All drawings appearing in this Recommendation have been done in Autocad.

Recommendation Q.543

DIGITAL EXCHANGE PERFORMANCE DESIGN OBJECTIVES

1 General

This Recommendation applies to digital local, combined, transit and international exchanges for telephony in Integrated Digital Networks (IDN) and mixed (analogue/digital) networks, and also to local, combined, transit and international exchanges in an Integrated Services Digital Network (ISDN).

The field of application of this Recommendation is more fully defined in Recommendation Q.500. As to the application in an ISDN, transit connections and exchange connections types I, II, III and IV as defined in Recommendation Q.522 are covered (Notes 1 and 2). Other types of connection and variants of these connections may be feasible in ISDN and will be the subject of further study.

These performance design objectives are applicable to all exchange implementations at all points in the growth cycle up to the maximum size. These reference loads and performance objectives may be used by manufacturers in designing digital switching systems and by Administrations in evaluating a specific exchange design or for comparing different exchange designs for potential use in the Administration's intended implementation.

These recommended performance design objectives relate to the technical capabilities of exchange design. They are intended to assure that exchanges operating in their intended implementation will be capable of supporting the network grades of service recommended in the E.500–series of Recommendations and will offer a level of performance consistent with the overall network performance objectives given in the I–series of Recommendations. The recommended parameters are *design objectives* which should not be construed to be grade of service or operating requirements. In actual operation, exchanges will be engineered to provide adequate grades of service as economically as possible and the *performance requirements* (delays, blocking, etc.) of the exchange in operation will *differ from* the recommended values for these performance *design objectives*.

2 Performance design objectives

2.1 *xe ""§Reference loads*

The given reference loads are traffic load conditions under which the performance design objectives stated in §§ 2.2 to 2.7 are to be met. In order to have a comprehensive characterization of exchange reference loads, supplementary services and other types of services must be taken into account. Administrations may specify hypothetical models for use in computing exchange

loading. These models should characterize the sets of traffic parameters and services that are considered to be typical in the intended application of the exchange, and should include the traffic mix (originating–internal, originating–outgoing, incoming–terminating, transit, abandoned, busy non–answer, etc.), the mix of service classes (residential, business, PABX, coin, etc.), the types and volume of supplementary services (call waiting, call forwarding, etc.) and any other pertinent characteristics. Using the above information, it should be possible to "engineer" the exchange to produce the model. It should also be possible to determine the maximum size of the exchange by the computations discussed in § 2.1.4.

Reference load A is intended to represent the normal upper mean level of activity which Administrations would wish to provide for on customer lines and inter–exchange activities. Reference load B is intended to represent an increased level beyond normal planned activity levels. (Recommendations E.500 and E.520 recommended that the normal provisioning of international circuits in automatic and semi–automatic operation be based on a particular loss probability during the mean busy hour and the average traffic estimated for the "five busiest days" as set down in Recommendation E.500.)

Note 1 – For the time being, the following definitions and corresponding values are only applicable to 64 kbit/s circuit switched connections, i.e., including transit connections and connection types I, II and III option a). Other rates and transfer modes require further study.

Note 2 – The applicability of this document to connections originating or terminating on PABXs is for further study.

2.1.1 *Reference load on incoming interexchange circuits*

a) Reference load A

–

Call attempts/h =

Note – Ineffective call attempts must be included in reference call attempts.

b) Reference load B

–

with 1.2 times the call attempts/h for reference load A.

2.1.2 *Reference load on subscriber lines (originating traffic)*

Characteristics of traffic offered to local exchanges vary widely depending upon factors such as the proportions of residence and business lines that are served. The following Table 1/Q.543 provides reference load characteristics for lines typical of four possible local exchange applications. Also provided are representative ISDN cases which are discussed below. Administrations may elect to use other models and/or loads that are more suitable for their intended application.

In the following text, ISDN lines will be referred to as digital lines and non–ISDN lines as analogue lines.

