3.17 An IBRULS qualified metallic loop facility shall meet the following non-loaded cable Revised Resistance Design criteria:

(a) The metallic cable shall be non-loaded.
(b) The total length of the cable shall be less than 18 kft.
(c) The direct current resistance measured between the CODF and the EU-RDP shall be 1300 ohms or less.
(d) Loaded bridged tap is not permitted.
(e) The total length of all bridged tap shall be less than 6 kft.
(f) The total cable length plus the bridged tap length shall not exceed 18 kft.
(g) The 40 kHz loss when measured with 135 ohm impedances at each end shall be 40.0 dB or less.

3.18 Metallic loops between the CODF and the RDP that have a 40 kHz loss between 40 and 76 dB will require intermediate transmission enhancement equipment such as a mid-span repeater or similar device. Bell Atlantic spectrum management rules do not permit the placement of more than one mid-span repeater per loop. If a loop will not operate with one repeater, construction of DLC will be necessary..

3.19 The leakage resistance between the tip conductor and ground and the ring conductor and ground on the metallic loop portion of any IBRULS shall each be greater than 100 K ohms.

3.20 The longitudinal noise or power influence (PI) measured per IEEE Std 743-1984 [8] on an IBRULS metallic loop should be less than 90 dBrnC.

3.21 The longitudinal balance of a metallic IBRULS loop is defined as the longitudinal noise (in dBrnC) minus the C-message noise (in dBrnC). The longitudinal balance shall be >50 dB.

3.22 IBRULS will not operate properly on non-staggered twist cable (installed prior to 1923) or on flat ribbon cables, such as those used for some CPE interconnections. Such cable may need to be replaced to accommodate IBRULS.

3.23 It is currently known that Basic Rate ISDN technology is spectrally incompatible with a number of embedded services and technologies. These services and technologies include 15 kHz Program Audio Service, Type I and Type II PSDS, DVM technology associated with CO-LAN service, and analog carrier systems.

3.24 15 kHz Program Audio and IBRULS services should be separated into different binder groups to prevent the Basic Rate ISDN technology from interfering with the 15 kHz Program Audio service. Non-adjacent binder groups are preferred but adjacent binder groups may be adequate.

3.25 Type II PSDS, which is also known as AT&T CSDC, is no longer available from BA. Type III PSDS, which is also known as the Nortel Datapath technology, should be separated into different binder groups than IBRULS in order to prevent the Basic Rate ISDN technology from interfering with Type III PSDS services.

3.26 BA LANGATE service, which is a CO-LAN service that uses DVM technology, is widely deployed in BA. DVMs are spectrally incompatible with IBRULS services depending upon the range at which the DVMs are deployed. If DVMs are operated at less than 80% of the maximum specified range, they are spectrally compatible with IBRULS services. If operated at or above the 80% range, DVMs are not spectrally compatible with IBRULS services and the two should be separated into different binder groups.

3.27 Analog carrier systems are being phased out in BA. Analog Carrier systems and IBRULS services should be assigned to pairs in different cables to prevent IBRULS services from interfering with the Analog Carrier technology.

ii. DS1ULS

3.28 DS1ULS uses a subscriber loop facility between the CO and the EU-RDP. The loop is either:

(a) a qualified metallic non-loaded facility consisting of cable and wire between the CODF and the RDP wire with no intermediate electronics; or,

(b) a qualified metallic non-loaded facility consisting of cable and wire between the CODF and the RDP wire with transmission enhancement equipment such as regenerators or HDSL technology; or,

(c) a fiber facility with optical multiplexing equipment at each end from the CO to a Remote Terminal (RT) location with qualified metallic non-loaded cable and wire between the DLC RT and the RDP.

3.29 When DS1ULS is provided using 4-wire facilities with HDSL electronics at each end, each pair shall meet Carrier Serving Area (CSA) design criteria.

3.30 When DS1ULS facilities are 4-wire non-loaded facilities without electronics, the facility must not have bridged tap and the length is limited to 3000 feet (nominal).

3.31 4-wire T1 span facilities used with DS1ULS are designed with regenerators spaced every 6000 feet (nominal) and with nominal 3000 foot end sections toward the CO and the end-user.

3.32 It is currently known that T1 technology is spectrally incompatible with Analog Carrier systems and ADSL technology and ADULS services.

3.33 Analog Carrier systems are being phased out in BA. Analog Carrier systems and the T1 technology used for DS1ULS services should be assigned to pairs in different cables to prevent the DS1ULS services from interfering with the Analog Carrier systems.

3.34 ADSL technology (including ADULS services) and T1 technology (including applicable DS1ULS services) should be separated into non-adjacent binder groups in order to prevent the ADSL technology from interfering with the T1 technology.

iii. DDSULS

3.35 DDSULS uses a subscriber loop facility between the BA CO and the EU-RDP. The DDSULS loop is either:

(a) a DDS qualified metallic non-loaded facility consisting of cable and wire between the CODF and the RDP wire with no intermediate electronics; or,

(b) a metallic loop facility with intermediate transmission enhancement equipment that consists of a qualified metallic non-loaded facility between the CODF and intermediate transmission enhancement equipment and a qualified metallic non-loaded facility between the intermediate transmission enhancement equipment and the RDP; or,

(c) a universal digital loop carrier (DLC) facility with DDS dataport transport capability a single DS0 channel. The DLC facility consists of:

- CO cabling between the CODF and a DLC Central Office Terminal (COT) equipped with a DDS DS0 channel unit;

- a fiber or metallic facility from the DLC COT to the DLC Remote Terminal (RT) equipped with a DDS OCU channel unit; and,

- a qualified metallic non-loaded facility consisting of cable and wire between the DLC RT and the RDP.

3.36 A DDSULS qualified metallic loop facility shall meet the following non-loaded cable Revised Resistance Design criteria:

(a) The metallic cable shall be non-loaded.
(b) The total length of the cable shall be less than 18 kft.
(c) The direct current resistance measured between the CODF and the EU-RDP shall be 1300 ohms or less.
(d) Loaded bridged tap is not permitted.
(e) The total length of all bridged tap shall be less than 2.0 kft.
(f) The total cable length plus the bridged tap length shall not exceed 18 kft.
(g) The 28 kHz loss when measured with 135 ohm impedances at each end shall be 34.0 dB or less.

3.37 Metallic loops between the CODF and the RDP that have a 28 kHz loss greater than 34 dB when measured with 135 ohm impedances, will require intermediate transmission enhancement equipment such as a mid-span repeater or similar device. Bell Atlantic spectrum management rules do not permit the placement of more than one mid-span repeater per loop. If a loop will not operate with one repeater, construction of DLC will be necessary..

