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

This TOP provides an overview of desert environmental testing required for evaluation of the fuel vapor handling capability of wheeled and tracked vehicles having gasoline powered internal combustion engines.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-101 15 January 1982
Test Operation Procedure 2-2-539
AD No.

WHEELED AND TRACKED VEHICLE FUEL VAPOR HANDLING CAPABILITY

PARA NO.

1. SCOPE. This ~~TOP~~ covers a field performance test: the fuel vapor handling capability of wheeled and tracked vehicles. This test is particularly appropriate for desert environmental testing of vehicles having gasoline powered internal combustion engines which have low or non-pressurized fuel systems. At low pressures and high temperatures, fuel can vaporize in the fuel system and potentially immobilize the vehicle.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Item	Characteristic	Accuracy or Minimum Acceptable
Fuel blending facility	Blend and dispense two fuel stocks in several volumetric ratios evenly spaced between 0 and 100 percent and also deliver both of the fuel stocks not blended with the other	
	Measure total fuel delivered	$9.8 \times 10^{-5} m^3$ in $1.89 \times 10^{-2} m^3$ at $6.31 \times 10^{-5} m^3/s$ (6 $in.^3$ in 5 gal. at 1 gpm)
Fuel cold storage facility	Store sample containers of fuel at temperatures of 4°C to 10°C	

Item	Characteristic	Accuracy or Minimum Acceptable
Soak shelter	Four-sided inclosure that will open at each end to allow the vehicle to be driven in and out of it. Sides extend from ground surface up to the maximum vehicle height.	
Paved test course	A level, straight, and smooth paved surface with a turn-around at each end	Less than 1 percent grade
	Grade, 1 percent maximum	
Dry wash	Loose, deep mixture of course gravel and sand	
Highway test course, mountain grade	Paved surface	
	Length - 10 miles Grade, averaged, not less than 5 percent.	Not less than 5 percent grade

2.2 Instrumentation.

Characteristic	Accuracy
Time	±0.5 second or ±2 percent of the true value, whichever is larger
Road speed	0-50 km/h, ±0.2 km/h 0-100 km/h, ±1.0 km-h 0-200 km/h, ±2.0 km/h
Engine speed	0-3000 rpm, ±5 rpm 0-6000 rpm, ±10 rpm
Pressure	±4% full range at any value
Dynamometer load measurement	±2%
Reid vapor pressure (Rvp) apparatus	ASTM D 323 (Ref 2)*
Vapor/liquid ratio (V/L) apparatus	ASTM D 2533 (Ref 2)

*Number match reference numbers in Appendix C.

Characteristic	Accuracy
Oscillograph or data recorder	Commensurate with the above
Weight measurement	±5%
Meteorological conditions	
Ambient temperature	±3°C
Relative humidity	±2%
Wind speed	±1 mph
Wind direction	±10°
Barometric pressure	±4 millibars
Acceleration	±0.1 meter/sec^2
Slope indicator	±2°
Accrued mileage	±10%
Temperature	±3°C

3. PREPARATION FOR TEST.

3.1 Test Procedure Selection.

a. Full-Load (Dynamometer Course)

(1) Applicability: Medium and heavy tactical vehicles and combat vehicles.

(2) Generally, most severe

(3) Test conditions easily reproduced

(4) Expensive when several fuels are required to define characteristics

(5) Not usable if vehicle cooling capacity is not adequate

b. Road-Load, Cross-Country (dry wash)

(1) Applicability: Cross-country vehicles not designed for continuous full-load duty and for confirmatory checks

(2) Severe normal service (with towed load), intermediate load

(3) Time consuming if several fuels required to define characteristics

(4) Possible variation in performance from accumulation of dust and debris

c. Road-Load, Highway (Death Valley or Oatman-Topock)

(1) Applicability: Highway vehicles not designed for continuous full-load duty

(2) Moderate to severe load condition with towed load

(3) Requires moving personnel, equipment and fuels to test site

d. Road-Load, Acceleration (CRC)

(1) Applicability: Light tactical vehicles and commercial vehicles

(2) Comparatively light load cycle (lower temperatures)

(3) Less time consuming and less expensive

3.2 Facilities. Assure that all facilities are available for use and in proper working order.

3.3 Equipment.

a. Specific checks to be made on test vehicle:

(1) Engine ignition timing as specified (reset if necessary)

(2) Spark plugs in good condition (replace if necessary)

(3) Coolant thermostat operates correctly

(4) Throttle can be opened to maximum

(5) Proper type and amount of lubricants and coolant

(6) Correct idle speed

(7) Normal power output

(8) Automatic transmission shift points correct

(9) Vehicle braking is adequate

(10) Correct tire pressure or track tension

(11) Normal starting time and speed

(12) Fuel System:

(a) No fuel leaks

(b) Vents operate properly

(c) Carburetor properly adjusted and the needle valves set properly

(d) Clean fuel filters

(e) Proper fuel pump pressure or suction

(f) Clean fuel tanks and lines

(g) Fuel lines properly routed and not damaged

(h) Instrumentation does not obstruct or agitate fuel flow

b. Fuel Requirements:

(1) Low Rvp and high Rvp fuels

(2) Clean containers for blended fuel

(3) Test fuel sample containers

(4) Fuel transfer pump

(5) Siphon apparatus to obtain samples

(6) Waste fuel containers

(7) Ice chest or other means to refrigerate the fuel samples

(8) Tags for marking samples

c. Manufacturer's or technical manuals recommendations:

(1) Starting procedure

(2) Maximum permissible cranking time

3.4 Instrumentation.

a. Thermocouple Locations:

(1) Fuel tank at fuel line

(2) Fuel pump inlet and outlet

(3) Fuel at carburetor inlet

(4) Carburetor inlet air

(5) Engine oil sump

(6) Coolant temperature (for liquid-cooled engines)

(7) Spark plug temperature (for air-cooled engines)

b. Pressure Transducer Locations:

(1) Fuel tank outlet

(2) Fuel pump inlet and outlet

(3) Carburetor inlet

c. Road Speed Transducer

d. Engine Speed Transducer

e. Elapsed Time Transducer

f. Drawbar Pull Transducer

3.5 Data Required.

a. Test procedure selected

b. Method of the particular test procedure

c. Results of test vehicle checks, 3.3

d. Meteorological data

(1) Ambient temperature, °C

(2) Relative humidity, %

(3) Wind velocity, km/h

(4) Wind direction, degrees

(5) Barometric pressure, millibars

e. Thermocouple locations

f. Pressure locations

g. Instrumentation system accuracies

h. Transducer identification

i. Fuel system schematic

j. Vapor emission control techniques or carburetor vent conditions which may cause problems

k. For nongasoline powered vehicle, determine which specified fuel has* the greatest volatility (lowest temperature for a vapor/liquid ratio of 20) and use this fuel as the test fuel.

l. For gasoline powered engines, determine the preliminary gasoline vapor handling capacity as follows:

(1) Determine the Rvp of high and low Rvp base stock fuels and of several blends of the two stocks

(2) Determine the temperatures for a vapor/liquid ratio (V/L) of 10, 20, and 30 of the base stocks and for blends of the base stocks

(3) Graph V/L vs temperature for each base stock fuel and blend (Fig. 1)

(4) Assume that the fuel system temperatures will vary one degree for each degree of change of ambient temperature

(5) Assume that the critical V/L limiting the performance of most vehicles is about 20:1 (V/L = 20)

(6) Select a test fuel blend as follows (see Table 1 for definitions):

(a) Enter the V/L versus fuel temperature chart (Step (3) above) at a temperature of T_1 ($T_1 = T_e + T_d - T_{fs}$).

(b) Select the next higher Rvp blend of fuel along the V/L = 20 line (corresponds to a temperature of T_o) to use as a test fuel.*

(c) Compute the ambient temperature (T_t) at which to conduct the fuel vapor handling test where $T_t = T_o + T_d - T_{fs}$.

(d) Conduct test within -3°C to 2°C of T_t.

*The use of V/L = 20 corresponds to commercial practice.

