Performance Specification for Automotive Universal Serial Bus (USB) Connection System

SAE/USCAR-30 REVISION 1
July 2023

ISBN: 978-1-4686-0644-7

SAE/USCAR-30 REVISION 1

Issued 2006-11
Reaffirmed 2022-07
Stabilized 2023-07

PERFORMANCE SPECIFICATION FOR AUTOMOTIVE UNIVERSAL SERIAL BUS (USB) CONNECTION SYSTEM

STABILIZED NOTICE

This document has been declared “Stabilized” by USCAR and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

QUESTIONS REGARDING THIS DOCUMENT: (248) 273-2470 FAX (248) 273-2494
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX (724) 776-0790

TABLE OF CONTENTS

WARNING

No electrical connector, terminal, or related USB component may be represented as having met USCAR/EWCAP specifications unless conformance to all applicable requirements of this specification have been verified and documented. All required verification and documentation must be done by the supplier of the part or parts. If testing is performed by another source, it does not relieve the primary supplier of responsibility for documentation of all test results and for verification that all samples tested met all applicable Acceptance Criteria. See section 4.3.

1 SCOPE

Procedures included within this specification are intended to cover performance testing at all phases of development, production, and field analysis of any USB cable assemblies and associated connections that constitute the electrical connection systems between the consumer peripheral interface and the USB computer source in road vehicle applications. These procedures are only applicable to the USB connector and the cable. Unless otherwise specified, all of the tests listed in this specification are for both consumer and nonconsumer interface connectors.

IMPORTANT NOTICE: All suppliers developing an automotive grade USB system must use components that have been validated and approved by an authorized USB testing facility per USB 2.0. In any intended vehicle application, if the products covered by this specification are, or may be, subjected to conditions beyond those described in this document, they must pass special tests simulating the actual conditions to be encountered before they can be considered acceptable for actual vehicle application. Products certified by their supplier as having passed specific applicable portions of this specification are not to be used in applications where conditions may exceed those for which the product has been satisfactorily tested.

The high frequency test methods are written for test professionals who are knowledgeable in the electronics field and are trained to use the referenced equipment. Because the measurement values are heavily influenced by the fixturing and equipment this method cannot describe all of the possible combinations. The major equipment manufacturers provide Application Notes for more in-depth technical description of how to optimize the use of their equipment.

The Authorized Person is the final authority as to what tests are to be performed on his or her parts and for what purpose these tests are required. He or she is also the final authority for resolving any questions related to testing to this specification and to authorizing any deviations to the equipment or procedures contained in this specification. Any such deviation must be documented and included in the final test report.

Guidance as to the recommended tests for selected purposes is given in the charts in Appendix C. In the absence of contrary direction from the Authorized Person in the test request/order, all electrical connectors and their associated terminals and other components are required to meet all applicable portions of this document with the following exception:

Specific tests that are not required or additional test requirements as specified in any document in the hierarchy of Section 3.1.

All suppliers of USB automotive assemblies must use certified USB 2.0 components (ie. USB mini-B receptacle, standard A stainless steel receptacle or equivalent ruggedized receptacle, mini B plug). For non-consumer interfaces, please refer to the USCAR footprint drawing labeled 999-U-USB-Z01.pdf. The drawing can be found at https://uscar.org

Refer to USB 2.0 website (www.usb.org) for approved supplier list

2 OUTLINE & GLOSSARY OF TERMS

2.1 GENERAL

Diagrams are provided where necessary to clarify the details of the various test procedures. The tests in each section must be performed in the order given unless otherwise specified in the test request/order. Construction details for selected test fixtures and equipment are provided in this specification.

A glossary of terms is provided in Appendix B. Terms defined in the definitions or glossary are capitalized (i.e. Room Temperature, Steady State, etc.). A list of definitions is provided in Appendix A.

3 REFERENCED DOCUMENTS REQUIRED

3.1 DOCUMENT HIERARCHY

In the event there is a conflict between performance specifications, part drawings, and other related standards or specifications, the requirements shall be prioritized as follows:

1st - Applicable FMVSS requirements and other applicable state and Federal requirements.
2nd - Applicable part drawings
3rd - Applicable product design specification(s).
4th - Automotive Industry Action Group (AIAG) Production Part Approval Process (PPAP)
5th - Applicable USCAR/EWCAP performance specifications
6th - Universal Serial Bus (USB) Specifications
7th - USB 2.0
8th - Other applicable standards and specifications

3.2 PART DRAWING

The part drawing for each connection system component should contain or reference:

All dimensional requirements (which must be in GD&T format).
Performance requirements.
Component part number.
Reference to applicable portions of this specification.
The typical mating connector.
Maximum permissible Temperature Class 1 (-40º C to +85º C) (per USCAR-2)

3.3 PRODUCT DESIGN SPECIFICATION

The product design specification may or may not be an integral part of the part drawing. Instructions must be included in the product design specification for any special tests required for the associated part and for any exceptions or modifications to the general specifications and requirements in this document.

3.4 TEST REQUEST/ORDER

3.4.1 Samples, Test Type and Special Tests

The laboratory test request/order shall provide location and documentation of test samples, identify the type of test to be performed (development, validation, special purpose, etc.) and describe any special tests that are not a part of this specification. Any required revisions to, or deviations from any tests in this specification must include detailed instructions for each change.

3.4.2 Test Request/Order Instructions

Instructions must be included in the test request/order concerning applicable tests and the order in which the tests are to be performed if different than outlined by this specification.

3.4.3 Performance and Durability Test Instructions

Instructions must be given in the test request/order concerning limits for performance and durability tests, including definition of the conditions under which those limits apply, if they are different than outlined in this specification.

3.4.4 Development Tests

Development tests are frequently used to evaluate specific areas of the design. They are tools for evaluating design alternatives, proposed improvements, cost reduction proposals, or determining root causes of field problems.

3.4.5 Validation Tests

Validation tests or sample approval tests are acceptance type tests. Consideration must be given to the inherent repeatability or subjectivity of certain tests outlined by this specification before designating it as a validation or compliance test.

3.4.6 Special Purpose Tests

Portions of this specification may be useful for special purpose testing. For example, verifying a process or material change may, in the judgment of the Authorized Person, require only one or two specific tests, or a portion of a test, to verify that no adverse consequence resulted from the change. Any portion of a test or any combination of tests contained in this specification may be used individually or may be combined with other testing, described outside this specification, in any phase of product development, production testing, or analysis of parts from the field.

