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Voice and Voiceband Data IntraLATA Special Channels Transmission Test Requirements and Limits

Prepared by the Network Performance and Transmission Engineering Department under Project 422241, Digital Network Transition Engineering - Transmission, part of the End-to-End Transmission, Synchronization and Performance Product.

For further information, please contact:

Director, Transmission Technical Specifications
(201) 829-2483

To obtain copies of this document, Regional Company/BCC personnel should contact their company's document coordinator; Bellcore personnel should call (908)699-5802.

Voice and Voiceband Data IntraLATA Special Channels
Transmission Test Requirements and Limits

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1. Introduction

1.1 Purpose

This Bellcore Practice specifies transmission test requirements and transmission performance parameter limits for intraLATA special voiceband channels that are used for end-to-end applications. It is a technical practice, intended for use as a reference by communications technicians in the provisioning and maintenance of these channels. The specified transmission test requirements and limits are based upon engineering recommendations and the capabilities of current intraLATA special channels.

1.2 Reason for Reissue

The addition of modern digital components and facilities to the telecommunications plant, and the circuit architectures designed to accommodate the new technology, logically lead to a simplified consolidation of the special channels specified in previous issues of this practice. The practice is reissued to accomplish the consolidation and to more nearly reflect the configuration of services provided by exchange carriers to their customers. Issue 6 is a complete revision and includes expanded information concerning transmission testing and impairments.

1.3 Scope

The test requirements and limits specified herein are applicable:

(1) between two end users' network interfaces (NI-NI),

(2) between an end user's network interface and an exchange carrier (EC) central office switch (NI-SW), or

(3) between two exchange carrier central office switches (SW-SW).

Both two-point and multipoint channels are included in these specifications. It is stressed that the requirements and limits apply to only the channel identified by the endpoints specified above and not to other segments or elements of the circuit.

Some ECs use Network Channel (NC) and Network Channel Interface (NCI) codes to identify the characteristics of the channel and the network interfaces, and to provision intraLATA services. NC/NCI codes are not used in this document, but Bellcore Technical References TR-TSY-000335[1] and TR-NWT-000965[2] provide descriptions and details of appropriate interface combinations. Additional information concerning NC/NCI codes can be found in BR 795-403-100.[3]

2. Channel Options - Technical Considerations

This section identifies various channel options and discusses signal-level considerations that must be taken into account to avoid degraded quality resulting from signal distortion.

2.1 Facility Options

Voice grade channels can be provided on either effective 2-wire channels, effective 4-wire channels or 4-wire channels.

An effective 2-wire channel contains at least one 2-wire segment and has a 2-wire interface at the NI. The channel may contain some 4-wire segments.

An effective 4-wire channel consists entirely of 4-wire facilities and has a 2-wire interface at the NI.

A 4-wire channel consists entirely of 4-wire facilities and has a 4-wire interface at the NI.

When the specified transmission performance of an effective 2-wire channel is different from that of an effective 4-wire channel, these differences are noted in the performance limit tables in Section 4.

2.2 Transmission Performance Options

Various conditioning options are available to improve the performance of channels used for data transmission. C-conditioning provides improved limits for attenuation distortion and envelope delay distortion, while D-conditioning tightens the limits for signal-to-C-Notched-noise ratio and signal-to-intermodulation-distortion ratio. This practice supports conditioning options C1, C2, C4, C5 and D for private-line data circuits and C3 for switched services networks.

2.3 Signal-Level Considerations

Signal-level power on a channel must be constrained to a range that approximates the average telephone voice power that traverses the telecommunications network. This is necessary to avoid overloading carrier systems or overdriving metallic loops which results in signal distortion, noise and crosstalk.

When measuring various transmission parameters, it is sometimes necessary to describe the power present at a particular point in a circuit as compared to the power present at other points in the same circuit. The power present at any point in a circuit is dependent upon the power at the source and the loss or gain between the source and that point. Since this information is not always available, it is convenient to describe the power present at the point by comparing it to the power at a standard reference point. In this document, the reference point for measuring power is called the Zero

Transmission Level Point (0-TLP).

Using the TLP concept, the power present at a point in a circuit is described by stating what this power would be if it were measured at the 0-TLP. The units used to specify the power in this case are dBm0. For example, the term "– 13 dBm0" signifies that – 13 dBm was measured at the 0-TLP. Using Figure 1 for illustration, if the power measured at some point in the circuit is corrected to account for the gains or losses between the point and the 0-TLP, that power at the 0-TLP would measure – 13 dBm.

Considering compatible voice and signal power levels described above and relating these levels to the TLP concept, voice and signal levels should be kept at least 13 dB below TLP.*

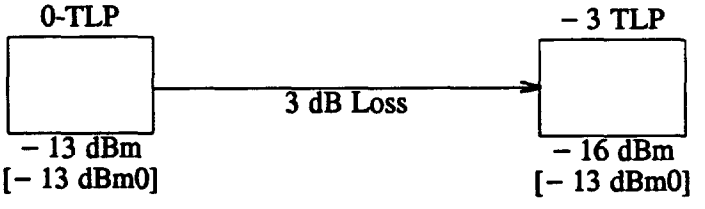

Figure 1. Transmission Level Point Concept

* Test tones of short duration, used for adjusting circuit equipment and localizing reported trouble, are commonly applied at TLP on voice circuits and at 13 dB below TLP on data circuits.

3. Transmission Testing Information

3.1 General

Transmission tests are performed to ensure that high-quality service is provided to customers when channels are established and to ensure that an in-service channel continues to operate to the customer's expectation. Additional transmission tests are performed to isolate trouble when an abnormality causes an in-service channel to fail. This section provides information concerning transmission testing applicable to intraLATA special channels.

3.2 Transmission Test Requirements - Application

The transmission test requirements and transmission performance parameter limits specified in this practice are determined by the performance requirements of the channel. Each channel is identified by a COMMON LANGUAGE® CLCI™ service code and modifier. Historically, similar types of voice grade channels were grouped and assigned a two-letter transmission grade designation. As indicated in Section 1.2, this issue has accomplished a simplified consolidation or grouping of the special channels specified in this practice. For ease of transition to the new groupings, Table 1 provides the historical association of transmission grade designations with the various channel categories and Table 2 provides a cross-reference of transmission grades to applicable COMMON LANGUAGE CLCI service codes and modifiers. Table 3 extends this cross-reference by indicating the service code, modifier and transmission grade application to the network architectures (i.e., NI-SW, SW-SW or NI-NI) specified in this practice. Additional information concerning service codes and modifiers can be found in BR 795-402-100[4] and the associated job aids, JA-ISD-000025[5] and JA-STS-000042.[6]

The channels to which this practice applies are designed to pass signals in the voice frequency band of 300 to 3000 Hz. The signals may be voice, voiceband data or both, as determined by the customer. Transmission test requirements and performance limits for data applications are more stringent than those for voice applications. On channels used for both voice and data signals, the more stringent requirements and limits apply.

COMMON LANGUAGE is a registered trademark and CLCI is a trademark of Bellcore.

