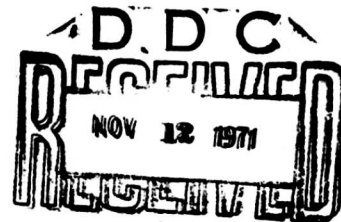


15 June 1966

Material Test Procedure 2-2-503*
Aberdeen Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

MAINTENANCE (VEHICLE)



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1. OBJECTIVE

The objective of this procedure is to provide guidance to test personnel in the techniques and methods of evaluation of the maintainability of military vehicles.

2. BACKGROUND

The Army program for materiel readiness emphasizes the complementary attributes of reliability and maintainability (AR 705-25 and AR 705-26). Maintainability can be expressed as the efficiency, in time, tools, spare parts, and skills, with which materiel can be restored to readiness when maintenance is required. Reliability, on the other hand, can be expressed as the probability that materiel will perform its intended function, i.e., remain in a state of readiness, without maintenance or with only planned maintenance. Both maintainability and reliability data can be obtained from any type of testing, but may also be the specific objective of designated subtests (AR 70-10).

Although both scheduled and unscheduled maintenance time should be reduced as much as possible, reduction in unscheduled maintenance is the principal objective of maintenance evaluation; it is the unexpected failures that cause vehicles to be deadlined. When unscheduled maintenance is reduced, the equipment gains in reliability and combat effectiveness. Other benefits include a reduced reserve requirement for both vehicles and spare parts (leading to lower costs), and fewer support personnel. Appendix A lists design criteria which should have been used to increase the vehicle's maintainability.

Correct maintenance of mechanical equipment is essential for satisfactory service life. The amount of maintenance needed for an item, however, is directly related to severity of use and inherent durability. To a lesser extent, the complexity of the item is also a factor.

3. REQUIRED EQUIPMENT

- a. Standard Vehicular Tool Sets
- b. Vehicle Service Facilities including Steam Cleaning Equipment

4. REFERENCES

- A. AR 70-10, Army Materiel Testing
- B. AR 705-25, Reliability Program for Materiel and Equipment
- C. AR 705-26, Maintainability Program for Materiel and Equipment

*Supersedes Ordnance Proof Manual 60-45

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13

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MTP 2-2-503
15 June 1966

- D. TM 38-750, Army Equipment Record Procedures
- E. MIL-STD-470, Maintainability Program Requirements (for systems and equipments)
- F. MIL-STD-471, Maintainability Demonstration
- G. AMCP 706-134, Engineering Design Handbook, Maintenance Engineering Guide for Ordnance Design
- H. HEL Technical Memorandum 21-62, Manual of Standard Practice for Human Factors in Military Vehicle Design, Aberdeen Proving Ground, Md.
- I. MTP 2-4-001, Desert Environmental Test of Wheeled & Tracked Vehicles
- J. MTP 2-4-002, Arctic Environmental Test of Wheeled & Tracked Vehicles
- K. MTP 2-4-003, Tropic Environmental Test of Wheeled & Tracked Vehicles
- L. MTP 2-2-502, Inspection (Automotive)
- M. MTP 2-2-505, Preliminary Operation
- N. MTP 2-2-506, Durability Testing of Wheeled Vehicles
- O. MTP 2-2-507, Durability Testing of Tracked Vehicles
- P. MTP 2-2-551, Tropical Testing

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5. SCOPE
5.1 SUMMARY

This MTP provides guidance for, but is not limited to, the evaluation of vehicle maintenance based upon the following:

- a. Frequency of maintenance services.
- b. Labor (man-hours).
- c. Ease of maintenance.
- d. Analysis of service and adjustment.
- e. Analysis of repair and replacement.
- f. Cost of parts (if specifically requested).
- g. Environmental effects (if applicable).
- h. Tools.
- i. Standardization and parts interchangeability.
- j. Adequacy of maintenance package.
- k. Safety of maintenance operations.

This pamphlet discusses the application of these considerations in analyzing the test item from the maintenance point of view.

