SELWOOD RESEARCH, INC.

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STANDARD TESTS FOR

ENGINEERING TESTING OF

AMPHIBIOUS LANDING VEHICLES (TRACKED)

Contract N00014-66-C0337
Report Number 105-1-004

June 1967

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by

SELWOOD RESEARCH, INC.

Approved: John L. B. Selwood

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13. ABSTRACT

The test handbook provides very brief descriptions of the tests that might be required in the engineering testing of amphibious landing vehicles, tracked (LVT). The purpose is to provide simple and standard methods for issuing test directives. It consists of three sections covering: an introduction dealing with definitions, proceedures and policy instructions, etc.; a section on land tests; a section on water tests.

Tests are briefly described in terms of objectives, method and data required. References are provided for source material on the detailed methods of conducting tests.

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1.0 INTRODUCTION

1.1 Purpose

The United States Marine Corps is reviewing a standard series of tests for the engineering testing of Amphibious Assault Landing Vehicles, Tracked (LVT). Test programs for individual vehicles will consist of selections from this series. This report is intended to contribute material for this review.

1.2 Authorization

This work was done by Selwood Research, Inc. under Office of Naval Research Contract No. N00014-66-C0337 dated 23 June 1966.

1.3 Background

The U. S. Marine Corps in Fy 1968 will commence engineering testing on a new series of amphibious assault vehicles designated LVTPX-12. This is the only type of vehicle the development of which is solely vested in the U. S. Marine Corps. A standard test handbook for the testing of these vehicles does not exist. This report lists the engineering tests involved mainly in temperate climate testing and references other works for detailed information where applicable. The U. S. Marine Corps test agency for the testing of these vehicles is the Amphibian Vehicle Division, Landing Forces Development Center, Marine Corps Schools, Quantico, Virginia.

2.0 DETAILS OF LAND TESTS

Introduction

The following engineering tests are to measure the LVTPX-12's performance in temperate climate conditions and to determine if it complies with the

requirements stated in the SOR.

Appropriate Interim Pamphlets of the U. S. Army Test and Evaluation Command Test Procedures, TECP 700-700, Volume II (Ref. 1), will be referenced in the method section of appropriate subtests.

2.1 Initial Inspection and Servicing

2.1.1 Objectives

To assure that the vehicle is in good mechanical condition and that major component serial numbers and pretest data are recorded prior to start of test program, also to establish fuel and lubricant requirements, determine refueling rate, accessibility of fittings, and drain plugs, tools required and time involved in performing complete servicing.

2.1.2 Method

Limited technical inspections will be made, major component serial numbers recorded, initial condition of rubber components noted, and other pretest observations will be made. (Material Test Proceedure 2-2-502 dated 23 March 1966).

All fluid systems and lubrication points are to be fully serviced with the proper fuels, lubricants, and fluids and purged if necessary. Inaccessibility, special tools required, extremely long drain periods, capacities, and other pertinent data will be recorded (Interim Pamphlet 60-45).

2.1.3 Data Required

The following are required:

a. Major component serial numbers.

b. Electrical system output.

c. Nomenclature and specification of fuel, lubricants, coolant, and hydraulic fluids.

d. Refueling rate. Ease of refueling with five-gallon cans.

e. Unusual or extraordinary quantities of lubricants, drain or fill times, or fill and drain plugs odd sizes.

2.2 Preliminary Operation

2.2.1 Objectives

To assure proper break-in of the various components and provide a period of familiarization for the operator prior to conducting additional tests; also, to stress operations that will make inherent hazards or weaknesses apparent.

2.2.2 Method

Vehicles will be operated on the West Coast Branch Tracked Vehicle Courses for a total of 50 miles in accordance with the following (Material Test Proceedure 2-2-505 dated 23 March 1966):

a. Five miles at 5 to 10 mph.

b. Ten miles at 11 to 20 mph.

c. Fifteen miles at 21 to 30 mph.

d. Twenty miles at 31 to 40 mph.

During this period of operation, the vehicle operator will be afforded the opportunity to familiarize himself with any special operating requirements of the vehicle.

Prior to conducting engineering performance tests, the vehicle used for performance tests will be operated a total of 200 miles including

that recorded on the odometer when the vehicle is received; this operation will permit adequate break-in to assure maximum engine performance.

2.2.3 Data Required

The following are required:

a. Training requirements.

b. Driver effort (normal, excessive, etc.).

c. Maintenance required after break-in.

2.3 Vehicle Characteristics

2.3.1 Objective

To record basic dimensions, data, and characteristics of the vehicle to determine compliance with the specifications, compatibility with air, water, and rail transportability programs, engineering studies, and final evaluation.

