AD A093823

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

LEVEL II

B.S.

(12)

(14)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: TOP-2-2-607 ✓	2. GOVT ACCESSION NO.: AD A093823
3. RECIPIENT'S CATALOG NUMBER:	
4. TITLE (and Subtitle): US ARMY TEST AND EVALUATION COMMAND TEST OPERATIONS PROCEDURE (6) COOLING SYSTEMS (AUTOMOTIVE)	5. TYPE OF REPORT & PERIOD COVERED: (9) Final rept. on test operations
	6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s):	8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US ARMY ABERDEEN PROVING GROUND (STEAP-MT-M) ABERDEEN PROVING GROUND, MARYLAND 21005	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: DARCOM-R-310-6
11. CONTROLLING OFFICE NAME AND ADDRESS: US ARMY TEST AND EVALUATION COMMAND (DRSTE-AD-M) ABERDEEN PROVING GROUND, MARYLAND 21005	12. REPORT DATE: (11) 13 Jan 81
	13. NUMBER OF PAGES: 12 (12a) (13)
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

DTIC ELECTE JAN 15 1981 S D E

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Air-Cooled Engines	Liquid-Cooled Engines	Steering Effect
Auxiliary Engine	Mechanical Transmissions	Wide-Open Throttle
Cooling Tests	Operating Gears	
Fluid Transmissions	Part Throttle	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Provides guidance on how to evaluate the cooling characteristics of engine, power train, and auxiliary components when subjected to full- and part-throttle vehicle operations, repeated steering maneuvers, and exposure to extreme environments.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-101
*Test Operations Procedure 2-2-607 13 January 1981
AD No.

COOLING SYSTEMS (AUTOMOTIVE)

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1. SCOPE. The procedures in this TOP describe how to evaluate the cooling characteristics of engine, power-train, and auxiliary components when subjected to full- and part-throttle vehicle operations, repeated steering maneuvers, and exposure to extreme environments. The necessity for engine and power-train cooling arises from inherent mechanical and thermal limitations of vehicle components and their lubricants, heat buildup from sources such as ambient temperature and solar radiation, and increased operational demands resulting from overloads or increasing loads. To prevent deleterious effects to power-producing and power-transmitting components, care must be exercised by the user to see that operating temperatures are maintained within specified limits under all conditions.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Mobile field dynamometer.

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*This TOP supersedes MTP 2-2-607, 7 November 1980.

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Cross-country test courses, as required.

Paved test courses which provide for continued operation at sustained speeds.

2.2 Instrumentation.

ITEM	MAXIMUM ERROR OF MEASUREMENT*
Temperature transducers and recording systems	±1°C (±2°F)
Pressure-measuring devices	±1% of full scale range
Tachometers (engine and wheel or sprocket speeds)	±0.5% of full scale range
Vehicle speed-measuring device	±0.2 km/hr (±0.2 mph)
Force-measuring device	±0.5% of full scale range
Air flow indicators	±10% of reading
Meteorological equipment	Ambient air temperature to ±1°C (±2°F) Relative humidity to ±3% Atmospheric pressure to ±0.3 MB (±0.01 in. Hg) Wind speed to ±1.5 knots Wind direction to ±3 degrees Solar radiation to ±4% of full scale

3. PREPARATIONS FOR TESTS.

3.1. Vehicle Identification. Record the following:

a. Vehicle model, serial number, and manufacturer.

b. Vehicle engine model, serial number, manufacturer, and maximum operating temperature (engine oil and coolant or cylinder head).

c. Vehicle transmission model, serial number, manufacturer, and maximum operating temperature.

d. Maximum operating temperatures of other gearboxes.

e. Gear ratios of all gearboxes.

*Values may be assumed to represent ±2 standard deviations except where indicated; thus the stated tolerances should not be exceeded in more than 1 measurement out of 20.

f. Sprocket rolling distance.

g. Vehicle cooling requirements per vehicle specifications, materiel need, etc.

3.2 Vehicle Preparation.

3.2.1 Method.

a. Insure that the vehicle has been subject to the applicable portions of TOP 2-2-505 prior to performing tests.

b. Perform maintenance and servicing to insure that the vehicle is in condition for optimum performance. Give particular attention to:

(1) Cooling system.

(2) Ignition timing.

(3) Fan belt tension.

(4) Proper lubricants and lubricant levels.

