



Device Hardware Reliability Test Plan

Version Number	1.0
Date	September 2015

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Section 1 Introduction

1.1 Purpose

The purpose of this document is to define a minimum set of industry standardized Smartphone hardware reliability test requirements. It is designed with the intent to minimize both test cost and test time within the industry by aligning test methodology amongst all of the participants.

With aligned test methodologies, the manufactures and the service providers can run the same test procedures, while at the same time retaining the flexibility to define their unique acceptance criteria. This is accomplished by incorporating a standard stress test cycle for each test environment, and allowing the participants to define the number of stress cycles required to pass or fail. This provides the further benefit of allowing the manufacturers and service providers to have an understanding of the devices' performance margin against the common test requirement.

1.2 Scope

The scope of testing is limited to the hardware reliability of Smartphones.

1.3 Applicable Documents

The following documents are referenced in this test plan. Unless otherwise specified, the latest released version shall be used:

- JESD22-B104C Mechanical Shock Test Method
- IEC 60068-2-32, Environmental testing. Part 2: Tests. Test Ed: Free fall
- IEC 60068-2-31, Environmental testing. Part 2: Tests. Test Ec: Rough handling shocks, primarily for equipment-type specimens
- IPC-TR-467, Supporting Data and Numerical Examples for ANSI./J-STD-001B: Appendix D (Control of Fluxes)
- IEC 60529, Degrees of Protection Provided by Enclosures

Section 2 Physical Shock

2.1 Drop Testing

Reference: JESD22-B104-B, IEC 60068-2-32, IEC 60068-2-31, IPC-TR-467 (Sample size).

Purpose: Simulate and evaluate the phone's endurance and performance after an accidental drop condition as well as simulate stress induced by the end user during shipping and handling.

Test Equipment To be added.

Procedure:

- Test Surface: 25 mm (1") Steel surface over concrete.
- Test Height: 1 m
- Sample size: 5 – Based on IPC-TR-467

Entry Criteria:

- Devices have completed and passed functionality validation per [Appendix A—Device Functionality Validation](#).

Testing Prerequisites:

- Ensure that the test surface is clear of all debris and is smooth.
- Devices are to be tested while powered on with back covers and batteries in place. For devices with removable covers and batteries, do not tape the cover to the phone.

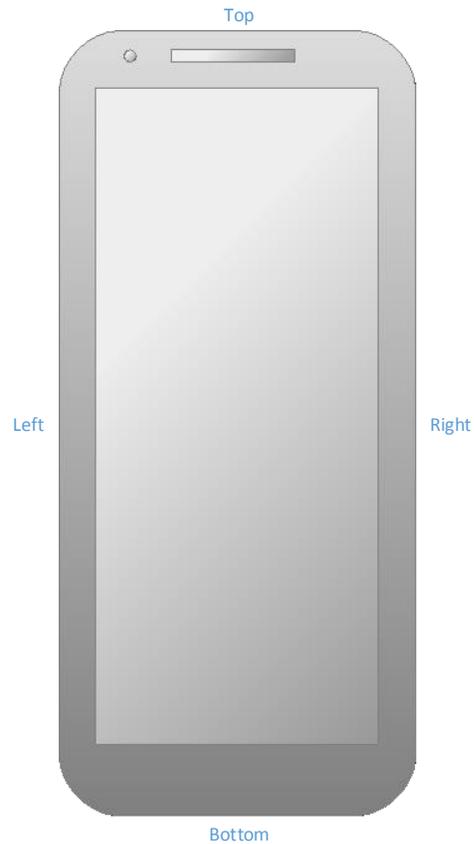
Test Steps:

1. Drop the phone on all 6 surface orientations plus 4 corners for a total of 10 drops in the following sequence (See [Error! Reference source not found.](#)):
 - Front > Back > Right > Left > Top > Bottom > Top Right Corner > Top Left Corner > Bottom Right Corner > Bottom Left Corner
 - Repeat the testing as specified above according to the sequence for a total number of 20 drops.
2. After each impact inspect for obvious physical damage. For devices without removable batteries, note if the device powered off during the drop.
3. Make sure the device comes back on if it powered off or if the battery and cover came off.
4. At the end of each round of 10 drops, perform full functional testing and denote any failures.