2.1.2.1 *Reference load A*

TABLE 1/Q.543

Subscriber line traffic model

a) *Non–ISDN subscriber lines with or without supplementary services*

Exchange type	Average traffic intensity	Average BHCA
W	0.03 E	1.2
X	0.06 E	2.4
Y	0.10 E	4.8
Z	0.17 E	

6.8

b) *ISDN digital subscriber access 2B + D*

The following ISDN models and traffic parameters are provisional and may be revised in subsequent study periods.

Line type	Average traffic intensity per B channel	Average BHCA per B channel	Average packets per second per D channel
Y`	0.05 E	2	0.05 (signalling) + Data packets a)
Y``	0.10 E	4	0.1 (signalling) + Data packets a)
Y```	0.55 E	2	0.05 (signalling) + Data packets a)

BHCA Busy hour call attempts.

a) Data packet rates are for further study. These include teleaction and packet services data.

Even though only limited ISDN traffic data is available, the specification of the corresponding reference loads remains an important factor in exchange evaluation. For the case of digital subscriber lines in Table 1/Q.543 b), access is assumed to utilize the Basic Access with 2B + D channels. The B channels are available for circuit–switched calls, while the D channel is used to carry signalling information or may be used to carry teleaction data and packet switched data. It is assumed that digital lines typically carry traffic comparable with the heavy–traffic analogue lines designated as case Y in Table 1/Q.543 a). Three cases representing likely ISDN applications are included in the table.

Case Y`
: traffic per pair of B channels comparable to 1 Case Y line.

Case Y``
: traffic per pair of B channels comparable to 2 Case Y lines.

Case Y``` : traffic per pair of B channels comparable 1 Case Y line plus some very high traffic (e.g., circuit switched data traffic at 1 erlang).

Each of these digital lines also carries the associated ISDN signalling and data services on the D channel. For the circuit switched calling rates specified in Table 1/Q.543 b), ISDN signalling is expected to contribute less than 0.05 packet per second per digital subscriber line. The packet rates for D channel ISDN data services can be much larger than this; however, these are left for further study.

2.1.2.2 *Reference load B*

Reference load B is defined as a traffic increase over reference load A of:

+25% in erlangs, with +35% in BHCA.

Reference load B levels for D channel activity are for further study.

2.1.3 *Impact of supplementary services*

If the reference model exchange assumes that significant use is made of supplementary services, the performance of the exchange can be strongly affected, especially in exchange designs where processor capacity can become a limiting item. The performance delays recommended in §§ 2.3 and 2.4 can be significantly lengthened at a given call load under such circumstances. The Administration or Operating Agency defining the reference model should estimate the fractions of calls which use various supplementary services so that an average processor impact relative to a basic telephone call can be calculated (e.g., possibly by a methodology similar to that of Annex A to this Recommendation).

2.1.4 *Exchange capacity*

In order to evaluate and compare exchange designs, an Administration will usually want

to know the maximum possible size of the exchange for the intended implementation. While several factors may limit exchange capacity, processing capacity will frequently be the limiting factor. The maximum possible number of lines and circuits served by an exchange, *while meeting performance objectives*, will depend on the mix, volumes and types of traffic and the services expected in the particular implementation.

Two methods of determining exchange processing capacity are provided in the annexes to this Recommendation:

– Annex A provides an example of methodology for computing processing capacity of an exchange using information provided by the manufacturer and estimates of traffic mix and load provided by the Administration.

– Annex B provides an example of methodology for estimating the capacity of an exchange by making projections from measurements made on a functioning exchange in the laboratory or in the field. The test exchange must be representative of mix and load of traffic and services expected at maximum size.

2.1.5 *Reference loads on other accesses and interfaces*

At this time, other applications, such as n × 64 kbit/s on the Primary Rate Interface, are left for further study.

2.2 **inadequately handled call attempts**

2.2.1 *Definition*

Inadequately handled call attempts are attempts which are blocked (as defined in the E.600–series of Recommendations) or are excessively delayed within the exchange. "Excessive delays" are those that are greater than three times the "0.95 probability of not exceeding" values recommended in the tables in §§ 2.3 and 2.4. (See Note.)

For originating and transit calls, this inadequately handled call attempt parameter applies only when there is at least one appropriate outlet available.