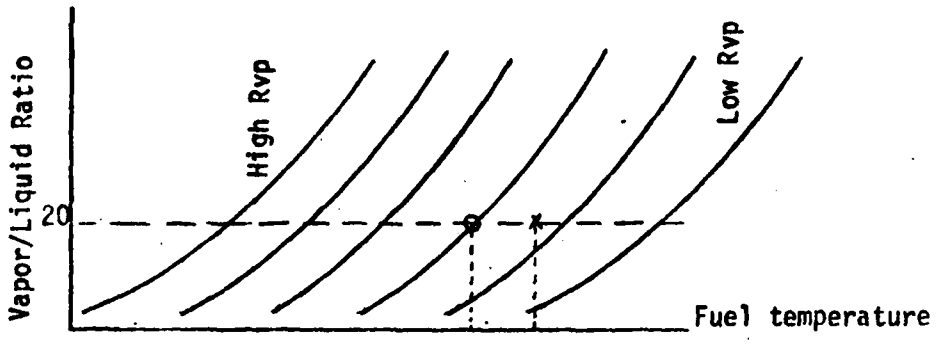

FIGURE 1. Representative chart of vapor/liquid ratio versus fuel temperature

TABLE 1. Definitions of Temperature Symbols

Term	Definition
T_e	Expected ambient temperature during the fuel vapor handling test
T_d	Maximum ambient temperature that the vehicle is designed to operate in (use 51.5°C (125°F) if not specified)
T_{fs}	Fuel specification minimum temperature for V/L of 20
T_l	Calculated fuel temperature used to enter V/L vs temperature chart and determine which fuel blend to use during the test
T_o	The temperature at which a blend of fuel has a V/L of 20
T_t	The ambient temperature at which the fuel vapor handling test is to be conducted corresponding to the blend of fuel having a V/L of 20 at T_o

4. TEST CONTROLS.

4.1 Environmental Factors.

a. Wind Speed: Average ≤3 km/h. Gusts ≤20 km/h

b. Ambient Temperature: -3°C to +2°C of test temperature (T_t)

4.2 Other Factors.

a. All equipment checks (para 3.3) were satisfactory or adjustments were made

b. Instrumentation system is calibrated under test conditions

c. Specify shift points during acceleration for manual shift transmissions

d. Instrumentation list specifically states the installed location

e. Determine the item-particular controls critical to achieving accurate and reproducible test results

5. PERFORMANCE TESTS.

5.1 Full-Load.

5.1.1 Method (see Table 2).

NOTE: This full-throttle, full-load test is most suitable for medium and heavy tactical vehicles and all combat vehicles.

a. Attach a field dynamometer to the test vehicle.

b. Drain the fuel tank and fill it to 80 percent capacity with the test fuel that has been soaked at ambient air conditions so its temperature is close to ambient temperature.

NOTE: For gasoline-powered test items, use a fuel blended to simulate, at the forecast ambient temperature, the volatility at design temperature of the most volatile specification fuel. For other than gasoline-fueled vehicles, use specification fuel of the highest volatility, i.e. lowest temperature for V/L = 20.

c. Collect a tank sample of this fuel just prior to beginning testing and label the sample "SAMPLE 1." Refrigerate the sample for subsequent analysis.

d. Perform a warm-up cycle as follows:

(1) Select a gear range that will provide maximum heat rejection and a road speed of less than 24 km/h under maximum rated load applied by the dynamometer. Record the gear range and speed obtained.

(2) Operate the test vehicle on a level paved course at full throttle under full load until all temperatures are stabilized or the vehicle has been operated for a maximum of 30 minutes. Record the temperature and pressure of all instrumented points.

(3) Drive the test vehicle into a "soak" shelter.

(4) Idle the test vehicle for 2 minutes and shut down the engine.

(5) Collect a fuel sample, "SAMPLE 2," from the fuel tank when the gasoline at instrumented locations reaches maximum temperature or the vehicle engine has been shut down for 15 minutes, whichever is longer. Record temperatures of all instrumented points and shut-down time.