Compliance:

- The device shall survive all 20 falls without major physical damage or malfunctions.
- The device shall pass passed functionality validation per Appendix A without failures at the end of both rounds.
- There shall be no screen cracks or malfunctions of any HW keys or touch-screen display.

FIGURE 2.1-1 SURFACE ORIENTATION FOR DROP TESTING



2.2 Tumble/Barrel Test

Reference: JESD22-B104-B, IEC 60068-2-32, IEC 60068-2-31, IPC-TR-467 (Sample size).

Purpose: Mechanically stress all of the phone components to simulate the end user handling or shipping.

Test Equipment To be added.

Procedure: Requirements:

- Ensure that the test surface is clean, clear of all debris and is smooth.
- Test Surface: Steel (~3 mm backed by ~19 mm wood) as defined in 60068-2-31.
- Test Height: 1 m.
- Sample size: 5.

Entry Criteria:

- Devices have completed and passed functionality validation per [Appendix A—Device Functionality Validation](#).

Test Conditions:

- Device is to be powered on during the test.
- Note that the back cover should be taped on for devices with removable covers and batteries.
- The rotational speed (typically 12 drops / minute) of the tumbler shall be adjusted to prevent the DUT from hitting the sides of the chamber during each rotation.

Test Steps:

1. Cycle the device in the barrel for a total of 100 falls at 1 m.
2. Perform Interactive Functional Tests after each 10 falls.

Compliance:

- The device shall survive 100 falls at 1 m without major physical damage or malfunctions.
 - No Screen Cracks or malfunction of any hardware keys.
- The device shall pass Interactive Functional Tests without failures.
- See [Appendix A—Device Functionality Validation](#).

Section 3 Water Ingress

3.1 Ingress Protection based on IPX1

Reference: IEC 60529, Section 14.2.1.

Purpose: The purpose of the test is to ensure that vertically falling drops of water have no harmful effects to the device according to IP classification IPX1.

Test

Equipment: Drip box based on IEC 60529.

Tap Water (local city supplied).

Water flow can be calibrated using the following procedure:

1. Take a box without a top and weigh it with 0.1 g accuracy.
2. Insert the box in the dripping water chamber for 3 minutes.
3. Dry the external areas of the box.
4. Weigh the box with the water inside with 0.1 g accuracy.
5. Use the formula below to calculate the flow rate.

$$R = \frac{M_{after} - M_{before}}{\rho \cdot A \cdot t} \cdot 10$$

R = flow rate (mm/min)

M_{before} = weight of box before exposure to dripping water (g)

M_{after} = weight of box after exposure to dripping water (g)

ρ_{water} = density of water (1 g/cm³ at room temperature) (g/cm³)

A = area of opening where the water can run into the box (cm²)

T = time (min)

10 = conversion factor from cm to mm

Minimum test time for water flow: 3 minutes

The water flow can be adjusted the following ways:

- By controlling the water level of the basin
- By controlling the inlet pressure of a pressurized tank
- Minimum size box (square or rectangle): 200 cm²

Procedure: Requirements:

Sample Size:

- 3 devices with live (or test) SIM/UICC cards, memory cards, new and fully-charged batteries.

Test Equipment:

- To be added.

Entry Criteria:

- Passed full mechanical, functional, and visual inspection.

Test Conditions:

- Test is to be performed in ambient temperature.

Test Steps:

1. Device is powered on and, if possible, in a voice call, while in test.
2. Device orientation on the turntable is 90 degrees vertical (upright position making a call).
3. Place the device on the turntable in the drip box and expose it to dripping water for 10 minutes.
4. If the call is dropped during water exposure, no attempt to re-establish call is needed until after exposure.
5. After water exposure is completed, remove the sample from the drip box keeping it in vertical position.
6. Remove any excess water with a paper towel or cloth; removable parts may be removed and dried off (e.g., SIM/UICC card, memory card, removable battery cover and battery); no moving air may be used (e.g., compressed air, blowdryer, vacuum).
7. If the call dropped during water exposure, re-establish the call within an hour after the test and ensure it stays on the call for 5 minutes.
8. The device is to remain in its vertical position during the dry cycles.

