6.8.14 TCL

Connecting hardware TCL shall meet or exceed the values determined using the equations shown in Table 103 for all specified frequencies. Calculations that result in category 6 and 6A connecting hardware TCL values greater than 40 dB shall revert to a requirement of 40 dB minimum.

Table 103 - Connecting hardware TCL

	Frequency (MHz)	TCL (dB)
Category 3	$1 \le f \le 16$	n/s
Category 5e	$1 \le f \le 100$	n/s
Category 6	$1 \le f \le 250$	$28 - 20\log(f/100)$
Category 6A	$1 \le f \le 500$	$28 - 20\log(f/100)$

The connecting hardware TCL values in Table 104 are provided for information only.

Table 104 - Minimum connecting hardware TCL

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	n/s	n/s	40.0	40.0
4.00	n/s	n/s	40.0	40.0
8.00	n/s	n/s	40.0	40.0
10.00	n/s	n/s	40.0	40.0
16.00	n/s	n/s	40.0	40.0
20.00	-	n/s	40.0	40.0
25.00	-	n/s	40.0	40.0
31.25	-	n/s	38.1	38.1
62.50	-	n/s	32.1	32.1
100.00	-	n/s	28.0	28.0
200.00	-	-	22.0	22.0
250.00	-	-	20.0	20.0
300.00	-	-	-	18.5
400.00	-	-	-	16.0
500.00	-	-	-	14.0

6.8.15 TCTL

TCTL shall be measured for all connecting hardware pairs. Connecting hardware TCTL shall be measured in accordance with clause C.4.8 for all frequencies from 1 MHz up to the maximum frequency specified for the category of the connecting hardware under test.

Connecting hardware TCTL shall meet or exceed the values determined using the equations shown in Table 105 for all specified frequencies. Calculations that result in category 6 and 6A connecting hardware TCTL values greater than 40 dB shall revert to a requirement of 40 dB minimum.

Table 105 - Connecting hardware TCTL

	Frequency (MHz)	TCL (dB)
Category 3	$1 \le f \le 16$	n/s
Category 5e	$1 \le f \le 100$	n/s
Category 6	$1 \le f \le 250$	$28 - 20\log(f/100)$
Category 6A	$1 \le f \le 500$	$28 - 20\log(f/100)$

The connecting hardware TCTL values in Table 106 are provided for information only.

Table 106 - Minimum connecting hardware TCTL

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	n/s	n/s	40.0	40.0
4.00	n/s	n/s	40.0	40.0
8.00	n/s	n/s	40.0	40.0
10.00	n/s	n/s	40.0	40.0
16.00	n/s	n/s	40.0	40.0
20.00	-	n/s	40.0	40.0
25.00	-	n/s	40.0	40.0
31.25	-	n/s	38.1	38.1
62.50	-	n/s	32.1	32.1
100.00	-	n/s	28.0	28.0
200.00	-	n/s	22.0	22.0
250.00	-	-	20.0	20.0
300.00	-	-	-	18.5
400.00	-	-	-	16.0
500.00	-	-	-	14.0

6.8.16 ELTCTL

ELTCTL is not specified for connecting hardware.

6.8.17 Coupling attenuation (screened only)

Coupling attenuation for connecting hardware is under study.

6.8.18 Propagation delay

For all categories of connecting hardware, the propagation delay contribution of each installed mated connection is assumed to not exceed 2.5 ns from 1 MHz to the highest referenced frequency.

6.8.19 Propagation delay skew

For all categories of connecting hardware, the propagation delay skew of each installed mated connection is assumed to not exceed 1.25 ns from 1 MHz to the highest referenced frequency.

6.8.20 Shield transfer impedance (screened only)

The shield transfer impedance of screened connecting hardware, measured in accordance with Annex D shall not exceed the values determined using equations (26) and (27).

