# METHOD 512.6

# IMMERSION

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**NOTE:** Tailoring is essential. Select methods, procedures, and parameter levels based on the tailoring process described in Part One, paragraph 4.2.2, and Annex C. Apply the general guidelines for laboratory test methods described in Part One, paragraph 5 of this Standard.

## 1. SCOPE.

### 1.1 Purpose.

The immersion test is performed to determine if materiel can withstand immersion or partial immersion in water (e.g., fording), and operate as required during or following immersion.

### 1.2 Application.

Use this Method for materiel that may be exposed to partial or complete immersion, with or without operation. This test may, in some cases, be used to verify watertightness in lieu of a rain test, provided the materiel configuration would be the same for both situations, and the method of water ingress is well understood. There are documented situations in which the impact of rain causes pumping of water across seals during the rain test that does not occur when seals are held tight against a backing plate by the static pressure of the immersion test. In most cases, both tests should be performed.

### 1.3 Limitations.

Immersion tests are not intended to be used for buoyant items unless the life cycle profile identifies specific applications such as restraints (including palletized loads) that could hold the materiel under water.

## 2. TAILORING GUIDANCE.

### 2.1 Selecting the Immersion Method.

After examining requirements documents and applying the tailoring process in Part One of this Standard to determine where immersion or fording is anticipated in the life cycle of materiel, use the following to confirm the need for this Method and to place it in sequence with other methods.

#### 2.1.1 Effects of Leakage During Immersion.

Penetration of water into materiel or packaging enclosures can result in problems. Consider the following typical problems to help determine if this Method is appropriate for the materiel being tested. This list is not intended to be all-inclusive.

a. Fouling of lubricants between moving parts.

b. Formation of electrically conductive paths that may cause electrical or electronic equipment to malfunction or become unsafe to operate.

c. Corrosion due to direct exposure to the water or to the relatively high humidity levels caused by the water.

d. Impairment of the burning qualities of explosives, propellants, fuels, etc.

e. Failure of vehicle engines to operate.

#### 2.1.2 Sequence Among Other Methods.

a. General. Use the anticipated life cycle sequence of events as a general sequence guide (see Part One, paragraph 5.5).

b. Unique to this Method.

(1) There are at least two philosophies related to test sequence. One approach is to conserve test item life by applying what are perceived to be the least damaging environments first. For this approach, generally apply the immersion test prior to most other climatic tests.

(2) Another approach is to apply environments to maximize the likelihood of disclosing sequential problems. For this approach, consider the immersion test both before and after structural tests such as shock and vibration to aid in determining the test item's resistance to dynamic tests.

**2.2 Selecting Procedures.**

This Method includes two test procedures, Procedure I (Immersion) and Procedure II (Fording). Determine the procedure(s) to be used.

**2.2.1 Procedure Selection Considerations.**

When selecting procedures, consider:

a. The operational purpose of the materiel. From the requirements documents, determine the functions to be performed by the materiel when partially or completely immersed in water.

b. The natural exposure circumstances.

c. The test data required to determine whether the operational purpose of the materiel has been met.

**2.2.2 Difference Between Procedures.**

While both procedures involve some degree of immersion, they differ in that Procedure I (Immersion) primarily addresses leakage during immersion of encased materiel, while Procedure II (Fording) focuses on vehicles traversing a body of water or materiel secured to such vehicles.

**2.3 Determine Test Levels and Conditions.**

Having selected this Method and relevant procedures (based on the materiel's requirements documents and the tailoring process), it is necessary to complete the tailoring process by selecting specific parameter levels and special test conditions/techniques for these procedures based on requirements documents, Life Cycle Environmental Profile (LCEP), and information provided with this procedure. From these sources of information, determine the functions to be performed by the materiel while immersed or following exposure to immersion. Then, determine the depth and duration of immersion anticipated in areas in which the materiel is designed to be employed. To do this, consider the following in light of the operational purpose and life cycle of the materiel.

**2.3.1 Identify Climatic Conditions.**

Identify the appropriate climatic conditions for the geographic areas in which the materiel will be operated and stored, and whether or not test item needs to be operated during the test.

**2.3.2 Determine Exposure Conditions.**

Base the specific test conditions on field data if available. In the absence of field data, determine the test conditions from the applicable requirements documents. If this information is not available, use the following guidance:

**2.3.2.1 Test Item Configuration.**

Use a test item configuration that reproduces, as close as possible, the anticipated materiel configuration during storage or use, such as:

a. Enclosed in a shipping/storage container or transit case.

b. Protected or unprotected.

c. Deployed realistically or with restraints, such as with openings that are normally covered.