Table 1. Transmission Grades and Associated Channel Categories

Transmission Grade	Channel Category
DA	Data or Voice/Data Channel 2-Point Voiceband Data Multipoint Voiceband Data AIOD Link
DB	Voice and Data Public Switched Network (PSN) Access Foreign Exchange Line PBX/Centrex/ACD Foreign Exchange Trunk
DC	Voice and Data Switched Service Network (SSN) Access CCSA DCTN Access Line CCSA DCTN Directly-Homed Station Line
DD	Voice and Data SSN Intermachine Trunk CCSA Intermachine Trunk Tie Trunk Long Distance Trunk ACD Overflow Trunk
DE	Voice and Data Tie Trunk Tie Trunks
DG	WATS Service
DJ	Public Switched Network Line Local Loop Data Jack
DL	Protective Relaying Channel
TA	Telephoto

(Continued)

Table 1. Transmission Grades and Associated Channel Categories (continued)

Transmission Grade	Channel Category
VA	Voice Non-switched Line 2-Point Voice Channel Multipoint Voice Channel Remote Metering Dial Dictation Line Wired Music Line (Unequalized) Paging Line Radio Land Line FAA Voice-Only Channel
VB	Voice-Switched Line Centrex Line Off-Premises Extension Line Secretarial Line Long Distance Line
VC	Voice-Switched Trunk PBX/Centrex/ACD Foreign Exchange Trunk CCSA DCTN Access Line CCSA DCTN Directly-Homed Station Line CCSA Intermachine Trunk Cellular Access Trunk

Table 2. CLCI Service Code/Transmission Grade Cross-reference

CLCI Service Code (Char 3 & 4)	Service Code Modifier (Char 5)		Service Description	Transmission Grade
	Data (A,B,D,E)	Voice (N,L)		
AA		X	Packet Analog Access Line	VB
AB	X		Packet Network Trunk	DB
AD		X	Attendant Line	VC
	X		Attendant Line	DB
AI	X		AIOD line	DA
AL	X	X	Alternate Services	VB
AM	X		Packet Off-Network Access Line	DA
AN		X	Announcement Service	VB
AU		X	Autoscript	VA
CA,CE		X	SSN Station and Access Lines	VC
	X		SSN Station and Access Lines	DC
CI		X	Concentrator Identifier Trunk	VC
CL		X	Centrex Line	VB
CN		X	SSN Network Trunk	VC
	X		SSN Network Trunk	DD
CP	X	X	Concentrator Identifier Signaling Link	DB
CT		X	SSN Tie Trunk	VC
	X		SSN Tie Trunk	DE
DI,DO		X	Direct In/Out Dial Trunk	VC
	X		Direct In/Out Dial Trunk	DB
DL		X	Dictation Line	VA
EL		X	Emergency Reporting Line	VA
EM		X	Emergency Reporting Trunk	VB
EV		X	Enhanced Emergency Reporting Trunk	VC

(continued)

Table 2. CLCI Service Code/Transmission Grade Cross-reference (continued)

CLCI Service Code (Char 3 & 4)	Service Code Modifier (Char 5)		Service Description	Transmission Grade
	Data (A,B,D,E)	Voice (N,L)		
FD	X		2-Point or Multipoint Data	DA
FT		X	Foreign Exchange Trunk	VC
	X		Foreign Exchange Trunk	DB
FX		X	Foreign Exchange Line	VB
	X		Foreign Exchange Line	DB
IT,TA,TL		X	Tie Trunks	VC
	X		Tie Trunks	DE
LL		X	Long Distance Terminal Line	VB
LT		X	Long Distance Terminal Trunk	VC
MA		X	Cellular Access Trunk	VC
MT		X	Wired Music (Unequalized)	VA
ND	X		Network Data Line (Data Jack)	DJ
OC,OS		X	Centrex/PBX Off-Premises Station	VB
	X		Centrex/PBX Off-Premises Station	DB
OI		X	Off-Premises Intercom Line	VA
ON		X	SSN Off-Network Access Line	VC
OP		X	Off-Premises Extension	VB
PA,PM		X	Protective Alarm or Monitoring	VA
	X		Protective Alarm or Monitoring	DA
PG		X	Paging	VA
PL		X	2-Point or Multipoint Voice	VA
PR	X		Protective Relaying	DL
RA		X	Remote Attendant Line	VC
	X		Remote Attendant Line	DB

(continued)

Table 2. CLCI Service Code/Transmission Grade Cross-reference (continued)

CLCI Service Code (Char 3 & 4)	Service Code Modifier (Char 5)		Service Description	Transmission Grade
	Data (A,B,D,E)	Voice (N,L)		
RT		X	Radio Land-line	VA
SA		X	Satellite Tie Trunk	VC
	X		Satellite Tie Trunk	DE
SL		X	Secretarial Line	VB
SS	X		DATAPHONE® Select-a-Station	DA
TF	X		Telephoto and Facsimile	TA
TK		X	Local PBX Trunk	VC
	X		Local PBX Trunk	DB
TR		X	ACD Trunk	VC
TU		X	ACD Line	VB
UC		X	Voice Line	VA
	X		Voice Line	DB
UD		X	Voice Trunk	VC
	X		Voice Trunk	DD
UG	X		Analog Data	DA
VM		X	Remote Metering	VA
	X		Remote Metering	DA
WO,WX,WZ		X	WATS/800 Service Lines	VB
	X		WATS/800 Service Lines	DG
WI,WS,WY		X	WATS/800 Service Trunks	VC
	X		WATS/800 Service Trunks	DG

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Table 3. Channel Application/Network Architecture Cross-reference

CLCI Service Code (Char 3 & 4)	Service Code Modifier (Char 5)		Transmission Grade	Application		
	Data (A,B,D,E)	Voice (N,L)		NI to SW	SW to SW	NI to NI
AA		X	VB	X		
AB	X		DB		X	
AD		X	VC	X		
	X		DB	X		
AI	X		DA	X		
AL	X	X	VB	X		X
AM	X		DA	X		X
AN		X	VB	X	X	
AU		X	VA			X
CA		X	VC	X	X	
	X		DC	X	X	
CE		X	VC	X		
	X		DC	X		
CI		X	VC	X	X	
CL		X	VB	X		
CN		X	VC		X	
	X		DD		X	
CP	X	X	DB	X	X	
CT		X	VC	X		X
	X		DE	X		X
DI,DO		X	VC	X	X	
	X		DB	X	X	
DL		X	VA	X		X
EL		X	VA			X

(continued)

Table 3. Channel Application/Network Architecture Cross-reference (continued)

CLCI Service Code (Char 3 & 4)	Service Code Modifier (Char 5)		Transmission Grade	Application		
	Data (A,B,D,E)	Voice (N,L)		NI to SW	SW to SW	NI to NI
EM		X	VB	X		
EV		X	VC	X	X	
FD	X		DA			X
FT		X	VC	X	X	
	X		DB	X	X	
FX		X	VB	X		
	X		DB	X		
IT,TA,TL		X	VC	X	X	X
	X		DE	X	X	X
LL		X	VB	X		
LT		X	VC	X		
MA		X	VC	X		
MT		X	VA			X
ND	X		DJ	X		
OC,OS		X	VB			X
	X		DB			X
OI		X	VA	X		X
ON		X	VC		X	
OP		X	VB	X		
PA,PM		X	VA			X
	X		DA			X
PG		X	VA	X		X
PL		X	VA			X
PR	X		DL			X

(continued)

Table 3. Channel Application/Network Architecture Cross-reference (continued)

CLCI Service Code (Char 3 & 4)	Service Code Modifier (Char 5)		Transmission Grade	Application		
	Data (A,B,D,E)	Voice (N,L)		NI to SW	SW to SW	NI to NI
RA		X	VC			X
	X		DB			X
RT		X	VA			X
SA		X	VC	X		X
	X		DE	X		X
SL		X	VB	X		
SS	X		DA			X
TF	X		TA			X
TK		X	VC	X		
	X		DB	X		
TR		X	VC	X		X
TU		X	VB	X		X
UC		X	VA			X
	X		DB			X
UD		X	VC	X	X	X
	X		DD	X	X	X
UG	X		DA			X
VM		X	VA			X
	X		DA			X
WO,WX,WZ		X	VB	X		
	X		DG	X		
WI,WS,WY		X	VC		X	
	X		DG		X	

3.3 Transmission Performance Limits

When transmission tests are conducted, the test results should, as a minimum, meet the level of performance specified for each particular test. These levels of performance are designated the maintenance limit (ML) and immediate action limit (IAL).

