Table 147 - Minimum category 3 through 6A 5 meter cord NEXT loss

Frequency (MHz)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	65.0	65.0	65.0
4.00	64.5	65.0	65.0
8.00	58.6	65.0	65.0
10.00	56.7	64.5	64.5
16.00	52.8	60.5	60.5
20.00	50.9	58.6	58.7
25.00	49.1	56.8	56.8
31.25	47.2	54.9	54.9
62.50	41.6	49.2	49.2
100.00	37.8	45.3	45.4
200.00	-	39.8	39.9
250.00	-	38.1	38.1
300.00	-	-	35.9
400.00	-	-	32.1
500.00	-	-	29.0

Table 148 - Minimum category 3 through 6A 10 meter cord NEXT loss

Frequency (MHz)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	65.0	65.0	65.0
4.00	62.5	65.0	65.0
8.00	56.7	64.8	64.8
10.00	54.9	62.9	63.0
16.00	51.0	59.0	59.1
20.00	49.2	57.2	57.3
25.00	47.4	55.4	55.4
31.25	45.6	53.6	53.6
62.50	40.2	48.1	48.1
100.00	36.7	44.4	44.5
200.00	-	39.3	39.3
250.00	-	37.6	37.7
300.00	-	-	35.8
400.00	-	-	32.5
500.00	-	-	29.8

Table 149 - Minimum category 8
1 meter, 2 meter and 3 meter equipment cord NEXT loss

Frequency (MHz)	1 meter cord NEXT loss (dB)	2 meter cord NEXT loss (dB)	3 meter cord NEXT loss (dB)
1.00	65.0	65.0	65.0
4.00	65.0	65.0	65.0
8.00	65.0	65.0	65.0
10.00	65.0	65.0	65.0
16.00	62.8	62.3	61.8
20.00	60.9	60.4	59.9
25.00	59.0	58.5	58.0
31.25	57.1	56.6	56.2
62.50	51.2	50.7	50.3
100.00	47.2	46.8	46.4
200.00	41.3	41.0	40.8
250.00	39.5	39.2	39.0
300.00	37.3	37.1	37.0
400.00	33.8	33.8	33.8
500.00	31.0	31.1	31.3
600.00	28.1	28.3	28.6
1000.00	19.8	20.3	20.7
1500.00	13.2	13.8	14.4
2000.00	8.6	9.3	9.9

Annex A (normative) - Reliability testing of connecting hardware

A.1 General

Connecting hardware reliability is critical to the overall cabling system operation. Changes in contact resistance due to operational and environmental stress can negatively affect the electrical transmission characteristics and performance of the building telecommunications cabling system. Connecting hardware reliability assurance is an integral part of the requirements for connecting hardware. Reliability testing and qualification is no less important for connecting hardware than the performance parameters specified in clause 6.10. Connecting hardware shall meet the requirements of this annex.

Connecting hardware reliability is the ability to conduct electronic signals without impairment over a long period of time. During this time the device may be exposed to varying environmental conditions, such as temperature, humidity, vibration, and wear. To assess and qualify connecting hardware reliability, accelerated life testing is performed on sample connectors. Accelerated life testing subjects the DUT's to temperature and humidity cycling, extremes of temperature, humidity, voltage and durability, to simulate long term exposure within a shortened test procedure. DUT's are conditioned using a standard sequence of stress variables. Low level dc contact resistance measurement is the primary qualification requirement. Prior to conditioning, the contact resistance of a mated connector is measured. After conditioning, the contact resistance is re-measured and the change in resistance is calculated. Limits are prescribed for initial contact resistance, the difference after conditioning, and the maximum after conditioning. Some environmental conditions, such as vibration testing, require that the contact disturbance is monitored during the conditioning phase. Some qualifications require a visual inspection of the DUT for conformance. In addition to low level dc contact resistance measurements, connecting hardware is qualified by high voltage dielectric withstand testing and by insulation resistance testing.

