# Device Hardware Reliability Test Plan

Version 2.1

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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 participants.

With aligned test methodologies, manufacturers and 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 participants to define the number of stress cycles required to pass or fail. This provides the further benefit of allowing manufacturers and service providers to have an understanding of the device's performance margin against the common test requirement.

## 1.2 Scope

The scope of testing is limited to the hardware reliability of smartphones (generally less than 92mm in width).

## 1.3 Documents

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

- JEDEC JESD22-B110A, Subassembly Mechanical Shock
- IEC 60068-2-31, Environmental testing - Part 2-31: Tests - Test Ec: Rough handling shocks, primarily for equipment-type specimens
- IEC 60529, Degrees of Protection Provided by Enclosures (IP Code)

# Section 2 Physical Shock

## 2.1 Tumble/Barrel Test

**Reference:**

Equipment used shall be in accordance with Appendix A (Schedules 1 & 2) of IEC 60068-2-31:2008 with the following addendums:

- The steel used as an impact surface shall be 3mm-thick EN10130 carbon steel with 7-10 um zinc plating. 316 stainless steel plate may be used instead, but this substitution must be noted in the test report.
- The surface roughness of the impact plate shall be machined to 1.6 microns $R_a$ or better.
- Impact plates must be replaced every 7,500 impacts.
- Impact plates shall be resurfaced every 1,500 impacts to a surface roughness of 15 microns $R_a$ or better.
- Use 3M 471 vinyl tape, or any other polymeric adhesive tape with similar adhesive properties, to secure any removal parts (stylus, SIM/SD card tray, etc.) during tumble testing. Tape should be applied to secure the removable part while minimizing coverage of the front or back surface of the phone. Tape should only be applied after the removable part has fallen out during testing.

**Purpose:**

Mechanically stress all phone components to simulate end-user handling or shipping and to artificially age the device for forecasting purposes.

**Procedure:**

1. Ensure device meets Appendix A (Schedules 1 & 2).
2. Deburr the test surface with a flat file, blow off all interior surfaces of the test barrel with compressed air, vacuum any debris, and wipe down the impact plates with a damp cloth.
3. The test height shall be 1 meter.
4. Sample size shall be 10 devices.
5. Device shall be powered on during the test.
6. For devices with removable covers and batteries, the back cover shall be taped on.
   a) When taping a device with a removable battery, the tape shall be 3M model VHB 4926 double-sided tape or equivalent and shall be applied across the back of the device frame. The tape shall not contact the surface of the battery, or any locking features used to secure the back cover in place. The geometry and location of tape should be consistent across all tested devices and images of each tested device with tape applied shall be provided in the test report. The back cover shall then be pressed firmly to the tape surface. Thicker tape may be used if a gap exists between convenient taping surfaces and the back cover under normal circumstances.
7. The rotational speed (typically 10 drops / minute) of the tumbler shall be adjusted to prevent the device from hitting the sides of the chamber during each rotation.

8. Cycle the device in the barrel for a total of 250 falls or until the device suffers a fatal failure as defined in Appendix B (whichever comes first).
9. After each 10 cycles, perform an inspection of critical features in accordance with Appendix A (Schedules 1 & 2). Continue critical feature inspections every 10 cycles until 50 total cycles and perform full functional testing according to Appendix A (Schedules 1 & 2) and note any failures. Continue inspections every 25 cycles to 100 total cycles, then every 50 cycles until a failure is seen. The test samples should be actively monitored during testing and any suspected failures seen through the equipment inspection window is cause to immediately terminate the test. Table 2.1-1 below details this inspection schedule:

Table 2.1-1 Inspection Schedule

| Cycles | Inspection |
|---|---|
| 10 | Critical Only |
| 20 | Critical Only |
| 30 | Critical Only |
| 40 | Critical Only |
| 50 | Full |
| 75 | Critical Only |
| 100 | Full |
| 150 | Full |
| 200 | Full |
| 250 | Full |

**Reporting:**

Report results according to Appendix C.

# Section 3 Water Ingress

The manufacturer shall declare the Ingress Protection level of the candidate device per IEC 60529. If the second numeral of the IP rating is 1, 2, 3, 4, 7, or 8, testing shall be conducted by a CTIA Authorized Test Lab (ATL) in accordance with the sections below. For other IP ratings, these tests are optional, and the manufacturer shall provide a declaration of compliance, indicating the IPX level, to the ATL.

## 3.1 Common Requirements

All testing covered in the following sections shall be performed per IEC 60529 except as specifically addressed in those sections. Subsections 3.1.1 through 3.1.3 cover requirements common to all liquid ingress ratings presented in Section 3.

### 3.1.1 Water Quality

The following requirements apply to the water used to test all liquid ingress numerals presented in this test plan:

- Water used for testing shall be fresh water with a measured conductivity between 300 and 500 µS/cm.
- Water used for testing shall be in accordance with the standard temperature range defined in IEC 60068-1 (15-35°C) rather than dependent upon the temperature of the device under test as indicated by IEC 60529.

### 3.1.2 Test Preparation

All devices used for testing shall conform with the following requirements and procedures:

- The sample size shall be 3 devices unless otherwise specified by m1utual agreement of the vendor, client, and ATL.
- All devices shall be inspected in accordance with Appendix A (Schedules 1 & 2) prior to testing.
- Devices shall have live (or test) SIM/UICC cards, memory cards, and new, fully-charged batteries.
- Devices shall be powered on and performing local media playback at the initiation of the test.
- Devices shall be weighed before the test using a mass scale with precision of at least +/- 0.01 gram.

### 3.1.3 Test Conclusion

After testing is complete, devices shall be handled and inspected in accordance with the following requirements:

- The device shall be removed from contact with the test fluid, and excess water removed with a dry paper towel or cloth. Removable parts may be disassembled and dried (e.g., SIM/UICC card, memory card, removable battery cover and battery). No moving air may be employed, and no disassembly prohibited to a normal user may be performed.

- Immediately after conclusion of the test, weigh the device as in section 3.1.2, and perform a full functional inspection per Appendix A (Schedules 1 & 2).
- The tested and inspected device shall be stored for 72 hours powered on with display side down on a horizontal surface. The device may be connected to a charging cable if necessary.
- After the 72-hour soak-in process, the device shall be inspected again in accordance with Appendix A (schedules 1 & 2) and weighed using a mass scale in the manner described in section 3.1.2.
- Report test results in accordance with Appendix C and include the following additional information:
    - Water conductivity measured in µS/cm.
    - Mass of the tested device before, immediately after, and 72 hours after the test.

