Downloaded from http://www.everyspec.com

4.6.4.2 Test Tolerances – Fragility (Procedure III).

It is assumed that the instrumentation noise in the measurements is low so that tolerances may be established. For complex transients from measured data, ensure test tolerances are consistent with the general guidelines provided in paragraph 4.2.2. For classical pulse testing, ensure the test tolerances specified in Figure 516.8-4, with respect to the information provided in Table 516.8-VIII, are satisfied.

4.6.4.3 Test Procedure – Fragility (Procedure III).

This test is designed to build up in severity as measured in peak acceleration or velocity change until a test item failure occurs, or a predetermined goal is reached. It may be necessary to switch axes between each shock event unless critical axes are determined prior to test. In general, all axes of importance will be tested at the same level before moving to another level. The order of test activity and the calibration requirements for each test setup should be clearly established in the test plan. It is also desirable to pre-select the steps in severity based on knowledge of the materiel item or the test environment, and document this in the test plan. Unless critical stress thresholds are analytically predicted and instrumentation used to track stress threshold buildup, there is no rational way to estimate the potential for stress threshold exceedance at the next shock input level. The following procedures, one for a classical pulse and the other for a complex transient, are written as if the test will be conducted in one axis alone. In cases where more test axes are required, modify the procedure accordingly.

a. Classical Pulse. This part of the procedure assumes that the classical pulse approach is being used to establish the fragility level by increasing the drop height of the test item, thereby increasing the ΔV directly. The fragility level is given in terms of the measurement variable-peak acceleration of the classical pulse while holding the pulse duration as a function of the materiel modal characteristics a constant. In using this procedure, estimate the first mode mounted frequency of the materiel in order to specify the pulse duration T_D.

Step 1 Mount the calibration load to the test apparatus in a configuration similar to that of the actual test item. Use a fixture similar in configuration to the interface of the shock attenuation system (if any) that will support the materiel. The fixture should be as rigid as possible to prevent distortion of the shock pulse input to the test item.

Step 2 Perform calibration shocks until two consecutive shock applications to the calibration load reproduce the waveforms that are within the specified test tolerances. If response to the calibration shock is nonlinear with respect to shock input level, other test procedures may need to be applied to establish materiel fragility levels depending upon the extent of the nonlinearity prior to reaching the "stress threshold".

Step 3 Select an initial drop height low enough to assure that no damage will occur by selecting a fraction of the anticipated service drop height established from Transit Drop Tables 516.8-IX thru 516.8-XI. The maximum velocity change can be taken to be:

$$\Delta V = 2\sqrt{2gh}$$

Where:
ΔV = maximum test item velocity change, m/s (in/s) (assumes full resilient rebound of test item)
h = drop height, m (in.)
g = acceleration of gravity 9.81 m/s^2 (386.09 in/s^2)

Step 4 Mount the test item in the fixture. Perform an operational check and document the pre-test condition. If the test item operates satisfactorily, proceed to Step 5. If not, resolve the problems and repeat this step.

Step 5 Perform the shock test at the selected level, and examine the recorded data to assure the test is within tolerance.

Step 6 Visually examine and operationally check the test item to determine if damage has occurred. If the test item does not operate satisfactorily, follow the guidance in paragraph 4.3.2 for test item failure.

Downloaded from http://www.everyspec.com

Step 7 If it is required to determine the fragility of the test item in more than one axis, proceed to test the item (Steps 4-6) in the other axes (before changing the drop height).

Step 8 If the test item integrity is preserved, select the next drop height.

Step 9 Repeat Steps 4 through 8 until the test objectives have been met.

Step 10 Perform a post shock operational test of the test item. See paragraph 5 for analysis of results. Document the results, including plots of the measured test response waveforms, and any pre- or post-shock operational anomalies.

b. Synthesized Pulse. This part of the procedure assumes that the fragility level is some function of the peak acceleration level that correlates with a maximax acceleration SRS of a complex transient base input (because stress relates to velocity a peak pseudo-velocity level determined from a maximax pseudo-velocity SRS of a complex transient is preferable). For a complex transient specified in the time domain, this procedure generally uses the peak acceleration of the time history to define the fragility level.

Step 1 Mount the calibration load to the test apparatus in a configuration similar to that of the actual test item. Use a fixture similar in configuration to the interface of the shock attenuation system (if any) that will support the materiel. The fixture should be as rigid as possible to prevent distortion of the shock pulse input to the test item.