3.38 The leakage resistance between the tip conductor and ground and the ring conductor and ground on the metallic loop portion of any DDSULS shall each be greater than 300 K ohms.

3.39 The longitudinal noise or power influence (PI) measured per ANSI IEEE Std 743-1995 [8] on an DDSULS metallic loop should be less than 90 dBrnC.

3.40 The longitudinal balance of a metallic DDSULS loop is defined as the longitudinal noise (in dBrnC) minus the C-message noise (in dBrnC). The longitudinal balance shall be >50 dB.

3.41 DDSULS will not operate properly on non-staggered twist cable (installed prior to 1923) or on flat ribbon cables, such as those used for some CPE interconnections. Such cable may need to be replaced to accommodate DDSULS.

iv. 2-Wire and 4-wire HDULS

3.42 2-Wire and 4-Wire HDULS use a subscriber loop facility between the CO and the EU-RDP. The subscriber loop is a 2-wire or 4-wire metallic non-loaded facility consisting of cable and wire between the CODF and the RDP wire with no intermediate electronics.

3.43 Qualified 2-Wire and 4-Wire HDULS metallic loop facilities should meet the following selected Carrier Serving Area design criteria:

(a) The cable shall be non-loaded.
(b) The total of all bridged tap length shall not exceed 2.5 kilofeet (kft).
(c) The total length of a cable consisting entirely of 26 gauge plus the total bridged tap length shall not exceed 9 kft.
(d) The total length of a cable consisting entirely of 19, 22, or 24 gauge cable or a mixed gauge cable plus the total bridged tap length shall not exceed 12 kft.
(e) The dc resistance of the loop measured between the CODF and the EU-RDP shall be 750 ohms or less.

(f) Loaded bridged tap is not permitted.

3.44 The leakage resistance between the tip conductor and ground and the ring conductor and ground on the metallic loop portion of any HDULS shall each be greater than 300 K ohms.

3.45 It is currently known that HDSL technology is spectrally incompatible with a number of embedded services and technologies. These services and technologies include 15 kHz Program Audio Service, Type I and Type II PSDS, DVM technology associated with CO-LAN service, and Analog Carrier systems.

3.46 15 kHz Program Audio and HDULS services should be separated into different binder groups to prevent the HDSL technology from interfering with the 15 kHz Program Audio service. Non-adjacent binder groups are preferred but adjacent binder groups may be adequate.

3.47 Type II PSDS, which is also known as AT&T CSDC, is no longer available from BA. Type III PSDS services (Nortel Datapath technology) and HDULS services should be separated into different binder groups to prevent the HDULS services from interfering with the Type III PSDS services.

3.48 BA LANGATE service, which is a CO-LAN service that uses DVM technology, is widely deployed in BA. DVMs are spectrally incompatible with HDULS services depending upon the range at which the DVMs are deployed. If DVMs are operated at less than 80% of the maximum specified range, they are spectrally compatible with HDULS services. If operated at or above the 80% range, DVMs are not spectrally compatible with HDULS services and the two should be separated into different binder groups.

3.49 Analog Carrier systems are being phased out in BA. Analog Carrier systems and HDULS services should be assigned to pairs in different cables to prevent HDULS services from interfering with the Analog Carrier systems.

v. ADULS-R and ADULS-C

3.50 ADULS-R and ADULS-C use a subscriber loop facility between the CO and the EU-RDP.

3.51 An ADULS-R metallic loop facility should meet the following Revised Resistance Design criteria:

(a) The cable shall be non-loaded.
(b) The total length of all bridged tap shall be less than 6 kft.
(c) The total length of the cable shall be less than 18 kft.
(d) The total length of the cable plus the bridged tap length shall not exceed 18 kft.
(e) The direct current resistance of the loop measured between the CODF and the EU-RDP shall be 1300 ohms or less.
(f) Loaded bridged tap is not permitted.

3.52 An ADULS-C metallic loop facility should meet the following selected Carrier Serving Area design criteria:

(a) The cable shall be non-loaded.
(b) The total of all bridged tap length shall not exceed 2.5 kft.
(c) The total length of a cable consisting entirely of 26 gauge plus the total bridged tap length shall not exceed 9 kft.
(d) The total length of a cable consisting entirely of 19, 22, or 24 gauge cable or a mixed gauge cable plus the total bridged tap length shall not exceed 12 kft.
(e) The dc resistance of the loop measured between the CODF and the EU-RDP shall be 750 ohms or less.
(f) Loaded bridged tap is not permitted.

3.53 The leakage resistance between the tip conductor and ground and the ring conductor and ground on ADULS metallic loops shall each be greater than 300 K ohms.

3.54 The 1kHz loss acceptance limit of an ADULS-R metallic loop facility when measured with a 900 ohm impedance at the CODF and a 600 ohm impedance at the RDP shall be 8.5 dB or less.

3.55 The 1kHz loss acceptance limit of an ADULS-C metallic loop facility when measured with a 900 ohm impedance at the CODF and a 600 ohm impedance at the RDP shall be 5.0 dB or less.

3.56 The C-message noise measured on an ADULS-R or ADULS-C metallic loop at the RDP shall be less than 30 dBrnC.

3.57 The longitudinal noise or power influence (PI) measured per IEEE Std 743-1995 [8] on an ADULS-R or ADULS-C metallic loop should be less than 90 dBrnC.

3.58 The longitudinal balance of a metallic ADULS loop is defined as the longitudinal noise (in dBrnC) minus the C-message noise (in dBrnC). The longitudinal balance shall be >50 dB.

3.59 ADULS will not operate properly on non-staggered twist cable (installed prior to 1923) or on flat ribbon cables, such as those used for some CPE interconnections. Such cable may need to be replaced to accommodate ADULS.

3.60 It is currently known that ADSL technology is spectrally incompatible with a number of embedded services and technologies. These services and technologies include the DVM technology associated with CO-LAN service, Analog Carrier systems, T1 technology (including some DS1ULS), and some ADSL applications.

3.61 BA LANGATE service, which is a CO-LAN service that uses DVM technology, is widely deployed in BA. DVMs are spectrally incompatible with ADULS services depending upon the range at which the DVMs are deployed. If DVMs are operated at less than 80% of the maximum specified range, they are spectrally compatible with ADULS services. If operated at or above the 80% range, DVMs are not spectrally compatible with ADULS services and the two should be separated into different binder groups.

3.62 Analog Carrier systems are being phased out in BA. Analog Carrier systems and ADULS services should be assigned to pairs in different cables to prevent ADULS services from interfering with the Analog Carrier systems.