### 3.2 Ingress Protection based on IPX1

IPx1 testing shall be performed in accordance with IEC 60529 and Section 3.1 of this test plan, with the following changes:

- Water flow shall be calibrated by placing a conical rainfall meter on the test chamber turntable and measuring accumulated liquid after 3 minutes. Target accumulation is 9 +1.5/-0.0 mm.
- The rainfall meter shall be placed immediately adjacent to the test device on the test chamber turntable at the start of the test.
- At the conclusion of the test, the device shall be removed and kept in a vertical position until dried in accordance with section 3.1.3.
- At the conclusion of the test, the rainfall meter shall be removed and the measured accumulation recorded.
- Test results shall be reported in accordance with section 3.1.3 with the following additional information:
    - Accumulated liquid as measured via the rainfall meter at the end of the test.

### 3.3 Ingress Protection based on IPX2

IPx2 testing shall be performed in accordance with IEC 60529 and Section 3.1 of this test plan, with the following changes:

- Water flow shall be calibrated by placing a conical rainfall meter on the test chamber turntable and measuring accumulated liquid after 3 minutes. Target accumulation is 9 +1.5/-0.0 mm.
- The rainfall meter shall be placed immediately adjacent to the test device on the test chamber turntable at the start of the test.
- The test chamber turntable shall be powered on and rotating at 1 RPM during the entire duration of the test.

- At the conclusion of the test, the device shall be removed and kept in a vertical position until dried in accordance with section 3.1.3.
- At the conclusion of the test, the rainfall meter shall be removed and the measured accumulation recorded.
- Test results shall be reported in accordance with section 3.1.3 with the following additional information:
    - Accumulated liquid as measured via the rainfall meter at the end of the test.

### 3.4 Ingress Protection based on IPX3

IPx3 testing shall be performed in accordance with IEC 60529 and Section 3.1 of this test plan, with the following changes:

- Testing shall be performed with a spray head in accordance with IEC 60529 section 14.2.3 part a. The oscillating tube test setup outline in section 14.2.3 part b is prohibited.
- At the conclusion of the test, the device shall be removed and kept in a vertical position until dried in accordance with section 3.1.3.

### 3.5 Ingress Protection based on IPX4

IPx4 testing shall be performed in accordance with IEC 60529 and Section 3.1 of this test plan, with the following changes:

- Testing shall be performed with a spray head in accordance with IEC 60529 section 14.2.4 part a. The oscillating tube test setup outline in section 14.2.3 part b is prohibited.
- At the conclusion of the test, the device shall be removed and kept in a vertical position until dried in accordance with section 3.1.3.

### 3.6 Ingress Protection based on IPx7

IPx7 testing shall be performed in accordance with IEC 60529 and Section 3.1 of this test plan, with the following changes:

- The immersion vessel for testing must be deep enough to suspend the test specimen with the bottom of the unit at the target depth without contacting the sides or bottom of the vessel.
- The immersion vessel used for testing must be constructed of chemically inert materials to avoid inducing electrolysis in the tested device.

### 3.7 Ingress Protection based on IPx8

IPx7 testing shall be performed in accordance with IEC 60529 and Section 3.1 of this test plan, with the following changes:

- The immersion vessel for testing must be deep enough to suspend the test specimen with the bottom of the unit at the target depth without contacting the sides or bottom of the vessel.
- The immersion vessel used for testing must be constructed of chemically inert materials to avoid inducing electrolysis in the tested device.
- The tested device must be exposed Pto pressure of 1.5 meters WC or higher.

# Section 4 PCBA Inspection

This section defines criteria for a visual inspection of a single device for PCBA quality, reliability, and workmanship by a CTIA Authorized Test Lab (ATL). Inspections shall be performed in accordance with IPC-A-600K and IPC-A-610H in conjunction with the guidelines laid out in the following subsections.

## 4.1 Inspected Device Requirements

Devices used for PCBA inspection per Section 1 of this test plan shall be randomly selected from the samples delivered to the ATL. The manufacturer shall provide the ATL with any non-standard procedures and/or tooling necessary to safely disassemble one device without inducing damage to the PCBA. The inspected device's battery shall be fully drained before disassembly is attempted. Any incidental damage caused to the device during disassembly shall be noted, and if full inspection of the device is rendered impossible as the result of said damage, a second device shall be used to fulfill the requirements of this section.

## 4.2 Device Inspector Requirements

ATLs performing PCBA inspections under this test plan must have a Certified IPC Trainer (CIT) on staff, and the inspection report must be signed by a CIT. The device inspection may be performed by a Certified IPC Specialist (CIS). Each point of inspection shall be considered and reported as 'Acceptable' if it meets the requirements of Class II boards, 'Class I', or 'Non-Conforming'.

## 4.3 Inspection Per IPC-A-600K

All applicable PCBAs, Flex Circuits, and other features covered under the IPC-A-600K standard shall be inspected, with the following changes:

- This inspection shall encompass only features and defects termed as 'externally visible' under the guidelines of the specification.
- Ionic cleanliness inspections shall not be performed
- Minimum conductor spacing shall be inspected per the default spacing allowed under the IPC specification regardless of any overriding manufacturer's specification. Any such overriding specifications may be declared by the manufacturer to the ATL and noted on the inspection report or declared to the operator.

## 4.4 Inspection Per IPC-A-610H

All applicable PCBAs, Flex Circuits, and other features covered under the IPC-A-610H standard shall be inspected, but only the following sections shall be considered during the inspection:

- Section 4.1.5 – Hardware Installation: Threaded Fasteners' shall be considered where applicable.
- Section 5 – Soldering' shall be considered in its entirety.
- Section 8 – Surface Mount Assemblies' shall be considered with the exception of 'Section 8.6 – Jumper Wires'.
- Section 9 – Component Damage' shall be considered in its entirety.
- Section 10 – Printed Circuit Boards & Assemblies' shall be considered in its entirety.

### 4.5 Inspection Deviations

Certain sections of the IPC specifications noted above may not pertain to the particular features, design choices, overriding specifications, etc. Some inspections may also be outside of the reasonable ability of an ATL to perform. In such cases, the inspection point shall be marked as 'Not Inspected' and an accompanying explanation for the omission shall be provided by the manufacturer or ATL.

