



Device Hardware Reliability Test Plan

Version 1.1.1

November 2020

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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 Applicable 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 Smooth-Surface Drop Test

Reference:

JEDEC JESD22-B110A, IEC 60068-2-31.

Purpose:

Simulate and evaluate the device's endurance and performance after accidental drop conditions, as well as simulate stress induced by the end user during shipping and handling.

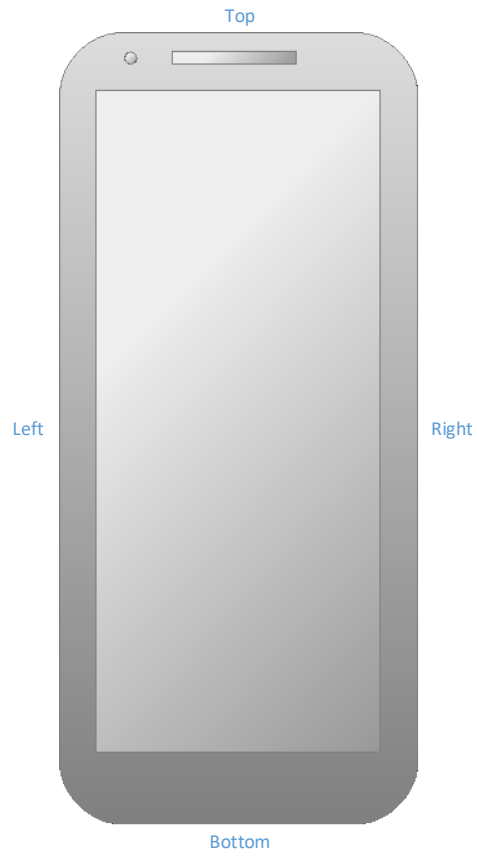
Procedure:

1. Ensure device meets [Appendix A](#).
2. Test surface shall be 25 mm (1") steel over concrete. Ensure surface is clear of all debris and is smooth.
3. Drop height shall be 1 m (or higher if requested by vendor).
4. Sample size shall be 5 devices. 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](#).
5. 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.
6. Drop the device on all 6 surface orientations plus 4 corners for a total of 10 drops in the following sequence (See [Figure 2.1-1](#)),
 - 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.
7. After each impact inspect for obvious physical damage. For devices without removable batteries, note if the device powered off as a result of the drop.
8. Make sure the device comes back on if it powered off, or if the battery and cover came off.
9. At the end of each round of 10 drops, perform full functional testing according to [Appendix A](#) and note any failures.

Reporting:

Report results according to [Appendix A](#).

FIGURE 2.1-1 SURFACE ORIENTATION FOR SMOOTH-SURFACE DROP TEST



2.2 Rough-Surface Drop Test (Optional)

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).

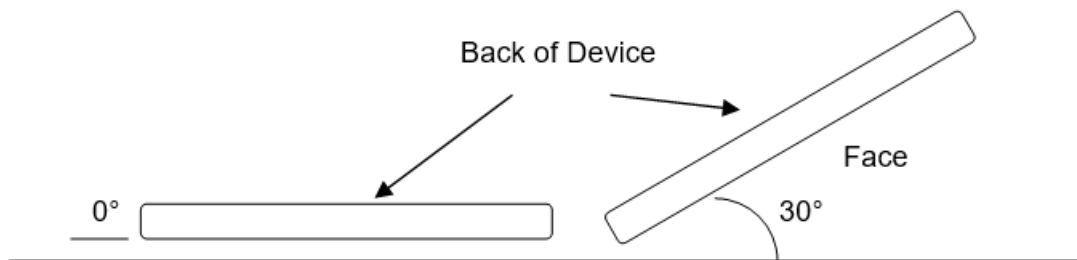
Procedure:

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 $0 \pm 0.05^\circ$ with respect to drop surface and angled face drop with glass cover at $30 \pm 0.05^\circ$ with respect to drop surface; see [Figure 2.2-1](#))
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.
 - a. 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 $\pm 2^\circ$ at instant of contact with test surface.
 - b. After each impact, inspect for obvious physical damage (e.g., cracked cover glass, dented enclosure, etc.).
 - i. If physical damage observed, stop testing of device and note any failures of the device.
11. Repeat drop testing and inspection for other orientation.
12. After second drop, perform full functional testing according to [Appendix A](#) and note any failures.