TABLE 3. Fuel Vapor Lock Test Methods Summary

TEST METHODS Applicability	FULL-THROTTLE FULL-LOAD Medium and heavy tactical vehicles Combat vehicles	ROAD-LOAD, CROSS-COUNTRY Cross-country vehicles not designed for continuous full-load duty. Confirmatory checks.	ROAD-LOAD, HIGHWAY Highway vehicles not designed for continuous full-load duty. Confirmatory checks.	ROAD-LOAD, ACCELERATION (CRC) Tactical vehicles. Commercial vehicles.
TEST SITE Facilities	DYNAMOMETER COURSE Field dynamometer	VAPOR LOCK GULCH - SAND DUNES Towed load if appropriate	DEATH VALLEY OR OATMAN-TOPOCK Rated towed load if appropriate.	DYNAMOMETER COURSE - PAVED COURSE Soak shelter.
PREPARATION Fuel Blending	Blend fuel to simulate maximum fuel allowable under specification at the ambient temperature predicted for the period of test.	Normal Test. Same as Full-Throttle, Full-Load test. Confirmatory Check. Same as Road-Load, Highway test.	Blend fuel with Rvp equal to maximum allowable order specification and seal in 55-gallon drums.	Fuel blended in nine increments from 6 to 14 psig Rvp. Base line run on low vapor pressure fuel using test cycle procedure to determine base line acceleration time. Determination of most severe soak sequence using test cycle procedure to select idle-soak or shutdown-soak cycle.
Fueling	Fill fuel tank to 80 percent with test fuel.	Fill fuel tank to 80 percent with test fuel.	Fill fuel tank to normal full level from drums with transfer pump.	Fill to 20 percent tank capacity with fuel blends of increasing vapor pressure.
Initial Fuel Sample	Sample No. 1 - Tank initial (pump) sample.	Analysis of performance based on this sample.		
LOAD CONDITION SELECTION	Select a gear range that will provide: (1) Maximum heat rejection (2) Road speed of less than 15 mph under full load	Select a gear which will provide maximum speed on the terrain selected.	Select gears that will provide maximum speed on the grade and best acceleration.	Select gears, initial and final acceleration speeds which will provide: (1) Minimum number of shifts over a time period sufficiently long (not less than 10 seconds) (2) Provide the initial speed in 5 seconds (3) Cover a large part of the vehicle speed range
FIRST TEST CYCLE STEP 1: Warm-up	A. Operate until temperatures stabilize but not to exceed 30 minutes and stop vehicle.	A. Operate approximately 40 minutes and stop vehicle.	A. Operate minimum of 1 hour before fueling. At Death Valley, operate on Daylight Pass to 2000 feet elevation and stop. At Oatman-Topock, operate to 9 miles from Topock end and stop.	A. 20-Minute warm-up period at maximum sustained vehicle speed (reduced to one lap between idle-shutdown checks). Return to blending area and park vehicle in soak shelter.
STEP 2: Soak	A. Idle 2 minutes and shut down until fuel temperature reaches maximum or for 15 minutes.	A. Idle for 2 minutes and shut down until fuel temperature reaches maximum or for 15 minutes.	A. Idle for 2 minutes and shut down until fuel temperature reaches maximum or for 15 minutes.	A. Stop engine and either idle or shut down for soak, whichever was most severe.
STEP 3. Sample Fuel	Sample No. 2			
STEP 4. Restart	Record starting attempts and starting time			
STEP 5. Load	A. Accelerate vehicle with no drawbar load to speed and gear range desired and apply drawbar load. Observe drawbar load. Operate until temperature stabilizes but not to exceed 20 minutes.	A. Accelerate at wide open throttle at maximum speed. Operate 40 minutes.	A. Accelerate at wide open throttle and operate to summit.	A. Accelerate to initial speed at part throttle and then at wide open throttle to final speed. Record acceleration times to 25, 50, 75 and 100 percent of acceleration speed range.
SECOND TEST CYCLE STEP 6: Soak	B. Stop and idle engine until temperature reaches maximum but not to exceed 10 minutes.	B. Stop and idle engine until temperature reaches maximum but not to exceed 10 minutes.	B. Stop at summit and idle engine until temperature reaches maximum or for 10 minutes.	B. Change fuels. Stop, drain or pump out fuel. Refill with next blend.
STEP 7: Sample Fuel	Sample No. 3			
STEP 8: Load	B. Accelerate vehicle with no drawbar load to speed and gear range selected and apply drawbar load. Observe drawbar pull. Operate until temperatures stabilize but not to exceed 20 minutes.	B. Accelerate at wide open throttle to maximum speed. Operate 40 minutes.	B. Return to base of hill. Take fuel sample.	B. Repeat warm-up. Follow with Soak, Sample, and Load test sequence.
TEST CYCLE SEQUENCE	Repeat test alternating Cycles A and B until worst soak cycle is determined then continue using worst condition. Continue test until severe vapor lock is experienced, or a minimum of 3 cycles is completed, or fuel is consumed.	Repeat test alternating Cycles A and B until worst condition is determined then continue using worst condition. Continue test until severe vapor lock is experienced, or a minimum of 4 cycles is completed. Add fuel only if required.	Repeat test on same fuel load using sequence B-A. Continue test until fuel is nearly consumed. Alternate A-B sequence until worst condition is determined then continue on worst cycle. Do not add fuel until supply is nearly exhausted.	Continue test cycle on as many blends of fuel as is required to develop a performance curve as limited by: (1) Increase in acceleration of 50 percent (2) Severe vapor lock (3) Vapor pressure of fuel exceeds 9.5 psig, fuel corrected to 120°F.

e. Perform a drawbar cycle as follows:

(1) Restart the engine and record the following:

(a) Time required to restart the engine

(b) Number of attempts required to start the engine

(2) Accelerate the vehicle, in the gear range of Step d(1) with no drawbar load, to the speed of Step d(1).

(3) Apply the drawbar load and record the drawbar pull.

(4) Operate the test vehicle under load until the temperatures stabilize, or a maximum of 20 minutes, whichever is shorter.

(5) Stop the test vehicle in the "soak" shelter and idle the engine until the fuel system temperatures reach maximum or for 10 minutes, whichever is shorter. Record the idling time and temperature and pressure of the instrumented points.