Inspection points:

1. **Immediately after test** (if device remained in a call during water exposure) – check for fatal failures only; after inspection turn off the device and turn on again after 24 hours for full functional inspection.
2. **1 hour after test** (if call dropped during water exposure) – check for fatal failures only; after inspection turn off the device and turn on again after 24 hours for full functional inspection.
3. **24 hours after test** – perform full functional inspection.

Compliance:

Immediately After Test	1 Hour After Test	24 Hours After Test
No Level 1 Failures	No Level 1 Failures	No Level 1 Failures
Level 2 Failures OK	Level 2 Failures OK	No Level 2 Failures

Definitions:

- **Level 1 Failure** – any failure that prevents making a call such as:
 - No cell signal
 - Will not power on
 - Will not stay in a call for 5 minutes after test (if call dropped during test)
 - SIM/UICC card not recognized
 - Touch not working
 - No display
 - Earpiece does not work
 - Mic does not work

- **Level 2 Failure** – any failure that causes degradation of use of device such as:
 - Vibration not working
 - Camera not working
 - Side keys not working
 - Loudspeaker not working
 - Headset Jack not functional

3.2 Ingress Protection based on IPX2

Reference: IEC 60529, Section 14.2.1.

Purpose: The purpose of the test is to ensure that vertically falling drops of water have no harmful effects on the device according to IP classification IPX2.

Test

Equipment:

- Dripping water chamber based on IEC 60529
- Tap water(local city supplied)
- Water flow rate of 3 + 0.5 mm/min. Water flow can be calibrated using the following procedure:
 1. Take a box without a top and weigh it with 0.1 g accuracy.
 2. Insert the box in the dripping water chamber for 3 minutes.
 3. Dry the external areas of the box.
 4. Weigh the box with the water inside with 0.1 g accuracy.
 5. Use the formula below to calculate the water flow rate:

$$R = \frac{M_{after} - M_{before}}{\rho \cdot A \cdot t} \cdot 10$$

R = flow rate (mm/min)

M_{before} = weight of box before exposure to dripping water (g)

M_{after} = weight of box after exposure to dripping water (g)

ρ_{water} = density of water (1 g/cm³ at room temperature) (g/cm³)

A = area of opening where the water can get into the box (cm²)

t = length of time box is exposed to dripping water (min)

10 = conversion factor from cm to mm

* Minimum test time for water flow exposure: 3 minutes

* Water flow can be adjusted the following ways:

- By controlling the water level of the basin
- By controlling the inlet pressure of a pressurized tank
- Minimum size box (square or rectangle): 200 cm²

Sample Size:

- 3 devices with live SIM/UICC cards, memory cards, new and fully-charged batteries

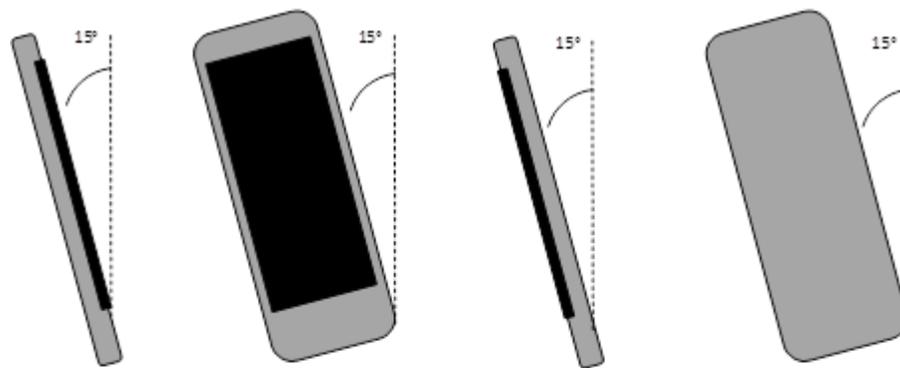
Entry Criteria:

- Passed full mechanical, electrical, and visual inspection

Test Conditions:

- Device is upright, powered on and, if possible, in a voice call, while in test.
- Expose device to water flow in 4 orientations on the turntable 15° tilted from the vertical (See Figure 3.2-1) for a total of 10 minutes at 2.5 minutes per orientation:
 1. Display facing up
 2. Right side facing up
 3. Display facing down
 4. Left side facing up

FIGURE 3.2-1 INGRESS PROTECTION BASED ON IPX2



Test Steps:

1. If call drops during water exposure, no attempt to re-establish call is needed until after the exposure is completed. Re-establish the call within an hour after exposure. It must stay in a call for 10 minutes.
2. After the 10-minute water exposure is completed, remove the sample from the dripping water chamber keeping it in vertical position.
3. Remove any excess water with a paper towel or cloth. Removable parts may be disassembled and dried off (e.g., SIM/UICC card, memory card, removable battery cover and battery). No moving air may be used (e.g., compressed air, blow-dryer, vacuum).

Inspection points:

- **Immediately after the 10-minute water exposure** (if device remained in a call during water exposure) – check for fatal failures only; after inspection turn off the device and turn on again after 24 hours for full functional inspection.
- **1 hour after the 10-minute water exposure** (only if call dropped during water exposure) – check for fatal failures only; after inspection turn off the device and turn on again after 24 hours for full functional inspection.
- **24 hours after 10-minute water exposure** – perform full functional inspection.

Compliance:

Immediately After Test	1 Hour After Test (If call dropped during water exposure)	24 Hours After Test
No Level 1 Failures Level 2 Failures OK	No Level 1 Failures Level 2 Failures OK	No Level 1 Failures No Level 2 Failures

Definitions:

- **Level 1 Failure** – any failure that prevents making a call such as:
 - No cell signal
 - Will not power on
 - Will not stay in a call for 10 minutes after test (if call dropped during test)
 - SIM/UICC card not recognized
 - Touch not working
 - No display
 - Earpiece does not work
 - Mic does not work
- **Level 2 Failure** – any failure that causes degradation of use of device such as:
 - Vibration not working
 - Camera not working
 - Side keys not working
 - Antennas not working (e.g., Bluetooth, GPS, Wi-Fi, NFC)
 - Loudspeaker not working

Section 4 Connectors

4.1 Connector Reliability— I/O, Data

Reference: This test simulates the stresses caused by an end user bending the connector while it is plugged into the device. It also provides general assurance of connector jack durability against other heavy loading scenarios such as accidentally dropping the device on the connector side while the cable is connected to the device. This applies to all connectors except for Audio which is described in [Figure 4.2-1](#).

Purpose: Ensure the strength of assembled system connector, (i.e., micro USB, mini HDMI, micro HDMI), is above the required minimum force.

Test Equipment:

Procedure: Test is performed with a test adapter plug on 6 devices; 2 for up direction, 2 for down direction, 1 for left direction and 1 for right direction.