(5) Proper operation of pressure caps, heat riser valves, and any other components that affect engine and power-train component temperature directly.

c. Block open all thermostats to permit maximum coolant or oil flow, and alter thermostatically controlled fans to obtain positive drive, as required.

d. Insure that the vehicle contains the proper fuel per engine specifications, and the appropriate liquid coolant when applicable. Specific guidance in TMs; if none, 50% water/50% ethylene-glycol mixture, except when arctic antifreeze is required.

e. Load noncombat test vehicles to gross weight and combat vehicles to combat weight.

3.2.2 Data Required. Record the fact that actions specified in Paragraph 3.2.1 above have been completed.

3.3 Vehicle Instrumentation.

3.3.1 Method. Instrumentation includes the following:

a. Thermocouples to measure critical engine, power-train and auxiliary component temperatures as required for each specific vehicle to adequately determine and evaluate cooling characteristics.

b. Transducers, pressure gages, and vacuum gages as required.

c. Air flow indicators as required.

d. Engine tachometer.

e. Vehicle speed-measuring device.

f. Sprocket or wheel speed tachometers.

4. TEST CONTROLS. These tests are limited to engines and power trains contained in vehicles. Tests will not be conducted in snow, rain, high wind, or when vehicle power is known to be below normal for reasons other than atmospheric conditions. Since wind effects may vary appreciably with vehicle design because of influences on air flow and recirculation, the limits are based on temperature effect rather than pressure. Tests, therefore, will not be conducted in wind causing a variation greater than 6°C (10°F) in engine oil, 3°C (5°F) in engine coolant, or 30°C (54°F) in average cylinder-head temperatures when the direction of vehicle travel is reversed. Cooling tests are not conducted at ambient temperatures below 21°C (70°F), due to probable extrapolation error. (Extrapolation of results is based on a one-degree rise in component temperature per one-degree rise in ambient temperature.)

5. PERFORMANCE TESTS.

5.1 Wide-Open-Throttle Cooling Tests (Full Load).

a. Method.

(1) Use a mobile field dynamometer and its related equipment to supply a full-load condition to the vehicle under test.

(2) Operate the vehicle at full throttle over a straight, approximately level, paved road.

b. Data Required. Record applicable data in Paragraph 5.1.5.

5.1.1 Vehicles with Liquid-Cooled or Air-Cooled Engines and Mechanical Transmissions (Transmission in Lowest Operating Gear).

a. Method.

(1) Place the transmission in the lowest operating gear in which the vehicle has sufficient traction.

(2) Operate the vehicle at an engine speed which provides maximum engine torque output until all component temperatures stabilize at or below the critical limits specified for components. If a critical temperature is experienced, increase vehicle speed (decrease drawbar loading).

(3) Repeat above test at maximum engine power or at maximum engine speed (governor interference must be eliminated).

(4) Additional tests may be conducted at speeds between those obtained in (2) and (3) above to predict cooling characteristics in higher ambient temperatures up to 49°C (120°F), or as specified in the equipment specification.

(5) Data obtained after temperature stabilization must be derived from equal operational time in both directions to minimize wind effects.

b. Data Required. Record the applicable data requirements of Paragraph 5.1.5.

5.1.2 Vehicles with Liquid-Cooled or Air-Cooled Engines and Mechanical Transmissions (Transmission in Highest Operating Gear).

a. Method.

(1) Place the transmission in the highest gear.

(2) Operate the vehicle at the maximum vehicle/engine speed limited by power, without the dynamometer, until the power-train component temperatures stabilize or exceed specified limits.

(3) Obtain equal amount of data with the vehicle traveling in each direction.

b. Data Required. Record the applicable data requirements of Paragraph 5.1.5, vehicle speed and engine speed.

5.1.3 Vehicles with Liquid-Cooled or Air-Cooled Engines and Fluid Transmissions (Transmission in Lowest Operating Range).

a. Method.

(1) Place the transmission in the lowest operating range in which the vehicle has sufficient traction.

(2) Operate the vehicle at maximum torque or lowest converter speed ratio that will permit component temperatures to stabilize within critical limits in the prevailing ambient temperature.

(3) Determine the converter speed ratio where components should cool in specified maximum, ambient temperature (by extrapolation of temperatures).

(4) Repeat the test at maximum engine power.

(5) Repeat the test at a minimum of two other speeds between maximum torque (or lowest converter speed ratio) and maximum power to establish component cooling characteristics.