5.2 LIMITATIONS

The maintenance package is not ordinarily evaluated, as such, during a proving ground test, but during normal operation such as that encountered during the conduct of MTPs 2-2-502, 2-2-505, 2-2-506 and 2-2-507. Any defects in the procedures revealed as a result of maintaining test vehicles shall be reported as part of the maintenance evaluation.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. The project engineer shall perform the following:

- 1) Familiarize himself with the maintenance requirements of the item under test as established by:
 - a) The test item's Technical Characteristics (TC's)
 - b) Purchase descriptions and specifications
 - c) Notes on materiel, manufacturer's instruction, and the item's maintenance package
 - d) The test vehicle's Technical Manuals (TM's)
 - e) MIL-STD-470 (reference 4E)
- 2) Prepare a schedule of preventive maintenance services and inspections in accordance with the procedures in TM 38-750 (reference 4D).
- 3) Familiarize himself with the accept/reject criteria of MIL-STD-471 (reference 4F).

b. Record the model, serial number and manufacturer of the test vehicle, its engine, transmission, and tires or track driving and steering mechanism, as applicable.

6.2 TEST CONDUCT

6.2.1 Standard Environmental Conditions (Temperate Climate)

a. Cumulatively record, during the conduct of MTP's 2-2-502, 2-2-505, 2-2-506 or 2-2-507 and as directed by the project engineer the following information:

- 1) Parts repaired, replaced, adjusted, or tightened and indicate the following:
 - a) Distance part was operated
 - b) Amount of time the part was used
 - c) Maintenance time
 - d) Maintenance cost
- 2) Amount of scheduled and unscheduled maintenance by category.
- 3) Down time
- 4) Distance operated (by course)
- 5) Description of difficult or unsafe maintenance operations, including time spent and suggested revisions in methods of applicable maintenance, or design of the part.
- 6) Defects
- 7) Tools required compared with tools specified

b. Thoroughly inspect the vehicle under test to ensure that:

- 1) All components are so designed, located, and installed as to provide adequate working clearances and visibility for the easiest practical servicing, cleaning, adjustment, removal and installation.
- 2) Replacement of parts and assemblies can be accomplished with the removal of a minimum number of other components, accessories, controls, lines, or wiring.

NOTE: The above operations shall be accomplished without damage to parts or assemblies as indicated in HEL-TM-21-62 (reference 4G) and AMCP 706-134 (reference 4F).

c. Determine that service points for checking, replenishing, and draining fuel, lubricant, hydraulic fluid, pneumatic pressures (including tires), coolant, electrolyte, and such, are readily accessible and incorporate features facilitating these operations without being vulnerable to damage or contamination.

d. Check vehicle fuel apertures to ensure that they are compatible with all refueling nozzles in use by NATO.

e. Determine that fuel tanks whose capacity exceeds 50 gallons, are capable of accepting fuel at a rate of 53 gallons per minute (smaller tanks should be refillable in less than one minute) under the following conditions:

- 1) Vehicle is on level ground
- 2) Vehicle is canted: Record the maximum cant at which the tank can be filled

f. Determine that all parts whose working surfaces are subject to wear or deterioration, are provided with appropriate means for lubrication.

NOTE: An exception to this would be surfaces on which lubricants are objectionable such as tank drive sprockets.

g. Ensure that permanently lubricated assemblies and those requiring no lubrication (such as rubber bushings) are used whenever they are economically feasible and can meet military requirements.

h. Steam-clean and inspect the test vehicle at least four times during the testing program and determine that:

- 1) All materials are resistant to, or protected against, chemical and electrolytic corrosion to the extent that such deterioration will not diminish the effectiveness or appreciably increase the maintenance requirements of the equipment. Particular attention shall be given to the following:
 - a) Surfaces subject to wear and abrasion such as the running board, cab, and load decks.
 - b) Tiny, light weight parts that are vulnerable to corrosion,

such as sheet metal items, screws, nuts, bolts, springs, retaining chains, and other thin-gage parts.