FIGURE 4.1-1 USB CONNECTOR RELIABILITY—UP/DOWN DIRECTION CASE

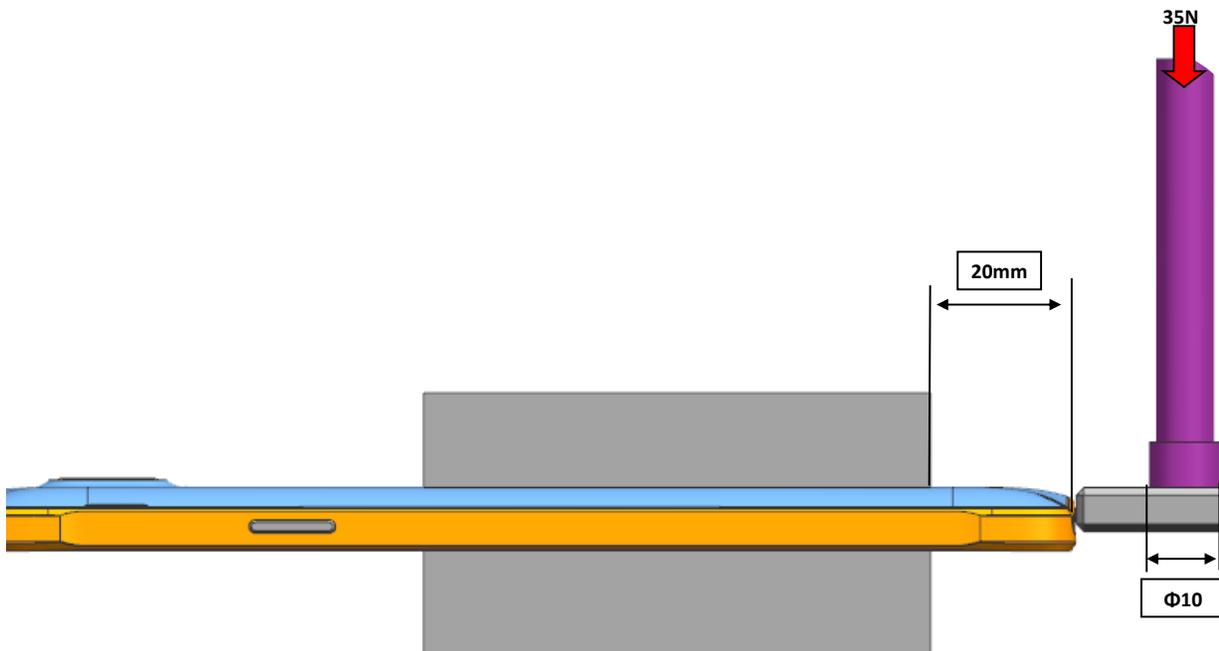
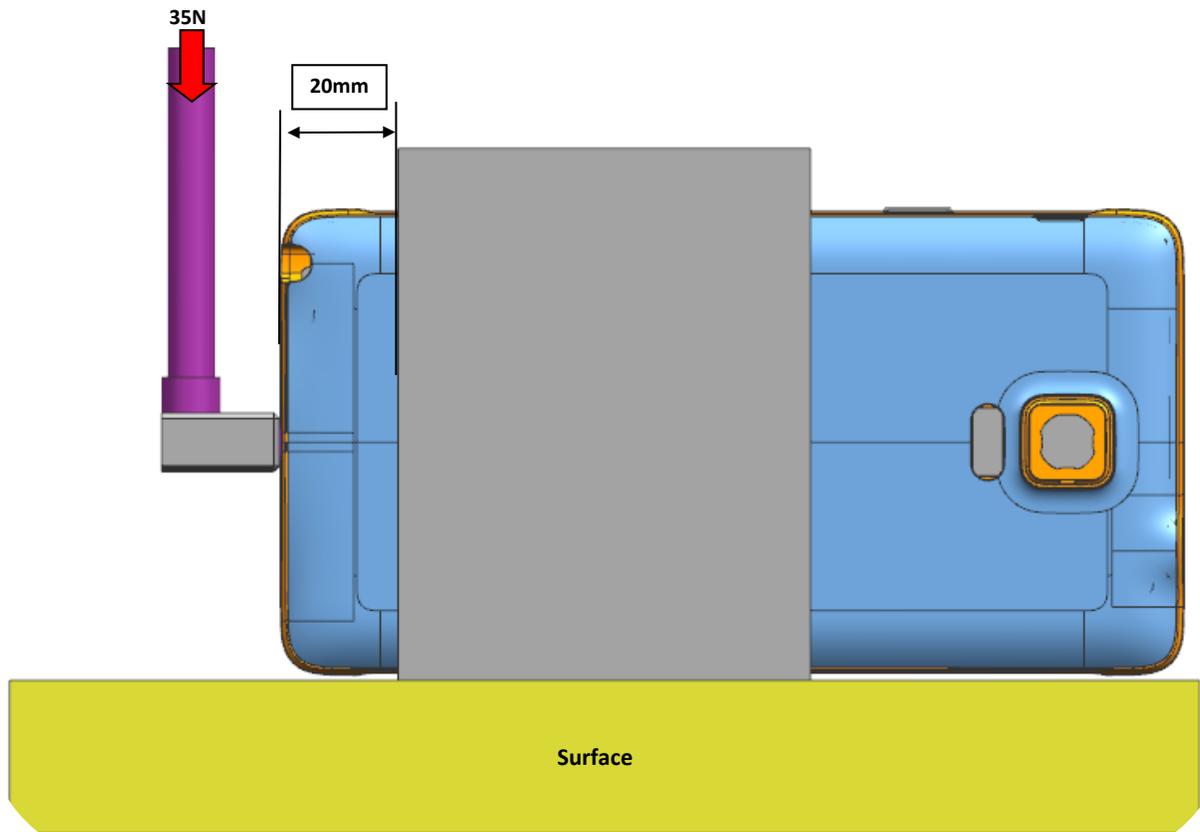