3.5 OTHER REFERENCED DOCUMENTS

SAE/USCAR-20: Field Correlated Life Test
SAE/USCAR-25: Electrical Connector Assembly Ergonomic Design Criteria
AIAG: Measurement Systems Analysis Reference Manual
ISO TS16949
IEC 68-2-32 – Basic Environmental Test Procedures – part 2
USB 2.0: Universal Serial Bus Specification
USB Cable and Connector Class Document

4 GENERAL REQUIREMENTS

4.1 RECORD RETENTION

The supplier shall maintain a central file for the storage of laboratory reports and calibration records. Such record storage must be in accordance with established ISO TS16949 and AIAG policies and practices.

4.2 SAMPLE DOCUMENTATION

All test samples shall be identified in accordance with the requirements of ISO TS16949 and the AIAG PPAP.

4.3 SAMPLE SIZE

Minimum sample sizes are given for each test in this specification. A greater number of samples may be required by the test request/order. However, no part or device may be represented as having met this specification unless the minimum sample size has been tested and all samples of the group tested have met the applicable Acceptance Criteria for that test. It is never permissible to test a larger group, then select the minimum sample size from among those that passed and represent that this specification has been met.

4.4 DEFAULT TEST TOLERANCES

Default Tolerances, expressed as a percentage of the nominal value unless otherwise indicated:

Temperature	=	± 3 ° C
Voltage	=	± 5%
Current	=	± 5%
Resistance	=	± 5%
Length	=	± 5%
Time	=	± 5%
Force	=	± 5%
Frequency	=	± 5%
Relative Humidity	=	± 5%

4.5 TEST DEFAULT CONDITIONS

When specific test conditions are not given either in the product design specification, the test request/order or elsewhere in this specification, the following basic conditions shall apply:

Room Temperature	=	23 ± 5° C
Relative Humidity	=	Ambient

4.6 EQUIPMENT

Neither this list nor the list in each test section is all-inclusive. It is meant to highlight specialized equipment or devices with particular accuracy requirements. Many other items of customary laboratory equipment and supplies will also be required.

ITEM	DESCRIPTION	REQUIREMENTS*
1	Micro-ohmmeter	⇒ 0-20 mV ⇒ 0-100 mA Limits the open circuit voltage to 20 mV and limits the current applied to 100 mA. The micro-ohmmeter must also use either offset compensation or current reversal methods to measure resistance
2	Digital Multimeter (DMM)	* Capable of measuring the following at an accuracy of ≤0.5% of full scale: ⇒ 0-50 Volts DC ⇒ 0-10 Megohms
3	Insertion/Extraction Force Tester	Capable of 1.0% accuracy, full scale
4	Temperature Chamber	⇒ -40°C to +100°C or as required by Temperature Class ⇒ 0% to 95% RH
5	Vibration Controller	As Required
6	Vibration Table	⇒ 2640N (600 Lbs.) Sine Force ⇒ 2200N (500 Lbs.) RMS Force
7	Megohmeter	Accuracy <5% of full scale
8	Decibel Meter	+/- 1.5 dB "C" scale
9	Durability Cycler	Capable of a maximum 200 cycles per hour
10	Network Analyzer	100 to 500 MHz
11	Digital Sampling Oscilloscope	Tektronix 11801B or equivalent (must be capable and able to measure up to 200ps and 5.2ns/meter)
12	Shielding Effectiveness	HP 8593EM signal analyzer or equivalent
13	Camera/Video Recorder	Typical industry standard equipment
14	Microscope	10x magnification
15	Discontinuity Analyzer	Capable of monitoring 1 microsecond

Table 4.6.1: Equipment

NOTE: on requirements: Use of equipment with a lesser range is acceptable for specific tests where the required range for that test can be met. The equipment range specified does not preclude use of equipment with a larger range, but the accuracy must remain within the specified tolerance. For example, a DMM with a range of 0-100 volts could be substituted for one specified as 0-50 volts, with the provision that the accuracy could be maintained as ±0.5% of the 50 volts full scale, or 0.25 volts, not 0.5% of the 100 volt full scale of the substituted equipment.

4.7 MEASUREMENT RESOLUTION

Unless otherwise specified, meters and gauges used in measurements of the test sample(s) shall be capable of measuring with a resolution one decimal place better than the specified value. For example, even though a wire diameter specified as 0.1 mm might actually be the same as one specified as 0.10 mm, calipers capable of 0.01 mm resolution may be used to measure the first wire but a micrometer with 0.001 mm resolution is required to measure the second wire.

4.8 TEST REPEATABILITY & CALIBRATION

All equipment used for test sample evaluation shall be calibrated and maintained according to the applicable standards and requirements set forth by ISO TS16949 and the AIAG publication Measurement Systems Analysis Reference Manual. Copies of this Manual can be obtained from the AIAG. Documentation is to be recorded and retained in accordance with Section 4.1 of this USCAR/EWCAP specification.

4.9 CONFORMANCE DETERMINATION

Test conformance shall be determined by the performance requirements of the test being conducted. All samples must satisfy the performance requirements regardless of sample age, test cycles, or test temperature, except where a test to failure is specified.

4.10 DISPOSITION OF SAMPLES

Should a premature non-conformance occur during a test, contact the requesting party to determine if the test is to be continued to gain additional product experience or if testing is to be suspended or terminated. When contact cannot be immediately made, the type of test shall determine the disposition of the samples. If the test order indicates that the test is investigative in nature, continue until the requesting party or parties are available. If the test order is for sample approval or validation, stop the test until the requesting party can be contacted. If the test must be stopped or terminated for any other reason (safety, equipment failure, etc.) the Authorized Person must be contacted for concurrence before the test is restarted. The test request/order should always specify desired sample disposition at the conclusion of the applicable testing.

4.11 PART ENDURANCE

Successful completion of all requirements of this specification is intended to demonstrate that the design and construction of the components and connector systems tested are capable of operating in their intended vehicle environment and application.

5 TEST & ACCEPTANCE REQUIREMENTS

5.1 GENERAL

The tests detailed in this specification are qualitative in nature and are not expected to stress any part beyond its anticipated application limit, except where tests to failure are specified.