3.3.1 Maintenance Limit (ML)

The maintenance limit is chosen to be close to the design objective to ensure that channels which meet the limit provide acceptable service for the customer. When the maintenance limit is exceeded on an in-service circuit, it is possible that a channel element is not performing properly. This is an indication that the channel should be monitored to determine if the condition is worsening or if the exceeded limit resulted from an inaccurate measurement. If acceptance tests are conducted when the circuit is put into service, the ML can be used as an acceptance limit. Additionally, the ML can be used as the preservice limit when provisioning the channel.

3.3.2 Immediate Action Limit (IAL)

The immediate action limit is the level of performance specified in tariffs and, therefore, the level of performance guaranteed to the customer. It defines the threshold beyond which the channel is considered to be providing unacceptable service. Accordingly, if the IAL is exceeded, the channel must be repaired. After repair, the channel performance should meet the specified maintenance limits (ML)*.

3.4 Categories of Transmission Tests

3.4.1 Preservice Tests

Preservice transmission tests are performed prior to placing a newly established or rearranged channel in service. These tests are intended to identify the need for repair or adjustments to transmission facilities or equipment so that the channel design objectives and tariff performance limits are met when placed in service. To ensure satisfactory transmission performance, the channel should meet the appropriate specified maintenance limits during preservice testing unless more stringent preservice limits have been set by the EC.

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* Multipoint services must be restored to maintenance limit requirements on a per segment basis (two-point) to ensure that the overall channel meets the specified immediate action limits.

3.4.2 Routine Tests

Routine transmission tests are performed by some ECs to identify transmission impairments so that the condition can be corrected before a customer complaint results. The decision to perform routine testing, the parameters tested, and the method and frequency of testing are determined by the EC.

3.4.3 Trouble Tests

After a channel has been established, trouble tests are conducted when the channel has been reported to be performing unsatisfactorily. A trouble may be reported by the customer or detected by EC personnel. If trouble testing reveals that the IAL is exceeded, and the trouble is sectionalized to the network side of the NI, corrective action must be taken. When the channel is returned to service, it must meet the specified maintenance limits*.

3.5 Transmission Parameters

This section provides definitions of the transmission parameters applicable to intraLATA special channels. Some measurement requirements and the affect of transmission impairments on service are also discussed. More detailed information on measurement techniques can be found in IEEE Standard 743-1984.[7]

3.5.1 Loss

Loss, in this document, is defined as the channel design loss or expected measured loss (EML). The channel design allows for a specified deviation between the EML and the actual measured loss (AML). The test is conducted using a 0 dBm0 [– 13 dBm0 for data services], 1004 Hz test signal.

3.5.2 C-Message Noise

C-message noise is the short-term, average noise power on an idle channel, i.e., a channel with a termination at the far end and no signal on the transmitting end. C-message noise is determined using a noise measuring set equipped with a C-message weighting filter. This filter approximates the response of the human ear in conjunction with a telephone instrument, to signals within the telephone voice band.

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* Multipoint services must be restored to maintenance limit requirements on a per segment basis (two-point) to ensure that the overall channel meets the specified immediate action limits.

3.5.3 C-Notched Noise/Signal-to-C-Notched-Noise Ratio

C-notched noise is a measure of the noise on the channel measured while it is in an operating state. The noise is measured with a – 13 dBm0, 1004 Hz holding tone applied to the channel. (A – 16 dBm0 holding tone is sometimes used on voice-only service.) The noise measuring set is equipped with a C-message filter designed with a narrow band-rejection notch at the frequency of the holding tone. The signal-to-C-notched-noise ratio is the ratio in dB of the holding tone signal power to the corresponding C-notched noise power.

3.5.4 Three-Tone Slope

Three-tone slope is a measure of the frequency response of the channel at 404 Hz, 1004 Hz and 2804 Hz. In this test, "slope" is defined as the variation in response at 404 Hz and 2804 Hz relative to the response at 1004 Hz. The test provides a quick check for improperly configured facilities which greatly impair the channel response at the low and high ends of the voice band. Care should be taken when drawing conclusions from the results of a three-tone slope test. Impairments that affect the channel response at frequencies other than the measurement frequencies (e.g., loaded bridged-tap) will not be detected with this test. Attenuation distortion measurements should be used to get a full "picture" of the facility configuration.

3.5.5 Attenuation Distortion

Attenuation distortion is a measure of the frequency response of the channel at several discrete frequencies across the voice band. In this test, "distortion" is defined as the variation in response at the discrete measurement frequencies relative to the response at 1004 Hz. It is a more accurate method of verifying facility configuration than the three-tone slope test.

3.5.6 Echo Control

Echo control measurements are a means to detect impedance mismatches in a built-up circuit and consist of echo return loss (ERL) and singing return loss (SRL). ERL at any point in a channel is the frequency-weighted average, over the middle of the voice band, of the return losses at that point with the channel terminated in a specified impedance. SRL is the lesser of SRL-LO and SRL-HI. SRL-LO is the frequency-weighted average of the return losses in a low-frequency band (260 Hz to 500 Hz), while SRL-HI is the frequency-weighted average of the return losses in a high-frequency band (2200 Hz to 3400 Hz). The return loss is the ratio in dB of the transmitted power to the reflected or returned power at a single frequency with the channel terminated in a standard impedance. Impedance mismatches at two-wire to four-wire junctions on the channel result in low return loss and, consequently, cause echoes and hollow-sounding transmission on the channel.

3.5.7 Envelope Delay Distortion

Envelope delay distortion, also called relative envelope delay, is the variation in delay of frequencies within a band, relative to the delay of a reference frequency. The reference frequency is usually taken to be the frequency at which the delay is minimum. The measurement of envelope delay verifies the phase linearity of the channel. High envelope delay distortion causes different frequency components of the signal to have different transit times which in turn leads to distortion in the received signal. Data transmission is particularly sensitive to this distortion.

3.5.8 Impulse Noise

Impulse noise is any short-duration, excursion (energy spike) of the total noise waveform that is much higher than the steady state circuit noise. High impulse noise causes "popping and cracking" on voice channels and errors on data channels.

3.5.9 Signal-to-Intermodulation-Distortion Ratio

Intermodulation distortion is the generation of extraneous new signal components not present in the original transmitted signal. Signal-to-intermodulation-distortion ratio is a measure, in dB, of the ratio of the composite received power of a four-tone test signal to the received power of the intermodulation products. Second and third order products are the most significant. High intermodulation distortion reflects nonlinearity in a channel and affects data performance. Limits are provided for both second-order and third-order intermodulation product ratios.