Note – Provisionally, call request delay is not included in this parameter. Further study is required.

2.2.2 *Probability of inadequately handled call attempts occurring*

The values in Table 2/Q.543 are recommended.

TABLE 2/Q.543

Type of connection

Reference load A

Reference load B

Internal

10–2

4 × 10–2

Originating

5 × 10–3

3 × 10–2

Terminating

5 × 10–3

3 × 10–2

Transit

10–3

10–2

2.3 *xe ""§Delay probability – non–ISDN or mixed (ISDN – non–ISDN) environmentt*

The non–ISDN environment is composed of analogue subscriber lines and/or circuits that use either channel associated or common channel signalling.

The ISDN environment is composed of digital (ISDN) subscriber lines and/or circuits that use common channel signalling.

This section defines delay parameters related to non–ISDN environment and mixed (ISDN – non–ISDN) environment.

When a delay parameter in this section is also applicable to the pure ISDN environment,

a reference to the appropriate part of § 2.4 (delay probability – ISDN environment) is provided.

In the following delay parameters, it is understood that delay timing begins when the signal is "recognizable", that is, after the completion of signal verification, where applicable. It does not include line–dependent delays for the recognition of induced voltage conditions or line transients.

The term "mean value" is understood to be the expected value in the probabilistic sense.

Where several messages are received at the exchange from a digital subscriber line signalling system (e.g., several alert messages are received from a multi–user configuration), the message that is accepted for call handling is the one considered in determining the start of a given delay interval.

Where common channel signalling (including inter–exchange and subscriber line signalling) is involved, the terms "received from" and "passed to" the signalling system are used. For CCITT Signalling System No. 7, this is designated as the instant the information is exchanged between the signalling data link (layer 1) and the signalling link functions (layer 2). For digital subscriber line signalling, this is designated as the instant the information is exchanged by means of primitives between the data link layer (layer 2) and the network layer (layer 3). Thus, the time intervals exclude the above layer 1 (CCITT Signalling System No. 7), and layer 2 (D channel) times. They do, however, include queuing delays that occur in the absence of disturbances but not any queuing delays that occur in the absence of disturbances but not any queuing delays caused by re–transmission.

2.3.1 xe ""§incoming response delay – transit and terminating incoming traffic connections

Incoming response delay is a characteristic that is applicable where channel associated signalling is used. It is defined as the interval from the instant an incoming circuit seizure signal is recognizable until a proceed–to–send signal is sent backwards by the exchange.

The values in Table 3/Q.543 are recommended.

TABLE 3/Q.543

	Reference load A	Reference load B
Mean value	£ 300 ms	

£ 400 ms

0.95 probability of not exceeding

400 ms

600 ms

2.3.2 xe ""§local exchange call request delay – originating outgoing and internal traffic connections

2.3.2.1 For ANALOGUE SUBSCRIBER LINES, call request delay is defined as the interval from the instant when the off–hook condition is recognizable at the subscriber line interface of the exchange until the exchange begins to apply dial tone to the line. The call request delay interval is assumed to correspond to the period at the beginning of a call attempt during which the exchange is unable to receive any call address information from the subscriber.

The values in Table 4/Q.543 are recommended.

TABLE 4/Q.543

Reference load A

Reference load B

Mean value

£ 400 ms

£ 800 ms

0.95 probability of not exceeding

600 ms

1000 ms

Note – The above values are understood to apply when a continuous tone, i.e., without a cadence, is used and do not include delays caused by functions such as line tests, which may be used in national networks.

2.3.2.2 For DIGITAL SUBSCRIBER LINES using overlap sending, call request delay is defined as the interval from the instant at which the SETUP message has been received from the subscriber signalling system until the SETUP ACKNOWLEDGE message is pased back to the subscriber signalling system.

Note – In this case this parameter is equivalent to the user signalling acknowledgement delay (see § 2.4.1).

The values in Table 5/Q.543 are recommended.