2.3.2 Method

Appropriate dimensions, weights, observations, descriptions, and other measurements will be made of the vehicle to provide a complete and detailed definition of the vehicle. A complete list of pertinent characteristics of each component or major component group will be prepared (OPM 60-15 dated 21 January 1963).

Performance data will be obtained from the results of engineering tests and recorded as performance characteristics.

General-view photographs will be taken and the characteristics photograph made incorporating significant components and data.

2.3.3 Data Required

The following are required:

a. Dimensions, weights, center of gravity, center of buoyancy, physical characteristics of vehicle components and complete assembly.

b. Vehicle performance characteristics as obtained by the subtests described in the succeeding paragraphs.

2.4 Stowage

2.4.1 Objective

To assure that all on-vehicle equipment (OVE) can be safely stowed in positions that provide proper utility for the crew without undue safety hazards and to ascertain the reliability of the stowage fixtures, brackets, straps, etc., as provided and to stow the OVE so that it will be visible in general-view photographs.

2.4.2 Method

The OVE will be stowed in designated positions and inspected for utility and safety. The equipment will remain in position throughout the duration of the test to further observe reliability and durability of the brackets (Materiel Test Proceedure 2-2-802 dated 22 October 1965).

2.4.3 Data Required

The following are required:

a. List of OVE provided or designated for installation on vehicle.

b. Photographs of installed OVE.

c. Reports, notations, and comments on inability to mount or secure the OVE and the failures or inability of the brackets or supports to perform the required service.

2.5 Weight Distribution and Ground Pressure

2.5.1 Objective

To determine the vehicle net and gross weight and weight distribution with payload and provide a loading that will properly simulate the normal combat loading of the vehicle.

2.5.2 Method

2.5.2.1 Weight. The vehicle will be weighed to determine curb weight. The vehicle will be checked with the designated combat payload including OVE, personnel, weapons, ammunition, and other equipment (simulated loads as required).

2.5.2.2 Ground Pressure. The average ground pressure is a function of the loading and the area in contact with the ground. These should be computed for the vehicle as a unit or possibly each side of the vehicle (Interim Pamphlet 60-60 dated 30 July 1957).

2.5.3 Data Required

The following are required:

a. Total vehicle weight (curb and combat-loaded).

b. Weight on each side of vehicle

c. Average ground contact area.

d. Average ground pressure.

2.6 Center of Gravity and Static Trim

2.6.1 Objective

To determine the center of gravity and trim of the vehicle in

three planes for the combat equipped and combat loaded conditions. The vehicle will be fitted with OVE and have full fuel tanks under both conditions. These center of gravity locations will be the basis for evaluating vehicle stability under various operating conditions.

2.6.2 Method

The location of the center of gravity on the lateral axis will be determined by using load reaction data (ref. paragraph 2.5). The location of the center of gravity along the vertical and longitudinal axes will be obtained by the suspension method (Interim Pamphlet 60-65 dated 4 November 1964).

The trim will be measured and marked using the flotation method (paragraph 3.1).

2.6.3 Data Required

Dimensions required to locate center of gravity. Use fixed reference points (for longitudinal and vertical axes, use sprocket center; for lateral or transverse axis, use vehicle centerline).

Relate vertical center of gravity location to distance above ground line with normally loaded vehicle and longitudinal location to distance from the front of the vehicle.

Mark trim lines port and starboard, foreward and aft.

2.7 Safety Evaluation

2.7.1 Objective

To determine the suitability of the vehicle for testing and use with regard to personnel safety, operational hazards, and provide safeguards

to prevent accidents occurring during use of the vehicle. To effect a recommendation for safety release early in the test and provide a more complete safety evaluation later in the test.

2.7.2 Method

The safety evaluation will be conducted in two parts; an early evaluation based on subjective data that will result in a recommendation for safety release and an over-all evaluation based on engineering test results (Materiel Test Proceedure 2-2-508 dated 27 October 1965).

The following tests should be considered in a safety evaluation with limited appraisal during the earlier evaluation:

a. Braking (ref. paragraph 2.11).

b. Steering (ref. paragraph 2.15).

c. Center of gravity and static trim (ref. paragraph 2.6).

d. Gradeability (ref. paragraph 2.16).

e. Side slopes (ref. paragraph 2.17).

f. Noise (ref. paragraph 2.24).

g. Static Stability (ref. paragraph 3.1).

h. Toxic fumes (ref. paragraph 2.21).

i. Heat (ref. paragraph 2.24).

j. Security of stowage

k. Security of payload

l. Structural strength.

m. Track retention.

2.7.3 Data Required

The following are required:

a. Limitations on operating or performance functions of the vehicle imposed due to safety considerations.

b. Notations of operating and personnel hazards.