3.5.10 Phase Jitter

Phase jitter is any deviation or fluctuation of the phase, measured peak-to-peak, of a specified test tone from its nominal phase. The received test tone (1004 Hz @ – 13 dBm0) is compared to a jitter-free reference signal in a phase detector. Passband filters, usually 20 Hz - 300 Hz and 4 Hz - 300 Hz, are used because the phase jitter rarely occurs above 300 Hz. Phase jitter can indicate the total effect on the test tone of impairments from sources such as impulse noise, quantizing and message noise, phase hits and digital timing jitter. This impairment can be driven by impulse noise or amplitude jitter; therefore, measurement of these parameters should be done in conjunction with phase-jitter tests. Commonly found components of phase jitter are 20 Hz (ringing), 60 Hz (commercial power), and the harmonics of these. Phase jitter can affect the error performance of voiceband data receivers that use phase detection techniques.

Typically, digital facilities do not generate phase modulation in significant amounts. Therefore, it is not usually necessary to measure phase jitter on an channel that is entirely digital.

3.5.11 Peak-to-Average Ratio

This parameter represents the measurement of the peak-to-average ratio of the power of a specifically designed test signal transmitted over a channel. The P/AR measurement is designed to evaluate the simultaneous effects of envelope delay distortion, bandwidth reduction and poor return loss on the intersymbol interference of voiceband data signals. The P/AR measurement is largely insensitive to noise and nonlinear distortion, and is unaffected by frequency shift or transient impairments. Misleading P/AR results can be obtained from channels exhibiting high listener echo; therefore, the measurement should be used with caution on 2-wire channels.

3.5.12 Frequency Shift

Frequency shift is any deviation in a frequency that occurs when it is transmitted over a channel. The shift can be measured using a precise frequency source at one end of the channel and a frequency counter at the receiving end. Frequency shift affects transmission systems that use narrow-band receiving filters. Frequency shift impairments cannot occur in digital facilities, but can occur in analog facilities that use single-sideband, suppressed-carrier transmission if a failure of the synchronization system occurs. The result is not valid when measured on looped-around facilities, since the shift in one direction can be cancelled by the shift in the other direction.

3.5.13 Phase Hits

A phase hit is a sudden change in the phase of a received – 13 dBm0, 1004 Hz holding tone. This transient impairment is measured by monitoring the received tone and counting hits that exceed a selectable threshold. In this practice, a phase change equal to or greater than 20° is considered to be a countable hit. Phase hits cause errors in voiceband data transmission.

3.5.14 Gain Hits

A gain hit is a sudden increase or decrease in the level of a received – 13 dBm0, 1004 Hz holding tone. This transient impairment is measured by monitoring the received tone and counting hits that exceed a selectable threshold. In this practice, a level change equal to or greater than 3 dB is considered to be a countable hit. Gain hits cause errors in voiceband data transmission.

3.5.15 Dropouts

A dropout is a decrease of 12 dB or greater in the level of a received – 13 dBm0, 1004 Hz holding tone, relative to the level of the received tone at the start of the measurement interval.

4. Test Requirements and Performance Parameter Limits

4.1 General

This section provides test requirements and transmission performance parameter limits for the various categories of intraLATA special channels. As noted in section 3.2, the number of channel categories specified in this practice has been reduced to four:

- **Private Line Voice** - This category includes services historically designated by transmission grade VA.
- **Private Line Data** - This category includes services historically designated by transmission grades DA and DJ.
- **Switched Voice Line** - This category includes services historically designated by transmission grades VB and DG (WATS Lines).
- **Switched Voice Trunk** - This category includes services historically designated by transmission grades VC, DB, DC, DD, DE and DG (WATS Trunks).

Two transmission grades, DL (Protective Relaying Channel) and TA (Telephoto) do not lend themselves to grouping in the four categories. Consequently, where necessary, performance limits for these channels are specified separately.

4.2 Test Requirements

Transmission test requirements for the various channel service categories are provided in Tables 4, 5, 6 and 7. These requirements can be applied to preservice, routine or trouble testing. Amplifying information for these tables is contained in Table 8. The required tests should be performed when the channel is placed in service as indicated in Section 3.4.1. When trouble is reported on an in-service channel, trouble localization should logically include those tests designated in the Tables as R (required) followed by the tests designated as NR (not required). If the trouble is not localized using the designated tests, troubleshooting may require the use of other tests listed in the tables.

4.3 Transmission Performance Parameter Limits

Transmission performance parameter limits for the various services and conditioning options are provided in Tables 9 through 24. Because of the wide deployment of digital network elements and the modernization of telecommunications facilities, some of the specified performance limits are more stringent than those contained in earlier issues of this practice. This is to ensure that the customer is realizing the benefit of the new equipment and facilities.

Table 4. Test Requirements - Network Interface to Central Office Switch (NI-SW)

Measurement Parameter	Limit Table	Service			
		Voice Private Line	Data Private Line	Switched Voice Line	Switched Voice Trunk
Continuity		R	R	R	R
Loss Deviation	9	R	R	R	R
C-Message Noise	11	R		R[4]	R[4]
C-Notched Noise	12		R[3]	R	R
Impulse Noise	13		NR[5]	NR[5]	NR[5]
Phase Jitter	14		NR[6,7]	NR[6,7]	NR[6,7]
3-Tone Slope	16	R	R[1]	R[1]	R[1]
P/AR	15		NR[2]	NR[2]	NR[2]
Attenuation Distortion	18	NR	NR	NR	NR
C-Conditioning	18		R	R	R
Intermodulation Distortion	20		NR[7]	NR[7]	NR[7]
Gain Hits, Phase Hits, Dropouts	21		NR[7]	NR[7]	NR[7]
Impedance Balance	10		R	R	R
Frequency Shift	22		NR[6]	NR[6]	NR[6]
Envelope Delay Distortion	23		NR	NR	NR
C-Conditioning	23		R	R	R

Note: Refer to Table 8 for an explanation of the superscript numbers.

R Required test.

NR The test is not required, but the parameter is supported either as a tariff guarantee or as a reasonable performance criterion for the intended use of the channel.

Table 5. Test Requirements - Central Office Switch to Central Office Switch (SW-SW)

Measurement Parameter	Limit Table	Service	
		Switched Voice Trunk	
		Voice	Data
Continuity		R	R
Loss Deviation	9	R	R
C-Message Noise	11	R	
C-Notched Noise	12		R[3]
Impulse Noise	13		NR[5]
Phase Jitter	14		NR[6,7]
3-Tone Slope	16	R	R[1]
P/AR	15		R[2]
Attenuation Distortion	18		NR
C-Conditioning	18		R
Intermodulation Distortion	20		NR[7]
Gain Hits, Phase Hits, Dropouts	21		NR[7]
Impedance Balance	10	R	R
Frequency Shift	22		NR[6]
Envelope Delay Distortion	23		NR
C-Conditioning	23		R

Note: Refer to Table 8 for an explanation of the superscript numbers.

R Required test.

NR The test is not required, but the parameter is supported either as a tariff guarantee or as a reasonable performance criterion for the intended use of the channel.