Reporting:

Report results according to [Appendix A](#).

FIGURE 2.2-1 SURFACE ORIENTATION FOR ROUGH-SURFACE DROP TEST



2.3 Tumble/Barrel Test

Reference:

IEC 60068-2-31.

Purpose:

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

Procedure:

1. Ensure device meets [Appendix A](#).
2. Test surface shall be steel (~3 mm backed by ~19 mm wood) as defined in IEC 60068-2-31. Ensure surface is clean, clear of all debris and is smooth.
3. The test height shall be 1 m.
4. Sample size shall be 5 devices. 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](#).
5. Device shall be powered on during the test.
6. For devices with removable covers and batteries, the back cover shall be taped on.
7. The rotational speed (typically 12 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 100 falls (or more if requested by vendor).
9. After each 10 falls, perform full functional testing according to [Appendix A](#) and note any failures.

Reporting:

Report results according to [Appendix A](#).

Section 3 Water Ingress

The manufacturer shall declare the IPX level. If IPX1 or IPX2, testing shall be conducted by the CTIA Certification Authorized Test Lab (ATL) according to the steps below. If above IPX2, these tests are optional and the manufacturer shall provide a declaration of compliance, indicating the IPX level, to the ATL.

3.1 Ingress Protection based on IPX1

Reference:

IEC 60529

Purpose:

Ensure that vertically falling drops of water have no harmful effects to the device according to IP classification IPX1.

Procedure:

1. Ensure device meets [Appendix A](#).
2. Sample size shall be 3 devices with live (or test) SIM/UICC cards, memory cards, and new and fully-charged batteries. 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. Tap water (local city supplied) may be used.
4. Calibrate the water flow using the following procedure:
 - a. Take a box without a top and weigh it within ± 0.1 g accuracy.
 - b. Insert the box in the dripping water chamber for 3 minutes.
 - c. Dry the external areas of the box.
 - d. Weigh the box with the water inside within ± 0.1 g accuracy.
 - e. 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

5. Perform test in ambient temperature.
6. Device shall be powered on and, if possible, in a voice call, while in test.
7. Device orientation on the turntable shall be 90° vertical (upright position making a call).
8. Place the device on the turntable in the drip box and expose it to dripping water for 10 minutes.
9. If the call is dropped during water exposure, no attempt to re-establish call is needed until after exposure.
10. After water exposure is completed, remove the sample from the drip box, keeping it in vertical position.
11. 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).
12. If the call is dropped during the water exposure, re-establish the call after one hour after the test and ensure it stays on the call for 5 minutes.
13. The device shall remain in its vertical position during the dry cycles.
14. Immediately after test (if device remained in a call during water exposure), check for fatal failures (see [Appendix B](#)) only and then turn off the device. After 24 hours, turn on again and perform full functional inspection according to [Appendix A](#).
15. 1 hour after test (if call dropped during water exposure), check for fatal failures only and then turn off the device. After 24 hours, turn on again and perform full functional inspection according to [Appendix A](#).

Reporting:

24 hours after test, report results according to [Appendix A](#).

3.2 Ingress Protection based on IPX2

Reference:

IEC 60529

Purpose:

Ensure that vertically falling drops of water have no harmful effects on the device according to IP classification IPX2.

Procedure:

1. Ensure device meets [Appendix A](#).
2. Sample size shall be 3 devices with live (or test) SIM/UICC cards, memory cards, and new and fully-charged batteries. 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. Tap water (local city supplied) may be used.
4. Calibrate the water flow using the following procedure:
 - a. Take a box without a top and weigh it within ± 0.1 g accuracy.
 - b. Insert the box in the dripping water chamber for 3 minutes.
 - c. Dry the external areas of the box.
 - d. Weigh the box with the water inside within ± 0.1 g accuracy.
 - e. 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