Step 2 Perform calibration shocks until two consecutive shock applications to the calibration load reproduce maximax acceleration SRS or pseudo-velocity SRS that are within the specified test tolerances. If response to the calibration shock is nonlinear with respect to shock input level, other test procedures along with simple modeling may need to be applied to establish materiel fragility levels, depending upon the extent of the nonlinearity prior to reaching the "stress threshold".

Step 3 Select a peak maximax acceleration (or pseudo-velocity) SRS level low enough to assure no damage will occur.

Step 4 Mount the test item in the fixture. Inspect and operationally test the item to document the pre-test condition. If the test item operates satisfactorily, proceed to Step 5. If not, resolve the problems and repeat this step.

Step 5 Perform the shock test at the selected level, and examine the recorded data to assure the test maximax acceleration (or pseudo-velocity) SRS is within tolerance.

Step 6 Visually examine and operationally check the test item to determine if damage has occurred. If so, follow the guidance in paragraph 4.3.2 for test item failure.

Step 7 If it is required to determine the fragility of the test item in more than one axis, proceed to test the item in the other axes (before changing the peak maximax acceleration (or pseudo-velocity) SRS level).

Step 8 If the test item integrity is preserved, select the next predetermined peak maximax acceleration (or pseudo-velocity) SRS level.

Step 9 Repeat Steps 5 through 8 until the test objectives have been met.

Step 10 Perform a post shock operational test of the test item. See paragraph 5 for analysis of results. Document the results, including plots of the measured test response waveforms and any pre- or post-shock operational anomalies.

4.6.5 Transit Drop (Procedure IV).

The intent of this test is to determine the structural and functional integrity of the materiel to a transit drop either outside or in its transit or combination case. In general, there is no instrumentation requirement for the test and measurement information is minimized, however, if measurements are made, the maximax acceleration SRS and the pseudo-velocity SRS will define the results of the test, along with the measurement amplitude time history.

Downloaded from http://www.everyspec.com

4.6.5.1 Test Controls - Transit Drop (Procedure IV).

Test levels for this test are based on information provided in Tables 516.8-IX thru 516.8-XI. Test the item in the same configuration that is used in transportation, handling, or a combat situation. Toppling of the item following impact will occur in the field and, therefore, toppling of the test item following its initial impact should not be restrained as long as the test item does not leave the required drop surface. Levels for this test were set by considering how materiel in the field might commonly be dropped. Conduct all drops using a quick release hook, or drop tester. Use of a standardized impact surface is recommended for test repeatability because the surface configuration can influence test results. For most drop test requirements, steel plate on reinforced concrete is the default impact surface. The plate shall be homogenous material with a minimum thickness of 3 inches (76 mm) and Brinell hardness of 200 or greater. The plate shall be uniformly flat within commercial mill production standards, level within 2 degrees, and free of surface irregularities that may influence impact results. The concrete shall have a minimum compressive strength of 2500 psi (17 MPa), and be reinforced as required to prevent fracture during testing. In high velocity hazard classification drop scenarios (e.g. 40 ft) it is necessary for the concrete strength be 4000 psi with a minimum thickness of 24 inches. The steel plate shall be bonded and/or bolted to the concrete to create a uniform rigid structure without separation. The concrete foundation plus the impact plate mass shall be a minimum of 20 times the mass of the test item. The plate surface dimensions shall be sufficiently large to provide direct and secondary rotational impacts, and if possible rebound impacts. Guidance systems which do not reduce the impact velocity may be employed to ensure correct impact angle; however the guidance shall be eliminated at a sufficient height above the impact surface to allow unimpeded fall and rebound. Use of armor plate or similar composition steel plate is recommended to improve steel surface durability and prevent impact indentation and cuts. The impact surface shall be free from standing water, ice, or other material during testing. The most severe damage potential is impact with a non-yielding mass that absorbs minimal energy. Thus, use of a single monolithic impact mass is recommended to reduce energy transfer into the mass rather than the test item. The impact mass rigidity and energy transfer can be evaluated by measurement of the mass acceleration during testing.