2.8 Standard Obstacles

2.8.1 Objective

To determine the ability and specify limitations of the vehicle to negotiate the following obstacles:

a. Vertical wall.

b. Trench crossing.

c. Bridging.

d. Six-inch washboard.

e. Spaced bump.

f. Landing ramp.

2.8.2 Method

Operate the vehicle at combat loaded weight over the obstacles outlined above. Establish the limitations over the obstacles (maximum height, maximum speed, etc.). In some cases, it may be necessary to operate in reverse to negotiate the obstacle (Materiel Test Proceedure 2-2-611 dated 1 September 1965).

2.8.3 Data Required

The following are required:

a. Maximum wall height vehicle can negotiate forward and reverse.

b. Maximum bridging span.

c. Ability and limitations for crossing trench profile.

d. Maximum speed or other limitations on other courses.

2.9 Maximum and Minimum Road Speeds

2.9.1 Objective

To determine the maximum road speed obtainable on a level, paved surface without exceeding the maximum rated engine speed and to determine minimum sustained speed in the lowest forward gear range without rough or irregular operation.

2.9.2 Method

Minimum and maximum road speeds will be measured on a level, paved highway using a calibrated fifth wheel and an engine tachometer. Both speed limitations will be obtained with the vehicle at combat equipped and combat-loaded weights. The vehicle will be operated at the lowest sustained road speed at which satisfactory engine operation can be obtained and the highest speed attainable as limited by available power (Materiel Test Proceedure 2-2-602 dated 23 March 1966).

2.9.3 Data Required

The following are required:

a. Vehicle road speed (calibrated fifth wheel).

b. Engine speed (calibrated engine tachometer).

c. Gear position.

These data will be obtained for maximum and minimum speed conditions.

2.10 Acceleration

2.10.1 Objective

To determine the acceleration performance and characteristics

of the vehicle and the level of acceleration consistent with engine and power train characteristics. Also, that sufficient power and gear ratios are provided and that gear changes can be accomplished quickly and easily to accelerate the vehicle to top road speed in the shortest time.

2.10.3 Method

Tests will be conducted on a level, paved road measuring acceleration from 0 mph to maximum speed. Delays due to initial or subsequent shifting and unusual shock conditions imposed on the power train will be noted. Tests will be conducted at combat equipped and combat loaded weights (Materiel Test Proceedure 2-2-602 dated 23 March 1966).

2.10.4 Data Required

The following are required:

a. Time (seconds) and distance (feet) to accelerate to various speeds up to maximum.

b. Sufficient speed increments to prepare a curve.

2.11 Braking

2.11.1 Objectives

To determine the ability of the vehicle to make a complete, safe, stable stop on a level, paved road from a speed of 20 mph and to determine if the brakes will safely stop and hold (parked) the vehicle in both directions on a 60 percent longitudinal slope.

2.11.2 Method

Stopping distance from 10, 20, 30 and 40 mph on a dry,

bituminous concrete roadway from point of application until the vehicle has been halted will be made with maximum braking effort. The stopping and holding ability on the 60 percent slope will be determined during gradeability tests (OPM 60-71 dated 17 January 1957).

2.11.3 Data Required

The following are required:

a. Initial road speed versus stopping distance.

b. Grade holding ability of both service and parking brakes will be detailed.

2.12 Drawbar Pull

2.12.1 Objectives

To determine the following:

a. That sufficient power and gear reduction have been provided so maximum drawbar pull is limited only by track slip on a paved surface.

b. That a satisfactory balance between engine power and gear ratios has been provided to effect smooth transition from gear position to gear position during both upshifting and downshifting.

c. That all power transmitting devices are capable of handling maximum torque as developed through the gear train.

d. That the output force the vehicle will develop is well in excess of that required to move the vehicle on a level road for use in acceleration or hill climbing.

Indications of unusual or rapid temperature rise of the various components will also be noted.

2.12.2 Method

The vehicle, at combat loaded weight, will tow a field dynamometer on a level, paved road under full throttle conditions and varying

road speeds and gear positions (Materiel Test Proceedure 2-2-604 dated 4 August 1965).

Temperatures of specific and potentially critical components will be monitored during this operation. These components could include engine cylinders, coolants, gearboxes, coolers, or drive elements.

Additional tests of cooling characteristics will be predicated on the result of this temperature-monitoring check (ref. paragraph 2.13).

2.12.3 Data Required

The following are required:

a. Drawbar pull (pounds).

b. Engine speed (rpm).

c. Road speed (mph).

d. Track speed (mph).

e. Gear range or position.

f. Temperatures (as required to monitor the critical components).