3.63 T1 technology (including applicable DS1ULS services) and ADULS services should be separated into non-adjacent binder groups in order to prevent the ADULS services from interfering with the T1 technology.

3.64 ADULS services are not intended for applications that have spectral energy in frequency bands that can interfere with ADSL technology or other ADULS services. Such applications include:

- Reverse ADSL applications (i.e., End-user CPE transmits downstream frequencies and CO equipment transmits upstream frequencies);
- End-user to end-user ADSL applications (i.e., The CPE at one end transmits downstream frequencies);
- Echo canceling ADSL technology that permits the upstream frequency band to overlap the downstream frequency band defined in this document.

E. Transmission Enhancement Equipment

3.65 Transmission enhancement equipment is sometimes used with IBRULS and DDSULS. Such equipment can consist of a CO span power module, a mid-span repeater, or BRI extended range system equipment.

3.66 The span power module is located in the CO and provides power to an IBRULS mid-span repeater. An IBRULS mid-span repeater regenerates the 2B1Q line code. The repeater has NT functionality that faces the OTC equipment and LT functionality that faces the RDP. A mid-span repeater is deployed when the calculated loss of the non-repeatered loop at 40 kHz (excluding BT) is > 40.0 < 76.0 dB.

3.67 BRI extended range systems consist of a unit located in the CO that has NT functionality and a 2B1Q line code that faces the OTC equipment and a remote unit near the RDP that has LT functionality and delivers a 2B1Q line code to the EU customer. The CO unit uses a line code that is spectrum compatible with BA services. The line code permits operation with a remote unit that is connected via a metallic cable that could have a 40 kHz loss of up to 60 dB.

3.68 A DDSULS mid-span repeater regenerates the DDS line code. A mid-span repeater is deployed when the calculated loss of the non-repeatered loop at 28 kHz is > 34.0 < 68.0 dB.

3.69 The impedance of transmission enhancement equipment used with IBRULS or DDSULS shall be a nominal 135 ohms.

3.70 Transmission enhancement equipment for IBRULS or DDSULS shall provide sealing current when the RDP is terminated by a direct-current resistance of 135 ohms.

4. Service Specifications

A. General

4.01 Parameters are tested at the RDP in response to trouble reports or when additional testing is purchased.

4.02 Network Channel (NC) and Network Channel Interface (NCI) codes are used for providing channel and interface information to customers. The NC/NCI code set facilitates the identification of network channel requirements and associated interface specifications for services described in tariffs.

4.03 For switched services, the NC code is an encoded representation of the channel that is provided by from the OTC Point Of Termination (POT) to the BA CO. By varying the NC code, the customer is allowed to further specify the type of service.

4.04 The NCI code is an encoded representation used to identify five interface elements located at a POT. The five elements reflect the following physical and electrical characteristics: number of physical conductors, protocol, impedance, protocol options, and transmission levels points (if applicable).

4.05 Examples of the most common NC and NCI codes are given for each service described in this section. The complete set of codes may be found in SR-STS-000307 [9].

4.06 Valid NCI code combinations are shown for each service described in this section. Complete NC/NCI compatibility information may be found in SR-STS-000323 [10].

B. IBRULS

4.07 The overall end-to-end IBRULS service is from the CODF termination of the OTC equipment to the EU customer's RDP. IBRULS services will use the DYVU service code.

4.08 IBRULS NC code information is shown in Figure 4-1 and IBRULS NCI code combinations are shown in Figure 4-2.

4.09 IBRULS Acceptance Limits (AL) and Immediate Action Limits (IAL) are shown in Table 4-3.

4.10 When digital loop carrier (DLC) is used to provide IBRULS, the DLC will provide an ISDN Basic Rate interface at the RDP that meets the network requirements in ANSI T1.601-1992 [1].

Figure 4-1: IBRULS NC Codes

NC CODE	Character 3	Character 4
UB	-	-

Figure 4-2: IBRULS NCI Code Combinations

OTC-POT	EU-POT
02QC5.OOS	02IS5

Figure 4-3: IBRULS Acceptance Limits (AL) and Immediate Action Limits (IAL)

Parameter	AL	IAL
40 kHz loss	< 40.0 dB	> 42.0 dB
Loop Resistance	< 1300 ohms	> 1300 ohms
Insulation Resistance	> 100 kilohms	< 100 kilohms
Power Influence	< 90 dB	> 90 dB

C. DS1ULS

4.11 The overall end-to-end DS1ULS service is from the DSX-1 termination of the OTC equipment to the EU customer's RDP. DS1ULS services will use the DHDU service code.

4.12 DS1ULS shall provide an electrical DSX-1 interface at the OTC-POT that meets the DSX-1 specifications in ANSI T1.102-1993 [11]. The DS1 interface at the RDP shall meets the network specifications in ANSI T1.403-1995 [2].

4.13 DS1ULS NC code information is shown in Figure 4-8, and DS1ULS NCI code combinations are shown in Figure 4-9.

4.14 DS1ULS performance objectives are shown in Figure 4-10 and DS1ULS test limits are shown in Figure 4-11.

4.15 Availability is a measure of the relative amount of time that a service is "usable" by the customer. Unavailability begins when the Bit Error Ratio (BER) in each second is worse than 1×10^{-3} for a period of 10 consecutive seconds. The DS1ULS objective is 99.925 percent availability in any twelve consecutive months. Availability equals the total time minus the outage time divided by the total time.

4.16 Accuracy denotes the error performance and is usually specified in terms of errored seconds (ES), or conversely, error-free seconds (EFS). EFS are the primary measure of error performance for DS1ULS. An EFS is any second that an error does not occur.

4.17 A Severely Errored Second (SES) is any one second interval that has a BER of less than (worse than) 1×10^{-3}.

Figure 4-4: DS1ULS NC Codes

NC CODE	Character 3	Character 4
HC	- (SF and AMI)	-
HC	D (ESF and AMI)	-
HC	E (ESF and B8ZS)	-
HC	Z (SF and B8ZS)	-
HC	E (ESF and B8ZS)	I (ISDN PRA)

Figure 4-5: DS1ULS NCI Code Combinations

OTC-POT	EU-POT
04QB9.11	04DU9-BN (SF and AMI)
04QB9.11	04DU9-DN (SF and B8ZS)
04QB9.11	04DU9-1KN (ESF and AMI)
04QB9.11	04DU9-1SN (ESF and B8ZS)

Figure 4-6: DS1ULS Performance Objectives

Parameter	Objective
Accuracy	0.25 % errored seconds long-term (30 days or more)
Availability	99.925 % per year

Figure 4-7: DS1ULS Test Limits

Test Duration	Errored Seconds	Severely Errored Seconds
15 min	0	0
30 min	3	0
45 min	5	2
24 hours	150	7

4.18 Acceptance testing for DS1ULS should be performed with a Quasi Random Signal Source (QRSS), on an OTC-POT to EU-POT basis, using ES performance parameters.