Table 6. Test Requirements - Network Interface to Network Interface (NI-NI) - Two-Point Service

Measurement Parameter	Limit Table	Service				
		Voice Private Line	Data Private Line	Switched Voice Line	Switched Voice Trunk	Telephoto
Continuity		R	R	R	R	R
Loss Deviation	9	R	R	R	R	R
C-Message Noise	11	R		R[4]	R[4]	R
C-Notched Noise	12		R[3]	R	R	R
D-Conditioning	12		R	R	R	
Impulse Noise	13		NR[5]	NR[5]	NR[5]	R
Phase Jitter	14		NR[6,7]	NR[6,7]	NR[6,7]	NR
3-Tone Slope	16	R	R[1]	R[1]	R[1]	
P/AR	15		NR[2]	NR[2]	NR[2]	
Attenuation Distortion	18		NR	NR	NR	
C-Conditioning	18		R	R	R	
T-Conditioning	18					R
Intermodulation Distortion	20		NR[7]	NR[7]	NR[7]	NR
D-Conditioning	20		R	R	R	
Gain Hits, Phase Hits, Dropouts	21		NR[7]	NR[7]	NR[7]	NR
Impedance Balance	10	NR	NR	NR	NR	
Frequency Shift	22		NR[6]	NR[6]	NR[6]	
Envelope Delay Distortion	23		NR	NR	NR	R
C-Conditioning	23		R	R	R	
T-Conditioning	23					R

Note: Refer to Table 8 for an explanation of the superscript numbers.

R Required test.

NR The test is not required, but the parameter is supported either as a tariff guarantee or as a reasonable performance criterion for the intended use of the channel.

Table 7. Test Requirements - Network Interface to Network Interface (NI-NI) - Multipoint Services

Measurement Parameter	Limit Table	Service	
		Private Line Voice	Private Line Data
Continuity		R	R
Loss Deviation	9	R	R
C-Message Noise	11	R	
C-Notched Noise	12		R[3]
Impulse Noise	13		NR[5]
Phase Jitter	14		NR[6,7]
3-Tone Slope	17	NR	
P/AR	15		NR
Attenuation Distortion	19		NR
C-Conditioning	19		R
Intermodulation Distortion	20		NR[7]
Gain Hits, Phase Hits, Dropouts	21		NR[7]
Impedance Balance	10	NR	NR
Frequency Shift	22		NR[6]
Envelope Delay Distortion	24		R
C-Conditioning	24		R

Note: Refer to Table 8 for an explanation of the superscript numbers.

R Required test.

NR The test is not required, but the parameter is supported either as a tariff guarantee or as a reasonable performance criterion for the intended use of the channel.

Table 8. Notes Pertaining to Test Requirement Tables 4, 5, 6 and 7

1. Attenuation distortion measurements should be substituted for 3-tone slope measurements on circuits with C-conditioning.

2. P/AR tests are required only on SSN trunks involving at least one analog switch, not on trunks between digital switches using digital facilities. They are a suggested preservice test on other analog trunks or lines to establish a benchmark for comparison in the event of a future trouble report.

3. C-Message Noise tests may be substituted for C-Notched Noise tests on channels composed entirely of VF cable.

4. C-Notched Noise tests should be substituted for C-Message noise tests on circuits carrying predominantly data.

5. On channels used for data transmission, the impulse noise limits of Table 13 apply from NI-to-NI on an overall basis. If data transmission troubles occur, this parameter must be tested.

6. Phase Jitter and Frequency Shift tests are not required on channels composed entirely of digital facilities.

7. These tests are not required, but should be considered on circuits carrying predominantly data.

Table 9. Loss Deviation (Note 1)

SW-SW or Midlink Segment of a Multipoint Circuit		NI-SW, NI-NI or End Link of a Multipoint Circuit	
Maintenance Limit (dB) (Note 2)	Immediate Action Limit (dB)	Maintenance Limit (dB) (Note 2)	Immediate Action Limit (dB)
± 1.0	± 3	± 2	± 4

Notes:

1. Loss deviation is the allowable variation, in dB, of the actual measured loss (AML) from the designed loss or expected measured loss (EML).

2. When performing preservice loss deviation tests, it is customary to use a preservice limit which is one-half of the maintenance limits specified in this table.

Table 10. Impedance Balance

Facility	Interface Measuring Point	Interface Terminated	Maintenance Limit (dB)		Immediate Action Limit (dB)	
			ERL	SRL	ERL	SRL
Effective 2-Wire	2-Wire	2-Wire or 4-Wire	5.5	3	5	2.5
	4-Wire	2-Wire	16	11	11	6
Effective 4-Wire	2-Wire	2-Wire or 4-Wire	19	13	18	12

Note:

An effective 2-wire facility may be all 2-wire or may contain 4-wire portions (such as carrier with 2-wire extensions); an effective 4-wire facility must be all 4-wire. Both must have a 2-wire interface at the NI.

Table 11. C-Message Noise

Facility Length (miles)	Maximum Noise (dBrnC0)				
	Immediate Action Limits	Maintenance Limits			
		VF Cable	A-Type Carrier	N-Type Carrier	T1-Type Carrier
0-50	40	25 dBrnC	31	26	28
51-100	40		33	28	28
101-200	40		35	30	28
201-400	42		37		28
401-1000	44		40		28
Local Loop (VF Cable)	36 dBrnC	20 dBrnC			
Local Loop (Other)	36 dBrnC				28

Notes:

1. When an intraLATA channel consists of more than one facility type or segment, combine the noise limits for each facility or segment on a power basis as follows:

   Take the difference between the two appropriate limits:

if the difference is 0 dB	–	add 3 dB to the greater limit;
if the difference is 1 to 3 dB	–	add 2 dB to the greater limit;
if the difference is 4 to 8 dB	–	add 1 dB to the greater limit;
if the difference is 9 dB or greater	–	use the greater limit.

   The result is the limit for the combined facilities. For three or more segments, combine two segments as above and continue iterative combinations with the remaining segments.

2. Except where indicated, these values are given in dBrnC0. To convert to dBrnC for comparison with values displayed by noise measuring equipment, algebraically add the receive TLP at the point of measurement to the value obtained from the table or to the result of multi-segment combinations (Note 1).

3. Immediate action limits (IAL) are not dependent upon facility type. Multi-segment limits are calculated as in Note 1.

4. VF cable noise limits are specified in dBrnC and need not be converted to dBrnC0. Multiple cable segments, connected in tandem, are considered to be a single facility. Accordingly, no combination of limits is required.

Table 12. C-Notched Noise & Signal-to-C-Notched-Noise Ratio

Facility Length (Miles)	Maintenance Limits (– 13 dBm0 Holding Tone) [Note 4]					
		N-Type Carrier		Digital Carrier		
	A-Type Carrier	Compandor Disabled	Compandor Enabled	D1D	D2	D3,D4 D5,DLC
0-50	31/46	48/29	42/35	40/37	39/38	45/32
51-100	33/44	49/28	43/34	40/37	39/38	45/32
101-200	35/42	51/26	46/31	40/37	39/38	45/32
201-400	37/40			40/37	39/38	45/32
401-1000	40/37			40/37	39/38	45/32
Local Loop						45/32

Service	Immediate Action Limit
All	53/24
D-Conditioning	49/28

Notes:

1. The first value given in the table is the C-notched noise limit (dBrnC0) – the noise measurement may not exceed this value. The second value is the signal-to-noise ratio limit (dB) – the signal-to-noise ratio measurement may not be less than this value.

2. When the channel consists of more than one facility type or segment, combine the noise limits for each facility or segment on a power basis as follows:

   Take the difference between the two appropriate limits:

if the difference is 0 dB	–	add 3 dB to the greater limit;
if the difference is 1 to 3 dB	–	add 2 dB to the greater limit;
if the difference is 4 to 8 dB	–	add 1 dB to the greater limit;
if the difference is 9 dB or greater	–	use the greater limit.