# Appendix A Device Functionality Validation

Prior to testing, device manufacturers, test labs and operators shall agree on the methods that will validate the features and functionality listed in the table below. These methods may include manual, automated or hybrid (manual/automated) processes. Using the manufacturer-specific device diagnostics program is preferred as it will allow quicker validation.

The table below is a recommended functional assessment of a sample and all its accompanying submodules. The table is separated by the Schedule column:

- Schedule 1: Metrics are to be tested any time Appendix A is referenced.
- Schedule 2: Metrics are to be tested as defined in this document.

Any metric with the prerequisite “ID2: Pass” will result in N/A when ID2 is a Fail. When ID2 is a Pass other IDs may also be N/A depending on other results. For example: If the display is black other functional metrics cannot be performed and their results would be listed as N/A.

Wherever a result on a test sample appears subjectively or qualitatively questionable the result shall be verified by comparison to a known “good” or control device to verify accuracy. Failures are defined in Appendix B.

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| Power | 1 | None | Power Button | Pass: Sample power button performs as expected.<br>Fail: Sample power button does not perform as expected<br>Expected:<br>Button can be pressed with minimal effort.<br>Button does not stick.<br>Button fully depresses.<br>Button returns to its original position following use. | 2 |
| | 2 | ID1: **Pass** | Power On | Pass: Sample powers on successfully.<br>Fail: Sample does not power on successfully.<br>Successfully:<br>Sample boots into that model’s expected OS (android, iOS, etc) with carrier expected splash screen where applicable | 1 |
| | 3 | USB Port<br>Lightning Port | Charging Port Insertion | Pass: Able to insert USB or Lightning connector fully and securely.<br>Fail: Unable to insert USB or Lightning connector fully and securely.<br>Assess for incomplete insertion, loose connection, etc. | 2 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| | 4 | USB Port<br>Lightning Port | Wired Charging Normal | Pass: The sample provides an indication that charging is in progress.<br>Fail: The sample does not provide any indication that charging is in progress. | 1 |
| | 5 | USB Port<br>Lightning Port<br>ID2: **Pass** | Wired Charging Fast | Pass: The sample provides an indication that fast charging is in progress.<br>Fail: The sample does not provide any indication that fast charging is in progress. | 1 |
| | 6 | Wireless Charging Capability | Wireless Charging | Pass: When placed on a compatible wireless charger the sample provides an indication that charging is in progress.<br>Fail: When placed on a compatible wireless charger the sample does not provide an indication that charging is in progress. | 1 |
| Data Connection | 7 | USB Port<br>Lightning Port<br>ID2: **Pass**<br>ID9: **Pass** | Wired Data Connection | Pass: Sample is recognized by computer.<br>Fail: Sample is not recognized by computer.<br>Expected:<br>Message appears on either the connected computer or Sample prompting the user to transfer files or allow access. | 1 |
| | 8 | USB Port<br>Type-C<br>ID2: **Pass**<br>ID7: **Pass**<br>Android only | USB 3.1 | Pass: Sample charges and transfers data at the expected rate.<br>Fail: Sample does not charge and/or transfer data at the expected rate. | 2 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| Display | 9 | ID2: **Pass** | Display | **Pass**: The sample display looks as expected.<br>**Fail:** The sample display does not look normal.<br>*Expected:*<br>*No lines, dead pixels or artifacts.*<br>*Colors appear as expected.*<br>*No cracking of the display glass*<br><br>Display may be partially functional and other tests can be performed. | 1 |
| Touchscreen | 10 | ID2: **Pass** | One Finger Tap | **Pass:** The sample screen responds to the gesture successfully.<br>**Fail:** The sample screen does not respond to the gesture successfully.<br>*Successfully: The gesture can be consistently & accurately performed with minimal effort.* | 1 |
| | 11 | ID2: **Pass** | Double Tap | **Pass:** The sample screen responds to the gesture successfully.<br>**Fail:** The sample screen does not respond to the gesture successfully.<br>*Successfully: The gesture can be consistently & accurately performed with minimal effort.* | 1 |
| | 12 | ID2: **Pass** | One Finger Hold | **Pass:** The sample screen responds to the gesture successfully.<br>**Fail:** The sample screen does not respond to the gesture successfully.<br>*Successfully: The gesture can be consistently & accurately performed with minimal effort.* | 1 |
| | 13 | ID2: **Pass** | One Finger Swipe | **Pass:** The sample screen responds to the gesture successfully.<br>**Fail:** The sample screen does not respond to the gesture successfully.<br>*Successfully: The gesture can be consistently & accurately performed with minimal effort.* | 1 |
| | 14 | ID2: **Pass** | One Finger Flick | **Pass:** The sample screen responds to the gesture successfully. | 1 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| | | | | **Fail:** The sample screen does not respond to the gesture successfully.<br>*Successfully: The gesture can be consistently & accurately performed with minimal effort.* | |
| | 15 | ID2: **Pass** | Two Finger Rotation | **Pass:** The sample screen responds to the gesture successfully.<br>**Fail:** The sample screen does not respond to the gesture successfully.<br>*Successfully: The gesture can be consistently & accurately performed with minimal effort.* | 1 |
| | 16 | ID2: **Pass** | Two Finger Scale | **Pass:** The sample screen responds to the gesture successfully.<br>**Fail:** The sample screen does not respond to the gesture successfully.<br>*Successfully: The gesture can be consistently & accurately performed with minimal effort.* | 1 |
| | 17 | ID2: **Pass**<br>iOS Only | 3D Touch | **Pass:** The sample screen responds to the gesture successfully.<br>**Fail:** The sample screen does not respond to the gesture successfully.<br>*Successfully: The gesture can be consistently & accurately performed with minimal effort.* | 1 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| Audio | 18 | None | Volume Buttons | **Pass**: Sample volume buttons perform as expected.<br>**Fail**: Sample volume buttons do not perform as expected.<br>*Expected:*<br>*Button can be pressed with minimal effort.*<br>*Button does not stick.*<br>*Button fully depresses.*<br>*Button returns to its original position following use.*<br>*Volume rocker to be treated as one button (bar).* | 2 |
| | 19 | ID2: **Pass** | Volume Adjustment | **Pass**: The sample volume changes successfully when the physical buttons are actuated.<br>**Fail**: The sample volume does not change successfully when the physical buttons are actuated.<br>*Successfully:*<br>*An on-screen indication that the volume has changed is provided.*<br>*The volume subjectively increases and decreases.* | 1 |