TABLE 5/Q.543

Reference load A

Reference load B

Mean value

£ 400 ms

£ 800 ms

0.95 probability of not exceeding

600 ms

1000 ms

2.3.2.3 For DIGITAL SUBSCRIBER LINES using en–bloc sending, call request delay is

defined as the interval from the instant at which the SETUP message is received from the subscriber signalling system until the call proceeding message is passed back to the subscriber signalling system.

The values in Table 6/Q.543 are recommended.

TABLE 6/Q.543

	Reference load A	Reference load B
Mean value	£ 600 ms	£ 900 ms
0.95 probability of not exceeding	800 ms	1200 ms

2.3.3 xe ""§exchange call set–up delay – transit and originating outgoing traffic connections

Exchange call set–up delay is defined as the interval from the instant that the information is required for outgoing circuit selection is available for processing in the exchange, or the signalling information required for call set–up is received from the signalling system, until the instant when the seizing signal has been sent to the subsequent exchange or the corresponding signalling information is passed to the signalling system.

2.3.3.1 *Exchange call set–up delay for transit connections*

2.3.3.1.1 For transit traffic connections that involve circuits that use channel associated signalling or a mix of channel associated and common channel signalling, the values in Table 7/Q.543 are recommended.

TABLE 7/Q.543

	Reference load A	Reference load B
Mean value	£ 250 ms	£ 400 ms
0.95 probability of not exceeding	300 ms	600 ms

2.3.3.1.2 For transit traffic connections between circuits that use CCITT Signalling System No. 7 signalling exclusively, the requirements of the appropriate signalling system Recommendation should apply, e.g. CCITT Recommendations Q.725 and Q.766 for Tcu value (case of a processing intensive message).

2.3.3.2 *Exchange call set–up delay for originating outgoing traffic connections*

2.3.3.2.1 For outgoing traffic connections originating from ANALOGUE SUBSCRIBER LINES, the values in Table 8/Q.543 are recommended.

TABLE 8/Q.543

	Reference load A	Reference load B

Mean value

£ 300 ms

£ 500 ms

0.95 probability of not exceeding

400 ms

800 ms

2.3.3.2.2 For outgoing traffic connections originating from DIGITAL SUBSCRIBER LINES using overlap sending, the time interval starts when the INFORMATION message received contains a “sending complete indication” or when the address information necessary for call set–up is complete.

The values in Table 9/Q.543 are recommended.

TABLE 9/Q.543

Reference load A

Reference load B

Mean value

£ 400 ms

£ 600 ms

0.95 probability of not exceeding

600 ms

1000 ms

2.3.3.2.3 For outgoing traffic connections originating from DIGITAL SUBSCRIBER LINES using en–bloc sending, the time interval starts when the SETUP message has been received from the digital subscriber signalling system.

The values in Table 10/Q.543 are recommended.

TABLE 10/Q.543

	Reference load A	Reference load B
Mean value	£ 600 ms	£ 800 ms
0.95 probability of not exceeding	800 ms	1200 ms

2.3.4 xe ""§through–connection delay

Through–connection delay is defined as the interval from the instant at which the information required for setting up a through–connection is available for processing in an exchange, or the signalling information required for setting up a through–connection is received from the signalling system, to the instant at which the appropriate transmission path is available for carrying traffic between the incoming and outgoing exchange terminations.

The exchange through–connection delay does not include an inter–office continuity check, if provided, but does include a cross–office check if one occurs during the defined

interval.

When the through–connection is established during call set–up, *the recommended values for exchange call set–up delay apply*. When the through–connection in an exchange is not established during the exchange call set–up interval, the through–connection delay may then contribute to the network call set–up delay.

2.3.4.1 *For transit and originating outgoing traffic connections*

The values in Table 11/Q.543 are recommended.

TABLE 11/Q.543

	Reference load A	Reference load B
	Without ancillary equipment	
	With ancillary equipment	
	Without ancillary equipment	
	With ancillary equipment	
Mean value	£ 250 ms	
	£ 350 ms	
	£ 400 ms	
	£ 500 ms	
0.95% probability of not exceeding		

300 ms

500 ms

600 ms

800 ms

The requirements for multi–slot connections require further study.