FIGURE 4.1-2 USB CONNECTOR RELIABILITY—LEFT/RIGHT DIRECTION CASE



Test Steps:

1. When executing the test, first fix the device on the testing table on tensile tester (see [Figure 4.1-1](#) and [Figure 4.1-2](#) for fixing instructions) for “up” test direction.
2. Attach the plug to connector receptacle.
3. Apply force to the centerline of the connector at 10mm distance from tip end. Force should be constantly monitored and increased up to 35N with rate of 10 mm/min. Connector or assembly physical break is indicated by sudden drop in force. Stop the test if break off force drop occurs below 35N. After 35N force has been reached, force is reduced gradually back to 0N. Repeat test with second device.
4. Repeat the same test procedure with a new connector plug to “down” direction with total of 2 devices.
5. Repeat the test procedure with new connector plug to “left” direction with one device.
6. Repeat test procedure with new connector plug to “right” direction with one device.
7. At the end devices shall be disassembled, visually examined and electrically/mechanically/functionally checked and ensured to be in fully functional condition without test induced failures.

Compliance: Connector receptacle or PWB on all 6 devices has no functional, mechanical or electrical damage after the test with 35N load.

4.2 Connector Reliability—Audio

Reference: N/A

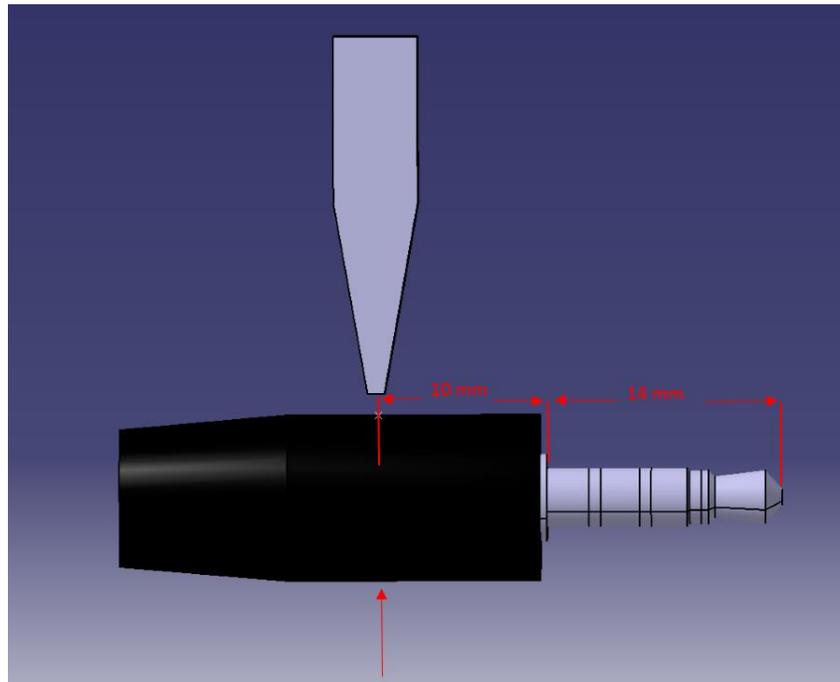
Purpose: Ensure mechanical strength of assembled headset connector. Connector shall withstand 45N force applied perpendicular to the connector plug.

