19 February 1971

Materiel Test Procedure 9-3-124
U. S. Army Armor and Engineer Board

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY SERVICE TEST PROCEDURE

ROAD GRADERS

1. OBJECTIVE

The objective of this Materiel Test Procedure (MTP) is to set forth test methodology and testing techniques necessary to determine to what degree road graders and their components perform their mission as described in the Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), or other approved criteria and to determine the suitability of the graders and accompanying maintenance test packages for U. S. Army use.

2. BACKGROUND

The U. S. Army uses road graders in all phases of construction, support, and service roles. They are used for general road maintenance, road construction, and improvement including coarse and fine grading, spreading, high and low bank sloping, removing slides, snow removal, scarifying, ditching, windrowing, and related operations in all types of materials from light soils to rocky materials. Road graders have never been standardized in the U. S. Army. Consequently, commercial graders are purchased competitively and adapted during manufacture to meet military requirements. The result is that there are a number of different makes and models presently in the Army inventory.

In order to determine the extent to which their functional performance and military characteristics conform to requirements of the applicable QMR, SDR, or other appropriate criteria, graders must be tested in the field by personnel representative of those who will actually use and maintain the item under combat conditions.

3. REQUIRED EQUIPMENT

a. Cold and wet weather gear.
b. Warming facilities/tents.
c. Platform scales.
d. Photographic equipment (still and motion).
e. Shop facilities.
f. Meteorological equipment or the capability to acquire weather data.
g. Areas suitable for grading operations.
h. Road and cross country courses.
i. Surface and air transport, as required.
j. Stopwatch (for timing speed of travel).
k. Bulldozer (for site preparation).
l. Medical personnel and evacuation capability.
m. Soil classification equipment or the capability to acquire analysis data.

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n. Other equipment as specified in MTP referenced in paragraph 4.

4. REFERENCES

A. MTP 10-3-501, Operator Training and Familiarization.
B. USATECOM REG 385-6, Verification of Safety of Materiel During Testing.
C. MTP 2-3-501, Safety Hazards.
D. MTP 2-3-500, Preoperational Inspection and Physical Characteristics.
E. MTP 9-3-509, Ease of Installation and/or Rigging and Operation.
F. MTP 2-3-512, Compatibility with Related Equipment.
G. MTP 2-3-505, Road Mobility.
H. MTP 2-3-504, Cross Country Mobility.
I. MTP 9-3-502, Transportability.
J. MTP 7-3-515, Air Portability, Internal - Suitability of Supplies and Equipment for.
K. MTP 7-3-516, Air Portability, External - Suitability of Supplies and Equipment for.
L. MTP 2-3-516, Human Factors Engineering.
M. MTP 2-3-513, Fuel and Oil Consumption.
N. MTP 2-3-502, Maintainability.
O. MTP 2-3-527, Maintenance Evaluation - Tools and Test Equipment.
P. MTP 2-3-528, Maintenance Evaluation - Technical Manuscripts and Manuals.
Q. MTP 9-3-503, Reliability.

5. SCOPE

5.1 SUMMARY

This MTP describes procedures to be used in evaluating graders which are outlined as follows:

a. Preparation for Test. Arrange for required facilities and review the safety release to determine the operational limitations, if any, placed on the test item due to safety hazards.

b. Operator Training and Familiarization. Procedure for conducting necessary training and familiarizing personnel with the test item and recording related data.

c. Preoperational Inspection and Physical Characteristics. Pretest inspection, service and repair of the test item as required to ensure that it is in proper condition for test operation, and to determine whether physical characteristics meet specified requirements.

d. Safety Hazards. A determination of the inherent safety hazards and a continuous evaluation of safety aspects of the test item throughout the service test to support the safety confirmation (safe for intended use) statement required in service test reports.

e. Ease of Installation and/or Rigging and Operation. An evaluation of the ease of installing attachments and/or rigging and a check of the functional operability of the end item.

f. Functional Suitability. A series of tests to determine whether or not the test item can adequately perform the functions for which it was designed.

g. Compatibility with Related Equipment. A series of test to determine:

1) The compatibility of the item with recovery vehicles, transporters, and emergency starting facilities.
2) Whether the item can tow and be towed by similar weight vehicles with which it will be associated.
3) The self-recovery capability of the test item, if applicable.

h. Road Mobility. A test to determine the capability of the test item to move over primary and secondary roads alone and in convoy with other vehicles with which it will be associated under varying weather conditions.

i. Cross Country Mobility. A test to determine the capability of the test item to move over various types of cross country terrain alone and with assoicated vehicles under varying weather and soil conditions.