The test procedures that follow were written as stand-alone tests and may be used as such. However, they should be performed in sequence as specified in section 6. Common sense is required to overcome any redundancies in sample preparation or in procedures. For example, if samples have already been prepared for the preceding test in a sequence, it should be obvious that the sample preparation step for that individual test (included so that test can be used as a stand alone test) should be skipped. Should any conflicts or questions arise concerning procedures and/or requirements, contact the Authorized Person.

5.1.1 Performance Requirements

All connection systems must meet all performance test requirements for the appropriate Temperature Class (-40º C to + 85º C.)

5.1.2 Dimensional Characteristics

Part construction shall conform to the dimensions, shape, and detail attributes specified in the latest revision of the applicable part drawing(s).

5.1.3 Material Characteristics

Parts are intended to be in their "as furnished for vehicle assembly" condition when testing begins, unless specific instructions as to any pre-test "conditioning" are contained in the test request/order. For example, electrical terminals typically have residual die lubricant on them when finally assembled into a vehicle. This same condition must prevail for test samples unless part cleaning is specified in the Test Request/Order.

All material used in each test sample shall conform to the material specifications shown on the latest revision of the applicable part drawing(s).

5.1.4 Temperature Classifications

USB assembly to meet USCAR class 1 temperature requirement (-40^{o} C to + 85^{o} C)

5.1.5 Testing Headers & Direct Connect Components

Cases frequently arise where only one half of a connector, usually the female half, is available and it mates directly to a Header or to a receptacle in an electrical component or device. This presents special problems for testing. In order to completely test the electrical connection, access must be gained to the terminals in the device or header.

Therefore, in situations where there is more than 50 mm from the point of contact in the connection nearest to the Header or device to the point where the terminal "tail" or buss bar connects to the device, these two options are available. (1) Attach the millivolt lead at a convenient common distance from the contact to be measured. Then subtract the bulk resistance of the selected common length when calculating the resistance of the associated Header or device connection. (2) Measure bulk resistance of each individual Header terminal or component buss bar from the connection to be measured to the point of millivolt lead attachment and subtract this resistance when calculating the resistance of the associated Header or device connection.

It may be that the electrical component or device being connected is not itself capable of withstanding the tests to which the connector is usually subjected. In these cases samples of just the connector receptacle portion of the device must be obtained

In any case, the Authorized Person must be consulted and must approve any deviation from the normal tests of this performance specification.

5.1.6 Sample Preparation (LLCR)

1. Perform Visual Inspection on all parts per Section 5.1.8 (reference page 15).
2. Identify and label all samples with a unique label (test request/order number) and relevant test name.
3. Test points can be any convenient length between 75 mm and 300 mm away from point where wires exit the back of the connector; use this length for all samples of this test.

NOTE: Wire lengths shorter than 75 mm introduce room for errors during setup.

4. If part of a longer wire harness/cable assembly, cut off relevant length of the wire for testing purposes.
5. Strip off jacket of cable, pull back shield to expose the circuits' wires.
6. Strip insulation from the appropriate wire to be tested using care not to nick or cut any individual wire strands. Tin the exposed conductor ends.

NOTE: Ensure that every length of wire stripped is matching to ensure repeatability in measurements.

7. Obtain a matching length/type of wire for each wire size tested for the wire deduct sample.
8. Prepare the ends of the deduct wire as described in Steps 4, 5 and 6 above.
9. Prepare any mating headers/devices as described in note on page 14 of this specification.

NOTE: Lead wires can be attached to the pins of the headers directly, pins can be shorted together to measure two contacts at a time, or test boards can be attached to the header to facilitate easier access for attachment points. Ensure to deduct all relevant bulk/wire resistances from the overall measurements.
NOTE: Seek prior approval of the Authorized Person for all preparation plans.

5.1.7 Connector Cycling

5.1.7.1 Purpose

This procedure preconditions a connection system pair or terminal system pair prior to a test sequence. Connectors may be subjected to repeated cycling due to in-plant and/or service repair prior to and during the life of the connector. Complete this procedure only once when conducted as part of a series of tests as in section 6 (Test Sequence).

5.1.7.2 Equipment

Durability Cycler

5.1.7.3 Sample Preparation

No special preparation required.

5.1.7.4 Procedure

The test shall be performed per the latest revision of the Universal Serial Bus Cables and Connectors Class Document with the following exceptions:

a) The consumer interface connection shall be cycled 5,000 times (each sample in the lot to be tested)
b) The mini-B connector shall be cycled 10 times (each sample in the lot to be tested).

Re-mate connectors for one last time in preparation for future test sequences.

5.1.7.5 Acceptance Criteria

Complete the Visual Examination per section 5.1.8

The low level circuit resistance shall meet the requirements listed in the Universal Serial Bus Specification 2.0 Electrical and Mechanical Compliance Standards.

5.1.8 Visual Inspection

5.1.8.1 Purpose

This test is used to document the physical appearance of test samples. A comparison can then be made with other test samples. Examinations in most cases can be accomplished by a person with normal or corrected vision, and normal color sensitivity, under cool white fluorescent lighting. Photographs and/or videos are encouraged as a more complete means of documentation. An appropriately identified untested sample from each test group must be retained for post-test physical comparisons.

5.1.8.2 Equipment

- ⇨ Camera
- ⇨ Video Recorder
- ⇨ Magnification Apparatus (as required)

5.1.8.3 Procedure

Visually examine each test specimen prior to testing and/or conditioning, noting in detail any manufacturing or material defects such as cracks, tarnishing, flash, etc. When specified in the test request/order, take photographs and/or video recordings of representative samples to be tested and keep a properly labeled control sample.

After testing and/or conditioning, re-examine each test sample and note in detail any observable changes, such as swelling, corrosion, discoloration, contact plating wear, physical distortions, cracks, etc. Compare the tested and/or conditioned samples to the control samples, the videos, and/or the photographs, recording any differences in the test report. The Authorized Person will need to provide an additional sample for this purpose.

Return test samples to requestor after all tests are completed and all necessary data have been obtained.

5.1.8.4 Acceptance Criteria

The connector assemblies must not show, with the aid of 10X magnification, any evidence of deterioration, cracks, deformities, etc. that could affect their functionality or distort their appearance. Connector locking mechanisms must function without breakage.