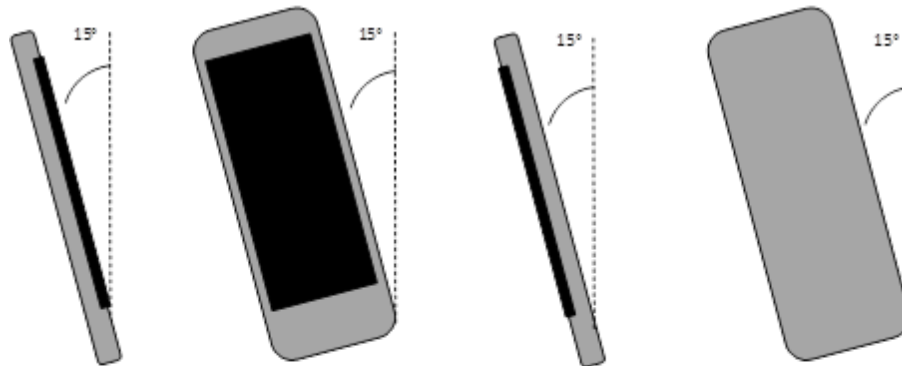
The water flow can be adjusted the following ways:

- 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

5. Perform test in ambient temperature.
6. Device shall be upright, powered on and, if possible, in a voice call, while in test.

7. 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:
 - a. Display facing up
 - b. Right side facing up
 - c. Display facing down
 - d. Left side facing up

FIGURE 3.2-1 INGRESS PROTECTION BASED ON IPX2



8. 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.
9. After the 10-minute water exposure is completed, remove the sample from the dripping water chamber keeping it in vertical position.
10. 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).
11. Immediately after test (if device remained in a call during water exposure), check for fatal failures (see [Appendix B](#)) only and then turn off the device. After 24 hours, turn on again and perform full functional testing according to [Appendix A](#).
12. 1 hour after test (if call dropped during water exposure), check for fatal failures only and then turn off the device. After 24 hours, turn on again and perform full functional testing according to [Appendix A](#).

Reporting:

24 hours after test, report results according to [Appendix A](#).

Section 4 Connectors

4.1 Connector Reliability— I/O, Data

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 4.1-1](#) and [Figure 4.1-2](#) for fixing instructions) for "up" test direction.