j. Transportability. A series of tests consisting of:

1) Surface Transportability. A study to determine the capability of the test item to be transported by various carriers other than aircraft.
2) Air Portability. A study to determine whether the test item can be carried effectively internally/externally by various aircraft.

k. Human Factors Engineering. An evaluation to determine the human factors engineering aspects of the test item, and its compatibility with the skills and aptitudes of personnel who will operate and service it.

l. Fuel and Oil Consumption. A test to determine the fuel and oil consumption, and compatibility of test item with refueling equipment.

m. Maintenance Evaluation

1) Maintainability. A determination of the maintenance requirements, both scheduled and unscheduled, of the test item and the ease of performing the required maintenance action.
2) Tools and Test Equipment. An evaluation to determine

whether common and special tools and test equipment furnished for the test item are suitable for the intended purpose and maintenance level.

3) Technical Manuscripts and Manuals. An evaluation to determine the adequacy of technical publications provided.

n. Reliability. An evaluation of the test item's reliability to include information regarding expected service life.

5.2 LIMITATIONS

None.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Personnel

Ensure that test personnel are properly licensed to operate the item being tested and are familiar with reference 4.A.

6.1.2 Equipment and Facilities

Ensure that equipment and facilities listed in paragraph 3 and in Materiel Test Procedures referenced in paragraph 4 above are avialable.

6.1.3 Safety Release

The project officer shall ensure that a Safety Release (ref 4.B), which includes information pertaining to operational limitations and specific hazards peculiar to the test item, has been received from HQ USATECOM, is understood, and complied with during testing.

6.2 TEST CONDUCT

6.2.1 Operator Training and Familiarization

Conduct tests and record data as described in MTP 10-3-501 (ref 4.A).

6.2.2 Safety Hazards

Conduct a continuing evaluation of all safety aspects of the test item as described in MTP 2-3-501 (ref 4.C).

6.2.3 Preoperational Inspection and Physcial Characteristics

Perform inspections, checks, inventories, measurements, weighing, and break-in operations as described in applicable portions of MTP 2-3-500 (ref 4.D).

6.2.4 Ease of Installation and/or Rigging and Operation

Determine the ease with which the test item can be assembled, rigged, checked for functional operability, and disassembled as described in MTP 9-3-509 (ref 4.E).

6.2.5 Functional Suitability

Determine the functional suitability of the test item in accordance with the requirements described in the applicable QMR, SDR, or other approved criteria using the procedures in the applicable technical manuals and the following tests.

6.2.5.1 Spreading, Windrowing and Sidecasting

a. The test item is to be used to spread representative types of loose materials (e.g., earth, sand, road surface mixes).

b. The materials to be spread should be spread dumped initially versus dumped in piles.

NOTE: The structural strength and the position of the moldboard prohibit the use of the grader for bulldozer type work.

c. For spreading operations, the materials are to be placed on a typical roadway or airfield construction site of a specified length (e.g., not less than 500 feet in length).

d. The front wheels are to be vertical and the blade is to be set at 0 degrees to carry the material in spreading operations.

NOTE: A blade set perpendicular to the line of travel of the test item is at 0 degrees.

e. In spreading operations, and especially when blending materials such as mixed-in place bitumen, the pitch of the blade should be slightly forward. Blending is to be done with the machine in its higher speed ranges (e.g., 4th to 6th gear).

NOTE: Ordinarily the blade is kept near the center of pitch adjustment so that the top of the blade is directly over the cutting edge. Increasing the lean forward decreases the cutting ability and permits the blade to ride over and spread the material. If the moldboard is pitched too far back, the material will hang in the moldboard and be dragged forward instead of rolling off the moldboard.

f. The test item is to be operated a specified number of hours (e.g., 50 hours) in spreading representative type materials listed in a above. Spreading of earth and sand is done with the machine in its intermediate speed ranges (e.g., 3rd and 4th gear).

g. A certain percentage (e.g., 10 percent) of spreading operations is to be conducted by reverse blading (i.e., rotating blade 180 degrees and travelling backwards).