Tables 516.8-IX thru 516.8-XI provide default drop conditions for transport from manufacturer to the end of its service life. Table 516.8-IX (Logistic Transit Drop Test) includes drop scenarios generally associated with non-tactical, logistical transport based on weight and test item dimensions. Table 516.8-X (Tactical Transport Drop Test) includes drop scenarios generally associated with tactical transport beyond the theatre storage area. As a default, the criteria for the tactical transport drop tests are to meet all performance requirements. For items that are incapable of meeting performance requirements, adjustments may be made to the drop height or configuration to accommodate the item performance limitations. If the drop conditions are modified, restrictions may be placed on the deployment of the item. Ensure an adequate test is performed and all deviations from this procedure are properly documented. Table 516.8-XI (Severe Tactical Transport Drop Test) includes severe drop scenarios, and the item is considered to have passed if it did not explode, burn, spread propellant or explosive material as a result of dropping, dragging or removal of the item for disposal. Other drop scenarios in the LCEP should be considered.

Realistic variations to the default values provided in Tables 516.8-IX thru 516.8-XI may be permitted when justified; e.g. large/complex systems in which specific handling considerations are identified in the LCEP may supersede the default levels provided.

Figure 516.8-8 illustrates the standard drop orientations as referenced in Tables 516.8-IX thru 516.8-XI. Figure 516.8-9 illustrates typical edge and corner drop configurations for large packages as discussed in Notes 2-4 of Table 516.8-IX.

Downloaded from http://www.everyspec.com

Table 516.8-IX. Logistic Transit Drop Test[1].

Weight of Test Item & Case kg (lbs)	Largest Dimension cm (in.)	Notes	Height of Drop, h cm (in.)	Number of Drops
Under 45.4 (100) Man-packed or man-portable	Under 91 (36)		122 (48)	Drop on each face, edge and corner; total of 26 drops[5]
	91 (36) & over		76 (30)	
45.4 - 90.8 (100 – 200) inclusive	Under 91		76 (30)	Drop on each corner; total of eight drops
	91 (36) & over		61 (24)	
90.8-454 (200 – 1000) inclusive	Under 91		61 (24)	
	91 – 152 (36 – 60)	2	61 (24)	
	Over 152 (over 60)	2	61 (24)	
Over 454 (1000)	No limit	3 4	46 (18)	Drop on each bottom edge. Drop on bottom face or skids; total of five drops

Note 1: *Perform drops from a quick-release hook or drop tester. Orient the test item so that, upon impact, a line from the struck corner or edge to the center of gravity of the case and contents is perpendicular to the impact surface. The default drop surface is steel backed by concrete. Concrete or 5 cm (2 in) plywood backed by concrete may be selected if (a) a concrete or wood surface is representative of the most severe service conditions or (b) it can be shown that the compressive strength of the impact surface is greater than that of the test item impact point(s). Note that the shorter shock duration associated with the steel impact surface may not excite all test item resonant modes.*

Note 2: *With the longest dimension parallel to the floor, support the transit, or combination case with the test item within, at the corner of one end by a block 13 cm (five inches) in height, and at the other corner or edge of the same end by a block 30 cm (12 inches) in height. Raise the opposite end of the case to the specified height at the lowest unsupported corner and allow it to fall freely.*

Note 3: *While in the normal transit position, subject the case and contents to the edgewise drop test as follows (if the normal transit position is unknown, orient the case so the two longest dimensions are parallel to the floor):*

Edgewise drop test: Support one edge of the base of the case on a sill 13-15 cm (five to six inches) in height. Raise the opposite edge to the specified height and allow it to fall freely. Apply the test once to each edge of the base of the case (total of four drops).

Note 4: *For shelters without shock attenuated skids, the drop height may be reduced to 15 cm (6 in) with a 10 cm (4 in) sill for edgewise drops.*

Note 5: *If desired, divide the 26 drops among no more than five test items (see paragraph 4.6.5.1).*

Downloaded from http://www.everyspec.com

Table 516.8-X. Tactical Transport Drop Test.