2.3.4.2 *For internal and terminating traffic connections*

For connections terminating on ANALOGUE SUBSCRIBER LINES, the through–connection delay is the interval from the instant at which the called subscriber off–hook condition (answer) is recognizable at the subscriber line interface of the exchange until the through–connection is established and available for the carrying traffic or a consequent signal is sent backwards by the exchange.

The maximum values applying to this parameter are included with those for incoming call indication sending delay in § 2.3.5.

For connections terminating on DIGITAL SUBSCRIBER LINES, the through–connection delay is the interval from the instant at which the CONNECT message is received from the signalling system until the through–connection is established and available for carrying traffic as those indicated by passing to the respective signalling systems of the ANSWER and CONNECT ACKNOWLEDGE messages.

The values in Table 12/Q.543 are recommended.

TABLE 12/Q.543

Reference load A

Reference load B

Mean value

£ 250 ms

£ 400 ms

0.95 probability of not exceeding

300 ms

600 ms

2.3.5 xe ""§incoming call indication sending delay – (for terminating and internal traffic connections)

2.3.5.1 For calls terminating on ANALOGUE SUBSCRIBER LINES, the incoming call indication sending delay is defined as the interval from the instant when the last digit of the called number is available for processing in the exchange until the instant that ringing signal is applied by the exchange to the called subscriber line.

It is recommended that the sum of the values for ringing signal sending delay and through–connection delay for internal and teminating traffic connection should not exceed the values in Table 13/Q.543. In addition, it is recommended that the value of the incoming call indication sending delay should not exceed 90% of these values nor the though–connection delay exceed 35% of these values.

TABLE 13/Q.543

Reference load A

Reference load B

Mean value

£ 650 ms

£ 1000 ms

0.95 probability of not exceeding

900 ms

1600 ms

Note – The above values assume that "immediate" ringing is applied and do not include delays caused by functions such as line tests, which may be used in national networks.

2.3.5.2 For calls terminating on DIGITAL SUBSCRIBER LINES, the incoming call indication sending delay is defined as the interval from the instant at which the necessary signalling information is received from the signalling system to the instant at which the SETUP message is passed to the signalling system of the called digital subscriber line.

In the case of overlap sending in the incoming signalling system, the values in Table 14/Q.543 are recommended.

TABLE 14/Q.543

Reference load A

Reference load B

Mean value

£ 400 ms

£ 600 ms

0.95 probability of not exceeding

600 ms

1000 ms

In the case of en–bloc sending in the incoming signalling system, the values in Table 15/Q.543 are recommended.

TABLE 15/Q.543

	Reference load A	Reference load B
Mean value	£ 600 ms	£ 800 ms
0.95 probability of not exceeding	800 ms	1200 ms

2.3.6 *xe ""§Alerting sending delay – terminating and internal traffic connections*

2.3.6.1 **alerting sending delay for terminating traffic**

2.3.6.1.1 For calls terminating on ANALOGUE SUBSCRIBER LINES, alerting sending delay is defined as the interval from the instant when the last digit is available for processing in the exchange until the ringing tone is sent backwards toward the calling user.

The values in Table 13/Q.543 are recommended.

2.3.6.1.2 For calls termining on DIGITAL SUBSCRIBER LINES, the alerting sending delay is defined as the interval from the instant that an ALERTING message is received from the digital subscriber line signalling system to the instant at which an ADDRESS COMPLETE message is passed to the interexchange signalling system or ringing tone is sent backward toward the calling user.

The values in Table 16/Q.543 are recommended.

TABLE 16/Q.543

	Reference load A	Reference load B
Mean value	£ 200 ms	£ 350 ms
0.95 probability of not exceeding	400 ms	700 ms

2.3.6.2 alerting sending delay for internal traffic

2.3.6.2.1 For calls terminating on ANALOGUE SUBSCRIBER LINES, alerting sending delay is defined as the interval from the instant that the signalling information is available for processing in the exchange until ringing tone is applied to an ANALOGUE calling subscriber line or an ALERTING message is sent to a DIGITAL calling subscriber line signalling system.

For calls from ANALOGUE SUBSCRIBER LINES to ANALOGUE SUBSCRIBER LINES, the values in Table 13/Q.543 are recommended.