NOTE: 1. Reverse blading is usually accomplished when it is necessary to move materials forward and backward but it is inconvenient to turn the test item around.
2. If reverse blade position is to be used, it will be necessary to remove all scarifier teeth in order to rotate the blade.

h. Windrowing and sidecasting operations are to be conducted on typical roadway and airfield construction sites of a specified length (e.g., 500 feet) and working with materials listed in a above. Sidecasting operations are also to be conducted by backfilling ditches.

i. Windrowing and sidecasting operations are to be started with the front wheels vertical and the moldboard at center of pitch adjustment so that material will roll with the blade.

j. In windrowing and sidecasting, the blade is to be angled at approximately 15 degrees and so positioned that the toe is outside of the front wheel (left or right) and the heel is delivering material outside the rear wheels. Working speeds are to span the intermediate to high speed ranges depending upon the type material.

k. If the material to be windrowed or sidecast causes side drift (i.e., a force at the blade that tends to pull the front of the test item to one side), the front wheels are to be leaned against the direction of the side drift.

NOTE: The leaning wheel feature is also to be used as an aid in steering, i.e., always lean the wheels sharply in the direction of turn.

l. A specified number of hours of sidecasting and windrowing operations are to be conducted (e.g., 200 hours).

m. A specified percentage (e.g., 15 percent) of spreading and windrowing and sidecasting operations is to be conducted during hours of darkness using light inherent to the test item.

n. Data on these operations are to be recorded and applicable portions documented photographically when appropriate.

6.2.5.2 Road and Ditch Construction Operations

a. The test item is to make an initial 3- to 4-inch deep marking cut at the outer edge of a bank slope. The marking cut is to be used as a guide for subsequent operations.

b. To make the marking cut, the toe of the blade is to be in line with the outside edge of the lead tire.

c. Ditch cuts are to be made with the toe of the blade in line with the center of the lead tire. Ditches are to as made as deep as possible without stalling and losing control of the grader.

d. Ditching is to be done in the lower gear ranges (e.g., first to second gear at full throttle).

e. Successive cuts are to be brought in from the edge of the bank slope so that the toe of the blade will be in line with the ditch bottom on the final cut.

f. Material that is windrowed from the ditch is to be moved and leveled off to form the shoulders and road bed. Spreading (leveling windrows) is to be accomplished as in paragraph 6.2.5.1 above.

g. Ditch banks are to be sloped to prevent immediate or excessive erosion. For sloping, the test item circle is to be shifted vertically left or right, as required, the blade is to be set at the slope angle desired, and the heel of the blade is to be at the bottom of the ditch. Sloping is to be done in the lower gear ranges (e.g., first gear).

NOTE: Most graders have the capability to place the blade heel on the ground with the toe raised vertically so that slopes up to 90 degrees can be cut.

h. Superfluous material that results from sloping operations is to be windrowed as stated in 6.2.5.1 above.

i. The test item is to be used to bring the roadway to the desired crown by spreading and leveling as stated in 6.2.5.1 above.

j. A specified number of hours (e.g., 200 hours) of road and ditch construction testing is to be conducted.

k. A specified percentage of these operations (e.g., 15 percent) is to be conducted during hours of darkness using light inherent to the test item.

l. Data on road and ditch testing are to be recorded and applicable portions documented photographically when appropriate.

6.2.5.3 Road Maintenance

a. Normal surface maintenance is done by working material across the road or runway from one side to the other. The test item blade is to be in the ordinary grading position (i.e., approximately 30 degrees) and the circle shifted well to the delivery side to balance the load.

b. The front wheels are to be leaned against side draft.

c. The blade pitch is to be tipped forward slightly to give more drag and less rolling action of material. Road maintenance is to be done at specified speeds (e.g., second or third gear) depending on the material.

d. Rough pitted surfaces are to be planed smooth by cutting action and the material respread over the smooth base. This type of maintenance requires the blade to be pitched backward slightly to achieve the necessary cutting (planing) action.

e. Roads that have a corrugated (i.e., washboard) surface may have to be scarified (see 6.2.5.4 below). Deep cuts on a washboard surface usually cause blade "clatter" which emphasizes, rather than corrects, the corrugations. This type of surface can best be maintained by premoisturizing, then setting the blade angle to cut diagonally across and to the full depth of the corrugations. The surface is then to be reshaped by spreading as in paragraph 6.2.5.1 above. The road should then be traffic or preferably roller compacted.

f. If the test item is to be used for snow removal, the blade is to be angled as for windrowing and sidecasting (see paragraph 6.2.5.1j and 6.2.5.1k above). However, the blade is to be raised 1/2 to 1 inch above the road surface to preclude scuffing or gouging the pavement. Snow removal is to be done at specified speeds (e.g., fifth to sixth gear).

g. A specified number of hours of road maintenance operations are to be conducted (e.g., 200 hours).

h. A specified percentage (e.g., 20 percent) of road maintenance testing is to be conducted during hours of darkness using light inherent to the test item.

i. Data on these operations are to be recorded and applicable portions documented photographically when appropriate.