5.1.9 Circuit Continuity Monitoring

5.1.9.1 Purpose

Some procedures require continuous circuit monitoring of connectors during conditioning. The purpose of circuit monitoring is to detect intermittencies caused by micro-motion and resultant wear or build-up of non-conductive debris at the contact interface. Use this procedure when specified in the individual test.

5.1.9.2 Equipment

Discontinuity Analyzer

5.1.9.3 Procedure

At least 10 individual power terminals and 5 connector pairs must be monitored, contacts shall be wired in two or more series circuit(s) with each circuit connected to a separate detector, or shall be individually connected to separate detectors (one detector for each contact).

False failure may be caused by electrical noise or interference. If a discontinuity is indicated, the detector shall be reset. If any further discontinuities occur, the time and test parameters resulting in said discontinuity shall be recorded and reported. Specimens shall not be failed by a single discontinuity indication when the detector is reset and the discontinuity does not recur.

NOTE: Monitored terminals shall not be the same samples used for subsequent LLCR readings for record, since the monitoring equipment may cause the potential across the circuit to exceed 20mvolts. LLCR readings, however, may be taken as an aid in root-cause diagnosis.

5.1.9.4 Acceptance Criteria

Where continuity monitoring is required during any conditioning procedure, there must be no loss of electrical continuity, for more than 1 microsecond. If one or more terminal pairs are monitored, rather than the series resistor, there must be no instance in which the resistance of any terminal pair exceeds 70Ω for more than 1 microsecond. Figure 5.1.9.4 illustrates the acceptance criteria graphically.

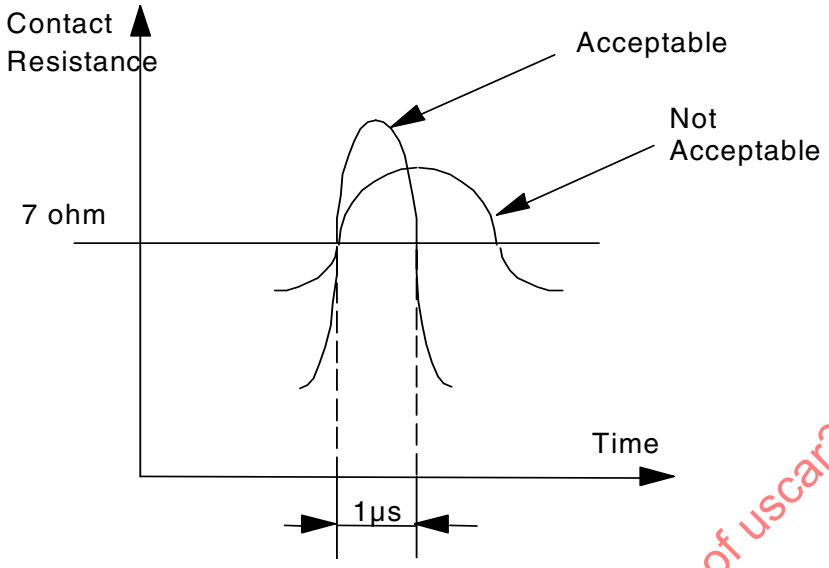


Figure 5.1.9.4: Intermittency Measurement

5.2 CABLE ASSEMBLY - MECHANICAL TESTS

5.2.1 Connector – Connector Mating/Unmating Force

5.2.1.1 Purpose

This test determines the mating/Un-mating Forces associated with manual mating and un-mating of complete connector assemblies. Mating Forces are an important consideration in determining the suitability of a given connector design for use in production. Un-mating Forces are important in determining serviceability of the design and ensuring the connection will stay mated for the service life of the vehicle.

5.2.1.2 Equipment

⇨ Insertion/Extraction Force Tester.

5.2.1.3 Procedure

A. MATING FORCE-Nonconsumer Interface Only

1. The connector on the end of the cable shall be tested. A minimum of 15 cable assemblies shall be tested.
2. Obtain the appropriate USB qualified mating parts or equivalent.
3. Number each cable assembly and mating part.

4. Secure the connector halves (one male and one female) in the appropriate fixtures of the force tester. Adjust the force tester to insert the Male Connector straight into the Female Connector. Straight-in engagement is critical to avoid side loads and binding which can affect force measurements.

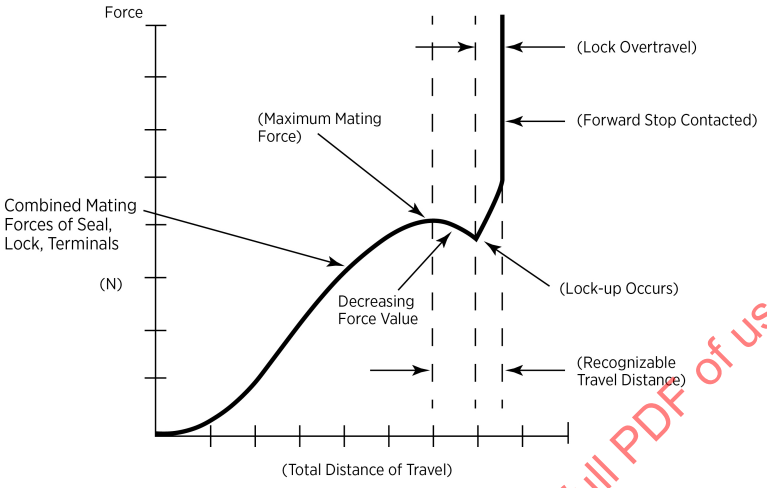


Figure 5.2.1.3: Typical Connector Mating Force Curve

NOTE: If appropriate equipment is available, a continuous graph of applied Mating Force vs. Insertion distance is highly recommended. A properly designed connector should produce a graph showing a smooth rise to a single peak force, then a fall off until the connector is fully mated. If the graph shows more than one force peak, the potential for a false lock condition exists.

5. Increase the Mating Force at a uniform rate not to exceed 50mm/min. until complete mating occurs. Test all samples.
6. Record the force required to completely mate each set of connector halves into their locked position and use these values to verify conformance of each connector pair to the Acceptance Criteria of Section 5.2.1.4.

A-1 MATING FORCE-Consumer Interface Only

1. The connector on the end of the cable shall be tested. A minimum of 15 cable assemblies shall be tested.
2. Obtain the appropriate USB qualified mating parts or equivalent.
3. Number each cable assembly and mating part.
4. Secure the connector halves (one male and one female) in the appropriate fixtures of the force tester. Adjust the force tester to insert the Male Connector straight into the Female Connector. Straight-in engagement is critical to avoid side loads and binding which can affect force measurements.