2.13 Cooling

2.13.1 Objective

To determine the suitability of the vehicle cooling characteristics. Test to be conducted only if overheating is observed during drawbar pull tests.

2.13.2 Criteria

Temperature limits of vehicle components (subject to manufacturer's recommendations) are as follows:

Engine coolant (if applicable	Water boiling temperature at maximum system pressure
Engine oil	275°F
Transmission and gearboxes	300°F
Driver and crew compartment	135°F

2.13.3 Method

The combat-loaded vehicle will tow a field dynamometer on a level, paved course under full throttle conditions. The vehicle will be loaded by the dynamometer to specific road speeds in several available gear ranges (maximum engine and transmission loadings) until the temperatures stabilize in the gear train components or until a critical component temperature is reached (Interim Pamphlet 60-95 dated 31 December 1964).

The recorded temperatures will be extrapolated on a degree-for-degree basis to the extent the ambient temperature is below 120°F.

2.13.4 Data Required

The following are required:

a. Road speed (mph).

b. Engine speed (rpm).

c. Gear position.

d. Drawbar pull (pounds).

e. Component temperatures and pressures.

f. Meterological data.

2.14 Power Losses

2.14.1 Objective

To determine the power loss of the vehicle over several typical media.

2.14.2 Method

Resistance-to-tow will be measured over paved, sand, sandy loam, and clay courses (Material Test Proceedure 2-2-605 dated 24 November 1965).

2.14.3 Data Required

The following are required:

a. Description of the course including soil strength.

b. Vehicle speed (mph).

c. Towing force (pounds).

2.15 Steering on Land

2.15.1 Objective

To determine vehicle land steer response and effort, minimum turning radius, and general characteristics of turning.

2.15.2 Method

The minimum turning circle will be measured over several media using the normal steering system. The media should include paved, gravel, dry grass, sand, and water (OPM 60-75 dated 26 December 1956).

General steering control will be evaluated by jury trial during operation over various courses.

2.15.3 Data Required

Turning diameter, wall-to-wall (feet).

2.16 Gradeability

2.16.1 Objective

To determine the ability of the vehicle to operate on slopes up to 60 percent; determine performance characteristics on various slopes; start, hold, and operate satisfactorily in both directions on a 60 percent longitudinal slope.

2.16.2 Method

Operations will be conducted on slopes up to and including the 60 percent slope. Surface conditions must be dry during the tests. Operations will be conducted to achieve the objectives and check for conformance to the stated criteria. Service and parking brake must be used on 60 percent slope (OPM 60-80 dated 27 September 1960).

Observations will be made with respect to the angle of approach and departure at the bottom of the slope and effect of weight transfer on steering.

2.16.3 Data Required

The following are required:

a. Engine speed (rpm).

b. Maximum sustained speed on specified slope (mph).

c. Engine oil pressure.

d. Fuel pressure.

e. Observation of fuel or oil leakage.

2.17 Side Slopes

2.17.1 Objective

To check for lateral stability and proper engine operation and vehicle performance on side slopes up to 60 percent.

2.17.2 Method

Calculate or measure the static tipping angle for safety reasons prior to actual operations.

Operations will be conducted on the 30 percent side slope in both directions. Under static conditions, the suspension deflections and maximum vehicle inclination of the body will be noted. Behavior of the vehicle will be noted at speeds up to 5 mph, particularly while steering up and down the slope. Operation on steeper slopes, up to 60 percent, will be conducted, in progressive steps, if this initial operation is entirely satisfactory. The engine should be started and stopped under each of the various conditions.

All components should operate without faulty lubrication, cooling, fuel supply, leakage, or other malfunction (OPM 60-80 dated 27 September 1960).

2.17.3 Data Required

Observations on 30, 40, 50 and 60 percent side slopes.

2.18 Fuel Consumption on Land

2.18.1 Objective

To determine maximum fuel consumption under various conditions of combat loaded operation, minimum fuel consumption (maximum fuel economy)

under combat equipped conditions, average fuel consumption on standard fuel course operation, useable fuel capacity, and refueling rate and conditions.

2.18.2 Method

Combat equipped, combat-loaded, and standard-course fuel consumption tests will be conducted in accordance with established procedures (OPM 60-40 dated 4 November 1959).

The useable fuel capacity (the actual volume of fuel that can be drawn from the supply) will be used in the computation of the cruising range. The cruising range can be related to a specific type or combination of operations.

Fuel consumption data will be obtained during performance and endurance operations to obtain over-all consumption data.