6.2.5.4 Scarifier Operations

a. Materiel too hard to cut with the test item blade is to be torn up with the scarifier.

b. The scarifier is to be used to tear up asphalt pavement by pitching the top of the scarifier log to the rear.

NOTE: By pitching the top of the log to the rear, a lifting and tearing action is applied to the material.

c. The scarifier teeth are to be forced into the asphalt deep enough to penetrate the surface but not too deep to disturb the subgrade.

d. Scarifying in asphalt pavement is to be done in the lower gear ranges (e.g., first gear).

NOTE: When operating in hard material, it may be necessary to remove teeth from the scarifier log. A maximum of 5 teeth can be removed. When removing teeth, the center tooth is to be removed first, then alternating removal of every other tooth. This alternating method of removal will balance the scarifier load by distributing the load evenly. If more than 5 teeth are removed, the force against the remaining teeth may cause them to shear off.

e. The test item scarifier is to be used to loosen base course material on a road/airfield construction project by placing the teeth approximately 2 inches into the material and operating in a lower gear range (e.g., second gear) for a specified distance (e.g., 30 yards).

f. The depth of the scarifier teeth is to be increased each 30 yards by 2-inch increments until it is necessary to shift to low gear.

g. Scarifying is to continue and if stalling is imminent, teeth are to be removed as described in d above and operations continued until the maximum number of teeth are removed (i.e., 5 each) and/or the specified maximum operating depth is reached (e.g., 12 inches).

h. Data on scarifying operations are to be recorded and documented photographically when appropriate.

6.2.6 Compatibility with Related Equipment

Conduct tests as described in MTP 2-3-512 (ref 4.F).

6.2.7 Road Mobility

Conduct road mobility testing as described in MTP 2-3-505 (ref 4.G).

6.2.8 Cross Country Mobility

Conduct cross country mobility testing as described in MTP 2-3-504 (ref 4.H).

6.2.9 Transportability

a. Transportability. Conduct tests as described in MTP 9-3-502 (ref 4.I).

b. Air Portability, Internal - Suitability of Supplies and Equipment for. Conduct tests as described in MTP 7-3-515 (ref 4.J), if applicable.

c. Air Portability - External, Suitability of Supplies and Equipment for. Conduct tests as described in MTP 7-3-516 (ref 4.K), if applicable.

6.2.10 Human Factors Engineering

Determine the effectiveness of the man-machine relationship during use of the test item as described in MTP 2-3-516 (ref 4.L).

6.2.11 Fuel and Oil Consumption

Conduct refueling tests and maintain records of all fuel and oil consumed and record data as described in MTP 2-3-513 (ref 4.M).

6.2.12 Maintenance Evaluation

a. Maintainability. Conduct maintainability evaluation and make required computations for the test item as described in MTP 2-3-502 (ref 4.N).

b. Tools and Test Equipment. Throughout the test, the special tools and test equipment supplied with the test item and tools applicable to the various levels of maintenance will be used. An evaluation of these items will be conducted as described in MTP 2-3-527 (ref 4.O).

c. Technical Manuscripts and Manuals. All equipment publications provided with the test item shall be evaluated as described in MTP 2-3-528 (ref 4.P).

6.2.13 Reliability

Conduct reliability testing and compute the reliability of the test item in accordance with the procedures outlined in MTP 9-3-503 (ref 4.Q) or other appropriate documents.

6.3 TEST DATA

6.3.1 Operator Training and Familiarization

Record data for each test participant as described in MTP 10-3-501 (ref 4.A).

6.3.2 Safety Hazards

Record data as described in MTP 2-3-501 (ref 4.C).

6.3.3 Preoperational Inspection and Physical Characteristics

Record data as described in MTP 2-3-500 (ref 4.D) or other appropriate documents. When services, adjustments, and repairs are required, these data will be recorded under the Maintainability Evaluation paragraph 6.3.12a.

6.3.4 Ease of Installation and/or Rigging

Record data concerning the ease with which the test item can be assembled, attached to the end item, rigged, and results of the functional operability testing as described in MTP 9-3-509 (ref 4.E).

6.3.5 Functional Suitability

Record the following for all functional suitability testing:

a. Ambient temperature and precipitation.

b. Ambient light (natural and artificial).

c. Type and model of grader.

d. Number of hours of testing with artificial light.

e. Adequacy of test item night lighting capability.