(6) Collect a fuel sample from the fuel tank and label it "SAMPLE 3."

f. Repeat steps (d) and (e) alternately, taking consecutively numbered fuel samples, until the severest cycle is determined. Rate severity of cycles by degree and frequency of symptoms of vaporization of fuel. Symptoms to be rated in order of decreasing importance are:

(1) Stalling or complete inability to start

(2) Overheating

(3) Reduced drawbar pull of 25 percent or more

(4) Severe misfiring or surging (rpm loss greater than 100 rpm)

(5) Difficult starting requiring more than half the manufacturer's recommended maximum cranking time

(6) Bucking or surging

(7) Rough idling

(8) Black exhaust smoke

g. Repeat the severest cycle until one of the following has been achieved:

(1) Complete vapor lock is encountered

(2) A minimum of four cycles has been completed

(3) Test fuel is consumed

5.1.2 Data Required.

a. Meteorological data to include ambient temperature, relative humidity, absolute barometric pressure, wind speed and direction

b. Test fuel used

c. Gear ratio used (2d, 3rd, etc)

d. Cycle number (1, 3, 5, etc)

e. Severity rating (overheating, misfiring, etc)

f. For each warm-up portion of the total cycle:

(1) Warm-up

(a) Vehicle speed

(b) Engine speed

(c) Stabilized temperature at:

1. Fuel at carburetor inlet

2. Fuel tank (at fuel line)

3. Fuel pump inlet and outlet

4. Carburetor inlet air

5. Engine oil sump

6. Coolant temperature (for liquid-cooled engines)

7. Spark plug temperature (for air-cooled engines)

(d) Fuel pressure at:

1. Fuel tank (at fuel line)

2. Carburetor inlet

3. Fuel pump inlet and outlet

(2) Post Idling:

(a) Shutdown time

(b) Maximum fuel temperature achieved (at fuel line)

(c) Temperatures at:

1. Fuel pump inlet

2. Carburetor inlet air

3. Engine oil sump

4. Coolant temperature (for liquid-cooled engines)

5. Spark plug temperature (for air-cooled engines)

g. For each drawbar pull portion of the total cycle:

(1) Time required to start engine, in minutes

(2) Number of starting attempts

(3) For drawbar pull:

(a) Drawbar load

(b) Operating time

(c) Temperatures at:

1. Fuel at carburetor inlet

2. Fuel tank (at fuel line)

3. Fuel pump inlet and outlet

4. Carburetor inlet air

5. Engine oil sump

6. Coolant temperature (for liquid-cooled engines)

7. Spark plug temperature (for air-cooled engines)

(d) Fuel pressure at:

1. Fuel tank (at fuel line)

2. Carburetor inlet

3. Fuel pump inlet and outlet

(3) For idling time:

(a) Idling time

(b) Temperatures at:

1. Fuel at carburetor inlet

2. Fuel tank (at fuel line)

3. Fuel pump inlet and outlet

4. Carburetor inlet air

5. Engine oil sump

6. Coolant temperature (for liquid-cooled engines)

7. Spark plug temperature (for air-cooled engines)

h. For each fuel sample chemical analysis:

(1) Sample number (1, 3, 5, etc)

(2) Temperature at which each fuel sample shows vapor-liquid ratios of:

(a) 10

(b) 20

(c) 30

i. Reason for suspending test (complete vapor lock, out of fuel, etc)

5.2 Cross-Country Test.

5.2.1 Method. (See Table 2)

NOTES: 1. This near-full throttle test is intended for high-mobility vehicles; not intended for continuous, full-load service. It shall be performed in desert terrain appropriate to the intended mission of the vehicle, such as level sand, dry washes, or a desert cross-country course.

2. Test the vehicle with a towed load when appropriate.

a. Drain the fuel tank and fill it to 80 percent capacity with test fuel that has been soaked at ambient air conditions so its temperature is close to ambient temperature.

b. Collect a sample of the test fuel immediately before beginning testing, label it "SAMPLE 1," and refrigerate it for subsequent analysis.

c. Perform a warm-up cycle as follows:

(1) Select a gear range, which will provide maximum speed over the chosen terrain. Record the gear range and type of terrain.

(2) Operate the vehicle at normal speed for 40 minutes, then stop in the "soak" shelter. Record the vehicle speed.

(3) Idle the vehicle for 2 minutes.