See Figure 5.4.2.3: Typical Connector Mating Force Curve

NOTE: If appropriate equipment is available, a continuous graph of applied Mating Force vs. Insertion distance is highly recommended. A properly designed connector should produce a graph showing a smooth rise to a single peak force, then a fall off until the connector is fully mated. If the graph shows more than one force peak, the potential for a false lock condition exists.

5. Increase the Mating Force at a uniform rate not to exceed 50mm/min. until complete mating occurs. Test all samples.
6. Record the force required to completely mate each set of connector halves into their locked position and use these values to verify conformance of each connector pair to the Acceptance Criteria of Section 5.2.1.4.

B. UNMATING FORCE-Non Consumer Interface Only

1. This test uses the same samples as in Section 5.2.1.3 Step 1 above. If the test equipment permits, each sample may be mated and then unmated without removing it from the force tester.
2. Half of the samples (at least 5) are to be tested with the connector primary locking mechanism fully engaged. For this group, completely un-mate the connector halves by applying a uniform force parallel to the centerlines of the fully mated connector halves. The force tester must be configured to apply the Un-mating Force directly to the connector halves, not through the conductor(s). Straight-out un-mating is critical to avoid side loads and binding which can affect force measurements.

*** CAUTION ***

The following step will result in sample breakage. Adequate shielding and personnel safeguards must be employed to ensure the safety of persons and property in the vicinity of the test.

3. Increase the Un-mating Force at a uniform rate not to exceed 50mm/min. until complete separation occurs. Test all samples (at least 5) in the first group.
4. Record the force required to completely separate the connector halves and verify conformance to the Acceptance Criteria of Section 5.2.1.4.
5. Repeat Steps 2, 3 and 4 above using the samples (at least 5) from Step A-5 above except completely remove/disable the primary connector locking mechanism(s).
6. For the remaining samples (at least 5) measure the force required to disengage the primary connector lock. This is the force a person would apply to the appropriate point such that the mated connector halves (or a connector mated to a device) could be unmated in the intended manner with no damage to any component. Apply the force perpendicular to the appropriate unlocking surface at a rate not to exceed 50mm/min. Record the force required to displace the lock so it just clears its mating feature. Verify conformance to the appropriate Acceptance Criteria of Section 5.2.1.4.

B-1 UNMATING FORCE-Consumer Interface Only

1. This test uses the same samples as in Section 5.2.1.3 Step 1 above. If the test equipment permits, each sample may be mated and then unmated without removing it from the force tester.
2. For this group, completely un-mate the connector halves by applying a uniform force parallel to the centerlines of the fully mated connector halves. The force tester must be configured to apply the Un-mating Force directly to the connector halves, not through the conductor(s). Straight-out un-mating is critical to avoid side loads and binding which can affect force measurements.
3. Increase the Un-mating Force at a uniform rate not to exceed 50mm/min. until complete separation occurs. Test all samples in the group.
4. Record the force required to completely separate the connector halves and verify conformance to the Acceptance Criteria of Section 5.2.1.4.

5.2.1.4 Acceptance Criteria

5.2.1.4.1 Non Consumer Interface Only

NOTE: The maximum mating effort is meant to simulate assembly in a vehicle when the assembler's body position and access to the connector being mated is not physically restricted. This specification will cover most operations, but not all conditions of vehicle assembly and connector location can be anticipated.

NOTE: The forces specified in the Acceptance Criteria must be met regardless of the moisture content of the connector housing material. Consult the test request/order to determine if any conditioning of the test samples is required prior to testing.

NOTE: The acceptance criteria of this section varies with the available contact (grip) area of the connector being tested. Reference SAE/USCAR-25 Electrical Connector Assembly Ergonomic Design Criteria for details of the acceptance criteria.

1. Mating (engage) force shall meet the requirements of SAE/USCAR-25.
2. Un-mating Force must be ≤ 45 Newtons with the primary connector lock completely disengaged/disabled.
3. Un-mating Force must be ≥ 110 Newtons with the primary connector lock fully engaged.
4. The force to completely disengage the primary connector lock must be >10N and ≤ 70N

5.2.1.4.2 Consumer Interface Only

Mating Force shall meet the requirements shown in USB 2.0
Un-mating Force prior to 5000 mating cycles should be collected for reference where applicable
Un-mating Force must be ≥ 10 Newtons after 5000 mating cycles.

5.2.2 Cable Flex

5.2.2.1 Purpose

To determine the effectiveness of the cable assembly to withstand strain under repeated alternating cable flexing stresses.

5.2.2.2 Equipment

Discontinuity Analyzer
Flex tester

5.2.2.3 Procedure

The test shall be performed per the latest revision of the Universal Serial Bus 2.0 specification.

5.2.2.4 Acceptance Criteria

Per the Universal Serial Bus Cable & Connector Class Specification

5.2.3 Vibration/Mechanical Shock

5.2.3.1 Purpose

This test subjects a connector system to variable vibration simulating accelerated exposure to actual vehicle conditions. Vibration and shock can cause wear of the terminal interfaces, intermittent electrical contact and failure of mechanical components of the connector system.

NOTE: This section does not apply to components mounted outside the passenger or luggage compartment or on un-sprung portions of the vehicle, such as the wheel hub. These components require special testing to ensure they can survive and function properly in the intended application.

5.2.3.2 Equipment

- ⇨ Vibration Table
- ⇨ Vibration Controller
- ⇨ Accelerometers
- ⇨ Discontinuity Analyzer

5.2.3.3 Procedure

Tested per USCAR-2. Mounting position B. Figure 5.4.6.3-E of USCAR-2 Components not coupled to the engine.

5.2.3.4 Acceptance Criteria

At the conclusion of the test, verify conformance of each terminal pair and each sample connector assembly, as appropriate, to the Acceptance Criteria of section 5.1.9.4 (Continuity Monitoring) and to the following tests:

After 48 hours at ambient conditions, terminals must meet the Acceptance Criteria of the USB 2.0 Low Level Contact Resistance and Electrical and Mechanical Compliance Standards. .