| | 20 | None<br>iOS Only | Volume Switch | **Pass**: Sample volume switch can be toggled as expected.<br>**Fail**: Sample volume switch does can be toggled as expected.<br>*Expected:*<br>*Switch can be toggled with minimal effort.*<br>*Switch does not stick.*<br>*Switch is secure on one side (not loose in the middle)* | 2 |
| | 21 | ID2: **Pass** | Volume Switch | **Pass**: The Sample volume switches on/off successfully.<br>**Fail**: The Sample volume does not switch on/off successfully.<br>*Successfully:*<br>*An on-screen indication that the volume has changed is provided.*<br>*The volume subjectively increases and decreases.* | 1 |
| | 22 | ID2: **Pass** | Speaker | **Pass:** The speaker is able to playback content when not on a phone call.<br>**Fail**: The speaker is unable to playback content when not on a phone call. | 1 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| | 22a | ID2: **Pass** | Speaker 2 | **Pass:** The second speaker is able to playback content when not on a phone call<br>**Fail**: The speaker is unable to playback content when not on a phone call. | 2 |
| | 23 | 3.5mm port<br>USB port<br>Lightning port | Audio Port | **Pass**: Able to insert connector fully and securely into the applicable port.<br>**Fail**: Unable to insert connector fully and securely into the applicable port.<br>*Assess for incomplete insertion, loose connection, etc.* | 2 |
| | 24 | ID2: **Pass**<br>3.5mm port<br>USB port<br>Lightning port | Wired Audio | **Pass:** The sample is able to playback audio via the applicable port.<br>**Fail**: The sample is unable to playback audio via the applicable port.<br>*Quality does not impact the result.*<br>*Use of a model appropriate adapter is required.* | 1 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| Sensors | 25 | ID2: **Pass**<br>Proximity Sensor | Proximity | **Pass:** The sensor functions as expected.<br>**Fail:** The sensor does not function as expected.<br>*Expected:*<br>*When in call, covering the proximity sensor should cause the screen to darken completely.* | 1 |
| | 26 | ID2: **Pass**<br>Accelerometer | Accelerometer | **Pass:** The sensor functions as expected.<br>**Fail:** The sensor does not function as expected.<br>*Expected*:<br>*When laying flat parallel to the ground, the X,Y, Z angle readings should display 0,0,90 respectively.*<br>*When held perpendicular to the ground, the X,Y, Z angle readings should display 0,90,0 respectively.* | 2 |
| | 27 | ID2: **Pass**<br>Barometer | Barometer | **Pass:** The sensor functions as expected.<br>**Fail:** The sensor does not function as expected.<br>*Expected*:<br>*Displays a barometric reading comparable (within ±10%) to that of a calibrated NIST traceable barometer.* | 2 |
| | 28 | ID2: **Pass**<br>Light Sensor | Light Sensor | **Pass:** The sensor functions as expected.<br>**Fail:** The sensor does not function as expected.<br>*Expected:*<br>*Lux sensor displays a lower number when covered by an opaque object.*<br>*Screen darkens in response to less light when adaptive brightness is enabled.* | 1 |
| | 29 | ID2: **Pass**<br>Gyroscope | Gyroscope | **Pass:** The sensor functions as expected.<br>**Fail:** The sensor does not function as expected.<br>*Expected*:<br>*The gyroscope is able to differentiate between when the sample is stationary and when it is rotated along one or more axis* | 2 |
| | 30 | ID2: **Pass**<br>Fingerprint | Fingerprint | **Pass:** Able to correctly recognize a fingerprint.<br>**Fail:** Unable to correctly recognize a fingerprint. | 1 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| Camera | 31 | ID2: **Pass**<br>Front Camera | Front Camera | **Pass**: Able to capture an image successfully.<br>**Fail**: Unable to capture an image successfully.<br>*Successfully:*<br>*The viewfinder is successfully populated with the target.*<br>*The captured image is consistent with the target as it appeared in the viewfinder.*<br>*Image quality does not impact the result.* | 1 |
| | 31a | ID2: **Pass**<br>Front Camera 2 | Front Camera 2<br>(Applies to devices which feature two or more front cameras. Additional cameras will be identified as "31a, 31b, 31c, etc"). | **Pass**: Able to capture an image successfully with alternate lens(es).<br>**Fail**: Unable to capture an image successfully with alternate lens(es).<br>*Successfully:*<br>*The viewfinder is successfully populated with the target.*<br>*The captured image is consistent with the target as it appeared in the viewfinder.*<br>*Image quality does not impact the result.* | 2 |
| | 32 | ID2: **Pass**<br>Rear Camera | Rear Camera | **Pass**: Able to capture an image successfully.<br>**Fail**: Unable to capture an image successfully.<br>*Successfully:*<br>*The viewfinder is successfully populated with the target.*<br>*The captured image is consistent with the target as it appeared in the viewfinder.* | 1 |
| | 32a | ID2: **Pass**<br>Rear Camera 2 | Rear Camera 2<br>(Applies to devices which feature two or more front cameras. Additional cameras will be identified as "32a, 32b, 32c, etc"). | **Pass**: Able to capture an image successfully with alternate lens(es).<br>**Fail**: Unable to capture an image successfully with alternate lens(es).<br>*Successfully:*<br>*The viewfinder is successfully populated with the target.*<br>*The captured image is consistent with the target as it appeared in the viewfinder.* | 2 |
| Calls | 33 | ID2: **Pass**<br>Network Connection | Phone Call | **Pass:** Able to make and receive a phone call.<br>**Fail**: Unable to make and/or receive a phone call.<br>*Quality does not impact the result.*<br>*Audio via earpiece.*<br>*Voice via microphone.* | 1 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| Home Button | 34 | Physical Button | Home Button | **Pass**: Sample home button performs as expected.<br>**Fail**: Sample home button does not perform as expected<br>*Expected:*<br>*Button can be pressed with minimal effort.*<br>*Button does not stick.*<br>*Button fully depresses.*<br>*Button returns to its original position following use.* | 2 |
| | 35 | ID2: **Pass** | Home Button | **Pass**: Sample returns to the home screen from any in-app location.<br>**Fail**: Sample does not return to the home screen from any in-app location. | 1 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| Misc. Physical Button | 36 | ID2: **Pass** | Misc. Physical Button<br>(Additional physical buttons will be identified as "36a, 36b, 36c, etc"). | **Pass**: Sample home button performs as expected.<br>**Fail**: Sample home button does not perform as expected<br>*Expected:*<br>*Button can be pressed with minimal effort.*<br>*Button does not stick.*<br>*Button fully depresses.*<br>*Button returns to its original position following use (if applicable)* | 2 |
| Connectivity | 37 | ID2: **Pass**<br>Network Connection | Data - Any | **Pass:** Able to access a mobile data connection.<br>**Fail:** Unable to access a mobile data connection.<br>*Network quality does not impact the result.*<br>*Network indicator present in the status bar.*<br>*Able to access www.fast.com.* | 1 |
| | 38 | ID2: **Pass**<br>Network Connection | Data | **Pass:** Able to access a mobile data connection up to sample's highest expected rating.<br>**Fail:** Unable to access a mobile data connection up to sample's highest expected rating.<br>*Network indicator present in the status bar.*<br>*Able to access www.fast.com.* | 1 |