4.19 If BA has installed a loopback device on the DS1ULS, a dispatch for "cooperative testing" will not ordinarily be made and testing will be performed remotely. Normally, a technician will be dispatched by BA in the following instances:

(a) The DS1ULS is not equipped with a loopback device;
(b) The loopback device is inoperable;
(c) Test results do not meet applicable limits;
(d) The OTC requests a dispatch.

4.20 At the request of the OTC, BA will provide the remote test results to the OTC.

4.21 Other tests may be performed in response to trouble reports or when additional testing is purchased. The 3/24, 1/8, and All Ones patterns are acceptable diagnostic stress tests for DS1ULS when used in accordance with Figure 4-8.

4.22 The patterns in Figure 4-8 may not detect all possible troubles. Additional tests may be required using other patterns designed to detect specific problems (e.g. bridged tap, etc).

4.23 If errors are detected using the QRSS, 3/24, or 1/8 patterns, it is recommended that the DS1ULS line code options (AMI/B8ZS) be verified using the procedures outlined in the Bell Atlantic Network Services Reference Manual Series 72710 & NS6050 [12]. These tests make use of the Framed 2/8 and Framed 1/8 patterns.

Figure 4-8: Pattern sensitivity test criteria (see notes 1 and 2)

TEST PATTERN (see note 3)	TEST DURATION	ACCEPTANCE LIMIT[1]
All Ones	5 minutes	0
3/24 (AMI only)	5 minutes	0
1/8	5 minutes	0
Framed All Zeros (4) (B8ZS only)	30 seconds	(see note 5)

Notes:

(1) Test patterns should be framed.

(2) One retest is allowed if the initial test fails.

(3) If compatible test equipment is not available to perform these tests, loopback testing should be utilized.

(4) WARNING: If used with the DS1 SF framing format, zeros will occur in time slot 2 of every octet (channel). Terminal equipment will display a false Remote Alarm Indication (a.k.a., yellow alarm). In addition, the use of the framed all-zeros pattern through some types of DS3 equipment may cause DS1 failure if the equipment is not properly optioned for B8ZS.

(5) As an equipment option check, failure will typically be seen as large error counts. Very low counts (e.g., 1 or 2 errors) are not indicative of an optioning problem.

D. DDSULS

4.24 The overall end-to-end DDSULS service is from the CODF termination of the OTC equipment to the EU customer's RDP. DDSULS services will use the DWDU (56 kbps), PCDU (Switched 56), DWHC (56 kbps with secondary channel), and DCDU (64 kbps) service codes.

4.25 DDSULS NC code information is shown in Figure 4-9 and DDSULS NCI code combinations are shown in Figure 4-10.

4.26 DDSULS Acceptance Limits (AL) and Immediate Action Limits (IAL) are shown in Table 4-11.

Figure 4-9: DDSULS NC Codes

NC CODE	Character 3	Character 4
LX	-	-

[1] While some of the entries in this table are "0", it should be noted that an isolated error event is not necessarily indicative of a service affecting problem.

Figure 4-10: DDSULS NCI Code Combinations

OTC-POT	EU-POT
04QC5.OOP (56 kbps)	04DU5.56 (56 kbps)
04QC5.OOP (56 kbps)	04DU5.56A (Switched 56 kbps)
04QC5.OOP (56 kbps)	04DU5.56S (56 kbps with Secondary Channel)
04QC5.OOQ (64 kbps)	04DU5.64 (64 kbps)

Figure 4-11: DDSULS Acceptance Limits (AL) and Immediate Action Limits (IAL)

Parameter	AL	IAL
Foreign Voltage	< 1 volt	> 1 volt
Insulation Resistance	> 300 kilohms	< 120 kilohms
Loop Resistance	< 1300 ohms	> 1300 ohms
28 kHz Loss	≤ 34 dB	> 34 dB
Background Noise (50 kb filter)	≤ 28 dBrn	> 28 dBrn
Impulse Noise	≤ 7 counts in 15 minutes with 44 dBrn threshold	> 7 counts in 15 minutes with 44 dBrn threshold
Power Influence	< 90 dB	> 90 dB

E. HDULS

4.27 The overall end-to-end HDULS service is from the CODF termination of the OTC equipment to the EU customer's RDP. HDULS services will use the AQDU service code.

4.28 HDULS NC code information is shown in Figure 4-12 and HDULS NCI code combinations are shown in Figure 4-13.

4.29 HDULS Acceptance Limits (AL) and Immediate Action Limits (IAL) are shown in Table 4-14.

Figure 4-12: HDULS NC Codes

NC CODE	Character 3	Character 4
LX	C (NL CSA < 12kft)	-

Figure 4-13: HDULS NCI Code Combinations

OTC-POT	EU-POT
02QB5.OOH (2-Wire HDULS)	02DU5.OOH
04QB5.OOH (4-Wire HDULS)	04DU5.OOH

Figure 4-14: HDULS Acceptance Limits (AL) and Immediate Action Limits (IAL)

Parameter	AL	IAL
Foreign Voltage	< 1 volt	> 1 volt
Insulation Resistance	> 300 kilohms	< 120 kilohms
Loop Resistance	< 750 ohms	> 750 ohms
100 kHz Loss	≤ 36 dB	> 36 dB
Wideband Noise (50 kb filter)	≤ 28 dBrn	> 28 dBrn
Impulse Noise	≤ 7 counts in 15 minutes with 44 dBrn threshold	> 7 counts in 15 minutes with 44 dBrn threshold
Power Influence	< 90 dB	> 90 dB

F. ADULS-R

4.30 The overall end-to-end ADULS-R service is from the CODF termination of the OTC equipment to the EU customer's RDP. ADULS-R services will use the ARSU and ARDU service codes.