For calls from DIGITAL SUBSCRIBER LINES to ANALOGUE SUBSCRIBER LINES, the values in Table 17/Q.543 are recommended.

TABLE 17/Q.543

	Reference load A	Reference load B

Mean value

£ 300 ms

£ 500 ms

0.95 probability of not exceeding

500 ms

800 ms

2.3.6.2.2 For internal calls terminating on DIGITAL SUBSCRIBER LINES originating from ANALOGUE SUBSCRIBER LINES, alerting sending delay is defined as the interval from the instant that an alerting message is received from the signalling system of the called subscriber's line until ringing tone is applied to the calling subscriber line.

The values in Table 13/Q.543 are recommended.

Alerting sending delay on internal calls between DIGITAL SUBSCRIBER LINES are covered by Table 28/Q.543.

2.3.7 xe ""§ringing tripping delay – internal and terminating traffic connections

Ringing tripping delay is a characteristic that is applicable for calls terminating on ANALOGUE SUBSCRIBER LINES only. It is defined as the interval from the instant that the called subscriber off–hook condition is reconizable at the subscriber line interface until the ringing signal at the same interface is suppressed.

The values in Table 18/Q.543 are recommended.

TABLE 18/Q.543

Reference load A

Reference load B

Mean value

£ 100 ms

£ 150 ms

0.95 probability of not exceeding

150 ms

200 ms

2.3.8 xe ""§exchange call release delay

Exchange call release delay is the interval from the instant at which the last information required for releasing a connection is available for processing in the exchange to the instant that the switching network through–connection in the exchange is no longer available for carrying traffic and the disconnection signal is sent to the subsequent exchange, if applicable. This interval does not include the time taken to detect the release signal, which might become significant during certain failure conditions, e.g., transmission system failures.

2.3.8.1 For transit traffic connections involving circuits using channel associated signalling or a mix of channel associated and common channel signalling, the values in Table 19/Q.543 are recommended.

TABLE 19/Q.543

Reference load A

Reference load B

Mean value

£ 250 ms

£ 400 ms

0.95 probability of not exceeding

300 ms

700 ms

For transit traffic connections involving circuits using CCITT Signalling System No. 7 signalling exclusively, the values in Table 35/Q.543 are recommended.

2.3.8.7 For originating, terminating and internal traffic connections, the values in Table 20/Q.543 are recommended.

TABLE 20/Q.543

Reference load A

Reference load B

Mean value

£ 250 ms

£ 400 ms

0.95 probability of not exceeding

300 ms

700 ms

2.3.9 xe ""§exchange signalling transfer delay – other than answer signal

Exchange signalling transfer delay is the time taken by the exchange to transfer a signal, no other exchange action being required. It is defined as the interval from the instant that the

incoming signal is recognizable, or the signalling information is received from the signalling system, until the instant when the corresponding outgoing signal has been transmitted, or the appropriate signalling information is passed to the signalling system.

2.3.9.1 For transit traffic connections involving circuits using channel associated signalling or a mix of channel associated and common channel signalling, the values in Table 21/Q.543 are recommended.

TABLE 21/Q.543

	Reference load A	Reference load B
Mean value	£ 100 ms	£ 150 ms
0.95 probability of not exceeding	150 ms	300 ms

For transit traffic connections between circuits that use CCITT Signalling System No. 7 signalling exclusively, the requirements of the appropriate signalling system Recommendations should apply, e.g., CCITT Recommendations Q.725/Q.726 for Tcu value (case of a simple message).

2.3.9.2 Exchange signalling transfer delay for originating, terminating and internal traffic involving a mix of ANALOGUE and DIGITAL SUBSCRIBER LINES is left for further study. Exchange signal transfer delay between DIGITAL SUBSCRIBER signalling systems or between DIGITAL SUBSCRIBER LINE signalling systems and CCITT Signalling System No. 7 is covered in § 2.4.2.