| | | | | | |
|---|---|---|---|---|---|
| | 39 | ID2: **Pass**<br>Wi-Fi Connection | Wi-Fi | **Pass:** Able to access a Wi-Fi connection.<br>**Fail:** Unable to access a Wi-fi connection.<br>*Wi-Fi indicator present in the status bar.*<br>*Able to access www.fast.com.* | 1 |
| | 40 | ID2: **Pass**<br>Network Connection | GPS<br>Location | **Pass:** Able to determine its current GPS location accurately.<br>**Fail:** Unable to determine its current GPS location accurately.<br>*Responsiveness does not impact functional result.* | 1 |
| | 41 | ID2: **Pass**<br>Bluetooth Connection | Bluetooth | **Pass:** Able to pair to any Bluetooth accessory.<br>**Fail:** Unable to pair to any Bluetooth accessory. | 1 |
| | 42 | ID2: **Pass**<br>NFC | NFC | **Pass:** Able to receive and/or transmit data.<br>**Fail**: Able to receive and/or transmit data. | 2 |
| Microphone | 43 | ID2: **Pass** | Microphone | **Pass:** The microphone is able to record content.<br>**Fail**: The microphone is unable to record content.<br>*Can be assessed through video recording or during a phone call.* | 1 |
| Vibration | 44 | ID2: **Pass** | Vibration | **Pass**: The sample is able to vibrate.<br>**Fail**: The sample is unable to vibrate. | 1 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| Stylus | 45 | None | Stylus Port | **Pass**: Able to insert native stylus fully and securely and, where enabled, the sample detects the stylus.<br>**Fail**: Unable to insert native stylus fully and securely and/or, where enabled, the sample detects the stylus. | 2 |
| | 46 | ID2: **Pass** | Stylus | **Pass:** Stylus performs as expected as applicable by the model.<br>**Fail:** Stylus does not perform as expected as applicable by the model.<br>*Specific functionality to be assessed based on model (touch, buttons, etc).* | 2 |
| External Storage | 47 | MicroSD Card Support | MicroSD Card Tray/Slot | **Pass**: Able to insert MicroSD Card and tray into slot fully and securely.<br>**Fail**: Unable to insert MicroSD Card and tray into slot fully and securely.<br>*Following insertion, housing is flush.* | 2 |
| | 48 | ID2: **Pass** | MicroSD Card Support | **Pass:** An inserted MicroSD Card is able to be successfully formatted.<br>**Fail:** An inserted MicroSD Card is unable to be successfully formatted.<br>*Any size* Micro*SD Card*<br>*Any format* Micro*SD Card*<br>Failures to be reviewed to determine model specific limitations. | 2 |
| SIM | 49 | Removable SIM | SIM Card Tray/Slot | **Pass**: Able to insert SIM Card and tray into slot fully and securely.<br>**Fail**: Unable to insert SIM Card and tray into slot fully and securely.<br>*Following insertion, housing is flush.* | 2 |
| | 50 | ID2: **Pass** | SIM Card | **Pass:** Sample recognizes when a SIM card is inserted and displays the expected signal strength symbol.<br>**Fail:** Sample does not recognize when a SIM card is inserted and/or does not display the expected signal strength symbol.<br>*Example: Sample recognizes when a SIM is inserted but displays a "no connectivity" symbol or message.* | 1 |
| LED | 51 | ID2: **Pass** | LED | **Pass**: Notification LED lights up as expected. | 2 |

| Group | ID | Prerequisite | Metric | Pass/Fail Criteria | Schedule |
|---|---|---|---|---|---|
| | | LED | | **Fail**: Notification LED does not light up as expected. | |
| Flashlight | 52 | ID2: **Pass**<br>Flashlight | Flashlight | **Pass**: Light enables as expected.<br>**Fail**: Light does not enable as expected.<br>*Example: Flickering, dim, inactive LED* | 2 |
| Soft Keys | 53 | ID2: **Pass**<br>Android | "Home Button" | **Pass**: Home soft key responds as expected<br>**Fail**: Home soft key does not respond as expected<br>*Expected:*<br>*Software exits out of any current application and displays the home screen* | 2 |
| Vibration | 54 | ID2: **Pass**<br>Android | "Left" and "Right" | **Pass**: Left and Right soft keys respond as expected<br>**Fail**: Left and/or Right soft key does not respond as expected<br>*This will vary by make and manufacturer* | 2 |