6.3.5.1 Spreading, Windrowing and Sidecasting

Record or retain the following:

a. Types of materials spread.

b. Adequacy of spread dumping (i.e., thickness of lift).

c. Surface on which material was spread (i.e., road or airfield).

d. Length in feet of spreading operations.

e. Blade setting in degrees by type material spread.

f. Attitude of front wheels for each material spread.

g. Pitch of blade for each material spread.

h. Working speeds by type material (e.g., fifth gear full throttle when blending mixed-in-place bituminous material).

i. Number of hours of spreading operations by type material.

j. Capability to reverse blade spread.

k. Number of hours of reverse blading operations.

l. Type of materials moved in windrowing and casting operations.

m. Length in feet of windrowing and casting operations.

n. Capability of test item to lean front wheels.

o. Attitude of front wheels while windrowing and casting.

p. Moldboard pitch and blade angle by type material while windrowing and casting.

q. Location of blade heel and toe (in relation to front and rear wheel while windrowing and casting).

r. Working speeds by type material (e.g., fourth gear full throttle when windrowing earth fill).

s. Number of hours of windrowing and side casting operations.

t. Adequacy of test item to spread, windrow, and sidecast various representative type materials.

u. Photographs.

6.3.5.2 Road and Ditch Construction

Record or retain the following:

a. Depth and length of marking cut.

b. Attitude of blade when marking cut.

c. Depth of ditching cuts.

d. Working speeds by type material.

e. Location of toe of blade in successive cuts.

f. Capability of test item to windrow material from ditches to shoulders and road bed.

g. Capability of test item to shift circle vertically.

h. Capability of test item to set blade at desired slope angle.

i. Working speed by type material in sloping operations.

j. Total number of road and ditching test hours.

k. Adequacy of test item to cut ditches and shape roadways.

l. Photographs.

6.3.5.3 Road Maintenance

Record and retain the following:

a. Type road or surface being maintained (e.g., rough pitted, corrugated, compacted extra hard).

b. Blade angle by type material and surface.

c. Attitude of front wheels (i.e., leaning or vertical) by type material.

d. Blade pitch by type material and surface.

e. Capability of test item to plane rough pitted surfaces.

f. Capability of test item to smooth corrugated surfaces.

g. Photographs.

h. Adequacy of test item in snow removal operations.

i. Working speeds by type materials in road maintenance operations.

6.3.5.4 Scarifier Operations

Record or retain the following:

a. Thickness of asphalt pavement to be scarified.

b. Ease of changing pitch of scarifier log.

c. Test item gear selection.

d. Necessity to remove scarifier teeth in asphalt operations and quantity removed.

e. Ease of removing teeth.

f. Description of base course material scarified.

g. Initial gear selection.

h. Distance scarified for each 2-inch increment of penetration.

i. Depth of penetration at which down shifting required.

j. Necessity to remove teeth in cutting base course material and quantity removed.

k. Capability of test item to scarify at prescribed depth.

l. Photographs.

6.3.6 Compatibility with Related Equipment

Record data as described in MTP 2-3-512 (ref 4.F).

6.3.7 Road Mobility

Record data as described in MTP 2-3-505 (ref 4.G).

6.3.8 Cross Country Mobility

Record data as described in MTP 2-3-504 (ref 4.H).

6.3.9 Transportability

a. Transportability. Record data as described in MTP 9-3-502 (ref 4.I).

b. Air Portability, Internal - Suitability of Supplies and Equipment for. Record data as described in MTP 7-3-515 (ref 4.J), if applicable.

c. Air Portability, External - Suitability of Supplies and Equipment for. Reocrd data as described in MTP 7-3-516 (ref 4.K), if applicable.

6.3.10 Human Factors Engineering

Record data as described in MTP 2-3-516 (ref 4.L).

6.3.11 Fuel and Oil Consumption

Record data as described in MTP 2-3-513 (ref 4.M).

6.3.12 Maintenance Evaluation

a. Maintainability. Record data and make the required computations as described in MTP 2-3-502 (ref 4.N).

b. Tools and Test Equipment. Record data as described in MTP 2-3-527 (ref 4.O).

c. Technical Manuscripts and Manuals. Record data as described in MTP 2-3-528 (ref 4.P).

6.3.13 Reliability

Record data and make the required computations described in MTP 9-3-503 (ref 4.Q).

6.4 DATA REDUCTION AND PRESENTATION

All data obtained by inspection, observation, questionnaires, and testing, including photographs, are to be analyzed and presented in a manner to indicate whether the test item meets the established criteria.

6.4.1 Safety Confirmation

A safety confirmation shall be presented in accordance with USATECOM Regulation 385-6 (ref 4.B).

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13. ABSTRACT

Procedures are prescribed for evaluating the functional suitability of road graders for Army use.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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