$Z_{Tconn} = 40\sqrt{f}$ from 1 MHz to 4 MHz (26)

$Z_{Tconn} = 20f$ from 4 MHz to 100 MHz (27)

Where:

Z_{Tconn} is the transfer impedance of the connecting hardware shield in mΩ

f is the frequency in MHz.

The values in Table 107 are derived from equations (26) and (27) and are provided for information only.

Table 107 - Maximum connecting hardware shield transfer impedance

Frequency (MHz)	Category 3 (mΩ)	Category 5e (mΩ)	Category 6 (mΩ)	Category 6A (mΩ)
1.00	n/s	40	40	40
4.00	n/s	80	80	80
8.00	n/s	160	160	160
10.00	n/s	200	200	200
16.00	n/s	320	320	320
20.00	-	400	400	400
25.00	-	500	500	500
30.00	-	600	600	600
31.25	-	625	625	625
62.50	-	1,250	1,250	1,250
100.00	-	2,000	2,000	2,000

NOTE - The maximum possible transfer impedance slope is 20 dB/decade and is evident when magnetic field coupling is the dominant coupling mode. A slope less than this value indicates a mixture of coupling modes. A slope of 10 dB/decade is characteristic at low frequencies when contact resistance at metallic contact points is the dominant coupling mode.

Compliant transfer impedance performance of cables and connecting hardware is not sufficient to ensure proper link and channel transfer impedance. Cable shields shall be terminated to the connecting hardware shields following manufacturer's instructions. The termination methods are dependent on the

shield design of both the cable and the connecting hardware. Connecting hardware shall be supplied with instructions on applicable cable shield termination procedures.

6.8.21 ANEXT loss

ANEXT loss is not specified for connecting hardware.

6.8.22 PSANEXT loss

Connecting hardware PSANEXT loss shall meet or exceed the values determined using the equations shown in Table 108 for all specified frequencies. Calculations that result in PSANEXT loss values greater than 67 dB shall revert to a requirement of 67 dB minimum.

Table 108 – Connecting hardware PSANEXT loss

	Frequency (MHz)	PSANEXT loss (dB)
Category 3	$1 \le f \le 16$	n/s
Category 5e	$1 \le f \le 100$	n/s
Category 6	$1 \le f \le 250$	n/s
Category 6A	$1 \le f \le 500$	$70.5 - 20\log(f/100)$

The connecting hardware PSANEXT loss values in Table 109 are provided for information only.

Table 109 - Minimum connecting hardware PSANEXT loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	n/s	n/s	n/s	67.0
4.00	n/s	n/s	n/s	67.0
8.00	n/s	n/s	n/s	67.0
10.00	n/s	n/s	n/s	67.0
16.00	n/s	n/s	n/s	67.0
20.00	-	n/s	n/s	67.0
25.00	-	n/s	n/s	67.0
31.25	-	n/s	n/s	67.0
62.50	-	n/s	n/s	67.0
100.00	-	n/s	n/s	67.0
200.00	-	-	n/s	64.5
250.00	-	-	n/s	62.5
300.00	-	-	-	61.0
400.00	-	-	-	58.5
500.00	-	-	-	56.5

6.8.23 Average PSANEXT loss

Average PSANEXT loss is not specified for connecting hardware.

6.8.24 AFEXT loss

AFEXT loss is not specified for connecting hardware.

6.8.25 PSAFEXT loss

Connecting hardware PSAFEXT loss shall meet or exceed the values determined using the equations shown in Table 110 for all specified frequencies. Calculations that result in PSANEXT loss values greater than 67 dB shall revert to a requirement of 67 dB minimum.

Table 110 – Connecting hardware PSAFEXT loss

	Frequency (MHz)	PSANEXT loss (dB)
Category 3	$1 \le f \le 16$	n/s
Category 5e	$1 \le f \le 100$	n/s
Category 6	$1 \le f \le 250$	n/s
Category 6A	$1 \le f \le 500$	$67 - 20\log(f/100)$

The connecting hardware PSAFEXT loss values in Table 111 are provided for information only.