4.31 ADULS-R NC code information is shown in Figure 4-15 and ADULS-R NCI code combinations are shown in Figure 4-16.

4.32 ADULS-R Acceptance Limits (AL) and Immediate Action Limits (IAL) are shown in Table 4-17.

Figure 4-15: ADULS-R NC Codes

NC CODE	Character 3	Character 4
LX	R (NL RRD < 18kft)	-

Figure 4-16: ADULS-R NCI Code Combinations

OTC-POT	EU-POT
02QB9.OOA (DMT)	02DU9.OOA (DMT)
02QB9.OOC (CAP)	02DU9.OOC (CAP)
02QB9.O1A (POTS + DMT)	02DU9.O1A (POTS + DMT)
02QB9.O1C (POTS + CAP)	02DU9.O1C (POTS + CAP)

Figure 4-17: ADULS-R Acceptance Limits (AL) and Immediate Action Limits (IAL)

Parameter	AL	IAL
Foreign Voltage	< 1 volt	> 1 volt
Insulation Resistance	> 300 kilohms	< 120 kilohms
Loop Resistance	< 1300 ohms	> 1300 ohms
1004 Hz loss *	< 8.5 dB	> 10.0 dB
100 kHz Loss	≤ 53 dB	> 53 dB
C-Message Noise *	< 30 dBrnC	> 30 dBrnC
Wideband Noise (50 kb filter)	≤ 28 dBrn	> 28 dBrn
Impulse Noise	≤ 7 counts in 15 minutes with 44 dBrn threshold	> 7 counts in 15 minutes with 44 dBrn threshold
Power Influence	< 90 dB	> 90 dB

* Voice band parameters do not apply to non-POTS applications.

G. ADULS-C

4.33 The overall end-to-end ADULS-C service is from the CODF termination of the OTC equipment to the EU customer's RDP. ADULS-C services will use the ARSU and ARDU service codes.

4.34 ADULS-C NC code information is shown in Figure 4-18 and ADULS-C NCI code combinations are shown in Figure 4-19.

4.35 ADULS-C Acceptance Limits (AL) and Immediate Action Limits (IAL) are shown in Table 4-20.

Figure 4-18: ADULS-C NC Codes

NC CODE	Character 3	Character 4
LX	C (NL CSA < 12kft)	-

Figure 4-19: ADULS-C NCI Code Combinations

OTC-POT	EU-POT
02QB9.OOA (DMT)	02DU9.OOA (DMT)
02QB9.OOC (CAP)	02DU9.OOC (CAP)
02QB9.O1A (POTS + DMT)	02DU9.O1A (POTS + DMT)
02QB9.O1C (POTS + CAP)	02DU9.O1C (POTS + CAP)

Figure 4-20: ADULS-C Acceptance Limits (AL) and Immediate Action Limits (IAL)

Parameter	AL	IAL
Foreign Voltage	< 1 volt	> 1 volt
Insulation Resistance	> 300 kilohms	< 120 kilohms
Loop Resistance	< 750 ohms	> 750 ohms
1004 Hz loss *	< 5.0 dB	> 6.0 dB
100 kHz Loss (between 100ohms)	≤ 36 dB	> 36 dB
C-Message Noise*	< 30 dBmC	> 30 dBmC
Wideband Noise (50 kb filter)	≤ 28 dBm	> 28 dBm
Impulse Noise	≤ 7 counts in 15 minutes with 44 dBm threshold	> 7 counts in 15 minutes with 44 dBm threshold
Power Influence	< 90 dB	> 90 dB

* Voice band parameters do not apply to non-POTS applications.

5. OTC Equipment and CO Cabling Requirements

A. OTC Equipment Requirements

5.01 Collocated OTC equipment used for interconnection with digital unbundled loop services shall meet all of the applicable generic equipment requirements in Bellcore GR-63-CORE [13] and Bellcore GR-1089-CORE [14].

5.02 Collocated OTC equipment used for interconnection with digital unbundled loop services shall be manufactured in accordance with FCC, NEC, UL, and USDL requirements and orders applicable to Federal, State, and local requirements including, but not limited to, statutes, rules, regulations, orders, or ordinances, or otherwise imposed by law. Requirements that are not specified in this document, contractual technical requirements, or other applicable documents, shall meet the manufacturer's requirements consistent with industry standards.

5.03 The open circuit tip-to-ring dc voltage that collocated OTC equipment applies to BA VF cabling shall be less than 80 Vdc.

5.04 Collocated OTC equipment shall not deliver more than 2.5 watts of power to any load via BA VF cable.

5.05 Collocated OTC equipment shall not deliver more than 150 mA of loop current to any load via BA VF cable.

5.06 The noise limits for digital unbundled loop services require collocated OTC equipment to have a longitudinal balance of >60 dB.

5.07 The loss and noise limits for IBRULS requires collocated OTC equipment to have a nominal impedance of 135 ohms.

5.08 The maximum power level of any transmitted signal on an IBRULS shall not exceed the PSD mask in Figure 2-2 and the specifications in ANSI T1.601-1992 [1].

5.09 The maximum power level of any transmitted signal on a DS1ULS shall not exceed the specifications in ANSI T1.403-1993 [2].

5.10 The maximum power level of any transmitted signal on a DDSULS shall not exceed the specifications in ANSI T1.410-1992 [3].

5.11 The maximum power level of any transmitted signal on an HDULS shall not exceed the PSD mask in Figure 2-7 and the specifications in T1 Technical Report No. 28 [4].

5.12 The maximum power level of any transmitted downstream signal on an ADULS-R shall not exceed the downstream PSD mask in Figure 2-10 and the maximum power level of any transmitted downstream signal on an ADULS-C shall not exceed the downstream PSD mask in Figure 2-11.

5.13 Loops may be exposed to electrical surges from lightning and commercial power system disturbances. Despite protective devices on the CODF, some of these disturbances are likely to reach OTC equipment. OTC equipment shall be designed to withstand certain surges without being damaged, and shall fail in a safe manner under infrequent high stress.

5.14 The prevalent voltage-limiting device available for CO use is the 3-mil carbon block. This device has an upper 3σ limiting voltage of 1000 volts peak under surge conditions and 600 volts rms (800 peak) at 60 Hz. OTC equipment connected to digital unbundled loop services with loops protected by carbon blocks may

be subjected to voltages up to these levels. Unexposed COs may not have primary protection, and OTC equipment not co-ordinating with carbon blocks may need protection in these locations.

5.15 If the subscriber loop facility is exposed to commercial ac power, the CO protector may also include 350 mA heat coils for limiting the current that is permitted to flow to CO equipment. In addition, a protective fuse cable located outside the CO incorporating 24 or 26 AWG conductors to coordinate with the protector, serves to limit current to safe levels in the event of prolonged operation of the protector during power fault conditions.

B. OTC Equipment CO Cabling Requirements

5.16 The CO cabling used to terminate OTC equipment on the CODF shall use twisted-pair conductors.

5.17 The type, gauge, and length of the OTC CODF cabling shall be specified based on this specification and OTC equipment requirements. If the specifications in this document differ from the OTC equipment manufacturers specifications, then the more stringent of the two shall be used.