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

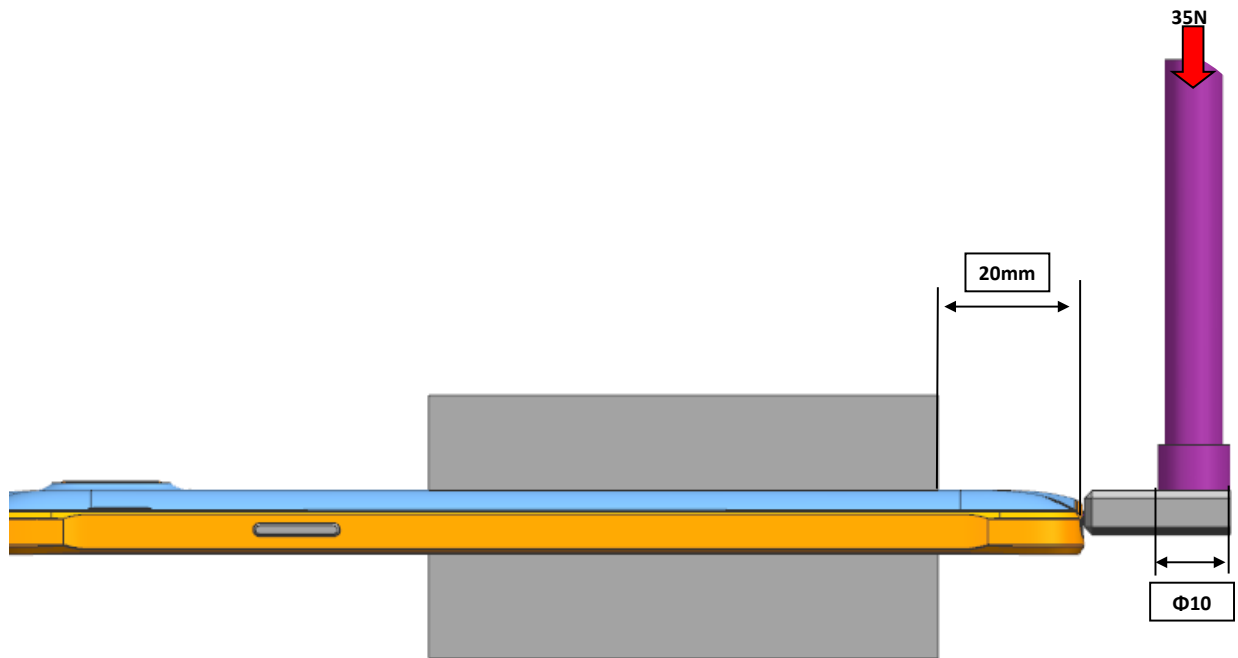
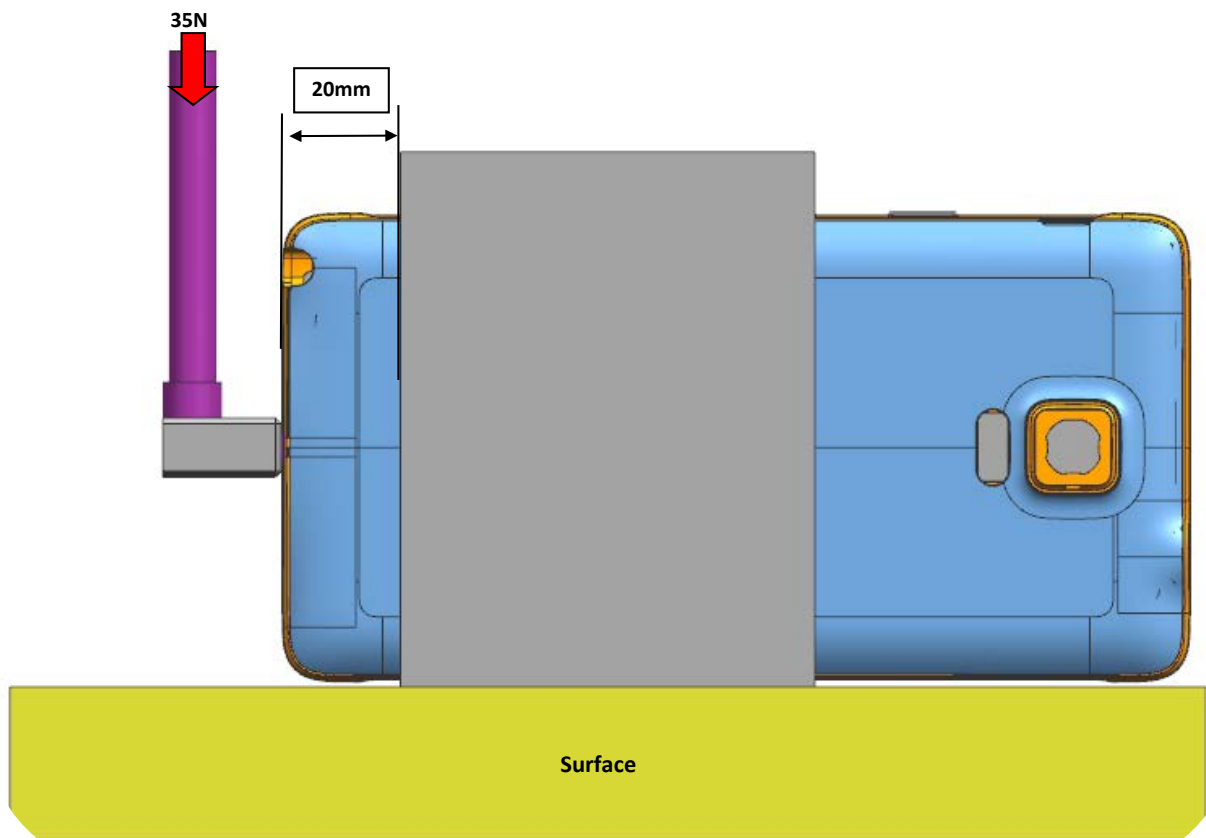


FIGURE 4.1-2 USB CONNECTOR RELIABILITY—LEFT/RIGHT DIRECTION CASE



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](#).