# Appendix B Fatal Failure Definition

| Severity | Criteria | Categories | Examples |
|---|---|---|---|
| Fatal Failure<br>**Level 2** | Failure is critical to the functionality of the device as a whole and/or liquid ingress | Applies to whole sample | Sample will not power on.<br>Sample will not fully boot.<br>Sample is non-functional due to thermal warning.<br>Sample display does not function.<br>Sample screen does not register input.<br>Sample exhibits liquid ingress per advertised rate. |
| Fatal Failure<br>**Level 1a** | Level 1a Failure: Failure is critical to the functionality of a specific category (as defined to the right) and/or can be attributed to the carrier. | Calls<br>Data (Mobile or Wi-Fi)<br>GPS<br>Messaging<br>Power Drain (When Attributed to [Network Type]) | Sample exhibits subjectively poor call quality.<br>Sample exhibits subjectively slow data connection.<br>Sample GPS is inaccurate.<br>SMS/MMS are not being sent.<br>Sample exhibits subjectively faster power loss when connected to a specific network type. |
| Fatal Failure<br>**Level 1b** | Failure is critical to the functionality of a specific category (as defined to the right) and is less likely to be attributed to the carrier | Audio sub-module(s)<br>Bluetooth<br>Camera(s)<br>Charging<br>Damage that poses a safety hazard<br>Display<br>Power Drain (When Not Attributed to [Network Type])<br>Responsiveness<br>Touchscreen<br>A quality based failure from any Level 1a category and/or a Level 1a failure that resolves itself within 24 hours.<br>Moderate or worse lift-up/gap failure as defined in Appendix C | Sample exhibits subjectively poor audio quality<br>Sample is subjectively slow to obtain lock GPS<br>Sample exhibits subjectively excessive power drain<br>Sample does not Fast Charge (or equivalent)<br>Broken display cover glass<br>Three (3) or more Nonfatal failures are considered a Level 1b Fatal Failure |

| Severity | Criteria | Categories | Examples |
|---|---|---|---|
| Nonfatal Failure | Failure is not critical to the functionality of the device and/or a specific category. | Thermal<br>Minor damage or defects that do not pose a safety hazard.<br>A quality based failure from any Level 1b category. | The sample feels uncomfortably warm but does not exceed safety standards; this can be considered a Level 1b failure upon operator recommendation.<br>Scratched exterior features.<br>Fast charging charges subjectively slow. |

## Appendix C Test Data Reporting Guidelines

The result of the preceding test plan shall be presented in a detailed test report as defined by the criteria in this Appendix. A report presenting the results of any test case listed in this document does not need to be in a standardized format, but must clearly present all of the following information:

- Name, location, and contact information for the laboratory performing the test
- Date report produced
- Name of the test case as listed in this document
- Revision level of this document under which the test was performed
- Revision level of any applicable specifications listed in the References section of the test case
- Name, job title, and signature of the performing lab technician
- Name, job title, and signature of an engineer that reviewed the report
- IMEI, model number, and the inspection and test dates for each sample
- Pre-test inspection results as performed under Appendix A
- Model, serial number, and calibration date (if applicable) of any and all serialized test equipment used
- List all test parameters including those in this document along with any equipment settings used
- Pre- and post-test images of each sample
- Detailed images and descriptions of any failure seen during testing
- Overall test result
- Any other information as specifically defined in the Reporting section of the test case

For simplicity, a test report template has been developed for use by test laboratories – Generic CTIA Certification Device Hardware Reliability Test Report Template.

## Appendix D Reuse of Samples

Samples cannot be reused within or across tests unless explicitly permitted by either the table below or with agreement between the carrier(s) and vendor. Sample reuse should only be permitted in cases where previous testing cannot conceivably cause cumulative damage to the test sample.

| Test | ID | Sample Reuse |
|---|---|---|
| Physical Shock - Tumble Test | 2.1 | Samples **shall not** be reused from any other test |
| Ingress Testing – IPX2 | 3.1 | Samples **shall not** be reused from any other test |

# Appendix E Optional Test Cases

The test cases listed in this appendix are under development, optional, or have been deemed potentially useful, but only for certain devices. Execution of these tests should be undertaken upon agreement between the carrier and the original equipment manufacturer.

## E.1 Rough-Surface Drop Test (Under Development)

Test method is optional and currently under evaluation. Test method to be used at vendor's discretion.

**Reference:**

N/A

**Purpose:**

Test smartphone cover glass survivability after accidental drop conditions onto rough surface (i.e., resistance of cover glass to sharp contact damage events).

**Procedure:**

1. Ensure device meets Appendix A.
2. Test surface shall be P180 grit or coarser aluminum oxide sandpaper on ≥ 20 mm thick steel base.
3. Drop height shall be 0.5 m (lower or higher if requested by vendor), measured from test surface to point of contact on device.
4. Sample size shall be 10 devices. At the vendors' discretion, samples may be reused to reduce the total number of samples required to complete the test program. An example test flow is shown in Appendix C.
5. Drop orientations shall be: 2 (flat face drop with glass cover at 0 ± 0.05° with respect to drop surface and angled face drop with glass cover at 30 ± 0.05° with respect to drop surface; see **Error! Reference source not found.**)
6. Install new sandpaper for each device under test and ensure test surface is clear of all debris. Sandpaper shall be secured to flat drop test base with magnets placed on all four corners of sandpaper.
7. Devices shall 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.
8. Bring test apparatus to 0.5 m drop height position.
9. Load device into test equipment, ensuring device is orientated correctly for desired drop orientation.
10. Drop device on test surface, maintaining orientation until point of impact.
11. Using a high-speed video camera capable of at least 3000 fps at resolution of 1024 x 720 or better, ensure device orientation is maintained within ±2° at instant of contact with test surface.
12. After each impact, inspect for obvious physical damage (e.g., cracked cover glass, dented enclosure, etc.).
13. If physical damage observed, stop testing of device and note any failures of the device.
14. Repeat drop testing and inspection for other orientation.
15. After second drop, perform full functional testing according to Appendix A and note any failures.

**Reporting:**

Report results according to Appendix A.

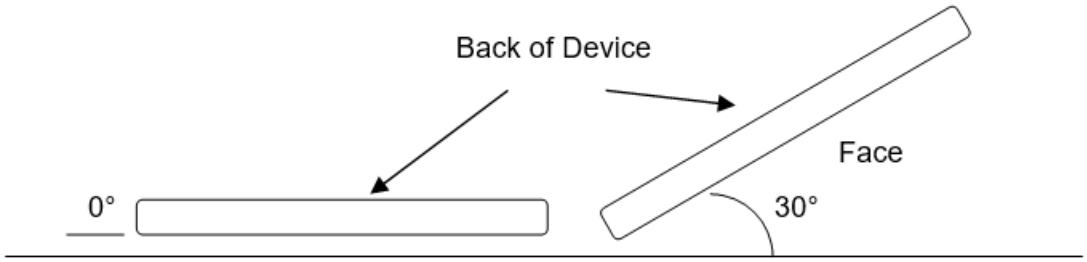



Figure E.1-1 Surface Orientation for Rough-Surface Drop Test

## E.2 Connector Reliability— I/O, Data (Under Development)

**Reference:**

N/A

**Purpose:**

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

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 Section 4.2.