Test Equipment:

Test Overview:

- Test is performed with a test adapter plug on 6 devices; 2 for up direction, 2 for down direction, 1 for left direction and 1 for right direction.
- Devices shall be visually examined and electrically/mechanically/functionally checked prior to test to be in fully functional condition without pre-existing failures.
- Device shall be powered on.
- Test equipment, tensile tester, for this cycle test shall be speed and force/load controllable.
- Force sensor shall have at minimum ± 0.1 N accuracy up to 50N force.
- Test is conducted with 10 mm/min speed.
- Test is performed with standard, stiff headset connector plug ([Figure 4.2-1](#)). For each test direction, test shall be conducted with a new, unused connector plug.
- Device shall be 50% supported for up/down direction tests ([Figure 4.1-1](#)) and is allowed to be up to 100% supported to left/right side tests ([Figure 4.1-2](#)).
- During the test, perpendicular forces (F_p) are applied to the connector plug from 4 directions; Top, Bottom, Left and Right. Force shall be applied 24mm from the tip of the connector. Tip of the connector plug must be inserted at minimum 14mm deep into the connector.
- Lifting connector receptacle from Printed Wire Board (PWB) is considered testing up direction and pushing down toward PWB is downward. Left or Right direction is from looking at the receptacle from its opening as PWB places bottom side of receptacle.

FIGURE 4.2-1 SUPPORT FOR LEFT & RIGHT DIRECTION TEST



Test Steps:

1. When executing the test, first fix the device on the testing table on tensile tester (see [Figure 4.1-1](#). and [Figure 4.1-2](#) for fixing instructions) for “up” test direction.
2. Attach the plug to connector receptacle.
3. Apply force to the centerline of the connector at 24 mm distance from tip end.
4. Force should be constantly monitored and increased up to 45N with rate of 10mm/min. Connector or assembly physical break is indicated by sudden drop in force. Record the break off force if it occurs below 45N.
5. After 45N force has been reached, force is reduced gradually back to 0N. Repeat test with second device.
6. Repeat the same test procedure with a new connector plug to “down” direction with total of 2 devices.
7. Repeat the test procedure with new connector plug to “left” direction with 1 device.
8. Repeat test procedure with new connector plug to “right” direction with 1 device.
9. At the end, devices shall be disassembled, visually examined and electrically/mechanically/functionally checked and ensured to be in fully functional condition without test induced failures.

Compliance:

Test is considered passing when all 6 devices have no functional, mechanical or electrical damage after the test with 45N load.

Appendix A—Device Functionality Validation

Purpose:

- Ensure common method to validate functionality of mobile devices:
- Prior to performing reliability testing herein
- During reliability testing herein where specified
- Upon completion of reliability testing requirements herein

Power – Device powers on and off properly.

Charging and Wireless Charging – Device will charge (using supplied charger) and display charging indication on the screen / LED.

Display/Touch – All areas of the display respond to touch.

All Physical Buttons – No loss of functionality.

Sensors (all) – Orientation/Proximity (vendor-specific diagnostics program).

Camera(s) – All function properly. (Quality not obviously diminished. Orientation correct. No cracks or debris.)

Memory Card – Insert and remove / read / write.

Call / Data Functionality (Tx + Rx) – Live network or simulated network testing.

Speakers – No obvious diminished quality (No distortion).

Microphones – No loss of functionality.

Headset Jack – No loss of functionality.

Vibrators – No loss of functionality.

Wi-Fi – No loss of functionality.

GPS – Vendor specific diagnostic program.

Bluetooth – No loss of functionality (or vendor-specific diagnostic program).

NFC – No loss of functionality (NFC tags and / or other devices).

SIM/UICC – No loss of connectivity or intermittent connectivity.

Procedure: Prior to testing, device manufacturers, test labs and operators shall agree on the methods that will validate the features and functionality listed above. These methods may include manual, automated or hybrid (manual/automated) processes. Special consideration shall be given to validate features and functionality not listed. Using the manufacturer-specific device diagnostics program is preferred as it will allow quicker functional checks.

Appendix B—Change History

Date	Revision	Description
September 2015	1.0	<ul style="list-style-type: none"><li>• Initial release