- 2) All electrical, pneumatic, hydraulic, and fuel systems are resistant to corrosion, fungi, and the entry of foreign matter.
- 3) Exposed surfaces are shaped to avoid recesses that tend to collect and retain dirt, water, servicing fluids (spilled in servicing or lost in operation), cleaning fluids, or other foreign matter. Where such recesses cannot be avoided, suitable deflectors and closures with drains must be provided.
- 4) The vehicle is designed to require a minimum of manpower, supplies, and equipment for cleaning, preserving, and refinishing. Consideration shall be given to the use of preservative materials, such as a thin film of rust-preventative compound, for protection of surfaces subject to deterioration such as:
 - a) Hidden surfaces whose complex shape or inaccessible location make them difficult to prepare and refinish, door interior panels, running gear, and power train components.
 - b) Surfaces subject to rubbing or chipping - winch cables, snatch blocks, clevises, and tire or tow chains.
 - c) Fastenings and small parts - retaining chains, sheet metal, screws, nuts, and bolts subject to corrosion, particularly in hidden locations.

i. Ascertain that aligning, piloting, guiding, lifting, and positioning features are provided to expedite replacement of components, particularly those which cannot be easily manhandled. (Fixtures for holding and retaining nuts, screws, and other fasteners should be provided when advantageous to facilitate or permit assembly and disassembly by one man, or to prevent loss or displacement of fastening devices in inaccessible locations).

j. Ensure that the least possible number, sizes, and types of fastening devices have been used in order to reduce the number of operations and tools required for installation and removal of components. Also, that fastenings which require tightening to predetermined torque values, are limited to necessary applications.

k. Determine that all electrical and fluid circuit lines, cables, and terminals are equipped with quick-disconnect features and are identified with durable markings.

6.2.2 Adverse Environmental Conditions

Cumulatively record, during the conduct of tests under adverse conditions, the following:

a. Parts repaired, replaced, adjusted or tightened and indicate the following:

MTP 2-2-503
15 June 1966

- 1) Distance part was operated
- 2) Amount of time the part was used
- 3) Maintenance time
- 4) Maintenance cost

- b. Amount of scheduled and unscheduled maintenance by category
- c. Vehicle down time
- d. Distance operated (by courses)

6.2.2.1 Arctic conditions

During the conduct of MTP 2-4-002 perform the following:

- a. Record the information requested under paragraph 6.2.2.
- b. Record the ability of personnel wearing arctic clothes (including arctic mittens) to perform the required maintenance routines.
- c. Record the inability to perform maintenance tasks due to the effect of the weather on the vehicle and its parts without additional tools.

6.2.2.2 Desert Conditions

During the conduct of MTP 2-4-001 perform the following:

- a. Record the information requested under paragraph 6.2.2.
- b. Record the time required, after halting the vehicle, to perform maintenance routines without danger of burning maintenance personnel.

NOTE: Components which must be manhandled under hot surface conditions, particularly heavy items which will not cool quickly, should be provided with handles, eyes, or other handling devices.

6.2.2.3 Tropic Conditions

During the conduct of MTP 2-4-003 and MTP 2-2-551 perform the following:

- a. Record the information requested under paragraph 6.2.2.
- b. Determine and record the following:
 - 1) Normal maintenance required to maintain the test vehicle in an operating condition.
 - 2) Maintenance required after one (1) year of storage under tropical rain forest conditions.

6.2.2.4 High Altitude Conditions

Operate the test vehicle for a minimum of 100 hours at altitudes from 5000 to 8500 feet and record the following:

- a. Information requested under paragraph 6.2.2.
- b. Difficulties encountered in performing maintenance functions.

6.3 TEST DATA

6.3.1 Preparation for Test

Record the following for each vehicle under test:

a. Vehicle:

- 1) Type (M 60 tank, 2½ ton truck)
- 2) Test vehicle No. (1st, 5th)
- 3) Serial No.
- 4) Model No.
- 5) Manufacturer

b) Engine:

- 1) Serial No.
- 2) Model No.
- 3) Manufacturer

c. Transmission:

- 1) Serial No.
- 2) Model No.
- 3) Manufacturer

d. Tires or Track Driving and Steer Mechanism (as applicable)