Table 111 - Minimum connecting hardware PSAFEXT loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	n/s	n/s	n/s	67.0
4.00	n/s	n/s	n/s	67.0
8.00	n/s	n/s	n/s	67.0
10.00	n/s	n/s	n/s	67.0
16.00	n/s	n/s	n/s	67.0
20.00	-	n/s	n/s	67.0
25.00	-	n/s	n/s	67.0
31.25	-	n/s	n/s	67.0
62.50	-	n/s	n/s	67.0
100.00	-	n/s	n/s	67.0
200.00	-	-	n/s	61.0
250.00	-	-	n/s	59.0
300.00	-	-	-	57.5
400.00	-	-	-	52.0
500.00	-	-	-	53.0

6.8.26 PSAACRF

PSAACRF is not specified for connecting hardware.

6.8.27 Average PSAACRF

Average PSAACRF is not specified for connecting hardware.

6.9 Cords and jumpers transmission performance

Modular plugs and other connectors used for 100 Ω twisted-pair cable assemblies shall meet the requirements specified in clause 6.8. Cables used to construct work area, equipment, and patch cords shall meet the transmission performance requirements for cord cable specified in clause 6.6.

6.9.1 Return loss

Return loss shall be measured for all work area, equipment, and patch cord pairs. Work area, equipment, and patch cord return loss shall be measured in accordance with clause C.5.3 for all frequencies from 1 MHz up to the maximum frequency specified for the category of the cable under test.

Work area, equipment, and patch cord return loss shall meet or exceed the values determined using the equations shown in Table 112 for all specified frequencies.

Table 112 - Work area, equipment, and patch cord return loss

	Frequency (MHz)	Return loss (dB)
Category 3	$1 \le f \le 16$	n/s
Category 5e	$1 \le f < 25$ $25 \le f \le 100$	$24 + 3\log(f/25)$ $24 - 10\log(f/25)$
Category 6	$1 \le f < 25$ $25 \le f \le 250$	$24 + 3\log(f/25)$ $24 - 10\log(f/25)$
Category 6A	$1 \le f < 25$ $25 \le f \le 250$ $250 < f \le 500$	$24 + 3\log(f/25)$ $24 - 10\log(f/25)$ $14 - 15\log(f/250)$

The work area, equipment, and patch cord return loss values in Table 113 are provided for information only.

Table 113 - Minimum work area, equipment, and patch cord return loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	n/s	19.8	19.8	19.8
4.00	n/s	21.6	21.6	21.6
8.00	n/s	22.5	22.5	22.5
10.00	n/s	22.8	22.8	22.8
16.00	n/s	23.4	23.4	23.4
20.00	-	23.7	23.7	23.7
25.00	-	24.0	24.0	24.0
31.25	-	23.0	23.0	23.0
62.50	-	20.0	20.0	20.0
100.00	-	18.0	18.0	18.0
200.00	-	-	15.0	15.0
250.00	-	-	14.0	14.0
300.00	-	-	-	12.8
400.00	-	-	-	10.9
500.00	-	-	-	9.5

6.9.2 NEXT loss

NEXT loss shall be measured for all work area, equipment, and patch cord pair combinations. Work area, equipment, and patch cord NEXT loss shall be measured in accordance with clause C.5 for all frequencies from 1 MHz up to the maximum frequency specified for the category of the cable under test.