Connecting hardware often contains a combination of solderless connections and a separable contact interface (jack/plug interface). All connections shall be tested. Each connection that comprises the connecting hardware may be isolated and tested independently or all connections may be tested as an assembly. When tested as an assembly, the total combined change in contact resistance may be used to determine pass and fail criteria in place of isolating individual effects of the various connections. If this method is employed, the test report shall state all test sequences used and which sequences are appropriate for qualification of each contact type. Procedures should be taken to ensure the use of the most stringent test schedule as the test schedules vary by type of connection.

Cable portions used in testing should comply with clauses 29-31 of ASTM D 4566.

Refer to local and national standards and codes for safety considerations.

A.2 Modular plugs and jacks

Modular connecting hardware reliability requirements and procedures for qualification are specified in ISO/IEC 60603-7 Clauses 6 and 7. Modular connecting hardware shall complete satisfactorily all test schedules as stated in Clause 7 of ISO/IEC 60603-7. Shielded and screened connecting hardware shall additionally comply with the requirements of IEC 60603-7-1 clause 6 and complete satisfactorily the test schedules of IEC 60603-7-1 clause 7.

Modular plugs and jacks shall comply with the reliability requirements of the applicable standard specified in Table A.1.

Table A.1 - Standards for modular plugs and jacks

Category and type	Standard
Category 3, unscreened	IEC 60603-7
Category 3, screened	IEC 60603-7-1
Category 5e, unscreened	IEC 60603-7-2
Category 5e, screened	IEC 60603-7-3
Category 6, unscreened	IEC 60603-7-4
Category 6, screened	IEC 60603-7-5
Category 6A, unscreened	IEC 60603-7-41
Category 6A, screened	IEC 60603-7-51
Category 8, screened	IEC 60603-7-81

A typical test schedule for IEC 60603-7 series of standards is outlined in clause A.5.3 of this Standard.

The default criteria and conditions in the relevant standards in Table A.1 apply, except as specified in the remainder of this clause.

The number of mating cycles (insertions and withdrawals) for modular plugs and jacks and the number of conductor re-terminations per solderless connection shall comply with the specifications in Table A.2.

Between terminations, the solderless connection should be inspected for debris and extraneous material should be removed.

Table A.2 - Modular connecting hardware durability matrix

Connecting hardware type	Insertion and withdrawal, and conductor re-termination, operations	Minimum number of operations
Modular plug	Insertion / withdrawal with modular jack	750
	Cable re-terminations	0
Modular jack	Insertion / withdrawal with modular plug	750
	Cable re-terminations	20 [1)]
[1)] Unless not intended for re-termination, in which case this value equals 0.		

Between terminations, the solderless connection should be inspected for debris and extraneous material should be removed.

A.3 Solderless connections

To ensure reliable solderless terminations of balanced twisted pair cable insulated conductors, and to ensure reliable solderless connections between component parts within connecting hardware, solderless connections shall meet the requirements of the applicable standards specified in Table A.3.

The number of conductor re-terminations for solderless connections included in modular connecting hardware shall comply with the specifications in Table A.3.

Table A.3 - Standards for solderless connections

Connection type	Standard
Crimped connection	IEC 60352-2
Accessible IDC	IEC 60352-3
Non-accessible IDC	IEC 60352-4
Press-in connection	IEC 60352-5
IPC	IEC 60352-6
Spring clamp connection	IEC 60352-7
Compression mount connection	IEC 60352-8

A typical test schedule for IEC 60352 series of standards is outlined in clause A.5.2 of this Standard.

The default criteria and conditions in the relevant standards in Table A.3 apply, except as specified in the remainder of this clause.

The maximum initial contact resistance for an insulation displacement connection shall be 2.5 mΩ and the maximum change in contact resistance during and after conditioning shall be 5 mΩ from the initial value.

The following test conditions are specified, as detailed by the type test requirements of IEC 60352 series of standards.

Vibration test severity: 10 to 500 Hz.
Low temperature (LCT): -40 °C (-40 °F).
Electrical load and temperature, test current: 1A dc.

A.4 Other connecting hardware

Other connecting hardware can generally be classified into two categories:

1. Separable connectors incorporating spring contact elements with gold or gold-equivalent finishes.
2. IDC connectors for direct cable termination.

The screen connections of the above connector types shall comply with the requirements of IEC 60603-7-1.