2.18.3 Data Required

The following are required:

a. Idle fuel consumption rate (pounds per hour) and engine speed (rpm).

b. Curve of fuel consumption (pounds per hour) versus engine speed (rpm) with all gear positions (road-load and full-load).

c. Curve of fuel consumption (miles per gallon) versus road speed (miles per hour) on standard fuel test course.

d. Curve of fuel consumption (miles per gallon) versus road speed (miles per hour) with all gear positions (road-load and full-load).

e. Useable fuel capacity (gal).

f. Refueling rate (gpm).

2.19 Load Functional Suitability

2.19.1 Objective

To determine the suitability for operation as a:

a. Cargo carrier

b. Personnel carrier.

2.19.2 Method

Operations will be conducted with Class I, III and V supplies. The total load in each case will not exceed the rated payload of the carrier. The test item will be driven cross-country a distance of at least 10 miles with each type load and then unloaded.

2.19.3 Data Required

The following is required:

a. Ease of loading and unloading cargo.

b. Adequacy of doors or ramps for loading and unloading cargo.

c. Types of load carried.

d. Adequacy of cargo space.

e. Suitability of cargo tie-downs.

f. Adverse effect on cargo and on test item.

g. Computed weight and center of gravity of different types of cargo.

h. Calculated required vehicle center of gravity limits to accomodate all types of cargo.

2.20 Mobility

2.20.1 Objective

To determine the operating characteristics and the range of soil conditions over which the vehicle can operate. The operating limitations should be defined.

2.20.2 Method

Operations should be conducted over the following conditions and areas to obtain an evaluation in various terrain environments (OPM 60-85 dated 15 August 1957).

a. Swamp or Marsh. Operations will be conducted in virgin marsh conditions of various solid and various moisture contents. Initial passes over virgin areas and multiple passes including areas traversed by other vehicles to obtain swamp operation data.

b. Mud Slopes. Observations will be made of operation on 10, 15, and 20 percent loam soil slopes that have been soaked to obtain the desired mud consistency.

c. Clay. Operation will be conducted in clay soils to evaluate operations in slick, sticky clay.

2.20.3 Data Required

Record observations on the various soil consitions. Comparative mobility compared with the LVTP-5.

2.21 Toxic Fumes

2.21.1 Objective

To determine if there is an accumulation of nauseous, noxious, or irritating fumes in an amount that would adversely affect personnel.

2.21.2 Method

Checks should be made of carbon monoxide concentration in and around the driver's position and the personnel compartment under varying static and dynamic conditions. Observe for nauseous and irritating fumes during this test period (Interim Pamphlet 60-105 dated 26 January 1965).

2.21.3 Data Required

The following are required:

a. Carbon monoxide concentration at or near the vehicle.

b. Irritating gas observations.

2.22 Radio Interference

2.22.1 Objective

To determine if the vehicle, along with electrical components, is designed to suppress radio interference in accordance with the specified criteria.

Specification MIL-I-11683B, "Interference Suppression, Radio Requirements, for Engine Generators and Miscellaneous Engines," dated 3 January 1956.

Specification MIL-S-10379A, "Suppression, Radio Interference General, Requirements for Vehicles (and Vehicular Subassemblies)," dated 8 July 1951.

2.22.2 Method

Radiated and conducted interferences will be measured from the various electrical components in the system (Interim Pamphlet 60-175 dated 20 August 1957).

2.22.3 Data Required

Intensity of interference in terms of microvolts per megacycle.

2.23 Electrical Systems

2.23.1 Objective

To determine the adequacy of the electrical supply system to provide sufficiently for the electrically powered components. The suitability should be determined for varied service life conditions, varied operating combinations of power equipment, and operational service at reduced and transient voltage.

2.23.2 Method

The electrical output of the generator will be measured across the engine speed range at the beginning and end of the test. Further, the performance of the electrical components will be judged at rated voltage and at 75 percent of rated voltage (Interim Pamphlet 60-150 dated 26 January 1965).

The power demand for the electrical components in the vehicle will be measured at the beginning and end of test. In addition to the power demand, the performance will be measured at full and 75 percent voltage.

The electrical components will be operated periodically during the test. They should be operated for periods commensurate with anticipated service.

The adequacy of the power system should be evaluated to indicate whether the current supply will adequately operate normal combinations of operating components and provide sufficient voltage and current to maintain fully charged batteries.

Possible damage to electrical components from voltage surges or other unusual power source should be specially noted.

2.23.3 Data Required

Voltages and current readings for test conditions.

2.24 Human Factors Engineering

2.24.1 Objective

To determine the suitability of the seating, visibility, arrangement of controls, instrument displays, entry and exit for all personnel, and general comfort to include noise level, vibration response, and vehicle pitch, bounce, and stability.