   The result is the limit for the combined facilities. For three or more segments, combine two segments and continue iterative combinations with the remaining segments.

3. To convert dBrnC0 to dBrnC for comparison with values displayed by noise measuring equipment, algebraically add the receive TLP at the point of measurement to the value obtained from the table or as the result of multi-segment combinations (Note 2).

4. C-notched noise measurements on voiceband data channels are made using a – 13 dBm0 holding tone. If a voice channel is being tested using a – 16 dBm0 holding tone, make the following adjustments to the values in this table:

   For digital carrier, subtract 3 from the C-notched noise limit.
   For analog carrier (non-compandored), subtract 3 from the signal-to-noise ratio limit.
   For N-carrier (compandored), subtract 1.5 from the C-notched noise and signal-to-noise ratio limits.

5. Immediate action limits are not dependent upon facility type. Multi-segment limits are calculated as in Note 2.

Table 13. Impulse Noise

Facility Type	1004 Hz Holding Tone Level (dBm0)	Threshold Level (dBrnC0)			
		Maintenance Limit			Immediate Action Limit
		Circuit Length (miles)			
		Any	0 - 125	126 - 1000	
A-Type Carrier	None	–	57	59	71
N-Carrier (compandored)	– 13	67	–	–	71
T-Carrier	– 13	67	–	–	71
VF Cable Interoffice	None	53	–	–	71
VF Cable Local Loop	None	59	–	–	71

Notes:

1. The impulse count must be ≤ 15 counts in a 15 minute interval for satisfactory impulse noise performance at either the maintenance or the immediate action limit threshold.

2. If the majority of impulse noise spikes occur during a particular interval of the test (e.g., 12 counts during the second minute of the test), but 15 counts is not exceeded, the test should be repeated. If a similar condition recurs, the cause should be pursued.

3. The immediate action limit applies to a complete channel (i.e., End-user NI to End-user NI).

Table 14. Phase Jitter – Two-Point and Multipoint Channels

Measurement Type	Frequency Range (Hz)	Peak-to-Peak Variation (degrees)	
		NI to NI	Multipoint End Link or Midlink
Bell + LF	4 - 300	≤ 13/15	≤ 5/12
Bell	20 - 300	≤ 8/10	≤ 3/8

Notes:

1. Phase jitter is measured with a – 13 dBm0/1004 Hz holding tone transmitted from the far end. It may also be measured with a 0 dBm test signal if it is found that the noise level controls the phase jitter reading.

2. Both the "Bell" and the "Bell + LF" tests are to be made.

3. The first number in the limit table is the maintenance limit; the second number is the immediate action limit.

4. The Bell + LF immediate action limits of 12 or 15 degrees peak-to-peak are the only values guaranteed.

5. If an end link or midlink of a multipoint channel exceeds the specified limit, the overall circuit phase jitter performance should be verified to ensure that it meets the performance specifications.

6. Phase Jitter tests are not required if the channel is entirely digital.

Table 15. Peak-to-Average Ratio - Single and Multi-Facility Channels

Maintenance Limits	
Facility Configuration	**P/AR Range**
T1 or DLC	93 - 102
T1 or DLC + A	86 - 95
T1 or DLC + N2	88 - 96
T1 or DLC + N3 or N4	87 - 95
T1 or DLC + T1 or DLC	88 - 97
A	87 - 99
A + A	82 - 92
A + N2	86 - 96
A + N3 or N4	83 - 91
A + A + A	74 - 83
A + T	86 - 95
N2	93 - 101
N2 + N2	88 - 96
N2 + N3	87 - 97
Cable: NL, 0-18 kf, no repeater	97
NL, 0-18 kf, repeatered	90
H 88, 0-18 kf, no repeater	94
H 88, 0-36 kf, repeatered	90
H 88, > 36 kf, repeatered	80

Notes:

1. The P/AR generator should be adjusted to transmit at -13 dBm0.
2. When two or more T1 channels are connected in tandem through a digital cross-connect system (DCS), the connection is electrically transparent. Accordingly, the limits for a single T1 facility should be used.
3. Only maintenance limits are specified because the P/AR measurement evaluates the simultaneous effects of several other parameter impairments. If the P/AR measurement exceeds the specified range, envelope delay distortion and return loss must be measured to localize the problem.

Table 16. Three-Tone Slope – Two-Point Channels

Service	Slope (dB)	
	Maintenance Limit	Immediate Action Limit
Private Line Voice	– 1.5/+ 10.5	– 2.0/+ 11.5
Private Line Data	– 1.5/+ 9.0	– 2.0/+ 10.0
Switched Voice Line		
Voice	– 1.5/+ 8.0	– 2.0/+ 9.0
Data	– 1.0/+ 4.0	– 1.5/+ 4.5
Switched Voice Trunk		
Voice	– 1.5/+ 5.0	– 2.0/+ 6.0
Data	– 1.0/+ 4.0	– 1.5/+ 4.5

Notes:

1. Three-tone slope test signals are transmitted at 0 dBm0 when testing voice channels and at – 13 dBm0 when testing data channels.
2. The limit values are interpreted as loss in dB at 404 Hz and 2804 Hz relative to the loss at 1004 Hz.
3. "+ " means "more loss" and "– " means "less loss" than the loss at 1004 Hz.

Table 17. Three-Tone Slope – Multipoint Channels

Service	Three-Tone Slope		
	Number of Midlinks	Immediate Action Limit (dB)	
		End Link	Midlink
Private Line Voice	0	– 1.5/+ 4.0	–
	1	– 1.0/+ 4.0	– 1.0/+ 3.5
	2	– 1.0/+ 4.0	– 1.0/+ 3.5
	3	– 1.0/+ 3.5	– 0.8/+ 3.5
	4	– 0.8/+ 3.5	– 0.8/+ 3.0
Private Line Data	0	– 1.5/+ 5.0	–
	1	– 1.0/+ 5.0	– 1.0/+ 5.0
	2	– 1.0/+ 4.5	– 1.0/+ 4.5
	3	– 1.0/+ 4.5	– 0.8/+ 4.0
	4	– 1.0/+ 4.0	– 0.8/+ 4.0

Notes:

1. Three-tone slope test signals are transmitted at 0 dBm0 when testing voice channels and at – 13 dBm0 when testing data channels.
2. The limit values are interpreted as loss in dB at 404 Hz and 2804 Hz relative to the loss at 1004 Hz.
3. "+ " means "more loss" and "– " means "less loss" than the loss at 1004 Hz.
4. When digital cross-connect systems (DCS) are used for bridging, for each completely digital midlink between DCSs, use the limits for a channel containing one fewer midlink than the number of physical midlinks in the channel. For example, in a 4-midlink channel with three digital midlinks between DCS bridges, use the limits for a 1-midlink configuration.