(4) Shut down the vehicle until the fuel system temperatures reach a maximum or for 15 minutes, whichever is longer. Record temperature and pressure of the instrumented points and shut down time. Take "SAMPLE 2" and refrigerate.

d. Perform a full-throttle cycle as follows:

(1) Restart the engine and record the following:

(a) Time required to restart the engine

(b) Number of attempts required to start the engine

(2) Accelerate the test vehicle at full-throttle to maximum safe speed, and operate it at maximum safe speed for 40 minutes. Record the maximum safe speed.

(3) Stop the test vehicle in the "soak" shelter and idle the engine until the fuel system temperatures reach maximum or for 10 minutes, whichever is shorter. Record the temperature and pressure of the instrumented points, and the idle time.

(4) Collect a fuel sample from the fuel tank and label it "SAMPLE 3."

e. Repeat Steps (c) and (d) alternately, taking consecutively numbered fuel samples, until the severest cycle, as rated in paragraph 5.1.1f is determined.

f. Repeat the severest cycle until a complete vapor lock has been achieved, or a minimum of four cycles has been completed.

NOTE: Fuel shall be added only to obtain the requirements of Step f.

5.2.2 Data Required.

a. Meteorological data to include ambient temperature, relative humidity, absolute barometric pressure, wind speed and direction

b. Test fuel used

c. Fuel Reid vapor pressure rating and temperature for V/L = 20

d. Gear ratio used

e. Cycle number

f. Type of terrain

g. Severity rating (black smoke, overheating, etc)

h. For each warm-up portion of the total cycle:

(1) Warm-up:

(a) Vehicle speed range

(b) Engine speed range

(2) Post idling:

(a) Shut down time

(b) Temperatures at:

1. Fuel at carburetor inlet
2. Fuel tank (at fuel line)
3. Fuel pump inlet
4. Carburetor inlet air
5. Engine oil sump
6. Coolant temperature (for liquid-cooled engines)
7. Spark plug temperature (for air-cooled engines)

(c) Fuel pressure at:

1. Fuel tank (at fuel line)
2. Carburetor inlet
3. Fuel pump inlet and outlet

i. For full-throttle portion of the total cycle:

(1) Time required to restart engine

(2) Number of attempts required to start engine

(3) Maximum vehicle speed obtained

(4) Idling:

(a) Idling time

(b) Temperatures at:

1. Fuel at carburetor inlet
2. Fuel tank (at fuel line)
3. Fuel pump inlet
4. Carburetor inlet air
5. Engine oil sump
6. Coolant temperature (for liquid-cooled engines)
7. Spark plug temperature (for air-cooled engines)

(c) Fuel pressure at:

1. Fuel tank (at fuel line)
2. Carburetor inlet
3. Fuel pump inlet and outlet

j. For each fuel sample chemical analysis:

(1) Sample number

(2) Temperature at which each fuel sample shows vapor-liquid ratios of 10, 20, and 30.

k. Reason for terminating the test (complete vapor lock, complete four cycles)

5.3 Highway Test.

5.3.1 Method. (See Table 2)

NOTE: This test is intended for vehicles designed for highway use or for tactical trucks. It is performed on steep desert highways such as the Daylight Pass or Oatman-Topock courses established for tests based at the TECOM permanent desert test facility, U.S. Army Yuma Proving Ground, Yuma, Arizona.

a. Operate the test item for a minimum of 1 hour, with its rated towed load, if appropriate. Record the length of operation and presence of load.

b. Drain the fuel tank and fill it to the normal full level with test fuel that has been soaked at ambient air conditions so its temperature is close to ambient temperature.

c. Collect a sample of the test fuel immediately before beginning testing, label it "SAMPLE 1," and refrigerate it for subsequent analysis.

d. Perform a warm-up cycle by operating for a minimum of 16 km.

e. First uphill portion of cycle:

(1) After warm-up, proceed up the hill at a maximum safe speed. Record the gear ranges used for each percent of grade.

(2) Stop the vehicle after proceeding uphill for approximately one-half the length of the course.

(3) Idle the engine for 2 minutes and then shut down the vehicle until the fuel system temperatures are a maximum or for 15 minutes, whichever is first. Record the temperature and pressure of the instrumented points and the shutdown time.

(4) Collect a fuel sample from the fuel tank just before starting the engine, and label it "SAMPLE 2."

f. Second uphill portion of cycle:

(1) Restart the engine and record the following:

(a) Time required to restart the engine

(b) Number of attempts required to start the engine

(2) Accelerate at wide open throttle to the maximum safe speed and operate to near the end of the course

(3) Stop the vehicle and idle the engine until the temperatures reach a maximum, or 10 minutes, whichever is shorter. Record temperatures and pressures.

(4) Take a fuel sample and label it "SAMPLE 3."