**Procedure:**

1. Ensure device meets Appendix A.
2. Test shall be 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. At the vendor's discretion, samples may be reused to reduce the total number of samples required to complete the test program. An example test flow is shown in Appendix C.
3. Fix the device on the testing table on tensile tester (see Figure E.2-1 and Figure E.2-2 for fixing instructions) for "up" test direction.

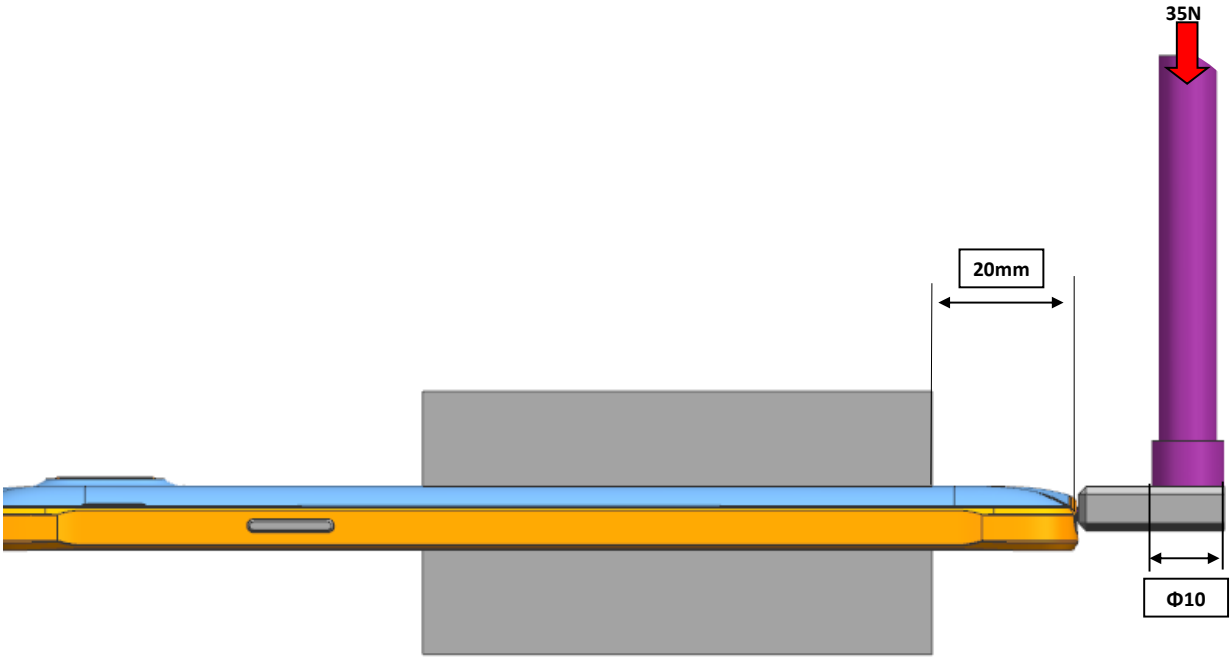



Figure E.2-1 USB Connector Reliability—Up/Down Direction Case

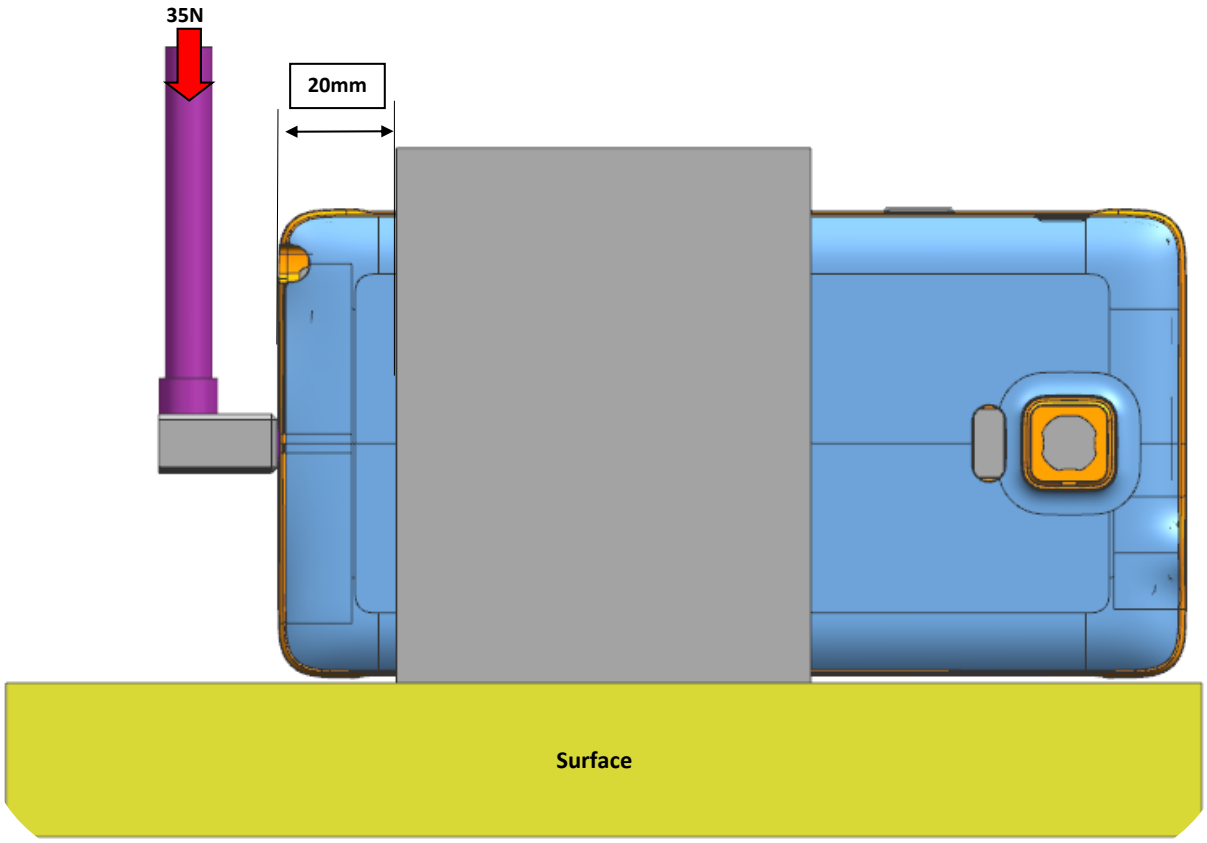



Figure E.2-2 USB Connector Reliability—Left/Right Direction Case

4. Attach the plug to connector receptacle.
5. Apply force to the centerline of the connector at 10 mm distance from tip end. Force should be constantly monitored and increased up to 35 N 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 35 N. After 35 N force has been reached, force is reduced gradually back to 0 N. 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 one device.
8. Repeat test procedure with new connector plug to “right” direction with one device.
9. At the end, perform relevant functional testing according to Appendix A and note any failures.