Table 18. Attenuation Distortion – Two-Point Channels

Service		Frequency Range (Hz)	Attenuation Distortion (dB)	
			Maintenance Limit	Immediate Action Limit
Private Line Voice		404 - 2804	– 1.5/+ 10.5	– 2.0/+ 11.5
		304 - 3004	–	– 3.0/+ 12.0
Private Line Data		504 - 2504	– 1.0/+ 7.0	– 2.0/+ 8.0
		404 - 2804	– 1.0/+ 9.0	– 2.0/+ 10.0
		304 - 3004	–	– 3.0/+ 12.0
Switched Voice Line	Voice	404 - 2804	– 1.5/+ 8.0	– 2.0/+ 9.0
	Voice/Data	304 - 3004	–	– 3.0/+ 12.0
	Data	404 - 2804	– 1.0/+ 4.0	– 1.5/+ 4.5
Switched Voice Trunk	Voice	404 - 2804	– 1.5/+ 5.0	– 2.0/+ 6.0
	Voice/Data	304 - 3004	–	– 3.0/+ 12.0
	Data	404 - 2804	– 1.0/+ 4.0	– 1.5/+ 4.5
Protective Relaying		505 - 2804	–	– 1.0/+ 3.0
		304 - 3004	–	– 2.0/+ 6.0
Telephoto		1204 - 2604	–	– 3.0/+ 3.0
		304 - 3004	–	– 3.0/+ 12.0
C1-Conditioning		1004 - 2404	–	– 1.0/+ 3.0
		304 - 2704	–	– 2.0/+ 6.0
		2704 - 3004	–	– 3.0/+ 12.0
C2-Conditioning		504 - 2804	–	– 1.0/+ 3.0
		304 - 3004	–	– 2.0/+ 6.0
C3-Conditioning		504 - 2804	–	– 0.5/+ 1.5
	NI-SW	304 - 3004	–	– 0.8/+ 3.0
	SW-SW	304 - 3004	–	– 0.8/+ 2.0
C4-Conditioning		504 - 3004	–	– 2.0/+ 3.0
		304 - 3204	–	– 2.0/+ 6.0
C5-Conditioning		504 - 2804	–	– 0.5/+ 1.5
		304 - 3004	–	– 1.0/+ 3.0
T1-Conditioning (Telephoto)		504 - 3004	–	– 1.0/+ 3.0
		304 - 3004	–	– 2.0/+ 6.0

Notes:

1. Attenuation distortion test signals are transmitted at 0 dBm0 when testing voice channels and at – 13 dBm0 when testing data channels.
2. The limit values are interpreted as loss in dB at the measurement frequency relative to the loss at 1004 Hz. (The reference frequency is 2204 Hz for telephoto circuits.)
3. "+ " means "more loss" and "– " means "less loss" than the loss at 1004 Hz.
4. Attenuation distortion is measured at the following frequencies (in Hz): 304, 404, 504, 604, 804, 1004, 1204, 1404, 1604, 1804, 2004, 2204, 2404, 2604, 2704, 2804, 3004, 3204. For channels that use 2600 Hz in-band signaling, measurements should be made at 2504 and 2704 Hz.

Table 19. Attenuation Distortion – Multipoint Channels

Service	Midlinks	Immediate Action Limit (dB)					
		Frequency Range (Hz)					
		404 - 2804		504 - 2504		304 - 3004	
		End Link	Midlink	End Link	Midlink	End Link	Midlink
Pvt Line Voice	0	– 1.5/+ 4.0	–	–	–	– 1.5/+ 6.0	–
	1	– 1.0/+ 4.0	– 1.0/+ 3.5	–	–	– 1.5/+ 6.0	– 1.5/+ 6.0
	2	– 1.0/+ 4.0	– 1.0/+ 3.5	–	–	– 1.5/+ 6.0	– 1.5/+ 5.0
	3	– 1.0/+ 3.5	– 0.8/+ 3.5	–	–	– 1.5/+ 5.0	– 1.5/+ 4.5
	4	– 0.8/+ 3.5	– 0.8/+ 3.0	–	–	– 1.5/+ 4.5	– 1.0/+ 4.5
Pvt Line Data	0	– 1.5/+ 5.0	–	– 1.5/+ 4.0	–	– 1.5/+ 6.0	–
	1	– 1.0/+ 5.0	– 1.0/+ 5.0	– 1.0/+ 4.0	– 1.0/+ 3.5	– 1.5/+ 6.0	– 1.5/+ 6.0
	2	– 1.0/+ 5.0	– 1.0/+ 4.5	– 1.0/+ 4.0	– 1.0/+ 3.5	– 1.5/+ 6.0	– 1.5/+ 5.0
	3	– 1.0/+ 4.5	– 0.8/+ 4.0	– 1.0/+ 3.5	– 0.8/+ 3.5	– 1.5/+ 5.0	– 1.0/+ 4.5
	4	– 1.0/+ 4.0	– 0.8/+ 4.0	– 0.8/+ 3.5	– 0.8/+ 3.0	– 1.5/+ 4.5	– 1.0/+ 4.5
		Frequency Range (Hz)					
		1004 - 2404		304 - 2704		2704 - 3004	
		End Link	Midlink	End Link	Midlink	End Link	Midlink
C1 Cond	0	– 0.7/+ 1.5	–	– 1.5/+ 3.0	–	– 1.5/+ 6.0	–
	1	– 0.6/+ 1.5	– 0.5/+ 1.5	– 1.0/+ 3.0	– 1.0/+ 3.0	– 1.5/+ 6.0	– 1.5/+ 6.0
	2	– 0.5/+ 1.5	– 0.5/+ 1.5	– 1.0/+ 3.0	– 1.0/+ 2.5	– 1.5/+ 6.0	– 1.5/+ 5.0
	3	– 0.5/+ 1.5	– 0.5/+ 1.0	– 1.0/+ 3.0	– 0.8/+ 2.0	– 1.5/+ 5.0	– 1.5/+ 4.5
	4	– 0.5/+ 1.5	– 0.5/+ 1.0	– 0.8/+ 3.0	– 0.8/+ 2.0	– 1.5/+ 4.5	– 1.0/+ 4.5
		Frequency Range (Hz)					
		504 - 2804		304 - 3204			
		End Link	Midlink	End Link	Midlink		
C2 Cond	0	– 0.7/+ 1.5	–	– 1.5/+ 3.0	–		
	1	– 0.6/+ 1.5	– 0.5/+ 1.5	– 1.0/+ 3.0	– 1.0/+ 3.0		
	2	– 0.5/+ 1.5	– 0.5/+ 1.5	– 1.0/+ 3.0	– 1.0/+ 2.5		
	3	– 0.5/+ 1.5	– 0.5/+ 1.0	– 1.0/+ 3.0	– 0.8/+ 2.0		
	4	– 0.5/+ 1.5	– 0.5/+ 1.0	– 0.8/+ 3.0	– 0.8/+ 2.0		

(See next page for additional limits and amplifying notes)

Table 19. Attenuation Distortion – Multipoint Channels (continued)

Service	Midlinks	Immediate Action Limit (dB)			
		Frequency Range (Hz)			
		504 - 3004		304 - 3204	
		End Link	Midlink	End Link	Midlink
C4 Cond	0	−1.0/+1.5	–	−1.0/+3.0	–
		Frequency Range (Hz)			
		1204 - 2604		304 - 3004	
		End Link	Midlink	End Link	Midlink
Telephoto	0	−2.0/+2.0	–	−2.0/+6.0	–
	1	−1.5/+1.5	−1.5/+1.5	−1.5/+6.0	−1.5/+6.0
	2	−1.5/+1.5	−1.5/+1.5	−1.5/+6.0	−1.5/+5.0
	3	−1.5/+1.5	−1.0/+1.0	−1.5/+5.0	−1.0/+4.5
	4	−1.5/+1.5	−1.0/+1.0	−1.5/+4.5	−1.0/+4.5
		Frequency Range (Hz)			
		504 - 3004		304 - 3204	
		End Link	Midlink	End Link	Midlink
T1 Cond	0	−0.7/+2.0	–	−1.5/+4.0	–
	1	−0.6/+1.7	−0.5/+1.5	−1.0/+3.5	−1.0/+3.5