(6) Obtain equal amount of data in each direction of travel.

b. Data Required. Record the data specified in Paragraph 5.1.5.

5.1.4 Vehicles with Liquid-Cooled or Air-Cooled Engines and Fluid Transmissions (Transmission in Highest Operating Range).

a. Method.

(1) Place the transmission in its highest range.

(2) Operate the vehicle at maximum vehicle/engine speed limited by power, without the dynamometer, until the power-train component temperatures stabilize.

(3) Obtain equal amount of data in each direction of travel.

b. Data Required. Record the applicable data requirements of Paragraph 5.1.5, vehicle speed and engine speed.

5.1.5 Data Required. Record the following during all full-throttle cooling tests:

a. Component temperatures, pressures, and cooling air flow rates directly pertinent to engine and power-train cooling characteristics.

b. Drawbar pull, engine speed and vehicle speed.

c. Meteorological data (ambient temperature, wind speed, wind direction, and solar radiation).

5.2 Part-Throttle Cooling Tests (Road Load).

5.2.1 Method.

a. Operate the test vehicle over the test course at one or more sustained operating speeds until the power-train component temperatures stabilize.

b. Obtain equal amount of data in each direction of travel.

5.2.2 Data Required. Record the following for all test vehicles:

a. Component temperatures, pressures, and cooling air flow rates directly pertinent to engine and power-train cooling characteristics.

b. Average vehicle and engine speeds.

c. Meteorological data.

5.3 Auxiliary Engine Tests. 1/

5.3.1 Method.

a. Determine the cooling characteristics of auxiliary engines.

b. Attach a load bank to the auxiliary engine, and subject it to tests with the main engine operating.

c. Operate the vehicle over a paved highway at maximum engine torque output until a critical component temperature exceeds established limitations. Record data in Paragraph 5.3.2a(5) through 5.3.2a(13).

d. Operate the auxiliary engine at 75% of its rated load until its critical component temperature stabilizes and record data as prescribed in 5.3.2b.

e. Operate the auxiliary engine at 90% of its rated load until its critical component temperature stabilizes and record data as prescribed in 5.3.2b.

f. Operate the auxiliary engine at 100% of its load until its critical component temperature stabilizes and record data as prescribed in 5.3.2b.

5.3.2 Data Required.

a. Record the following after step 5.3.1c:

(1) Location of the auxiliary engine.

(2) Auxiliary engine model, serial number, and manufacturer.

(3) Auxiliary engine maximum allowable temperature.

(4) Auxiliary engine rated load.

(5) Vehicle transmission position.

(6) Meteorological data.

(7) Vehicle direction.

1/ This subtest is not essential or relevant to every test program, but may be conducted at the discretion of the evaluator.

(8) Air induction through the vehicle engine compartment.

(9) Air induction through the turret, if applicable.

(10) Vehicle engine oil pressure.

(11) Engine speed.

(12) Vehicle speed.

(13) Air temperature around the auxiliary engine prior to operating the auxiliary engine.

b. Record the following:

(1) Auxiliary engine critical component stabilized temperature.

(2) Vehicle critical component temperatures.

5.4 Temperature Rise from Steering (Tracked Vehicles). 1/

5.4.1 Method. Determine the effect of transmission-controlled steering systems (track laying), when applicable, as follows:

a. Prepare the vehicle so that it is instrumented and loaded as stated in Paragraph 5.2.

b. Operate the test vehicle over a defined test course, requiring frequent steering maneuvers, at maximum safe operating speed.

c. Operate the vehicle a sufficient period of time to determine whether critical component temperatures exceed limitations.

5.4.2 Data Required. Record the following:

a. Meteorological data.

b. Component temperatures, pressures, and air flow rates pertinent to evaluation of differential steering effects.

c. Average vehicle speed.

d. Average engine speed.

5.5 Hot-Dry Temperature Tests. Test the vehicle-engine combination in accordance with TOP/MTP 2-4-001 and Paragraphs 5.1 and 5.2 of this TOP as applicable at an ambient air temperature as close to +49°C (+120°F), or as otherwise specified.

6. DATA REDUCTION AND PRESENTATION.

6.1 Full-Throttle and Part-Throttle Cooling Tests. Data shall be presented in tabular and/or graphic form (typical graphs are shown in Figures 1 and 2). Average stabilized temperatures are presented for each operational condition in the prevailing ambient, and these temperatures are also extrapolated to the specified maximum ambient temperature.