2.24.2 Method

A human factors review of the vehicle will be made under both static and dynamic conditions (OPM 60-305 dated 20 November 1957). This review will be integrated as much as possible with planned testing. Specific items to be considered with regard to human safety, comfort, efficiency, and ease of operation include the following:

a. Space requirement for ease of operation and maintenance.

b. Control display relationships.

c. Work space layout.

d. Safety in operation and maintenance.

e. Environmental factors such as temperature, humidity, dust, noise, vibration.

f. Communication.

g. Readability of such items as dials and meters.

h. Comfort, which may significantly affect efficiency of operation and personnel, adequacy of seats, padding of projections.

i. An accumulation of nauseous and irritating fumes in an amount that has an effect on personnel.

j. Emergency underwater exits.

k. Internal and external illumination, day and night, field of vision.

A survey of noise levels should be made to assure they fall within acceptable limits. Instrumentation will be used.

2.24.3 Data Required

Summary of noise survey (over-all decibel levels) generally done unless a problem is disclosed.

2.25 Maintenance

2.25.1 Objective

To evaluate the practicability, the ease of achievement, use of standard tools, and man-hour requirements for scheduled and unscheduled maintenance and adequacy of the maintenance package with regard to direct support and general support. Determine the special tool requirements other than provided with the OVE.

2.25.2 Method

Scheduled maintenance will be conducted in accordance with instructions supplied with the vehicle (Interim Pamphlet 60-45 dated 5 October 1964 and applicable portions of MIL-STD-1228, 27 September 1962, "Maintainability Criteria for Tank-Automotive Material").

Maintenance analysis will be developed by identifying and recording all maintenance time required during testing.

2.25.3 Data Required

The following are required:

a. Scheduled and unscheduled maintenance man-hours.

b. Ratio of maintenance time to operating time and mileage.

2.26 Endurance and Reliability

2.26.1 Objectives

To determine the durability characteristics and reliability of the vehicle over 1,000 hours of operation on prescribed test courses.

2.26.2 Method

The endurance operation with an objective of 1,000 hours will be divided into 250 hour cycles. Each cycle will consist of operation over the following courses:

Type Course	Hours	Condition
Primary road or secondary road	80	Paved or gravel
Cross-country	80 20	Earth or mud Swamp
Beach	20	Sand and shingle
Water	50	Water

All defects that occur throughout the test will be recorded and corrected.

2.26.4 Data Required

The following are required:

a. Mileage and hours of operation by test course.

b. Fuel and oil comsumption.

c. Scheduled and unscheduled maintenance man-hours.

d. Parts required to support operations.

e. Suitability of materials, seals, oils and greases to salt water operation.

2.27 Climatic Chamber Tests

2.27.1 Objective

To determine the operational characteristics of the vehicle at environmental extremes of intermediate and cold climate conditions (AR 705-15, Change 1, 4 October 1962). These tests will be limited to those tests that are practical for conducting in the available facilities.

The vehicle functions to be noted are engine starting, mechanical and electrical power output, interior heating, and functioning of vehicle controls and power train.

2.27.2 Method

The chamber testing will include cold room and rain chamber. These will be conducted according to procedures in TECP 700-700, Interim Pamphlets 60-300 dated 30 July 1964).

2.27.2.1 Cold Room Tests. These tests will be conducted at temperatures down to an ambient air temperature of -65°F or the lowest temperature at which these vehicles can be satisfactorily operated.

Specific components or functions to consider are:

a. Engine cold starting.

b. Electrical power output and requirements to operating functions.

c. Functioning of controls.

d. Drive component functioning.

e. Personnel heater operation.

2.27.2.2 Rain Chamber. The precipitation test will be a 4-inch rainfall in 1 hour and conducted without the wind factor.

2.27.3 Data Required

2.27.3.1 Cold Room Test. The following are required:

a. Ambient air temperature (cold soak time).

b. Engine oil temperature.

c. Coolant temperature.

d. Fuel temperature.

e. Battery temperature.

f. Starter resistance and current requirements.

2.28 Winch Tests

2.28.1 Objective

To determine the suitability of the winch to aid the self-recovery of the vehicle or recovery of other vehicles immobilized in adverse terrain and the recovery of vehicles from water (embankments otherwise impassable).

To obtain the winch physical and operating characteristics.

2.28.2 Method

Direct, instrumented tests will be conducted to determine operating characteristics including determination of adequate torque, suitable controls suitably mounted (location and strength), operational limitations, brake effectiveness and compatibility with vehicle (OPM 60-171 dated 26 May 1958).

Simulated recovery operations will be conducted over varied conditions to include swamp, steep banks, mud holes, etc.