**2.3.2.2 Conditioning Temperature.**

Experience has shown that a temperature differential between the test item and the water can affect the outcome (leakage) of an immersion test. The temperature of the water shall be 18 °C ±10 °C (64 °F ±18 °F). Increasing the test item temperature above the water temperature for the immersion test (Procedure I) usually includes heating of the test item to establish a pressure differential (while cooling) to determine if the seals or gaskets leak under relatively low pressure differential, and to induce expansion/contraction of materials. Although desired, establishing a specific temperature differential for fording tests is often impractical due to the size of the materiel. Also, consider materiel adjacent to heat-producing equipment such as engines, and use temperatures indicative of actual exposure.

a. Unless otherwise identified, three options are provided for the conditioning of the test item:

(1) 27 °C (49 °F) above the water temperature - to represent exposure to solar heating immediately prior to immersion.

(2) 10 °C (18 °F) above the water temperature - to represent a typical temperature difference between materiel and water.

(3) Equal to the water temperature - to represent situations in which little or no temperature differential exists. This may be used for large items for which adequate conditioning facilities are not available, provided the depth of immersion is adjusted to result in the same differential pressure.

b. Recommend the duration of conditioning immediately prior to immersion be at least two hours to ensure maximum heat loss during immersion and cooling.

**2.3.2.3 Depth of Immersion.**

a. Complete immersion. For testing the integrity of a test item, use a 1 m covering depth of water or to the required depth as identified in the LCEP or the requirements document (measured from the uppermost surface of the test item to the surface of the water). When testing to depths greater than 1 m within a pressure vessel, it is required to completely immerse the test item in water and then apply the required pressure. The relevant depth/pressure equation follows:

$$P = 9.8d \text{ (fresh water)}$$

$$P = 10.045d \text{ (salt water)}$$

Where:

d = depth of the water in meters

P = pressure in kPa (1 psi = 6.895 kPa).

**NOTE**: When testing to depths greater than 1 m, within a pressure vessel, the volume of water shall continue to surround the test item throughout the test. The equivalent head of sea water is 0.975 times the head of fresh water for the same pressure difference.

b. Partial immersion. Where materiel is unlikely to be completely immersed either due to anticipated water depths or to its ability to float, and being unlikely to be restrained, a partial immersion test may be appropriate. In this case, specify depths as being measured from the base of the materiel rather than from the top.

**2.3.2.4 Depth of Fording.**

The fording test may also be used to cover the requirements of STANAG 2805 (paragraph 6.1, reference a), that specifies the following depths.

a. Shallow fording.

(1) Tanks and armored cars:

(a) Light tanks and armored cars – 1 m (39.4 in.).

(b) Other tanks (slightly more ground compression) - 1.05 m (41.3 in.).

(2) Vehicles under 2 ton payload - 0.5 m (19.7 in.).

(3) Other vehicles - 0.75 m (29.5 in.).

b. Deep fording. It is essential that all tactical vehicles and guns, either with built-in waterproofing or by the use of waterproofing kits, be able to deep ford six (6) minutes in fresh or salt water to the depths indicated below (the depth to take into account ramp angle as well as wave height):

(1) Fully enclosed armored vehicles should be able to deep ford to the top of the turret. (Alternatively, these vehicles are to be fitted with flotation equipment.)

(2) All other prime movers or self propelled guns, except trailed loads, should be able to deep ford 1.5 m (59 in.).

(3) All trailers or towed guns should be capable of complete immersion. (Alternatively, this materiel should be capable of flotation.)

**2.3.2.5 Materiel Fording.**

Materiel designed to be transported on open vehicles and trailers (such as equipment trailers) should be capable of withstanding partial immersion as anticipated during fording exercises. Examples of fording depths for this type of materiel are as follow:

a. S-280 shelter: 53 cm (21 inches).

b. S-250 shelter: 76 cm (30 inches).

**2.3.2.6 Duration of Immersion or Exposure.**

Use a duration of immersion typical of that anticipated during use. If this duration is unknown, a 30-minute immersion period is considered adequate to develop leakage if it is to occur. Use one hour fording durations (other than as specified in paragraph 2.3.2.2) that may be extended if justified by the anticipated life cycle profile.