Examples of other connecting hardware include:

1) cross-connect blocks and plugs
2) pin and socket connectors
3) hermaphroditic connectors
4) card-edge connectors

The reliability of connecting hardware, other than modular plugs and jacks shall be demonstrated by complying with the applicable requirements of the standards specified in Table A.4. The connecting hardware shall be terminated, mounted, and operated in accordance with the manufacturer's instructions

for use. A minimum of 100 individual electrical contact paths (e.g. connecting hardware, input to output) shall be tested without failure.

The following tests shall be as per the manufacturer's specification:

a) Examination of dimensions and mass
b) Insertion and withdrawal force requirements
c) Effectiveness of any connector coupling device requirements
d) Gauging and gauging continuity requirements
e) Arrangement for contact resistance test
f) Arrangement for vibration (dynamic stress) test

Table A.4 - Standards for other connecting hardware

Connector type	Standard
Separable male and female (or hermaphroditic)	IEC 60603-7[1]
Separable male and female (or hermaphroditic) screened	IEC 60603-7[1] IEC 60603-7-1[1]
Accessible IDC	IEC 60352-3
Accessible IDC, screened	IEC 60352-3 IEC 60603-7-1
Non-accessible IDC	IEC 60352-4
Non-accessible IDC, screened	IEC 60352-4 IEC 60603-7-1
Spring clamp connection	IEC 60352-7
Spring clamp connection, screened	IEC 60352-7 IEC 60603-7-1

The default criteria and conditions in the relevant standards in Table A.4 apply, unless otherwise specified in this clause.

The number of mating cycles (insertions and withdrawals) for other connecting hardware and the number of conductor re-terminations per solderless connection shall comply with the specifications in Table A.5.

Table A.5 - Other connecting hardware operations matrix

Connecting hardware type	Insertion and withdrawal, and conductor re-termination, operations	Minimum number of operations
Other connecting hardware "plug"	Insertion / withdrawal operations with "jack"	200
	Cable re-termination	0
Other connecting hardware "jack"	Insertion / withdrawal operations with "plug"	200
	Cable re-termination	20 [1)]
	Jumper re-termination	200
[1)] Unless not intended for re-termination, in which case this value equals 0.		

Between terminations, the solderless connection should be inspected for debris and extraneous material should be removed.

A.5 Informative examples of referenced test schedules

A.5.1 General

As an example, the reliability of a modular jack with accessible insulation displacement connections is demonstrated by complying with the applicable requirements of both IEC 60352-3 and IEC 60603-7-4. The test schedules described in IEC 60352-3 and IEC 60603-7-4 at the time of this Standard's publication are outlined in clause A.5.2, as depicted in Figure A.1, and clause A.5.3, as depicted in Figure A.2. It is advisable to refer to the IEC Standards for updates and revisions.

A.5.2 Non-accessible IDC, IEC 60352-3

This full test schedule is used for qualification purposes where accessible insulation displacement connections have not been demonstrated to conform to all of the requirements in section 2 of IEC 60352-3. Where requirements covering workmanship, tools, termination (materials, dimensions, surface finish, design features), wires (materials, dimensions, surface finish, wire insulation) and connection are conformant, a basic (significantly reduced) test schedule is used for qualification purposes.