2.3.10 answer sending delay

Answer sending delay is defined as the interval from the instant that the answer indication is received at the exchange to the instant that the answer indication is passed on by the exchange toward the calling user. The objective of this parameter is to minimize the possible interruption of the transmission path for any significant interval during the initial response by the called user.

2.3.10.1 For transit traffic involving circuits that use channel associated signalling or a mix of channel associated and common channel signalling, the values in Table 22/Q.543 are recommended.

TABLE 22/Q.543

	Reference load A	Reference load B
Mean value	£ 100 ms	£ 150 ms
0.95 probability of not exceeding	150 ms	300 ms

More stringent values are recommended where in–band line signalling may be encountered in the national part of a built–up connection. The recommended values are given in Table 23/Q.543.

TABLE 23/Q.543

Reference load A

Reference load B

Mean value

£ 50 ms

£ 90 ms

0.95 probability of not exceeding

100 ms

180 ms

For transit traffic connections involving circuits that use CCITT Signalling System No. 7 exclusively, the requirements of the appropriate signalling system Recommendations should apply, e.g., CCITT Recommendations Q.725 and Q.766 for Tcu value (case of a simple message).

2.3.10.2For connections in a terminating exchange, exchange answer sending delay is defined as the interval from the instant that the off–hook condition is recognizable at the ANALOGUE SUBSCRIBER LINE interface on an incoming call or a CONNECT message is received from a DIGITAL SUBSCRIBER LINE signalling system until the instant that an answer indication is sent back toward the calling user.

The values in Table 24/Q.543 are recommended.

TABLE 24/Q.543

Reference load A

Reference load B

Mean value

£ 250 ms

£ 350 ms

0.95 probability of not exceeding

300 ms

700 ms

2.3.10.3For connections in an originating exchange, exchange answer sending delay is defined as the interval from the instant that the answer indication is received from the outgoing circuit signalling system or in the case of an internal call, from the called subscriber's line, until the instant that the answer indication is sent to the calling user. In the case of a call originated from a DIGITAL SUBSCRIBER LINE, the answer indication is a CONNECT message that is sent to the DIGITAL SUBSCRIBER LINE signalling system. If an ANALOGUE SUBSCRIBER LINE originated the call, the answer indication may not be sent.

The values in Table 25/Q.543 are recommended.

TABLE 25/Q.543

Reference load A

Reference load B

Mean value

£ 250 ms

£ 400 ms

0.95 probability of not exceeding

300 ms

700 ms

For ISDN operation involving DIGITAL SUBSCRIBER LINES and CCITT Signalling System No. 7 exclusively, the values in Table 28/Q.543 are recommended.

2.3.11 xe ""§timing for start of charging (circuit switched calls)

When required, timing for charging at the exchange where this function is performed, shall begin after receipt of an ANSWER indication from a connecting exchange or the called user. The start of timing for charging should occur within the intervals recommended in Table 26/Q.543.

TABLE 26/Q.543

	Reference load A	Reference load B
Mean value	£ 100 ms	£ 175 ms
0.95 probability of not exceeding	200 ms	350 ms

2.4 *xe ""§Delay probability – ISDN environment*

The following notes apply to the delay parameters included in this section:

1) The term “mean value” is understood as the expected value in the probabilistic sense.

2) Where several messages are received at the exchange from a digital subscriber line signalling system (e.g. several alert messages are received from a multi–user configuration), the message that is accepted for call handling is the one considered in determining the start of a given delay interval.

3) The terms “received from” and “passed to” the signalling system are used. For CCITT Signalling System No. 7 this is designated as the instant the information is exchanged between the signalling data link (layer 1) and the signalling link functions (layer 2). For digital subscriber line signalling, this is designated as the instant the information is exchanged by means of primitives between the data link layer (layer 2) and the network layer (layer 3). Thus, the time intervals exclude the above layer 1 (CCITT Signalling System No. 7) and layer 2 (D channel) times. They do, however, include queuing delays that occur in the absence of disturbances but not any queuing delays caused be re–transmission.