**3. INFORMATION REQUIRED.**

**3.1 Pretest.**

The following information is required to conduct immersion/fording tests adequately.

a. General. Information listed in Part One, paragraphs 5.7 and 5.9; and Annex A, Task 405 of this Standard.

b. Specific to this Method.

(1) Water temperature.

(2) The temperature to which to heat the test item (above the water temperature) and duration.

(3) The fording/immersion depths.

(4) The immersion durations.

(5) Tiedown precautions (to prevent unrealistic stress).

c. Tailoring. Necessary variations in the basic test procedures to accommodate environments identified in the LCEP.

**3.2 During Test.**

Collect the following information during conduct of the test:

a. General. Information listed in Part One, paragraph 5.10; and in Annex A, Tasks 405 and 406 of this Standard.

b. Specific to this Method.

(1) Location of any bubbles (indicating leaks).

(2) Water temperature 15 minutes following immersion.

### 3.3 Post-Test.

The following post test data shall be included in the test report.

a. General. Information listed in Part One, paragraph 5.13; and in Annex A, Task 406 of this Standard.

b. Specific to this Method.

(1) Pretest water and test item temperatures.

(2) Quantity of any free water found inside the test item and probable point(s) of entry.

(3) Actual covering depth of water.

(4) Duration of immersion.

(5) Any deviations from the original test plan.

(6) Photographs as appropriate.

## 4. TEST PROCESS.

### 4.1 Test Facility.

a. For immersion tests, in addition to a chamber or cabinet capable of conditioning the test item to the required temperature, use a water container that can achieve a covering depth of 1 m (or other required depth) of water over the uppermost point of the test item and maintain the test item at that depth. To represent greater depths, it may be necessary to apply air pressure to the surface of the water.

b. For fording tests, use a facility equipped with a tie-down capability to prevent buoyant test items from floating.

c. A water soluble dye such as fluorescein may be added to the water to aid in locating water leaks.

### 4.2 Controls.

Before each test, verify the critical parameters. Ensure the immersion test pull-down/hold-down device(s) are functioning properly and that there are no safety problems.

### 4.3 Test Interruption.

Test interruptions can result from two or more situations, one being from failure or malfunction of test chambers or associated test laboratory equipment. The second type of test interruption results from failure or malfunction of the test item itself during operational checks.

#### 4.3.1 Iterruption Due To Chamber Malfunction.

a. General. See Part One, paragraph 5.11 of this Standard.

b. Specific to this Method.

(1) Undertest interruption. Treat an interruption that results in less severe conditions than specified as an invalid test. Dry the test item and repeat the entire test procedure from the beginning. Treat any failure discovered during an undertest condition as a failure.

(2) Overtest interruption. If more severe conditions than intended are applied and a failure results, repeat the test, if possible, on a replacement item. If no failure occurs, the test need not be repeated.

#### 4.3.2 Interruption Due To Test Item Operation Failure.

Failure of the test item(s) to function as required during operational checks presents a situation with several possible options.

a. The preferable option is to replace the test item with a “new” one and restart from Step 1.

b. A second option is to replace / repair the failed or non-functioning component or assembly within the test item with one that functions as intended, and restart the entire test from Step 1.

**NOTE**: When evaluating failure interruptions, consider prior testing on the same test item, and the consequences of such.

### 4.4 Test Execution.

The following steps, alone or in combination, provide the basis for collecting necessary information concerning the test item when partially or completely immersed in water.

#### 4.4.1 Preparation for Test.

##### 4.4.1.1 Preliminary Steps.

Before starting the test, review pretest information in the currently approved test plan to determine test details (e.g., procedures, item configuration, cycles, durations, parameter levels for storage/operation, etc.). (See paragraph 3.1 above.)

**NOTE:** Do not use sealing, taping, caulking, etc., except as required in the design specification for the materiel.

a. If possible, when testing a shipping/storage container or transit case without the test items enclosed, remove all dunnage, packing, padding material, etc., that may absorb water before the test so that leakage can be detected. This option may not provide an adequate test of the container if the seals are not representatively stressed because of the absence of the contents.

b. Secure items that may experience immersion when mounted on, or secured to a carrying platform, representatively. If representative of the real life situation, stacking is an acceptable method of restraining items under water.