1. The cable assembly must not show, with the aid of 10X magnification, any evidence of deterioration, cracks, deformities, etc. that could affect its functionality or severely degrade its appearance.
2. The connector terminals must not show, with the aid of 10X magnification, any evidence of deterioration, cracks, deformities, excessive plating wear, etc. that could affect their functionality.

5.2.4 Connector-to-Connector Audible Click- Non Consumer Interface Only

5.2.4.1 Purpose

Studies show that assembly plant technicians depend on audible queues that indicate full seating of electrical connectors regardless of background noise. This test measures the level of noise generated when two connectors are mated. Connectors are mated by hand for this test rather than being clamped into a fixture which could dampen or amplify the sound.

5.2.4.2 Equipment

⇨ dB meter

5.2.4.3 Procedure

Tested per USCAR-2. Section 5.4.7

5.2.4.4 Acceptance Criteria

The minimum sound level required shall be as specified on the part drawing. If no value is specified, the requirement is 7dB above the recorded ambient for un-conditioned parts and 5dB for conditioned parts.

Note: To improve test repeatability, it is allowable to hold device mounted header connectors in a vice or similar fixture for this test. The fixture must not interfere with the normal mating sequence of the connector halves.

5.2.5 Connector Assembly Drop Test

5.2.5.1 Purpose

This test evaluates the ability of the connection to withstand impact due to dropping on a hard surface. This test does not apply to headers or any other connector not designed for use in a cable assembly.

Note: It is acceptable to cut the cable off at the back of the harness side connection to perform this test. This test as stated above applies to the connector only.

5.2.5.2 Equipment

No specific equipment is required.

5.2.5.3 Procedure

Tested per USCAR-2. Section 5.4.8.

5.2.5.4 Acceptance Criteria

Samples shall meet the Acceptance Criteria of USCAR-30 Section 5.1.8, Visual Inspection.

5.2.6 Cable Pull-Out (Retention)

5.2.6.1 Purpose

To detail a standard method for determining the holding effect of a USB plug cable clamp without causing any detrimental effects upon the cable or connector components when the cable is subjected to inadvertent axial tensile loads.

5.2.6.2 Equipment

Force Gauge/Load cell
Discontinuity Analyzer
Test Stand

5.2.6.3 Procedure

The test shall be performed per the latest revision of the Universal Serial Bus Cables and Connectors Class Document (EIA 364-38 Test Condition A).

5.2.6.4 Acceptance Criteria

Per USB 2.0 (Cable Pull Out)

5.2.7 Polarization Feature Effectiveness (Non-consumer Interface Only)

5.2.7.1 Purpose

This test ensures that the polarization feature(s) is adequate to meet its intended purpose of preventing incorrect mating of a connector housing with its intended mate, and preventing mating of a connector housing with any unintended mate. It also tests the adequacy of the polarization feature(s) in preventing terminal damage during incorrect assembly attempts. In addition to this objective force test, it is recommended that a jury evaluation be conducted among knowledgeable individuals trying "hands-on" mis-mating.

5.2.7.2 Equipment

⇨ Insertion/Extraction Force Tester with Peak Reading Feature

5.2.7.3 Procedure

The test shall be performed in accordance with the latest revision of the SAE/USCAR-2.

5.2.7.4 Acceptance Criteria

Minimum of 90N.

5.3 CABLE ASSEMBLY - ELECTRICAL TESTS

5.3.1 Low Level Contact Resistance

5.3.1.1 Purpose

To evaluate contact resistance characteristics of the contact systems under conditions where applied voltages and currents do not alter the physical contact interface and will detect oxides and films which degrade electrical stability.

5.3.1.2 Equipment

Keithley 580 Micro Ohm meter or equivalent

5.3.1.3 Procedure

NOTE: Take care to avoid any mechanical disturbance of mated terminal samples submitted for this test. Such disturbance could rupture any insulating film which may have developed on the contact surfaces.

NOTE: If the samples submitted for this test have already been subjected to any other electrical test, the purpose of this test has likely been defeated and the Authorized Person must be contacted for approval before proceeding.

1. Measure and record the resistance across a maximum length of 300mm of the conductor to be used for the test. For tests using an un-mounted header terminal as one half of the test connection, the resistance of the header terminal is negligible and may be ignored. If the header will be board mounted the resistance of the traces on the board must also be subtracted.

2. The sense point (Figure 5.3.1.3) must be soldered for all stranded cable. For Header type connectors, the sense point is attached to the Header terminal per Section 5.1.5

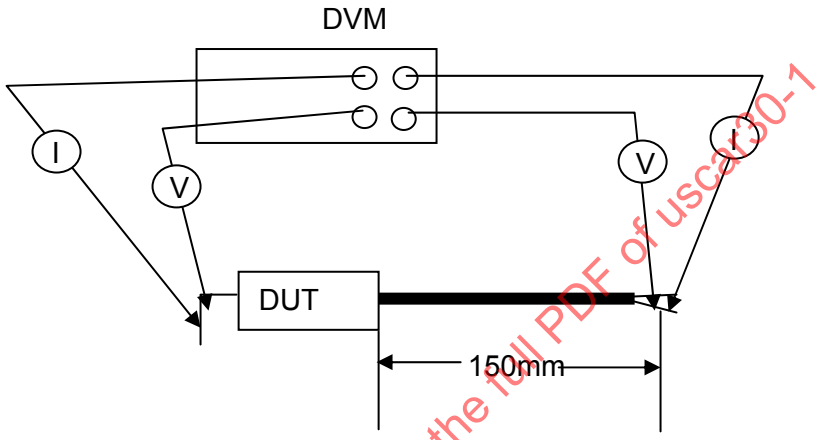


Figure 5.3.1.3

Measure the resistance of 150mm of conductor for future removal from the reported value. Note: Other lengths of conductor can be used as long as the bulk resistance of a corresponding length is removed.

3. Using the appropriate equipment, measure and record the resistance as shown in Figure 5.3.1.3. Then deduct the conductor resistance to find the total connection Low Level Contact Resistance.
4. Verify conformance to the Acceptance Criteria of Section 5.3.1.4

5.3.1.4 Acceptance Criteria

The Total Connection Resistance calculated in Step 3 must not exceed the value listed in the latest revision of the USB 2.0.

5.3.2 Insulation (Isolation) Resistance

5.3.2.1 Purpose

This test verifies the electrical conformance to USB 2.0. under automotive environment. This test is typically done after other environmental stress tests to ensure that any contaminants that may have entered the connector during testing are not sufficient to create an unintended electrical path.