(5) Accelerate at wide open throttle to the maximum safe speed and proceed to the end of the course. Return to the base of the hill.

g. Repeat Steps d, e, and f, interchanging Steps e(3) and f(3) and taking consecutively numbered fuel samples until the severest cycle as rated in paragraph 5.1.1f is determined.

h. Repeat the severest cycle until the fuel is nearly consumed. Do not add any fuel to the tank until the tank is nearly empty.

5.3.2 Data Required.

a. Meteorological data to include ambient temperature, relative humidity, absolute barometric pressure, wind speed and direction.

b. Test fuel used

c. Fuel Reid vapor pressure rating and temperature of V/L = 20

d. Cycle number

e. Severity rating (rough idling, bucking or surging, etc)

f. For first uphill portion of the total cycle:

(1) Gear range (2d, 3rd, etc) for each percent of grade

(2) Shutdown time, in minutes

(3) Temperatures at:

(a) Fuel at carburetor inlet

(b) Fuel tank (at fuel line)

(c) Fuel pump inlet and outlet

(d) Carburetor inlet air

(e) Engine oil sump

(f) Coolant temperature (for liquid-cooled engines)

(g) Spark plug temperature (for air-cooled engines)

(4) Fuel pressures at:

(a) Fuel tank (at fuel line)

(b) Carburetor inlet

(c) Fuel pump inlet and outlet

g. For second uphill portion of the total cycle:

(1) Time required to restart the engine

(2) Number of attempts required to restart the engine (1, 3, 5, etc)

(3) Maximum speed obtained and acceleration times

(4) Idling time

(5) Temperatures at:

(a) Fuel at carburetor inlet

(b) Fuel tank (at fuel line)

(c) Fuel pump inlet

(d) Carburetor inlet air

(e) Engine oil sump

(f) Coolant temperature (for liquid-cooled engines)

(g) Spark plug temperature (for air-cooled engines)

(6) Fuel pressure at:

(a) Fuel tank (at fuel line)

(b) Carburetor inlet

(c) Fuel pump inlet and outlet

h. For each fuel sample chemical analysis:

(1) Sample number (1, 3, 5, etc)

(2) Temperature at which each fuel sample shows vapor-liquid ratios of:

(a) 10

(b) 20

(c) 30

5.4 Acceleration Test.

5.4.1 Method. (See Table 2)

NOTES: 1. This road-load test is modeled on the automotive industry standard test of fuel vapor handling capability established by the Coordinating Research Council, Inc., (CRC). This procedure is recommended for measuring the maximum gasoline volatility tolerated by a vehicle and is particularly suitable for use with tactical and commercial type vehicles.

2. The test is performed on a dynamometer course or other level paved desert course provided with a "soak" shelter.

a. Drain the fuel tank and fill it to 20 percent capacity with a specification fuel having the lowest volatility in the range of 41.4 kPa (6 psi) through 96.5 kPa (14 psi) Rvp.

b. Determine a base line for measuring acceleration, under ambient conditions using the fuel blend of Step a as follows:

(1) Determine the vehicle's acceleration to obtain the average speed the test vehicle is capable of reaching in 5 seconds.

(2) Record the following:

(a) Acceleration rate

(b) Vehicle speed

(c) Elapsed time

(3) Repeat Step b for the following speeds:

(a) 25 percent of rated vehicle speed

(b) 50 percent of rated vehicle speed

(c) 75 percent of rated vehicle speed

(d) 100 percent of rated vehicle speed

c. Warm up the test vehicle by operating it for 20 minutes at its maximum sustained road speed, using the fuel blend of Step a. At the completion of the 20 minutes, stop the vehicle in the "soak" shelter.

d. Perform an idle soak cycle as follows:

(1) Idle the engine for 10 minutes in the "soak" shelter

(2) Accelerate the vehicle at part throttle to the 5-second average speed of Step b(1). Record the time required to reach speed.

(3) Accelerate the vehicle at full throttle to 100 percent of its rated speed and record the time required to reach each 25 percent rated speed.

(4) Operate the vehicle for 8 km after leaving the "soak" shelter.

e. Perform a hot-soak cycle as follows:

(1) Stop the vehicle in the "soak" shelter.

(2) Idle the engine for 1 minute, and then shut it off.

(3) Leave the engine off for 10 minutes.

(4) Restart the engine, and record the following:

(a) Time required to start the engine

(b) Number of attempts required to start the engine

(5) Accelerate the vehicle at part throttle to the 5-second average speed of Step b(1). Record the time required to reach speed.