Scenario	Category	Impact Velocity (m/sec)	Drop Height[1] (m)	Configuration	# Drops / Orientation[3,6]		Impact Surface
Ship Transport	Storage and transport to theatre storage area, transport by ship	5.4 (17.7 ft/sec)	1.5m (5 ft)	Packaged[5]	(minimum of 3)	Flat bottom and two faces.[4]	Steel[7,8] backed by concrete
Unpackaged Handling	Infantry and man-carried equipment	5.4 (17.7 ft/sec)	1.5m (5 ft)	Unpackaged	5	Flat bottom, two faces[4] and two edges[5]	Steel[7,8] backed by concrete
Packaged Handling	Loading and offloading from side of transport vehicle - transport by truck, forklift, & helicopter	6.4 (21 ft/sec)	2.1m (7 ft)	Packaged[5]	5		Steel[7,8] backed by concrete
Helicopter	Underslung load, quick release onto land or ship	6.4 (21 ft/sec)	2.1m (7 ft)	Packaged[5]	1	Flat bottom	Steel[7,8] backed by concrete
Parachute Drop[2]	Low velocity drop	8.7 (28.5 ft/sec)	3.8m (12.6 ft)	Packaged with appropriate honeycomb or other shock absorbing system used in delivery	1	Flat bottom	Concrete
Parachute Drop	High velocity drop	27.3 (90 ft/sec)	38.1m (125 ft)				Concrete

Note 1: *The test is not intended to encompass all credible accident conditions or severe mishandling conditions. Where the drop heights quoted are exceeded by those specified elsewhere in the table or for other phases of Service, the higher values should be substituted.*

Note 2: *Drop heights are provided for simulated parachute drops. This test may not fully address certain effects that can occur during parachute drops in high wind conditions. Consider different drop height and angles of impact to address these issues. Drop from aircraft may be required for airdrop certification.*

Note 3: *Sufficient assets are required to test in each of the orientations specified. Five standard drop orientations are listed in Table XII and illustrated in Figure 8. Consider other drop orientations if expected to have a greater damage potential. Expose each item to no more than 2 drops.*

Downloaded from http://www.everyspec.com

Note 4: *For munitions, the two faces shall be the forward and aft ends of the munition.*

Note 5: *For munitions, the two edges shall be at 45 degrees on the forward and aft ends.*

Note 6: *Unpackaged if required by LCEP or Test Plan.*

Note 7: *The default drop surface is steel backed by concrete. Concrete or 5 cm (2 in) plywood backed by concrete may be selected if (a) a concrete or wood surface is representative of the most severe service conditions or (b) it can be shown that the compressive strength of the impact surface is greater than that of the test item impact point(s). Note that the shorter shock duration associated with the steel impact surface may not excite all test item resonant modes.*

Note 8: *A steel impact surface shall have a Brinell hardness of at least 200. For test items less than 454 kg (1000 lbs) the steel plate shall be at least 2.5 cm (1 in) thick, otherwise it shall be at least 7.6 cm (3 in) thick.*

Table 516.8-XI. Severe Tactical Transport Drop Test.

Scenario	Category	Impact Velocity (m/sec)	Drop Height (m)	Configuration	# Drops / Orientation[4,5]	
Helicopter	External Carriage on Helicopter	6.4 (21 ft/sec)	2.1m (7 ft)	Unpackaged	5	Flat Bottom, two faces[2] and two edges[3]
Military Land Vehicles	Includes weapons loading and off loading	7.7 (25.3 ft/sec)	3.05m (10 ft)	Unpackaged		
Aircraft	External Carriage on Fixed Wing Aircraft	7.7 (25.3 ft/sec)	3.05m (10 ft)	Unpackaged		
Crane	Accidental Crane Drop	15.5 (50.9 ft/sec)	12.2m (40 ft)	Packaged[1]		
Ship Transport	Shipboard Loading	15.5 (50.9 ft/sec)	12.2m (40 ft)	Packaged[1]	(minimum of 3)	Flat Bottom and two faces.[2]
Ship Aircraft Carrier	Shipboard Loading and Handling	22.1 (72.5 ft/sec)	25m (82 ft)	Packaged[1]	5	Flat Bottom, two faces[2] and two edges[3]

Note 1: *Unpackaged if required by LCEP or Test Plan.*

Note 2: *For munitions, the two faces shall be the forward and aft ends of the munition.*

Note 3: *For munitions, the two edges shall be at 45 degrees on the forward and aft ends.*

Note 4: *Sufficient assets are required to test in each of the orientations specified. Five standard drop orientations are shown listed in Table 10 and illustrated in Figure 8. Other drop orientations should be considered if expected to have a greater damage potential. Each item should be exposed to no more than 2 drops.*