5.3.2.2 Equipment

⇨ Megohmeter

5.3.2.3 Procedure

NOTE: This test is typically used only in conjunction with another test that subjects the connector to the chance of some form of moisture or other contaminant intrusion. Test the same samples used for the related test.

NOTE: When samples are to be tested following exposure to moisture or other contaminants, it is important that this Isolation Resistance test be performed on each sample within one hour of concluding the associated test. Otherwise, particularly where samples are exposed to elevated temperatures in the preceding test, any contaminant that might invade the samples may dry to the point of being undetectable by this Isolation Resistance test.

The test shall be performed per the latest revision of the Universal Serial Bus Cables and Connectors Class Document. Test to be performed in the mated condition.

5.3.2.4 Acceptance Criteria

Per USB 2.0 (Isolation Resistance)

5.4 RF TESTS

NOTE: Cable and connector must be tested as a complete assembly.

5.4.1 Cable Assembly Impedance

5.4.1.1 Purpose

To determine the characteristic impedance of the cable assembly via time domain analysis.

5.4.1.2 Equipment

Digital Sampling Oscilloscope

5.4.1.3 Procedure

The test shall be performed in accordance with the latest revision of the Universal Serial Bus Cable and Connector Class Document. (EIA-364, Test Procedure 108)

5.4.1.4 Acceptance Criteria

The samples shall meet the requirements as listed in the latest revision of the Universal Serial Bus 2.0 Specification.

5.4.2 Cable Assembly Propagation Delay

5.4.2.1 Purpose

To determine the propagation delay of the cable assembly via time domain analysis.

5.4.2.2 Equipment

Digital Sampling Oscilloscope

5.4.2.3 Procedure

The test shall be performed in accordance with the latest revision of the Universal Serial Bus Cable and Connector Class Document. (EIA-364, Test Procedure 103)

5.4.2.4 Acceptance Criteria

The samples shall meet the requirements as listed in the latest revision of the Universal Serial Bus 2.0 Specification.

5.4.3 Cable Assembly Propagation Delay Skew

5.4.3.1 Purpose

To determine the propagation delay skew of the cable assembly via time domain analysis.

5.4.3.2 Equipment

Digital Sampling Oscilloscope

5.4.3.3 Procedure

The test shall be performed in accordance with the latest revision of the Universal Serial Bus Cable and Connector Class Document. (EIA-364, Test Procedure 103)

5.4.3.4 Acceptance Criteria

The samples shall meet the requirements as listed in the latest revision of the Universal Serial Bus 2.0 Specification.

5.4.4 Cable Assembly Attenuation

5.4.4.1 Purpose

To determine the attenuation of the cable assembly via network analysis.

5.4.4.2 Equipment

Network Analyzer

5.4.4.3 Procedure

The test shall be performed in accordance with the latest revision of the Universal Serial Bus Cable and Connector Class Document. (EIA-364, Test Procedure 101)

5.4.4.4 Acceptance Criteria

The samples shall meet the requirements as listed in the latest revision of the Universal Serial Bus 2.0 Specification.

5.4.5 Cable Assembly Shielding Effectiveness

5.4.5.1 Purpose

To determine how well the shield construction of the Cable/Connector Assembly prevents unwanted RF signal from radiating out and causing interference with outside equipment.

5.4.5.2 Equipment

Signal Analyzer and EMI Chamber

5.4.5.3 Procedure

The test shall be performed in accordance with the latest revision of the Universal Serial Bus Cable and Connector Class Document.

5.4.5.4 Acceptance Criteria

The samples shall meet the requirements as listed in the latest revision of the USB Cable and Connector Class Document.

5.5 CONNECTOR ENVIRONMENTAL TESTS

5.5.1 Thermal Shock

5.5.1.1 Purpose

This test subjects the connector assembly to extreme temperature cycles that cause expansion and contraction of the various materials used in the connector system. This is intended to produce accelerated wear at the terminal-to-terminal interface.

5.5.1.2 Equipment

⇨ Temp. Chamber(s) (-40° C to +100° C)
⇨ Discontinuity Analyzer

5.5.1.3 Procedure

The test shall be performed in accordance with the latest revision of the SAE/USCAR-2. Per Temperature Class 1.

5.5.1.4 Acceptance Criteria

Shall meet the requirements of Low Level Contact Resistance, Acceptance Criteria Shown in 5.3.1.4.

Shall meet the visual inspection acceptance criteria listed in section 5.1.8.4

Shall meet Circuit Continuity Monitoring, Acceptance Criteria shown in 5.1.9.4.

5.5.2 Temperature/Humidity Cycling

5.5.2.1 Purpose

This test simulates actual operating conditions using temperature and humidity variations as aging mechanisms for evaluation of a connector system's electrical durability. High humidity and temperature can promote galvanic and electrolytic corrosion of the terminals which may cause electrical and mechanical degradation. Temperature cycling promotes relative movement of the contact surfaces that can cause wear and fretting corrosion. Certain plastic materials may also degrade.

5.5.2.2 Equipment

Temperature Chamber(s) (-40° C to +100° C, 0%-95% Relative Humidity)

5.5.2.3 Procedure

The test shall be performed in accordance with the latest revision of the SAE/USCAR-2, Temperature Class 1.

5.5.2.4 Acceptance Criteria

Shall meet the requirements listed in the Universal Serial Bus Specification 2.0 (Table 6-7).

Shall meet the requirements of Low Level Contact Resistance, Acceptance Criteria Shown in 5.3.1.4

Shall meet the visual inspection acceptance criteria listed in section 5.1.8.4

5.5.3 High Temperature Exposure

5.5.3.1 Purpose

This test evaluates the effects of long-term exposure to elevated temperature on connector assembly components. Thermal aging may cause changes in metal and plastic materials, including stress relaxation in important flexing members of the terminal or its connector. These changes may be detrimental to electrical and physical performance.

5.5.3.2 Equipment

⇨ Temperature Chamber(s) (+100^{o} C)

5.5.3.3 Procedure

The test shall be performed in accordance with the latest revision of the SAE/USCAR-2. Per Temperature Class 1.

5.5.3.4 Acceptance Criteria

Per latest revision of Low Level Contact Resistance USB 2.0 (Table 6-7).