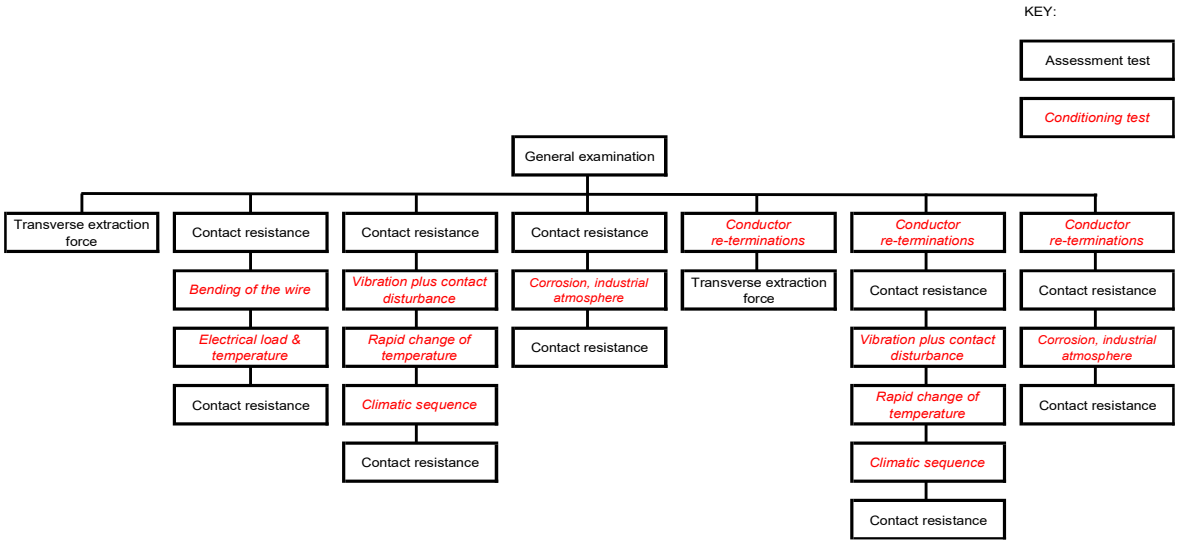

Figure A.1 - Reference test schedule for non-accessible IDC

A.5.3 Modular plug and jack, IEC 60603-7 series

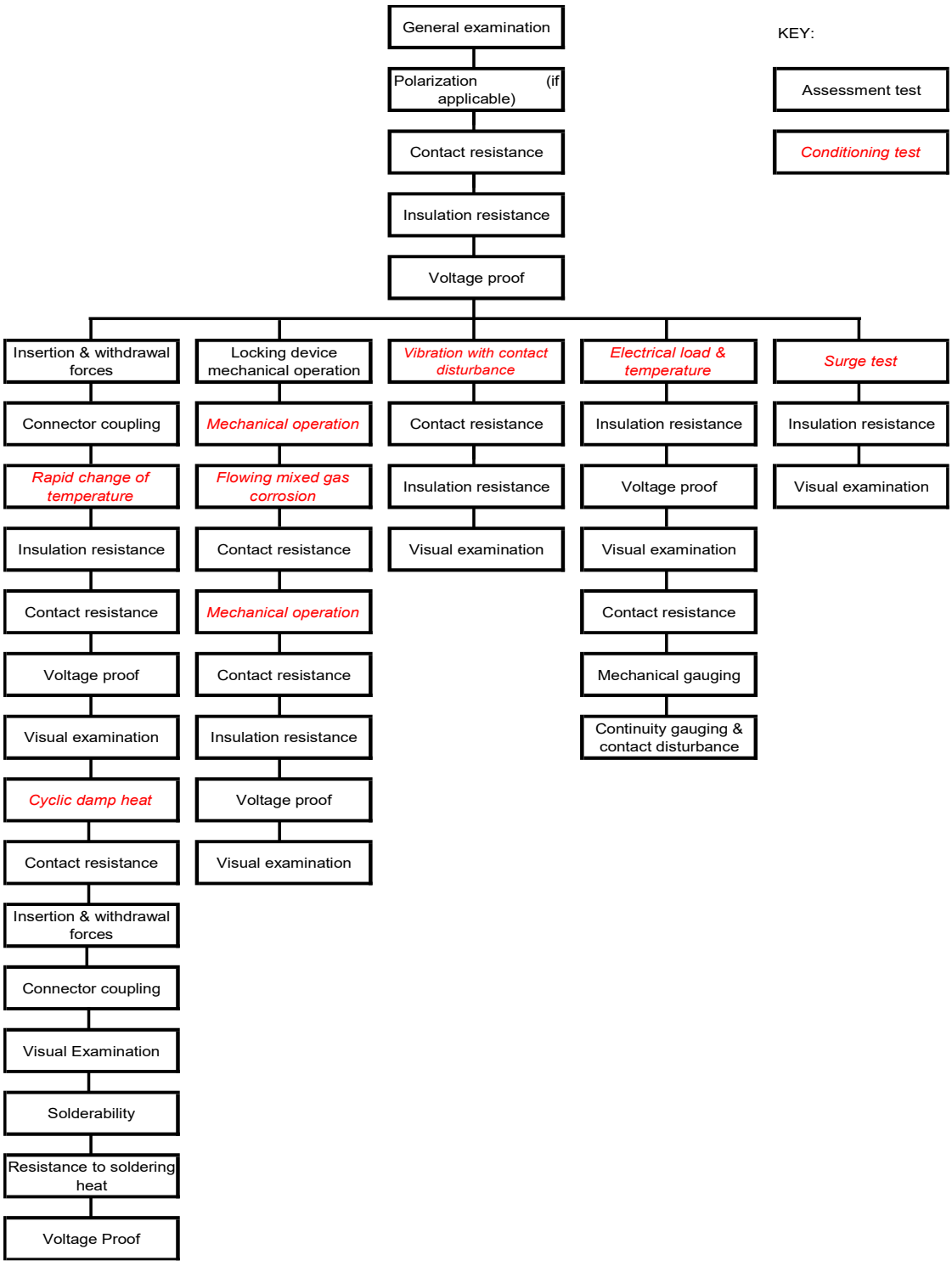

Figure A.2 - Reference test schedule for modular plugs and jacks

Annex B (normative) - Measurement requirements (general)

B.1 General test configuration

This annex describes general measurement requirements for 4-pair 100 Ω components and cabling systems from 1 MHz to the highest referenced frequency using laboratory equipment.
The transmission tests described in this Standard typically require the use of a network analyzer or equivalent, coaxial cables, baluns, UTP test leads, and impedance matching terminations. Network analyzers provide capability to correct for source and load port inaccuracies and measurement errors due to output port gain errors and measurement port sensitivity. In addition, signal leakage from the output port to measurement port can be compensated. Each component of the test setup shall be qualified over the frequency range specified for the category to which the DUT is being evaluated. Equivalent test setups may be used. For the case of balunless measurements, the general requirements for wire termination, test setup, configurations, and performance are detailed in ANSI/TIA-1183-A from 1 MHz to 2000 MHz.

The transmission tests described in this annex may be performed using a network analyzer or equivalent, coaxial cables, baluns, test leads, and impedance matching terminations. Each setup component shall be qualified to a measurement bandwidth of at least 1 MHz to the highest frequency of measurement for each category. Test equipment design, calibration and fixturing should be such as to ensure a measurement floor of 20 dB below the required measurement limit.

This document discusses in detail:

Network analyzer requirements
Test fixture requirements
Impedance matching termination requirements
Calibration artifacts and calibration procedures
Port identification and nomenclature