- 1) Serial No.
- 2) Model No.
- 3) Manufacturer

6.3.2 Standard Environmental Conditions

6.3.2.1 Cumulative Record:

Record the following:

a. Part(s) undergoing maintenance:

- 1) Tank tread - replaced
- 2) Tread sprocket - replaced

b. Distance part was operated (in miles):

- 1) 60 miles
- 2) 120 miles

MTP 2-2-503
15 June 1966

- c. Time used (in hours)
 - 1) 6 hours
 - 2) 12 hours
- d. Maintenance time (in hours)
 - 1) 1.5 hours
 - 2) 2 hours
- e. Maintenance cost (in percent maintenance time to operating time).
 - 1) 25%
 - 2) 16.67%
- f. Maintenance by category (in hours)
 - 1) Scheduled:
 - a) Category I - 8 hours
 - b) Category II - 6 hours
 - 2) Nonscheduled:
 - a) Category I - 4 hours
 - b) Category II - 9 hours
- g. Total vehicle down time (in hours)
- h. Distance operated (in miles and terrain):
 - 1) Paved road - 225 miles
 - 2) Hilly cross country - 400 miles
- i. Unsafe or difficult maintenance operations
- j. Vehicle defects
- k. Non-specified required tools

6.3.2.2 Maintainability

Record the following:

- a. Accessibility
- b. Refueling nozzle compatibility
- c. Fuel tank rate of flow (in gallons per minute):
 - 1) On level ground
 - 2) Canted and maximum value of cant, in degrees
- d. Adequacy of appropriate means of lubrication
- e. Presence of permanently lubricated or non-lubricated assemblies

where economically and militarily feasible.

- f. Ability of vehicle materials to withstand chemical and electrolytic corrosion.
- g. Ability of electrical, pneumatic, hydraulic, and fuel systems to resist corrosion, fungi and the entry of foreign matter.
- h. Presence of recesses capable of collecting and retaining dirt, water, servicing fluids, etc.
- i. Ease with which the vehicle can be cleaned and/or refinished in terms of manpower.
- j. Presence of features to aid in aligning, piloting guiding, lifting and positioning the vehicle to expedite maintainability.
- k. Number of different sizes and types of fastening devices.
- l. Presence of any electrical or fluid circuit lines, cables, and terminals which are not quick-disconnect or are not clearly identified with durable markings.

6.3.3 Arctic Conditions

6.3.3.1 Cumulative Record

Record the following:

- a. Part(s) undergoing maintenance
- b. Distance part was operated (in miles)
- c. Time used (in hours)
- d. Maintenance time (in hours)
- e. Maintenance cost (in percent of maintenance time to operational time)
- f. Maintenance by category. (in hours)
 - 1) Scheduled
 - 2) Unscheduled
- g. Total vehicle down time (in hours)
- h. Distance operated (in miles and terrain)

6.3.3.2 Maintainability

Record the following:

- a. Ability of the crew to perform in arctic gear.
- b. Maintenance tasks incapable of being performed under arctic conditions (external bolts require heating prior to removing).

6.3.4 Desert Conditions

6.3.4.1 Cumulative Record

Record the following:

MTP 2-2-503
15 June 1966

- a. Part(s) undergoing maintenance
- b. Distance part was operated (in miles)
- c. Time used (in hours)
- d. Maintenance time (in hours)
- e. Maintenance cost (in percent of maintenance time to operational time).
- f. Maintenance by category (in hours)
 - 1) Scheduled
 - 2) Unscheduled
- g. Total vehicle down time (in hours)
- h. Distance operated (in miles and terrain)

6.3.4.2 Maintainability

Record time required for vehicle to cool down (in hours)

6.3.5 Tropic Conditions

6.3.5.1 Cumulative Record

Record the following:

- a. Part(s) undergoing maintenance
- b. Distance part was operated (in miles)
- c. Time used (in hours)
- d. Maintenance time (in hours)
- e. Maintenance cost (in percent of maintenance time to operational time)
- f. Maintenance by category (in hours)
 - 1) Scheduled
 - 2) Unscheduled
- g. Total vehicle down time (in hours)
- h. Distance operated (in miles and terrain)

6.3.5.2 Maintainability

Record the following:

- a. Maintenance required to maintain the vehicle in operating condition.
- b. Maintenance required to return the vehicle to operating condition after 1 year's storage.