**Reporting:**

Report results according to Appendix A.

## E.3 Connector Reliability—Audio (Under Development)

**Reference:**

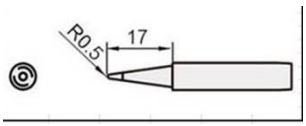
N/A

**Purpose:**

Ensure mechanical strength of assembled headset connector. Connector shall withstand 45 N force applied perpendicular to the connector plug. This test is only performed if the device has a separate audio connector.

**Procedure:**

1. Ensure device meets Appendix A.
2. Test shall be 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. At the vendor's discretion, samples may be reused to reduce the total number of samples required to complete the test program. An example test flow is shown in Appendix C.
3. Device shall be powered on.
4. Test equipment, tensile tester, for this cycle test shall be speed and force/load controllable.
5. Force sensor shall have at minimum ±0.1 N accuracy up to 50 N force.
6. Test shall be conducted with 10 mm/min speed.
7. Test shall be performed with standard, stiff headset connector plug (see Figure E.3-1). For each test direction, test shall be conducted with a new, unused connector plug.



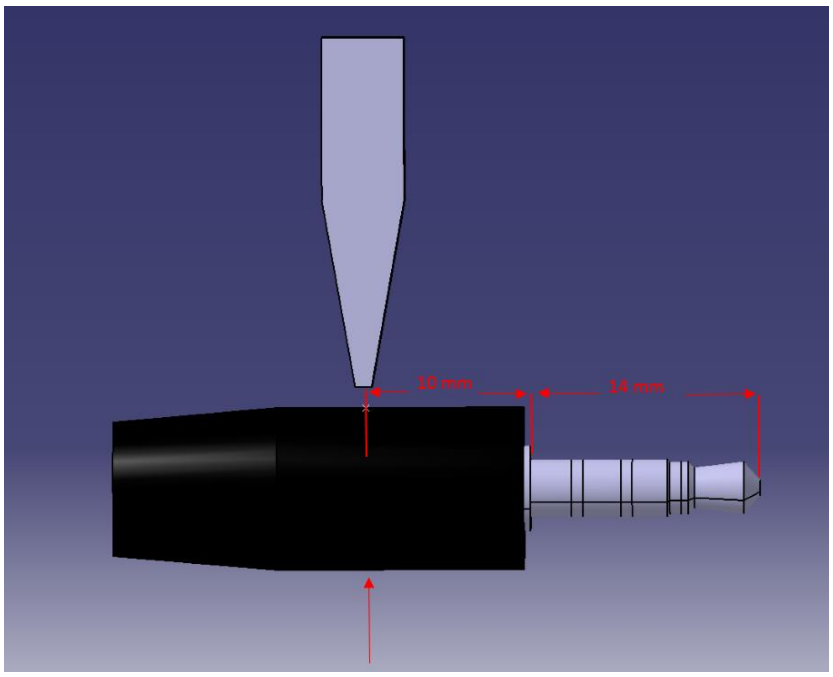




Figure E.3-1 Support for Left & Right Direction Test

8. Device shall be 50% supported for up/down direction tests (see Figure E.2-1) and allowed to be up to 100% supported to left/right side tests (see Figure E.2-2).
9. During the test, perpendicular forces (Fp) are applied to the connector plug from 4 directions: Top, Bottom, Left and Right. Force shall be applied 24 mm from the tip of the connector. Tip of the connector plug shall be inserted at minimum 14 mm deep into the connector.
10. 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.
11. Fix the device on the testing table on tensile tester (see Figure E.2-1 and Figure E.2-2 for fixing instructions) for “up” test direction.
12. Attach the plug to connector receptacle.
13. Apply force to the centerline of the connector at 24 mm distance from tip end.
14. Force shall be constantly monitored and increased up to 45 N 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 45 N.
15. After 45 N force has been reached, force is reduced gradually back to 0 N. Repeat test with second device.
16. Repeat the same test procedure with a new connector plug to “down” direction with total of 2 devices.
17. Repeat the test procedure with new connector plug to “left” direction with one device.
18. Repeat test procedure with new connector plug to “right” direction with one device.
19. At the end, perform relevant functional testing according to Appendix A and note any failures.

**Reporting:**

Report results according to Appendix A.

# Appendix F Revision History

| Date | Version | Description |
|---|---|---|
| September 2015 | 1.0 | • Initial release. |
| August 2017 | 1.1 | • Removed reference to IPC-TR-467.<br>• Renamed Section 2.1 from “Drop Testing” to “Smooth-Surface Drop Test.”<br>• Added Section 2.2 Rough-Surface Drop Test.<br>• Added Appendix B Fatal Failure Definition.<br>• Added Appendix C Example Sample Reuse Test Flow.<br>• Restructuring and editorial updates. |
| January 2021 | 2.0 | • Updated Appendices A and B.<br>• Updated Tumble/Barrel Test.<br>• Added solution to secure smartphone removal parts (e.g., stylus, SIM/SD card, etc.) during tumble testing.<br>• Updated Appendix C, which now defines test data reporting guidelines.<br>• Updated Appendix D, new reuse allowances.<br>• Updated Appendix E to reflect the removal of deprecated test cases from the test plan.<br>• Updated IPx2 Procedure.<br>• Reclassification and removal of select test cases.<br>• Created test plan addendum containing deprecated test cases. |
| April 2021 | 2.1 | • Incorporated new liquid ingress protection testing criterion. Replaced section 3.<br>• Incorporated PCBA inspection guidelines. Added Section 4. |