2.28.3 Data Required

The following are required:

a. Cable size (in.).

b. Cable capacity (ft.).

c. Line pull (lb.) versus cable layer and engine speed (rpm).

d. Line speed (rpm) versus engine speed (rpm).

e. Line pull at shear pin failure.

2.29 Security from Detection

2.29.1 Objective

To determine the characteristics that permit the vehicle to be readily detected by engine-produced smoke.

2.29.2 Method

Make a judgement on the engine exhaust smoke in accordance with procedures in TECP 700-700,Interim Pamphlet 60-55.

2.29.3 Data Required

Observations of exhaust smoke.

3.0 CALM, ROUGH WATER, AND SURF TESTS

3.1 Static Stability

3.1.1 Objective

To determine the transverse stability (righting moment) of the test item versus heel angle.

3.1.2 Method

Determine the relation between the center of gravity height at different loads up to 10,000 pounds plus 25 percent overload, angle of roll, period of roll and righting moment. Test item will be moored alongisde a control vessel at dock-side with a disturbing moment applied by ropes attached to the control vessel. Contamination in gear boxes and other components, and general leakage will be noted. Bilge pumps will be checked before testing is commenced and bilge water levels will be checked during tests. Draft marks will be painted on both sides of the vehicle fore and aft. Draft marks will be international orange one-quarter inch wide spaced one inch apart, and will range from eight inches below to twelve inches above the existing "Plimsoll" marks. Vehicle will be photographed, pounds of ballast will be added and photographed again.

Vehicle will be floated in the combat loaded condition and inclined in accordance with the proceedure outlined in Chapter 29 of the Bureau of Ships Manual Ref. 2.

Vehicle will be disturbed in the free condition and the pitch and roll frequencies measured.

Vehicle will be loaded with 1000 gallons of fresh water and sufficient weight added to effect first 9.25 degree bow up trim and second

on 5 degree bow down trim. The engine will then be run at rated speed and the bilges emptied.

3.1.3 Data Required

The following are required:

a. Center of buoyancy.

b. Vertical center of gravity.

c. Inclining angles and corresponding righting moments.

d. Natural pitch frequency.

e. Natural roll frequency.

f. Time to empty the bilges and the amount of water remaining.

3.2 Towing

3.2.1 Objective

To tow the test item in water and onto the beach, thus to insure adequate provisions for recovery in the event of a power or transmission failure.

3.2.2 Method

A towing bridle will be attached to the bow towing eyes. The test item will be towed at water speeds up to 8 knots or the safe maximum speed, whichever is lower. The test item will be winched or towed ashore on a shallow sand shelf.

3.2.3 Data Required

The following is required:

a. Comments on suitability of towing bridle, ease of attachment.

b. Comments on directional stability.

c. Influence of speed on pitch stability and photographs showing trim angle at maximum towing speed.

d. Towing resistance as a function of speed.

3.3 Water Speed

3.3.1 Objective

To calibrate the speed reading instruments mounted on test items with the speeds recorded separately and with great reliability by running test items at constant speed(s) over a time-distance course.

To measure the speed in different sea states at various power settings.

3.3.2 Method

Runs will be made at various engine rpm.

Buoys or markers will be set in pairs one statute mile (approximately) apart. The distance will be surveyed. Elapsed time between pairs coinciding at each end of the course will be measured by a stop watch. Three reciprocal runs will be made in calm water and the times averaged. Tests will be repeated in sea states 2 and 3.

The transverse component of current should be allowed for when significant. For example, a transverse component of 14 percent of the measured speed will give an error of 1 percent low. A component of 20 percent will give 2 percent low.

3.3.3 Data Required

a. A curve showing the relation between engine rpm and vehicle speed in calm water at the mid center of gravity position.

b. Effect of center of gravity position on maximum speed.

c. Effect of sea state on maximum speed at the mid center of gravity position.

3.4 Component Cooling in Water Operation

3.4.1 Objective

To determine stabilization of temperatures (heat balance) in critical areas and components.

3.4.2 Method

Water endurance runs will be conducted in the combat loaded condition in rough and calm water at maximum safe operating speeds for the prevailing sea condition.

3.4.3 Data Required

Curves showing the relation between time, component temperatures, engine rpm and water speed in calm and rough water.

3.5 Fuel and Oil Consumption in Water Operation

3.5.1 Objective

To determine maximum fuel and oil consumption under various conditions of combat loaded water operation and minimum fuel consumption (maximum fuel economy) under combat equipped conditions.

3.5.2 Method

Tests will be conducted by operating in combat loaded and combat equipped condition in calm and rough water at various engine rpm.

Oil consumption will be measured throughout the tests by dipping the tank before and after each test. Oil additions will be entered in the log book by time and date.