6.3.6 High Altitude Conditions

6.3.6.1 Cumulative Re

Record the following:

- a. Part(s) undergoing maintenance
- b. Distance part was operated (in miles)
- c. Time used (in hours)
- d. Maintenance time (in hours)
- e. Maintenance cost (in percent of maintenance time to operational time)
- f. Maintenance by category (in hours)
 - 1) Scheduled
 - 2) Unscheduled
- g. Total vehicle down time (in hours)
- h. Distance operated (in miles and altitude)
- i. Difficulties encountered in performing maintenance functions

6.4 DATA REDUCTION AND PRESENTATION

The ability of the test vehicle to successfully pass the accept-reject criteria shall be determined by using the appropriate method of MIL-STD-471 (reference 4F)

NOTE: The method used is dependent upon the number of samples tested and the confidence level required.

In the event that sufficient samples are not available to use the method of MIL-STD-471 the following standards shall be used:

- a. For wheeled vehicles: The maximum labor time (man hours) of both scheduled and unscheduled maintenance time shall not exceed 7 percent of operational hours, assuming 20 miles travelled for each hour of operation.
- b. For tracked vehicles: The maximum labor time (man hours) of both scheduled and unscheduled maintenance time shall not exceed 20 percent of operational time, assuming 10 miles travelled for each hour of operation.

Maintenance operations themselves should be analyzed to see that there are no unreasonable hazards inherent in replacement or adjustment operations such as risks of pinching, cutting, burning, electrical shock or undue physical effort.

The number and complexity of services per unit distance run and hours operated should be the minimum possible consistent with insuring reliability and acceptable service life. Maintenance services shall be reported on the basis of both time and distance.

Day-to-day maintenance problems shall be reported in periodic interim reports and defect records and then summarized and analyzed in the overall formal report on the vehicle. Changes in maintenance methods or modifications of the design to improve maintenance operations may be recommended and forwarded with the test results.

APPENDIX A

VEHICLE MAINTENANCE DESIGN CRITERIA

A. Emphasis must be placed upon insuring that the vehicle design is compatible with the following supply objectives:

1. A minimum practicable number of different line items of supply for aggressive maintenance support at all levels.
2. A minimum practicable weight and size of repair and replacement items, particularly those required at lower maintenance levels.

B. To meet the requirements enumerated above, the most advantageous use should be made of the following:

1. Standardized parts, hardware, and lubricants in general use throughout the Army supply system.
2. Interchangeable parts and assemblies, particularly those incorporated in equipment supported concurrently by direct support maintenance organizations.
3. Design features permitting simple and economical repair of component assemblies at lower maintenance levels through the use of individual replacement parts, repair kits, and, when economical or practical, modular "throw-away" assemblies or parts.

C. Provision for economical and easy replacement of working surfaces at lowest practicable maintenance levels should be incorporated into the design.

D. Ease of parts replacement should be consistent with the anticipated mortality rate, based upon prior related supply and maintenance experience.

E. The design should minimize the weight and size of the parts required to recondition high-mortality working surfaces. Maximum practicable use should be made of easily replaced lubrication seals, bushings, electrical contacts, and similar parts.

F. Particular emphasis in design should be placed upon the ease of replacing high-mortality parts and assemblies whose limited service life would otherwise require premature complete rebuild of the major unit or assembly in which they are incorporated.

G. The vehicle should be designed to require the minimum number of periodic maintenance adjustments. Maintenance adjustments that cannot feasibly be eliminated should be so simplified as to permit accomplishment at the lowest practicable maintenance level.

H. Maximum consideration should be given to the use of those materials and fabrications which are most easily repaired by field maintenance

MTP 2-2-503
15 June 1966

organizations.

I. To the greatest extent possible, the design of equipment should permit maintenance adjustment operations to be effected with standard tool sets issued with the vehicle. When special tools are required, they should be designed for maximum practical suitability and a variety of uses.