5.18 The direct-current resistance of the CO cabling between the OTC equipment and the CODF shall meet the CO cabling requirements in the Bellcore FR-TSY-000064 [15] (i.e., 23 ohms or less). This is equivalent to 275 feet or less of 26 gauge cable, 440 feet or less of 24 gauge cable, and 700 feet or less of 22 gauge cable.

5.19 All CO cabling between OTC equipment and the CODF shall be connected as specified by the BA CO Engineer.

5.20 The 1kHz loss of the CO cabling between the OTC equipment and the CODF, when measured between 900 ohm impedances, shall be less than .15 dB.

5.21 The C-message noise measured on the CO cabling between the OTC equipment and the CODF shall be 20 dBrnC or less.

C. OTC DSX-1 Cabling Requirements

5.22 OTC DSX-1 cabling and build-out in each direction of transmission shall be the equivalent of 655 feet of 22 gauge ABAM cable.

6. References

A. Definitions

Asymmetrical Digital Subscriber Line (ADSL)
A system that is capable of transmitting digital signals up to 6 Mbps toward the EU-POT and up to 640 kbps from the EU-POT.

ADSL Unbundled Loop Service (ADULS)
A service that provides an effective 2-wire channel, suitable for the transport of ADSL, between the Bell Atlantic central office distributing frame termination of collocated equipment belonging to an OTC and the rate demarcation point at a customer location. Two types of ADULS channels are offered: ADULS-R (up to 18 kft) and ADULS-C (up to 12 kft).

Basic Rate Integrated Services Digital Network Interface (BRI)
The BRI is a 2-wire ISDN interface that uses the two-binary one-quaternary line code at a 160 kilobit per second rate to transport overhead and up to two B channels and one D channel.

B Channel
The B channel is a 64 kilobit per second channel used for information transfer between users.

Bit
An abbreviation for binary digit; one of the members of a set of two in the binary numeration system, e.g., either or the digits 0 or 1. Also, a unit of information; one bit of information is sufficient to specify one of two equal and likely possibilities, usually meaning *yes* or *no*.

Bridged tap
Any branch section of a cable pair, or any extension of a cable pair beyond the point where it is used, in which no direct current flows when customer equipment is connected and used.

Carrierless AM/PM (CAP)
An ADSL line code technique that maps serial bits into phase and quadrature symbols and uses a filter to provide passband spectral shaping.

Carrier Serving Area (CSA) Design
Loop distribution design guidelines developed for wire extensions from Digital Loop Carrier Remote Terminals to customer premises. CSA design criteria allows up to 12 kft of 24 gauge cable less any bridged tap, or up to 9kft of 26 gauge cable less any bridged tap. Bridged tap is limited to 2.5 kft.

Central Office (CO)
A telephone company building which houses equipment and facilities used to provide switched access services.

Central Office Distributing Frame (CODF)
Framework located in a CO that holds wire cross-connects which are used to interconnect cable terminations for EU customer loops, switching system ports, and inter-office facilities.

Channel
An electrical, or photonic communications path between two or more points of transmission.

C-Message Noise
The frequency-weighted, short-term average noise within an idle channel. The frequency weighting, called C-message, is used to account for the variations in 500-type telephone set transducer efficiency and EU annoyance to tones as a function of frequency.

dBm
A unit for expression of power level in decibels relative to one milliwatt.

dBrn
A unit used to express noise power in decibels relative to one picowatt (-90 dBm).

dBm0
A unit used to express power level in decibels relative to one milliwatt referred to, or measured at, a zero transmission level point (0TLP). A unit used to express noise power in decibels relative to one picowatt measured with C-message weighting.

dBrnC0
Noise power in dBrnC referred to, or measured at, a zero transmission level point (0TLP).

D Channel
The D Channel is a 16 kilobit per second packet-switched channel that carries signaling and control for the B channels and also supports customer packet data traffic at speeds up to 9.6 kilobits per second.

Decibel (dB)
The logarithmic unit of signal power ratio most commonly used in telephony. It is used to express the relationship between two signal powers, usually between two acoustic, electric, or optical signals; it is equal to ten times the common logarithm of the ratio of the two signal powers.

Digital Data Service (DDS)
A service that permits the transmission of synchronous data, in a digital form, in both directions simultaneously (full duplex) at 64 kbps and subrates.

DDS Unbundled Loop Service (DDSULS)
A service that provides a 4-wire channel, suitable for the transport of Digital Data Service signals at 56 or 64 kbps between the Bell Atlantic central office distributing frame termination of collocated equipment belonging to an OTC and the rate demarcation point at a customer location.

Digital Signal Level One (DS1)
A digital signal transmitted at the nominal rate of 1.544 Mbit/s.

Discrete Multitone (DMT)
An ADSL line code that is a version of multi-carrier modulation that allows allocation of physical payload data bits and perhaps transmitter power among many subchannels depending on the loss and interference encountered.

Drop wire
The last portion of many subscriber loops that connects the distribution cable to the customer premises. The most common aerial drop wire (F-type) has parallel 18 ½ gauge steel conductors that are not twisted. Drop wires are usually less than 700 feet and less than 25 ohms.

Digital Signal Cross-Connect Level One (DSX-1)
A mechanical DS1 cross-connect frame where +/- 3 volt bipolar AMI signals are interconnected.

Facilities
Any cable, poles, conduit, microwave, or carrier equipment, central office distributing frames, central office switching equipment, computers (both hardware and software), business machines, etc., utilized to provide the services offered by a telephone company.

High-Bit-Rate Digital Subscriber Line (HDSL)
A system that is capable of transmitting bi-directional DS1 (1.544 Mbps) signals or bi-directional half DS1 (768 kbps) signals over metallic twisted-pair cables to provide access to digital telecommunications services.

HDSL Unbundled Loop Service (HDULS)
A service that provides a 2-wire or 4-wire metallic channel, suitable for the transport of HDSL, between the Bell Atlantic central office distributing frame termination of collocated equipment belonging to an OTC and the rate demarcation point at a customer location.

Insulation Resistance
The resistance between the tip and ring conductors of an insulated metallic pair or the resistance between each conductor and ground. Also known as leakage.

Integrated Services Digital Network (ISDN)
ISDN describes the end-to-end digital telecommunications network architecture which provides for the simultaneous access, transmission , and switching of voice, data, and image services. These functions are provided via channelized transport facilities over a limited number of standard user-network interfaces.