##### 4.4.1.2 Pretest Standard Ambient Checkout.

All items require a pretest standard ambient checkout to provide baseline data. Conduct the pretest checkout as follows:

Step 1 Stabilize the test item temperature at standard ambient conditions.

Step 2 Conduct a complete visual examination of the test item with special attention to sealed areas, gaskets/seals, and structural integrity, and document the results. Take photographs, if appropriate. Verify that no free water is present; if so, dry.

Step 3 Conduct an operational checkout in accordance with the test plan and record the results.

Step 4 If the test item operates satisfactorily and seals appear to function as intended, proceed to Step 1 of the test procedure. If not, resolve the problem and restart at Step 1 of pretest checkout.

#### 4.4.2 Procedure I - Immersion.

Step 1 If weight gain is likely to be an acceptable method of determining leakage, weigh the test item.

Step 2 Three times immediately before the test, open and close (or remove and replace) any doors, covers, etc., that would be opened during normal use to ensure any seals are functioning properly and are not adhering to the sealing (mating) surfaces.

Step 3 Measure and record the immersion water temperature.

Step 4 Condition the test item as in paragraph 2.3.2.2 and record the conditioning temperature and duration. Leave the test item's sealed areas (where appropriate) open throughout the conditioning cycle. Also, materiel occasionally incorporates valves or venting devices that may or may not be opened in normal service use. If the test item incorporates such devices, open them throughout the conditioning portion of the test.

Step 5 Close all sealed areas and valves; assemble the test item in its test configuration and, as quickly as possible, immerse the test item in water so that the uppermost point of the test item is 1 ±0.1 m below the surface of the water, or as otherwise required by the test plan. The orientation of the test item should represent that of its expected in-service orientation. If several orientations are possible, select that which is most severe.

Step 6 Following a 30-minute immersion period (or as otherwise specified in the test plan), remove the test item from the water, wipe the exterior surfaces dry (giving special attention to areas around seals and relief valves) and, if applicable, equalize the air pressure inside by activating any manual valves. Be careful to not allow water to enter the test item while activating the manual valves.

Step 7 If appropriate, re-weigh the test item.

Step 8 Open the test item and examine the interior and contents for evidence of, and quantity of any leakage and, if leakage occurred, for probable areas of entry. If using fluorescein use a blacklight to determine if any of the fluorescein dye has penetrated the test item.

Step 9 If appropriate; conduct an operational check of the test item and record results. See paragraph 5 for analysis of results.

**4.4.3 Procedure II - Fording.**

Conduct the fording test in one of two ways: by towing or driving the test item through water at the appropriate depth, or by securing the test item in a tank and flooding the tank to the required depth. Unless otherwise justified, condition the test item as in paragraph 2.3.2.2.

Step 1 If weight gain is likely to be an acceptable method of determining leakage, weigh the test item prior to the test.

Step 2 With the test item in its fording configuration, **ensure that any drain plugs or apparatus are closed**, and either:

a. Tow or drive the test item into the water at the required depth.

b. Secure the test item in a watertight tank.

Step 3 If using the tank method; flood the tank to the required height above the bottom of the test item.

Step 4 Maintain the test item in the water for a duration as determined in paragraph 2.3.2.6.

Step 5 Either remove the test item from the water, or drain the water from the facility, and inspect the interior of the test item for evidence of free water.

Step 6 Measure and record the amount of any free water, and the probable point(s) of entry. If appropriate, re-weigh the test item.

## 5. ANALYSIS OF RESULTS.

In addition to that specified in Part One, paragraphs 5.14 and 5.17, any evidence of water penetration into the test item following this test must be assessed for its short and long term effects, as well as the requirements of the test item specification. To assist in the evaluation of test results, consider the effects of free water as well as the increase of relative humidity in closed containers following the evaporation of any free water.

## 6. REFERENCE/RELATED DOCUMENTS.

### 6.1 Referenced Documents.

NATO STANAG 2805, Fording and Floatation Requirements for Combat and Support Ground Vehicles.

### 6.2 Related Documents.

a. NATO STANAG 4370, Environmental Testing.

b. NATO Allied Environmental Conditions and Test Publication (AECTP) 300, Climatic Environmental Testing (under STANAG 4370), Method 307.

c. Egbert, Herbert W. “The History and Rationale of MIL-STD-810 (Edition 2)”, January 2010; Institute of Environmental Sciences and Technology, Arlington Place One, 2340 S. Arlington Heights Road, Suite 100, Arlington Heights, IL 60005-4516.

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