The apparent effects of auxiliary engine, differential steering, etc., upon the vehicle engine cooling systems shall be summarized.

6.2 Auxiliary Engine Data. Data shall be summarized to indicate the effect of the main engine and heated compartments upon the auxiliary engine cooling ability under various loads.

Vehicle:

Engine Model:

Transmission Model:

Gear Range:

Ambient Temperature:

Vehicle Weight:

Date(s) of Test:

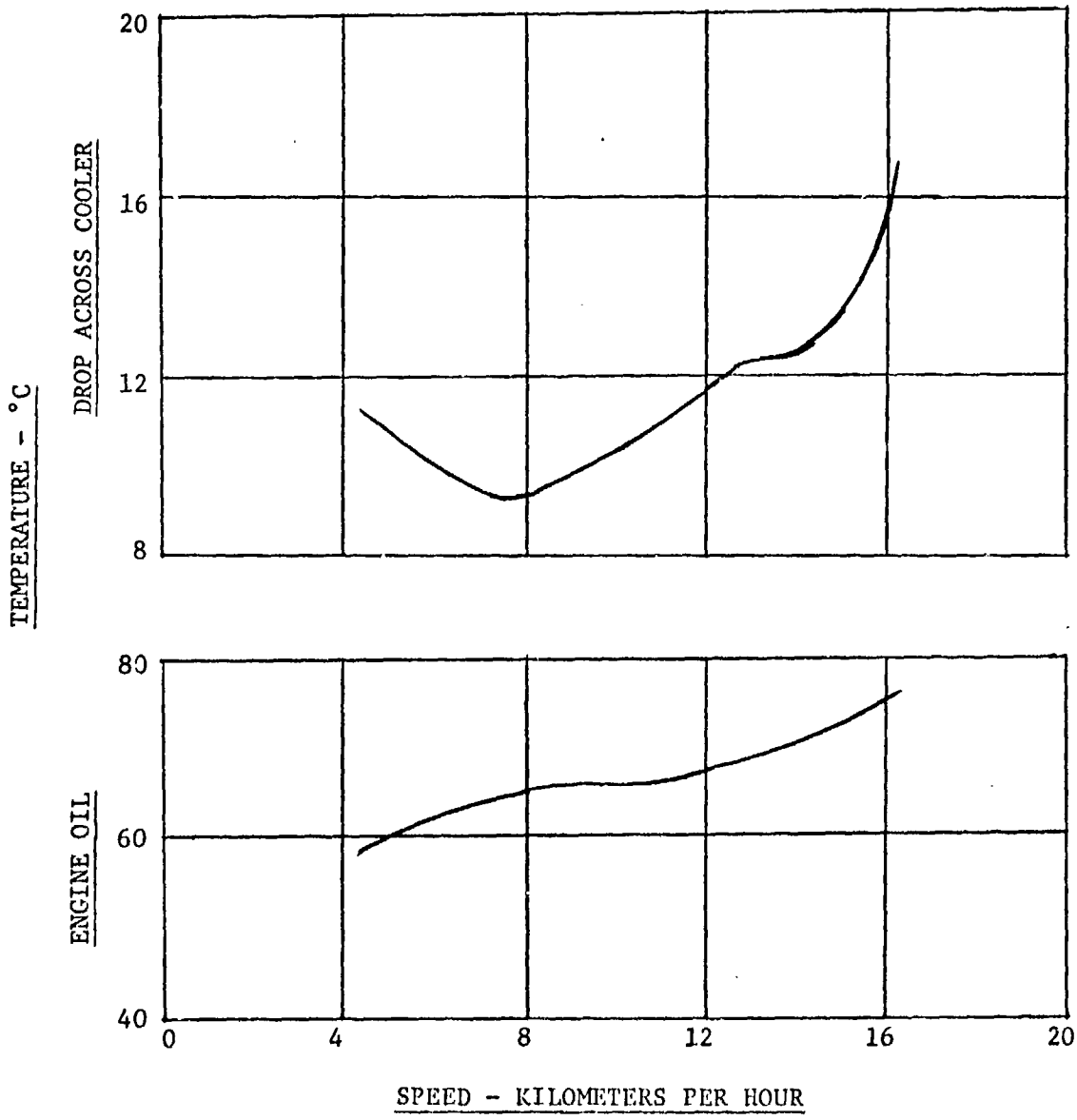


Figure 1. Engine Oil Temperature Characteristics During Full-Throttle Operation.