Notes:

1. Attenuation distortion test signals are transmitted at 0 dBm0 when testing voice channels and at − 13 dBm0 when testing data channels.
2. The limit values are interpreted as loss in dB at the measurement frequency relative to the loss at 1004 Hz. (The reference frequency is 2204 Hz for telephoto circuits.)
3. "+" means "more loss" and "−" means "less loss" than the loss at 1004 Hz.
4. Attenuation distortion is measured at the following frequencies (in Hz): 304, 404, 504, 604, 804, 1004, 1204, 1404, 1604, 1804, 2004, 2204, 2404, 2604, 2804, 3004, 3204. For channels that use 2600 Hz in-band signaling, measurements should be made at 2504 and 2704 Hz.
5. When digital cross-connect systems (DCS) are used for bridging, for each completely digital midlink between DCSs, use the limits for a channel containing one fewer midlink than the number of physical midlinks in the channel. For example, in a 4-midlink channel with three digital midlinks between DCS bridges, use the limits for a 1-midlink configuration.

Table 20. Signal-to-Intermodulation-Distortion Ratio

Ratio of Fundamental to Distortion Products (dB)			
		Distortion Product	
Service	Facility	Second Order (R2)	Third Order (R3)
Data	Analog	≥ 39/27	≥ 37/32
	Digital	≥ 48/40	≥ 51/42
D-Conditioning (NI-NI)	All	≥ NA/35	≥ NA/40

Note:

1. The first number in the limit table is the maintenance limit; the second number is the immediate action limit. To meet either limit, the measurement must equal or exceed the indicated values.
2. These limits are predicated on the use of the "4-Tone" test method with the test signal transmitted at – 13 dBm0.

Table 21. Gain Hits, Phase Hits and Dropouts

	Immediate Action Limit (Hits in 15 minutes)	
	Facility Type	
Parameter	N, T, Cable	A, A + T
Gain Hits ≥ 3 dB	0	≤ 2
Phase Hits ≥ 20°	0	≤ 2
Dropouts ≥ 12 dB	0	0

Notes:

1. These tests require a -13 dBm0, 1004-Hz tone applied at the far end.
2. If one dropout occurs, continue testing for another 15 minutes. If more than one dropout occurs in the 30-minute period, the cause should be pursued.

Table 22. Frequency Shift – Two-Point and Multipoint Channels

Service	Allowable Frequency Shift (Hz)	
	Maintenance Limit	Immediate Action Limit
Private Line Data (NI-NI)	± 2	± 3
Switched Voice Trunk - Data (SW-SW)	± 1	± 2
Protective Relaying	± 4	± 5
Multipoint End Link or Midlink	± 1	–

Note:

Frequency shift is generated only in certain types of analog carrier. A frequency shift test is not required if the facility is digital and/or cable.

Table 23. Envelope Delay Distortion – Two-Point Channels (NI-NI)

Service	Frequency Range (Hz)	Immediate Action Limit (μsec)
Private Line Data (NI-NI)	804 - 2604	>1750
Switched Voice Trunk - Data	804 - 2604	>1250
C1 Conditioning	1004 - 2404	>1000
	804 - 2604	>1750
C2 Conditioning	1004 - 2604	>500
	604 - 2604	>1500
	504 - 2804	>3000
C3 Conditioning (NI-SW)	1004 - 2604	>110
	604 - 1004	>300
	500 - 2800	>650
C3 Conditioning (SW-SW)	1004 - 2604	>80
	604 - 1004	>260
	500 - 2800	>500
C4 Conditioning	1004 - 2604	>300
	804 - 2804	>500
	604 - 3004	>1500
	504 - 3004	>3000
C5 Conditioning	1004 - 2604	>100
	604 - 1004	>300
	504 - 2804	>600
Protective Relaying	804 - 2604	>2000
Telephoto	1204 - 2604	>600
T1 Conditioning	1004 - 2604	>300
T1 Conditioning	804 - 2804	>500

Notes:

1. Envelope delay distortion (EDD) is measured at four-wire points using a −13 dBm0 test tone.
2. EDD is measured at the following frequencies (Hz) within the appropriate range specified in the table: 504, 604, 804, 1004, 1204, 1404, 1604, 1804, 2004, 2204, 2404, 2604, 2804, 3004.
3. When testing channels with 2600 Hz single-frequency signaling, measurements at 2504 and 2704 Hz are averaged to determine the 2604 Hz value.

Table 24. Envelope Delay Distortion – Multipoint Channels

Service	Freq Range (Hz)	Immediate Action Limit (μ sec)								
		Number of Midlinks								
		0	1		2		3		4	
		End Link	End Link	Mid-Link	End Link	Mid-Link	End Link	Mid-Link	End Link	Mid-Link
Pvt Line Data	804-2604	>960	>685	>550	>550	>400	>400	>375	>375	>275
Tele-photo	1204-2604	>330	>240	>180	>180	>150	>150	>120	>120	>105
T1	1004-2604	>165	>115	>100						
	804-2804	>275	>200	>150						
C1	1004-2404	>550	>400	>300	>300	>250	>250	>200	>200	>175
	804-2604	>960	>685	>550	>550	>400	>400	>375	>375	>275
C2	1004-2604	>275	>200	>150	>150	>125	>125	>100	>100	>80
	604-2604	>825	>600	>450	>450	>375	>375	>300	>300	>260
	504-2804	>1650	>1200	>900	>900	>750	>750	>600	>650	>500
C4	1004-2604	>165								
	804-2804	>275								
	604-3004	>825								
	504-3004	>1650								

Notes:

1. Envelope delay distortion (EDD) is measured at four-wire points using a – 13 dBm0 test tone.
2. EDD is measured at the following frequencies (Hz) within the appropriate range specified in the table: 504, 604, 804, 1004, 1204, 1404, 1604, 1804, 2004, 2204, 2404, 2604, 2804, 3004.
3. When testing channels with 2600 Hz single-frequency signaling, measurements at 2504 and 2704 Hz are averaged to determine the 2604 Hz value.
4. When digital cross-connect systems (DCS) are used for bridging, for each completely digital midlink between DCSs, use the limits for a channel containing one fewer midlink than the number of physical midlinks in the channel. For example, in a 4-midlink channel with three digital midlinks between DCS bridges, use the limits for a 1-midlink configuration.

5. Acronyms

ACD	–	Automatic Call Distributor
AIOD	–	Automatic Identified Outward Dialing
AML	–	Actual Measured Loss
CCSA	–	Common Control Switching Arrangement
DCS	–	Digital Cross-Connection System
DCTN	–	Defense Commercial Telecommunications Network (formerly AUTOVON)
DLC	–	Digital Loop Carrier
EC	–	Exchange Carrier
EDD	–	Envelope Delay Distortion
EML	–	Expected Measured Loss
ERL	–	Echo Return Loss
FAA	–	Federal Aviation Administration
IAL	–	Immediate Action Limit
ML	–	Maintenance Limit
NCI	–	Network Channel Interface
NI	–	Network Interface
P/AR	–	Peak-to-Average Ratio
PBX	–	Private Branch Exchange
PSN	–	Public Switched Network
SRL	–	Singing Return Loss
SSN	–	Switched Service Network
TLP	–	Transmission Level Point
VF	–	Voice Frequency
WATS	–	Wide Area Telecommunications Service

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