ISDN Basic Rate Unbundled Loop Service (IBRULS)
An unbundled loop service that provides an ISDN basic rate channel between the Bell Atlantic central office distributing frame termination of collocated equipment belonging to an OTC and the rate demarcation point at a customer location.

Loop
A transmission channel between a EU customer location and a BA CO that is used as a transmission channel for telephone company services.

Other Telephone Company (OTC)
An organization that provides telecommunications services to the public.

Plain Ordinary Telephone Service (POTS)
The basic single line switched access service offered by local exchange carriers to residential and business customers. POTS uses loop-start signaling.

Power Influence (PI)
The power of a longitudinal signal induced in a metallic loop by an electromagnetic field emanating from a conductor or conductors of a power system. PI is also called longitudinal noise or noise-to-ground.

Rate Demarcation Point (RDP)
The point at which Bell Atlantic network access recurring charges and responsibility stop and beyond which customer responsibility begins. The RDP is the point of demarcation and/or interconnection between a Bell Atlantic subscriber loop facility and EU premises cabling or terminal equipment. Bell Atlantic facilities at, or constituting, the rate demarcation point shall consist of wire or a connector conforming to Subpart F of Part 68 of FCC rules.

Revised Resistance Design (RRD)
Loop design guidelines used after 1986. RRD design criteria allows up to 1300 ohms of non-loaded cable. Non-loaded cable is further limited in length to 18 kft. The total length of all bridged tap should not exceed 6 kft. The total length of all non-loaded cable plus the length of all bridged tap should not exceed 18 kft. Loaded bridged tap is not permitted.

Secondary Channel
A capability that offers the customer a companion digital transmission channel independent of the Primary Channel at a lower bit rate than the Primary Channel.

Synchronous Transmission
Transmission that has three levels of synchronization: bit, character, and message. Bit synchronization refers to the need for the transmitter and receiver to operate at the same rate. Other levels of synchronization refer to the need for the transmitter and receiver to achieve proper phase alignment, so that the beginning and end of a character, message, time slot, or frame can be readily, identified for information retrieval.

Transmission Enhancement Equipment
In general, any equipment that improves the characteristics of a transmitted signal. In this document, transmission enhancement equipment is any equipment that regenerates a digital signal.

Unbundled Loop
A transmission channel between a EU customer location and a LEC CO that is not a part of, or connected to, other LEC services.

Voice Grade (VG)
A term used to describe a channel, circuit, facility, or service that is suitable for the transmission of speech, digital or analog data, or facsimile, generally with a frequency range of about 300 to 3000 Hz.

B. Acronyms

ADSL	Asymmetrical Digital Subscriber Line
ADULS	ADSL Unbundled Loop Service
ADULS-R	ADSL Unbundled Loop Service - Type 1
ADULS-C	ADSL Unbundled Loop Service - Type 3
AL	Acceptance Limit
AMI	Alternate Mark Inversion
ANSI	American National Standards Institute
BA	Bell Atlantic
BER	Bit Error Ratio
BRI	Basic Rate ISDN
BRITE	Basic Rate ISDN Terminal Equipment
B8ZS	Bit Eight Zero Suppression
CPE	Customer Premises Equipment
CAP	Carrierless AM/PM
CO	Central Office
CODF	Central Office Distributing Frame
COT	Central Office Terminal
CSA	Carrier Serving Area
DDS	Digital Data Service
DDSULS	DDS Unbundled Loop Service
DLC	Digital Loop Carrier
DMT	Discrete Multi-Tone
DSX-1	Digital Signal Cross-Connect Level One
DS0	Digital Signal Level Zero
DS1	Digital Signal Level One
DS1ULS	DS1 Unbundled Loop Service
DVM	Data-Voice Multiplexer
EFS	Error-Free Seconds
ESF	Extended Superframe Format
EU	End-User
HDSL	High-Bit-Rate Digital Subscriber Line
HDULS	High-Bit-Rate Digital Unbundled Loop Service
IAL	Immediate Action Limit
IBRULS	ISDN Basic Rate Unbundled Loop Service
ISDN	Integrated Services Digital Network
LAN	Local Area Network
LT	Line Terminating
NC	Network Channel
NCI	Network Channel Interface
NID	Network Interface Device
NT	Network Terminating
OTC	Other Telephone Company
PI	Power Influence
POT	Point of Termination
POTS	Plain Ordinary Telephone Service
RDP	Rate Demarcation Point
RRD	Revised Resistance Design
RT	Remote Terminal
SES	Severely Errored Second
SF	Superframe Format
USOC	Universal Service Order Code
VF	Voice Frequency
VG	Voice Grade
2B1Q	Two-Bit One-Quaternary

7. Bibliography

1- ANSI T1.601-1992, American National Standard for Telecommunications - *ISDN - Basic Access Interface for Use on Metallic Loops for Application at the Network Side of NT, Layer 1 Specification*.[2]

2- ANSI T1.403-1995, American National Standard for Telecommunications - *Network-to-Customer Installation - DS1 Metallic Interface*.[2]

3- ANSI T1.410-1992, American National Standard for Telecommunications - *Carrier-to-Customer Metallic Interface - Digital Data at 64 kbit/s and Subrates*,

4- Committee T1 - Telecommunications Report No. 28, *A Technical Report on High-Bit-Rate Digital Subscriber Lines (HDSL)*, 1992.

5- ANSI T1.413-1995, American National Standard for Telecommunications - *Network and Customer Installation Interfaces - Asymmetric Digital Subscriber Line (ADSL) Metallic Interface*.[2]

6- ANSI T1.401-1993, American National Standard for Telecommunications - *Interface Between Carriers and Customer Installations - Analog Voicegrade Switched Access Lines Using Loop-Start and Ground-Start Signaling*.

7- Special Report SR-TSV-002275, Issue 2, *BOC Notes on the LEC Networks - 1994*. Bellcore; 1994.[3]

8- ANSI/IEEE 743-1995, *Standard Methods and Equipment for Measuring the Transmission Characteristics of Analog Voice Frequency Circuits*.[2]

9- Special Report SR-STS-000307, *NC/NCI Code Dictionary,* Issue 6, Bellcore, May 1995.[3]

10- Special Report SR-STS-000323, *NC/NCI Compatibility Guide,* Issue 4, Bellcore, May 1994.[3]

11- ANSI T1.102-1993, American National Standard for Telecommunications - *Digital Hierarchy - Electrical Interfaces,*.[2]

12- Bell Atlantic Network Services Reference Manual Series 72710 & NS6050.