4.2 Connector Reliability—Audio**Reference:**

N/A

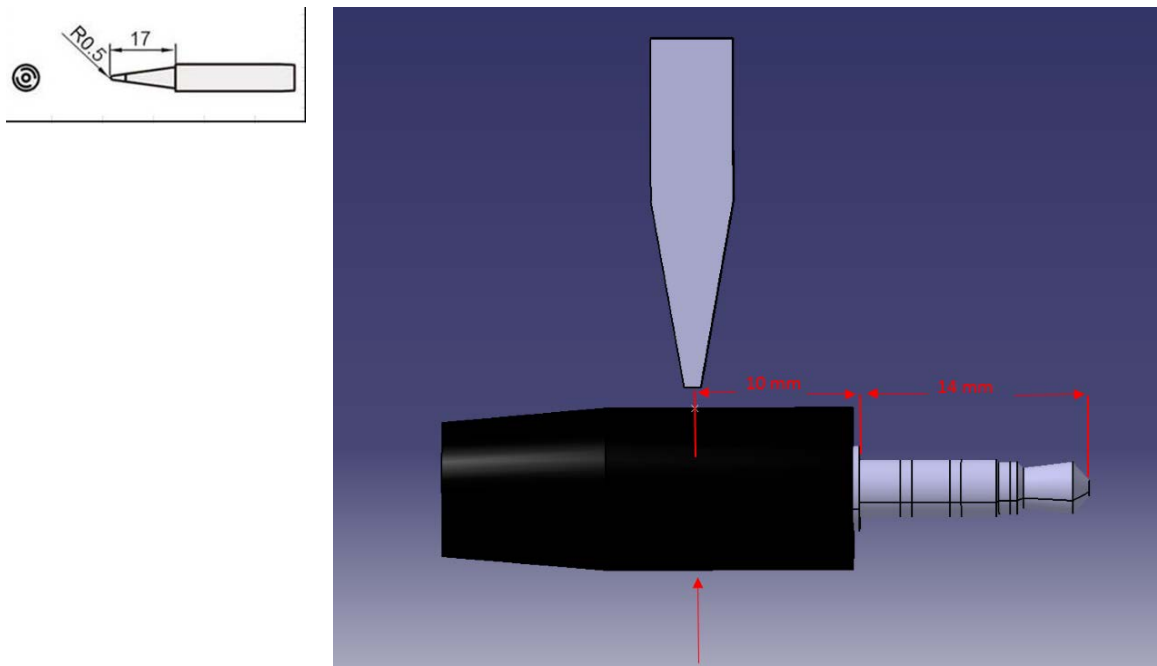
Purpose:

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 4.2-1](#)). For each test direction, test shall be conducted with a new, unused connector plug.

FIGURE 4.2-1 SUPPORT FOR LEFT & RIGHT DIRECTION TEST



8. Device shall be 50% supported for up/down direction tests (see [Figure 4.1-1](#)) and allowed to be up to 100% supported to left/right side tests (see [Figure 4.1-2](#)).
9. 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 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 4.1-1](#) and [Figure 4.2-1](#) 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 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 below. 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.

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 or loss of functionality (No distortion).

Microphones – No obvious diminished quality or loss of functionality.

Headset Jack – No obvious diminished quality or loss of functionality.

Vibrators – No obvious diminished quality or loss of functionality.

Wi-Fi – No obvious diminished quality or loss of functionality.

GPS – Vendor specific diagnostic program.