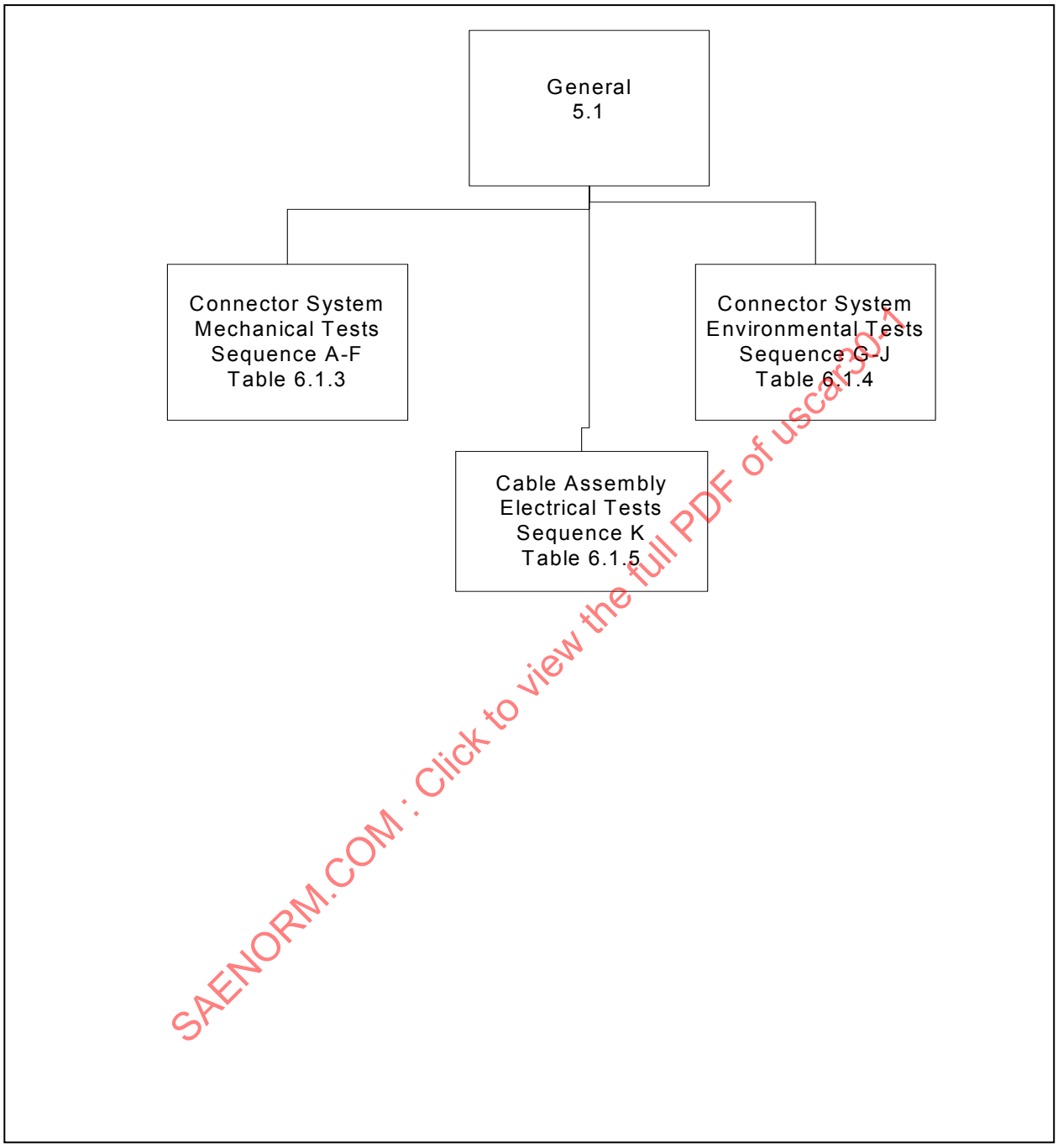
Shall meet the requirements of Low Level Contact Resistance, Acceptance Criteria Shown in 5.3.1.4

Shall meet the visual inspection acceptance criteria listed in section 5.1.8.4.

6 TEST SEQUENCE

6.1.1 General Notes

1. Test sequence is the order in which tests are performed. The sequence should be logical and interrelated in order to accurately establish the performance characteristics of the component or assembly.
2. Numbers in the body of charts Section 6 indicate the order in which the tests or conditioning procedures are performed. Where there are duplicate numbers in the same column, the procedures are performed concurrently.
3. Destructive tests should be performed only on samples that are not intended for use in further test sequences.
4. The LLCR Resistance test (Section 5.3.1) should always be performed before any other electrical test and prior to sample movement.
5. Fixtures and test set-ups should be reviewed by the Authorized Person prior to the start of testing.
6. The sequential test tables in section 6 are base sequences and may be altered according to the Authorized Person's request.
7. The total number of test samples needed for sequential tests is shown at the top of each column. It is important to note that, where parallel test paths are shown, a separate set of samples is required for each path. The same set of samples is never run through one path and then used again for a parallel test path unless specifically required in the test request/order. Exceptions are noted in each flow chart.



Section 6.1.2: General Test Flow Chart

Cable Assembly Mechanical Tests								
	Flow Chart	Durability (2)	Dimensional Inspection	Audible Click	Conn Conn Mating/Un-mating	Polarization Effectiveness	Drop	
	Test							
	Sequence ID	**A**	**B**	**C**	**D**	**E**	**F**	
	Sample Size (Refer to individual procedures)	10	10	8	15	(3)	3	
5.1	General	1	1	1	1	1	1	
5.1.8	Visual Inspection	2, 6	2	2, 4	2, 4	2, 4	2, 4	
5.1.7	Connector Cycling (2)	4						
5.1.2	Dimensional Characteristics		3					
5.3.1	Low Level Circuit Resistance	3, 5						
5.2.1	Connector-Connector Mating/Unmating Force (1)				3			
5.2.7	Polarization Feature Effectiveness (1)					3		
5.2.4	Connector-to-Connector Audible Click (1)			3				
5.2.5	Connector Drop Test (Both Ends)						3	
Notes: (1) Non consumer interface (2) Consumer Interface (3) Sample size for Polarization Effectiveness is determined by the procedure								

Table 6.1.3 Cable Assembly Mechanical Test Sequences