Other requirements

All of the requirements of this annex apply up to the maximum frequency of the DUT category.

B.2 Termination of a cable DUT to test system

The DUT connection point is to a cable pair. To minimize length of the termination and disturbance of the cable pairs, the cable pair should be connected to the reference plane with less than 5 mm (0.2”) of wire or pair unjacketed or untwisted. Shield terminations including individual pair shield terminations should be within 5 mm (0.2”) of the reference plane. Pair twist and spacing should be maintained to the reference plane as much as possible. Shield terminations should provide a 360 degree contact with the overall cable shield as close to the end of the screen as is possible. Example cable and shield terminations are shown in Figure B.1 and B.2.

B.2.1 Interconnections between the device under test (DUT) and the calibration plane

When testing DUT’s that do not present naturally a cable pair to the test interface, test leads may be constructed to provide that connection.

Twisted-pair test leads, printed circuits or other interconnections may be used between the DUT and the calibration plane. It is necessary to control the characteristics of these interconnections to the best extent possible as they are beyond the calibration plane. These interconnections should be as short as practical and their CM and DM impedances shall be managed to minimize their effects on measurements. The return loss performance of the interconnections shall meet the requirements of clause B.2.1.1. The insertion loss performance of the interconnections is assumed to be less than 0.1 dB over the frequency range from 1 MHz to 500 MHz and less than 0.2 dB for the frequency range from 500 MHz to 2.0 GHz.

When used, twisted-pair test leads shall have 100 Ω nominal characteristic impedance. The twisted-pairs should not exhibit gaps between the conductors insulation. The maximum length of the test leads extending from each end of the device shall be 51 mm (2 in).