(6) Accelerate the vehicle at full throttle to 100 percent of its rated speed and record the time required to reach its rated speed.

f. Repeat Steps d and e alternately until the severest cycle can be determined as judged by the criteria listed in paragraph 5.1.1f.

g. Repeat the severest cycle

h. Repeat Steps c through g with test fuels having an Rvp of 48.3 kPa (7 psi) through 96.5 kPa (14 psi) in steps of 6.9 kPa (1 psi) until performance is limited by an increase in acceleration time of 50 percent or severe vapor lock occurs.

5.4.2 Data Required.

a. Meteorological data including ambient temperature, relative humidity, absolute barometric pressure, wind speed and direction.

b. For base line measurements:

(1) Specification fuel used

(2) Octane rating (95, 100, etc)

(3) Speed requirements (5 seconds; 25, 50, 75, and 100% maximum)

(4) Average computed acceleration rate, meters/sec^2

(5) Vehicle direction

c. For each total cycle:

(1) Fuel Rvp rating, temperature at V/L = 20 and distillation curve of base stocks

(2) Cycle number

(3) Severity rating (rough idling, black smoke, etc)

(4) Time to obtain 5-second base line speed

(5) Time required to obtain 25, 50, 75, and 100 percent of rated speed or maximum speed obtained if not 100 percent

(6) Time to restart engine

(7) Number of attempts required to restart engine

d. Reason for terminating test (complete vapor lock, acceleration deterioration)

6. DATA REDUCTION AND PRESENTATION.

6.1 Presentation and Reduction.

a. Summary of performance, temperature and pressure

b. Summary of fuel inspection data

c. Performance Chart

(1) Acceleration Test: Curve of acceleration time vs fuel volatility

(2) Other Tests: Include as a minimum the following plotted on an elapsed time base:

(a) Ambient temperature

(b) Road speed

(c) Engine speed

(d) Critical fuel temperature(s)

(e) Critical fuel pressure(s)

(f) Engine temperature

(g) Drawbar pull (full-load test only)

(h) Reid vapor pressure of fuel samples

(i) Temperature for V/L = 20 of fuel samples

(j) Notes on performance observed

6.2 Analysis.

a. The criteria for satisfactory performance are (Ref 5):

(1) Ability to start within the manufacturer's recommended maximum cranking time, or 30 seconds if not specified.

(2) A loss in performance of no greater than:

(a) 25 percent of normal drawbar pull (full-load test)

(b) 50 percent increase in acceleration time

(3) No severe surging or misfiring (rpm loss no greater than 100 rpm)

(4) No stalling

(5) No running vapor lock

(6) No overheating or detonation from lean mixtures

b. Slight surging, misfiring, smoke and rough idling, while undesirable and indicative of the presence of excessive fuel vapor, are not normally causes for rejection of the item.

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APPENDIX A. FUEL VAPOR HANDLING CHECK LIST

1. Engine tuned per specifications
2. Thermostat operation checked
3. Proper lubricants and coolant in vehicle
4. Fluid levels checked
5. Automatic transmission shift points checked
6. Vehicle brakes checked
7. Tire pressure/track tension checked
8. Payload security checked
9. Fuel system checks:
   a. No fuel leaks
   b. Vents operational
   c. Carburetor properly adjusted
   d. New fuel filters installed
   e. Fuel pressure pump pressure checked
   f. Fuel lines secure without damage
   g. Instrumentation does not degrade fuel system
10. Low and high RVP fuels available
11. Blended fuel chosen
12. Clean containers for blended fuel available
13. Test fuel sample containers available
14. Fuel transfer pump operation satisfactory
15. Siphon apparatus available to obtain fuel samples
16. Waste fuel containers available
17. Means to refrigerate the fuel samples available
18. Tags available for fuel samples
19. Instrumentation systems calibrated and installed

APPENDIX B - DATA COLLECTION SHEET

Data Collection Sheet Fuel Vapor Handling	PROJECT NO.: VEHICLE:							PROJECT ENGR.: DATE:				
Test Procedure:												
Fuel Blend												
Meteorological Data												
Ambient Temp												
Relative Humidity												
Wind Velocity												
Wind Direction												
Barometric Pressure												
Time of Day												
Test Step												
Gear Range												
Dra-bar Pull												
Road Speed												
Engine speed												
Temperatures:												
1. Fuel tank at fuel line												
2. Fuel pump inlet												
3. Fuel pump outlet												
4. Fuel at carb inlet												
5. Carb inlet air												
6. Coolant to radiater/sparkplug temp												
Pressures:												
1. Fuel tank outlet												
2. Fuel pump inlet												
3. Fuel pump outlet												
4. Carb inlet												
Remarks:												

APPENDIX C. REFERENCES

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