13- Generic Requirements GR-63-CORE, *Network Equipment-Building System (NEBS) Requirements: Physical Protection*, Issue 1, Bellcore, December 1995.[3]

14- Generic Requirements GR-1089-CORE, *Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment*, Issue 1 Bellcore, December 1994.[3]

15- Technical Reference FR-NWT-000064, *LATA Switching Systems Generic Requirements* (LSSGR), Bellcore, 1994.[3]

NOTE: These documents are subject to change. References reflect the most current information available at the time of printing. Readers are advised to check the status and availability of all documents.

---

[2] To obtain ANSI documents, contact American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

EXHIBIT NO. 2

An office is considered unsatisfactory if four or more steady-state or average-peak measurements exceed the lower limits or if any single measurement of either type exceeds the upper limits. In this case, corrective action should be taken.

If one, two, or three measurements of both types exceed the lower but not the upper limits, the condition of the office is considered doubtful. In such cases, another 20 connections are tested to improve the sample accuracy. If no more than 3 of the 40 readings exceed the lower limits, the office is now acceptable. On the other hand, if 4 or more of the 40 measurements exceed the lower limits, the office is unacceptable and needs corrective action.

An RSU is a switching entity controlled by and classified as part of a host electronic switching system. In many respects, such a remote is analogous to a peripheral frame within the host switch. The RSU should be transparent to a subscriber served by it. Hence, the GOS for the RSU-served customer should be equivalent to that of a user served by the host. From a noise-impairment point of view, loops from the subscriber to the remote should satisfy the usual loop requirements. The combination of the remote, the connecting channel, and the host switching system is considered as a single unit, even though the link channel is a normal carrier facility. To maintain the necessary GOS, the noise level of the channel must be kept below 20 dBrnC.

7.14.6.2 Impulse Noise

In digital switches, impulse noise can come from defective circuit packs in the time-slot interchange, which cause bit errors. Impulse noise limits for switching offices are given in Table 7-8.

7.15 Loop Transmission — Design and Characterization

The loop between the demarcation point at the customer location and the end office is an important link in any telephone connection. Satisfactory design of the loop is as important to overall transmission performance as the design of a trunk or switch. Loss objectives for loops are not explicitly stated; instead, loop loss is controlled by the use of design rules.

Before 1980, almost all loops were designed according to resistance design (96 percent) or long-route design (3 percent). The success of DLC made possible a third design plan, the carrier serving area concept. Fundamental to all three plans is the notion that designing loop facilities on an individual basis would be prohibitively expensive and extremely difficult to administer. Instead, loops are laid out on a global basis through rules designed to help ensure the following:

1. No loop exceeds the office signaling range

2. All customers receive at least 20 mA of loop current into an assumed station resistance of 430 Ω
3. The distribution of loop transmission losses is satisfactory.

7.15.1 Revised Resistance Design

Revised Resistance Design (RRD) is the current, urban/suburban design plan replacing resistance design. RRD rules apply to loops with resistance of 1500 Ω or less and length of 24 kft or less. RRD is an outside-plant design that is consistent, economical, operationally simple, and most importantly, capable of providing improved loop transmission performance.

The major differences between this plan and resistance design are that RRD allows a higher, maximum loop resistance for loaded loops (1500 Ω instead of 1300, central office range permitting) and reduces the amount of bridged-tap allowed. The maximum length of 18 kft for nonloaded loops is the same in both plans, except that in RRD the maximum length includes the length of any bridged-tap. The rule changes result in transmission improvements and outside-plant savings. Under some circumstances, the RRD plan reduces dc signaling margins because of the increase in maximum loaded-loop resistance to 1500 Ω. However, few modern switches have loop ranges below 1600 Ω. Table 7-11 summarizes the RRD plan rules.

7.15.2 Modified Long-Route Design

Loops longer than 24 kft, typically found in rural areas, are designed using DLC as first choice, or Modified Long-Route Design (MLRD). MLRD, also summarized in Table 7-11, was introduced in 1980 to provide for loops range-extended on a per-line basis. Under this plan, the 1500- to 2000-Ω range is designated as Resistance Zone 18 (RZ 18) with additional gain (3 dB) required. The 2000- to 2800-Ω range (RZ 28) requires 6 dB of gain.

When a wire center is totally equipped with newer range extenders (which automatically switch their net-gain settings from 3 to 6 dB, as required), it is not necessary to maintain and administer separate transmission zones in that wire center. Therefore, all loops under MLRD can be considered to be in a single range-extended zone. However, some companies that administer ringing range limitations by zone or have a large number of older range-extension circuits may still use RZ 18 and RZ 28 zoning.

MLRD is not limited to long rural loops and can be applied anywhere it is economically justified. While existing loops need not be rebuilt to conform to the new plan, the gain application rules indicated here are used for new loop designs that utilize existing cable.

Table 7-11. Loop Design Plans

Design Parameter	Carrier Serving Area	Revised Resistance Design	Modified Long-Route Design
Loop Resistance (Ω)*	N/A (limited by loss)	0-18 kft: 1300 max. 18-24 kft: 1500 max.	1501-2800
Loading	None**	Full H88 > 18 kft	Full H88
Cable Gauging	Two gauges, except stubs and fuse cables (max. lengths including BT): • 24-, 22-, and/or 19-gauge: 12 kft • 26-gauge: 9 kft†	Two-gauge combinations (22-, 24-, 26-gauge) preferred	
Bridged Tap (BT) and End Section (ES)	Total BT 2.5 kft max. No single BT > 2 kft	Nonloaded cable & BT: 18 kft max. Total BT: 6 kft max.	ES & BT: 3 to 12 kft
		Loaded: ES & BT, 3 to 12 kft	
Transmission Limitations	None; supports ISDN DSL, 56-kb data, and "despecialized" special services	Compatible with ISDN DSL. No digital services > 18 kft.	No digital services. Needs range extender with gain if > 1500 Ω.

* Includes (only) the resistances of the cable and loading coils.

** At least one exchange carrier uses an "extended Carrier Serving Area (CSA)" in some rural areas. This variant allows loading but does not accommodate digital services.

† Multigauge designs incorporating 26 gauge are restricted in total length to $12 - [3L_{26}/(9 - BT]$ kft, where L_{26} is the total length of the 26-gauge and BT is the sum of bridged taps of all gauges.

7.15.3 Concentrated Range Extender with Gain

Some analog electronic wire centers use Concentrated Range Extender with Gain (CREG) design. This plan allows increased use of fine-gauge facilities in the outside plant by providing repeaters, each associated with a stage of switching concentration. The CREG design is compatible with the loading arrangements in both the RRD and MLRD plans.