For all frequencies from 1 MHz to the upper limit of each category, work area, equipment, and patch cord NEXT loss shall meet the values determined using equation (28). Calculations that result in NEXT loss values greater than 65 dB shall revert to a requirement of 65 dB minimum.

$$NEXT_{cord} \geq -10\log\left(10^{\frac{-NEXT_{connectors}}{10}} + 10^{\frac{-\left(NEXT_{cord\_cable} + 2\cdot IL_{conn}\right)}{10}}\right) - RFEXT \quad (28)$$

where:

$$NEXT_{connectors} = -20\log\left(10^{\frac{-NEXT_{conn\_spec}}{20}} + 10^{\frac{-\left(NEXT_{conn\_spec} + 2\left(IL_{cord\_cable} + IL_{conn}\right)\right)}{20}}\right) \quad (29)$$

$$IL_{cord\_cable} = IL_{cord\_cable,100m} \cdot \frac{CableLength}{100} \quad (30)$$

$$NEXT_{cord\_cable} = NEXT_{hor\_cable} - 10\log\left(1 - e^{-0.46\cdot IL_{cord\_cable}}\right) \quad (31)$$

$NEXT_{conn\_spec}$ is the NEXT loss assigned to the local and remote test jacks. The value for category 6 and category 6A test heads is specified in Table 97. The value for category 5e test heads is 47-20log (*f*/100) dB.

$IL_{cord\_cable,100m}$ is the insertion loss of 100 meters of cord cable as specified in Table 81

$NEXT_{cord\_cable}$ is the cable NEXT loss computed from the NEXT loss requirements for 100 meters of horizontal cable, the insertion loss requirements for 100 meters of cord cable, and the length correction formula in ASTM D 4566.

$NEXT_{hor\_cable}$ is the NEXT loss of horizontal cable as specified in Table 58

$CableLength$ is the length of the cable in the cord in meters

IL_{conn} is the insertion loss of one connector as specified in Table 95

$RFEXT$ is the reflected signal cross talk. For category 5e cords RFEXT = 0 dB, and for category 6 and 6A cords RFEXT = 0.5 dB.

NOTE - All variables are expressed in dB, except “CableLength”, which is expressed in meters.

The work area, equipment, and patch cord NEXT loss values in Table 114, Table 115, and Table 116 are calculated from equation (28) and are provided for information only.

Table 114 - Minimum 2 meter work area, equipment, and patch cord NEXT loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	n/s	65.0	65.0	65.0
4.00	n/s	65.0	65.0	65.0
8.00	n/s	60.6	65.0	65.0
10.00	n/s	58.7	65.0	65.0
16.00	n/s	54.7	62.0	62.0
20.00	-	52.8	60.1	60.1
25.00	-	50.9	58.1	58.2
31.25	-	49.0	56.2	56.3
62.50	-	43.2	50.4	50.4
100.00	-	39.3	46.4	46.4
200.00	-	-	40.6	40.7
250.00	-	-	38.8	38.9
300.00	-	-	-	36.2
400.00	-	-	-	31.9
500.00	-	-	-	28.4

Table 115 - Minimum 5 meter work area, equipment, and patch cord NEXT loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	n/s	65.0	65.0	65.0
4.00	n/s	64.5	65.0	65.0
8.00	n/s	58.6	65.0	65.0
10.00	n/s	56.7	64.5	64.5
16.00	n/s	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 116 - Minimum 10 meter work area, equipment, and patch cord NEXT loss

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)	Category 6 (dB)	Category 6A (dB)
1.00	n/s	65.0	65.0	65.0
4.00	n/s	62.5	65.0	65.0
8.00	n/s	56.7	64.8	64.8
10.00	n/s	54.9	62.9	63.0
16.00	n/s	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

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 testing shall be accomplished by subjecting the connecting hardware to various mechanical and environmental conditions, measuring parameters such as changes in contact resistance during and after individual test sequences.

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, care 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 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.1.

Table A.1 – 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.1 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.3 Modular plugs and jacks

Modular plugs and jacks shall comply with the reliability requirements of the applicable standard specified in Table A.2.

Table A.2 – 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

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.2 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.3.

Table A.3 – Modular plugs and jacks operations 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-termination	0
Modular jack	Insertion / withdrawal with modular plug	750
	Cable re-termination	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.