be recorded and maintained.
- 5.4 Run test to specified conditions mutually established between supplier and user or documented on part print. Types of tests are as follows:
- 5.4.1 New Heat exchanger (no previous testing) for comparison to previously established criteria
- 5.4.2 Used heat exchanger if specified (document previous history)
- 5.5 Remove and check heat exchanger for leaks and structural damage.
6. TEST DOCUMENTATION:
- 6.1 During and after test, document leakage rate and location of leaks as well as compare to acceptance criteria.
- 6.2 Document the following variables:
- Unit Orientation (Ref. 5.2)
 - Maximum Temperature (Ref. 5.3.2)
 - Temperature Differential (Ref. 5.3.3)
 - Fluid Type: Hot (Ref. 4.1)
Cold (Ref. 4.2)
 - Test Ambient (Ref. 5.3.6)
 - Unit Pressure Range (Ref. 5.3.7)
 - Cycle & Segment Duration (Ref. 5.3.5)
 - Number of Cycles to Completion (Ref. 5.4)

7. This recommended practice is valid for durability comparison of thermal cycle conditions only. Correlation to field results must be developed on individual basis. Other tests affecting heat exchanger durability are SAE J1597 (pressure cycle) and J1598 (vibration). These tests can be run in combination as well as independently.

NOTE: Combination testing may make it difficult to determine cause of failure.

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