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

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

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

Appendix B Fatal Failure Definition

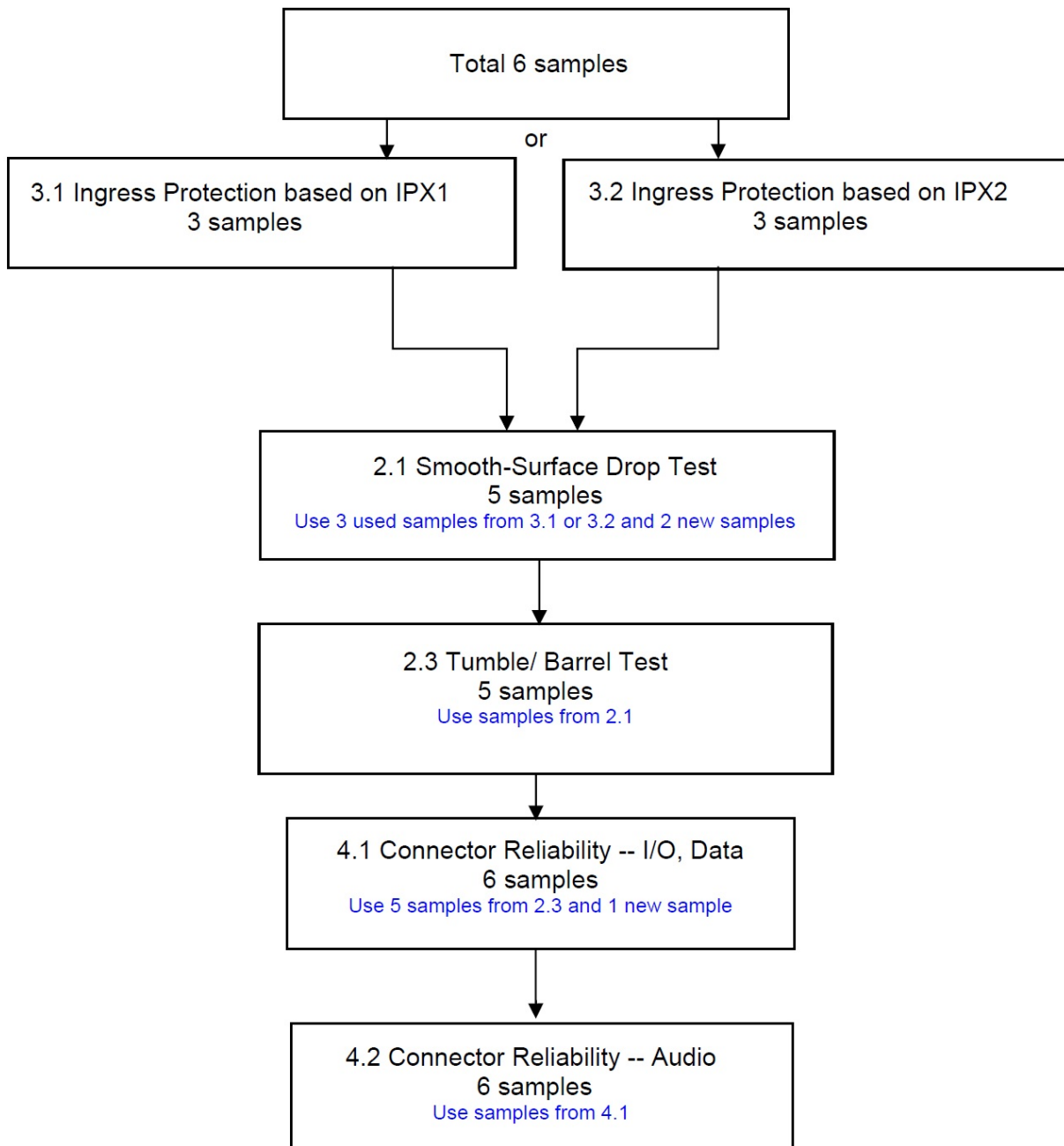
Level 1 Failure – any failure that prevents making a call such as:

- 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

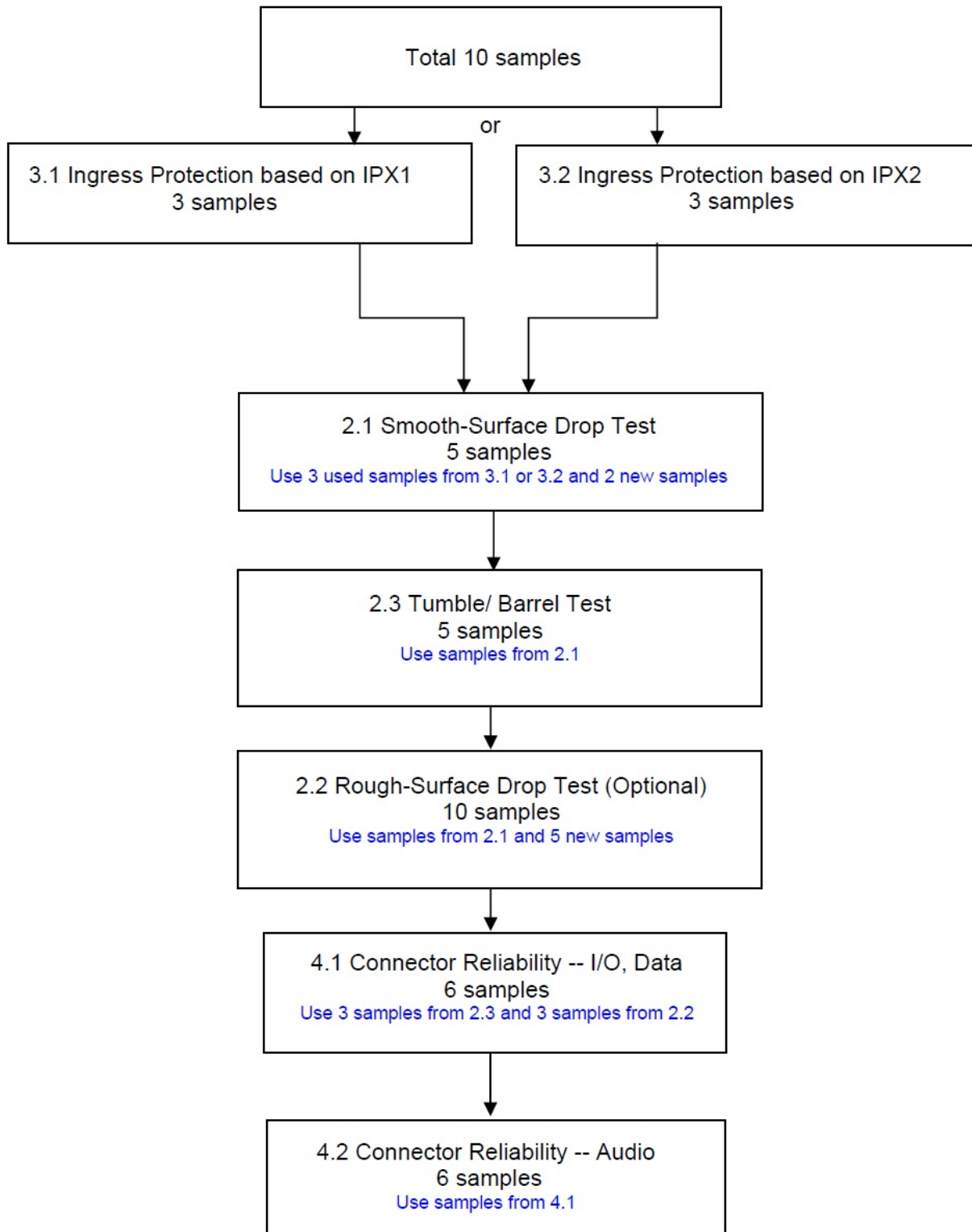
Level 2 Failure – any failure that causes degradation of use of device such as:

- Vibration not working
- Camera not working
- Side keys not working
- Loudspeaker not working
- Headset Jack not functional

Appendix C Example Sample Reuse Test Flows



Example 1: Section 2.2 Rough-Surface Drop Test (Optional) is not included



Example 2: Section 2.2 Rough-Surface Drop Test (Optional) is included

Appendix D Change History

Date	Revision	Description
September 2015	1.0	<ul style="list-style-type: none">Initial release.
August 2017	1.1	<ul style="list-style-type: none">Removed reference to IPC-TR-467.Renamed Section 2.1 from “Drop Testing” to “Smooth-Surface Drop Test.”Added Section 2.2 Rough-Surface Drop Test.Added Appendix B Fatal Failure Definition.Added Appendix C Example Sample Reuse Test Flow.Restructuring and editorial updates.
November 2020	1.1.1	<ul style="list-style-type: none">Changed CATL to ATL