Vehicle:

Engine Model:

Transmission Model:

Gear Range:

Ambient Temperature:

Vehicle Weight:

Date(s) of Test:

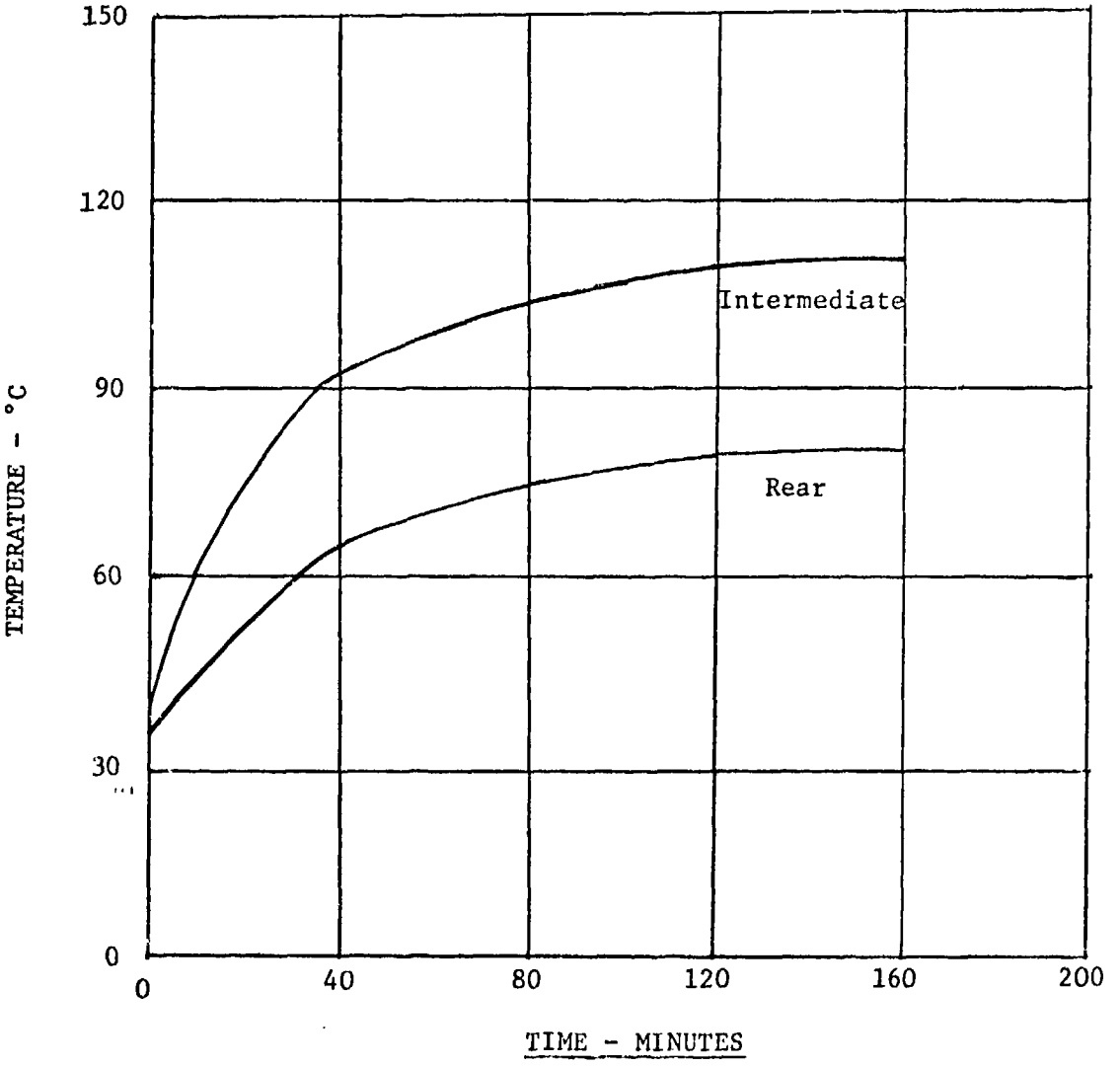


Figure 2. Differential Oil Temperature Rise Characteristics During Part-Throttle Operation.

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