3.5.3 Data Required

The following are required:

a. Curve of fuel consumption (pounds per hour) versus engine speed (rpm) and water speed (combat loaded and combat equipped). Sea state condition will be noted.

b. Record of oil consumption versus hours of operation.

3.6 Shaft Horse Power

3.6.1 Objective

To determine power input to the water jets.

To determine power output from the engine drive shaft.

Note: Unless specifically requested, the second item is usually not measured.

3.6.2 Method

Torque meters are inserted into the water jet shafts as close to the water jets as possible.

RPM is measured at some convenient location in the drive system, having a fixed gear ratio with the water jet shaft.

Torque and rpm are recorded during the speed trials described in Test 3.3.

3.6.3 Data Required

Curves giving engine rpm and torque versus water speed for combat loaded and combat equipped operation. Sea states will be recorded and reported.

3.7 Bollard Pull

3.7.1 Objective

To check towing ability; to provide data on the static thrust

of the water jets.

3.7.2 Method

The test item is secured to a suitable bollard by means of a cable containing a tension meter. The cable and bollard should be close to water level to reduce changes in the pitch angle as the load increases. Tests must be conducted in absence of currents. Remote read out should be provided to avoid the hazards of whiplash due to cable parting. RPM will be steadied at equal increments until maximum rpm is attained.

3.7.3 Data Required

Curve of water jet thrust versus engine rpm and shaft horse power.

3.8 Trim (Center of Gravity) and Turning

3.8.1 Objective

To determine by tests reasonable extremes of trim for satisfactory and safe operation.

3.8.2 Method

Operations will be conducted in the combat loaded and combat equipped conditions with the center of gravity at the mid and the extreme fore and aft positions as determined by Test No. 2.19 plus ten percent of the fore and aft movement. Operations will also be conducted with the center of gravity at the mid position but displaced beamwise an amount up to two percent of the beam width.

Speed runs will be made in different sea conditions. Speeds and rpm will be recorded.

Turns will be made at various speeds and turning rates will be recorded.

3.8.3 Data Required

a. Comparison between pitching and rolling action in sea states 1, 2, and 3 with the center of gravity at the mid and extreme positions.

b. Water speed versus rpm for the extreme center of gravity positions at the combat loaded and combat equipped weights.

c. Turning diameter versus speed at the extreme center of gravity positions in the combat loaded and combat equipped conditions.

d. Recommendations for safe reasonable trim angles.

3.9 Surf

3.9.1 Objective

To conduct operations through different types of surf, up to a possible maximum of ten feet plunging surf, when approaching and leaving the beach.

3.9.2 Method

The test item will be loaded in suitable increments with variations of center of gravity position and tests conducted in surf in suitable increments in height at the discretion of the test Project Officer, commencing with breaking surf and ending with plunging surf. The presence of wind and lateral currents will be noted and measured. Surf height and wave length will be recorded. The test item's ability to enter and leave the water and its controllability in surf will be noted. Roll, pitch, engine characteristics, rate of turn, and carbon monoxide concentration will be recorded.

Detailed surf testing proceedures are described in the high surf operating proceedures of the West Coast Branch, Amphibian Vehicle Division, Marine Corps Landing Forces Development Center, Quantico, Virginia, Ref. 3.

The maximum surf height to be attempted will vary with the type of vehicle and therefore will be specified by the Chief, Amphibian Vehicle Division individually for each test item.

3.9.3 Data Required

a. Surf height and period.

b. Wind and current velocities.

d. Maximum roll and pitch angles.

d. Rate of turn.

e. Carbon monoxide concentrations.

f. Engine rpm as a function of time.

g. Film records of all test runs in high plunging surf.

3.10 Compatibility with Shipping

3.10.1 Objective

To determine the capability of the test item to embark on or debark from the LSD, LPD, and LST.

3.10.2 Method

The test item will be engaged in boarding and debarking operations from LST, LPD, and LSD. Ability of the test item to enter and withdraw from mezzanine decks will be checked. Refuelling will be conducted.

Test item will be loaded from side booms and its ability to hold station and avoid entrapment by ship rolling and heaving will be checked.

3.10.3 Data Required

Refuelling rate and time.

3.11 River and Marsh

3.11.1 Objective

To determine the swimming characteristics in swift currents, entrance and exit limitations along inlet banks.

3.11.2 Method

Operations will be conducted in fast moving tides up to 8 knots with particular notice to stability, maneuverability, controllability, the ability to enter, depart and cross tidal currents.

Maneuverability will be checked by determining if the vehicle will hold a straight course and evaluating turning response in currents.

Entrance and exit limitations along stream banks should be determined including the use of aids or devices for the capability.

3.11.3 Data Required

Entry and exit bank angles.

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