Prior to attachment to the DUT, the return loss of each twisted-pair shall be tested. For this test, 100 mm (4 in) lengths of twisted-pair shall be used. The test leads shall be DM terminated across each pair at the far end with a precision 0.1% 0603 or similar chip resistor as described in clause B.6.1. The resistor shall be attached directly to the conductors of the pair in such a way as to minimize the disturbance of the twisted-pair. Potential disturbances include gaps between the conductor insulation in the twisted-pair, melted insulation, and excess solder. When tested, the test lead shall be attached to the balun or DM test port using the same fixtures as when testing the device. The test leads are then trimmed for attachment to the DUT and the test fixtures. See Annex H for an example of an appropriate test fixture. It is recommended to use the same load for both calibration and termination of the test lead during measurement.

B.2.1.1 Test lead return loss requirements

For connecting hardware return loss measurements, the interconnection shall meet the requirements in B.2.1 relative to the specified calibration resistor termination. These requirements apply up to the maximum frequency of the category of the DUT.

Table B.1 - Interconnection return loss

Frequency (MHz)	Return loss (dB)
$1 \le f < 80$ $80 \le f \le 2000$	40 dB 38 – 20log(f/100) dB

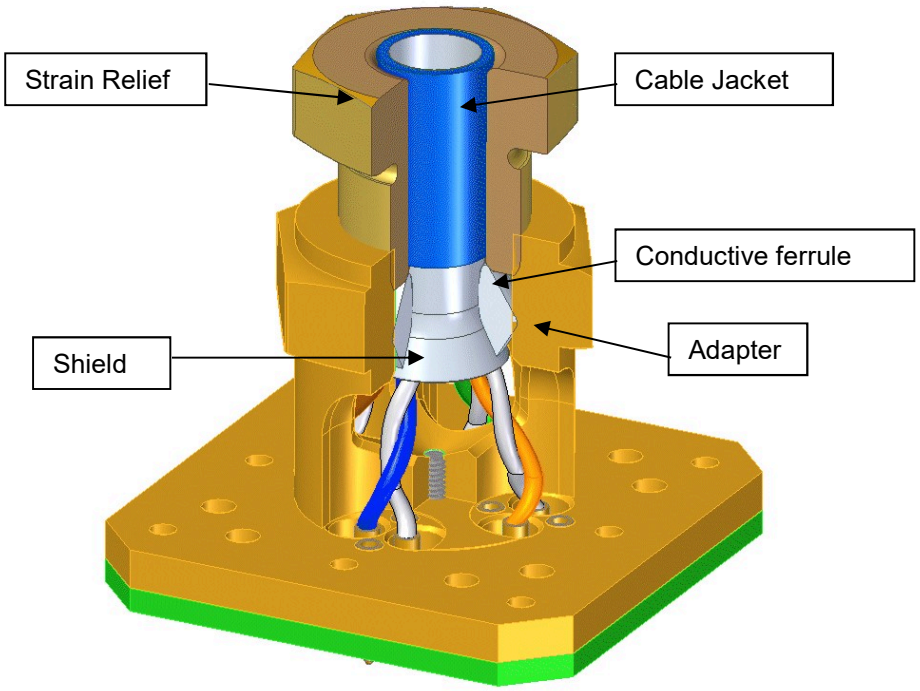

Figure B.1 - Example 360 degree shielded cable termination

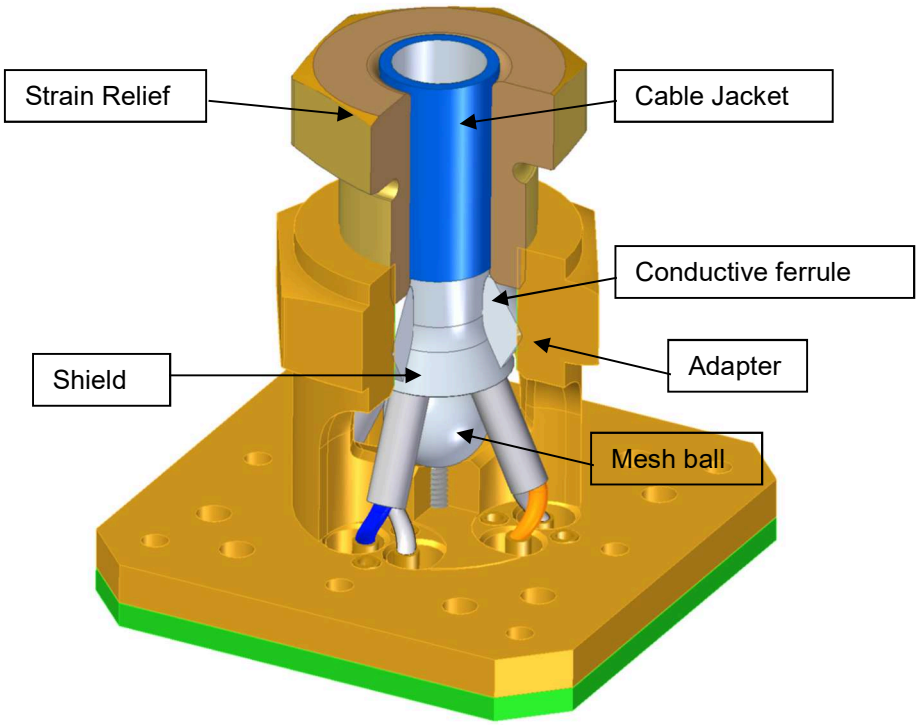

Figure B.2 - Example individually shielded pair cable termination

For ease of interfacing to test fixtures, the balun or balunless test interface should present a pin and socket interface with dimensions as shown in Figure B.3. Sockets should be gold plated contact material and should be compatible with an example socket as shown in Figure B.4.

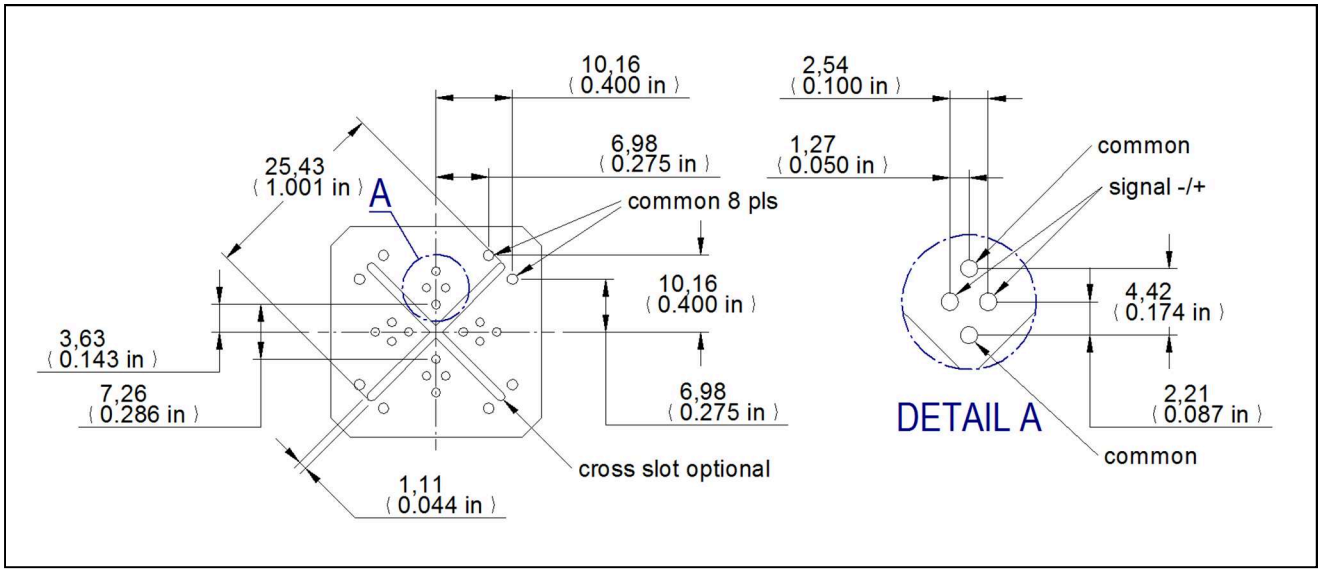

Figure B.3 - Example test fixture interface pattern