2.4.1 user signalling acknowledgement delay

User signalling acknowledgement delay is the interval from the instant a user signalling message has been received from the subscriber line signalling system until a message acknowledging the receipt of that message is passed back from the exchange to the user line signalling system. Examples of such messages are SETUP ACKNOWLEDGEMENT TO SETUP, CONNECT ACKNOWLEDGEMENT to CONNECT and RELEASE ACKNOWLEDGEMENT to RELEASE.

The values in Table 27/Q.543 are recommended.

TABLE 27/Q.543

	Reference load A	Reference load B
Mean value	£ 400 ms	£ 800 ms
0.95 probability of not exceeding	600 ms	

1000 ms

2.4.2 signalling transfer delay

The exchange signalling transfer delay is the time taken for the exchange to transfer a message from one signalling system to another with minimal or no other exchange actions required. The interval is measured from the instant that a message is received from a signalling system until the moment the corresponding message is passed to another signalling system. Examples of messages are ALERT to ADDRESS COMPLETE, ADDRESS COMPLETE to ADDRESS COMPLETE, CONNECT to ANSWER, RELEASE to DISCONNECT, etc.

The values in Table 28/Q.543 are recommended for originating and terminating connections.

TABLE 28/Q.543

	Reference load A	Reference load B
Mean value	£ 200 ms	£ 350 ms
0.95 probability of not exceeding	400 ms	700 ms

For transit connections, the requirements of the appropriate signalling system Recommendation should apply, e.g. CCITT Recommendations Q.725 and Q.766 for *Tcu* value (case of a simple message).

Note – User–to–user signalling may imply additional functions in the exchanges, e.g. charging, flow control, etc. The requirements for user–to–user signalling transfer delay and the impact of user–to–user signalling on exchange performance is for further study.

2.4.3 **call set up delay**

Call set up delay is defined as the interval from the instant when the signalling information required for outgoing circuit selection is received from the incoming signalling system until the instant when the corresponding signalling information is passed to the outgoing signalling system.

2.4.3.1 For originating 64 kbit/s circuit switched connections (types I, II and III option a).

i) If overlap sending is used, the interval starts when the information message received contains a “sending complete” indication or the address information for call set up is complete.

ii) If en–bloc sending is used, the time interval starts when the SETUP message has been received from the user signalling system.

For call attempts using overlap sending, the values in Table 29/Q.543 are recommended.

TABLE 29/Q.543

	Reference load a	Reference load B
Mean value	£ 400 ms	£ 600 ms
0.95 probability of not exceeding	600 ms	1000 ms

For call attempts using en–bloc sending, the values in Table 30/Q.543 are recommended.

TABLE 30/Q.543

	Reference load A	Reference load B
Mean value	£ 600 ms	£ 800 ms
0.95 probability of not exceeding	800 ms	1200 ms

2.4.3.2 For originating supplementary service call attempts:

for further study.

2.4.3.3 For transit 64 kbit/s circuit switched connections between circuits that use CCITT Signalling System No. 7, the requirements of CCITT Recommendations Q.725 and Q.766 should apply for *Tcu* value (case of a processing intensive message).

2.4.4 through connection delay

2.4.4.1 For originating outgoing and transit traffic 64 kbit/s switched circuit connections, through connection delay is defined as the interval from the instant that the signalling information required for setting up a connection through the exchange is received from the incoming signalling system to the instant that the transmission path is available for carrying traffic between the incoming and outgoing terminations on the exchange.

Usually, both directions of transmission will be switched through at the same time.

However, at an originating exchange, on certain calls, there may be a requirement to effect switch through in two stages, one direction at a time. In this case, different signalling messages will initiate the two stages of switch through and the recommended delay applies to each stage of switch through.

The values in Table 31/Q.543 are recommended.

TABLE 31/Q.543

	Reference load A		Reference load B	
	Without ancillary function	With ancillary function	Without ancillary function	With ancillary function
Mean value	£ 250 ms	£ 350 ms	£ 400 ms	£ 500 ms
0.95 probability of not exceeding	300 ms		500 ms	

600 ms

800 ms

2.4.4.2 For internal and terminating traffic 64 kbit/s switched circuit connections the through connection delay is defined as the interval from the instant that the CONNECT message is received from the called line signalling system until the through connection is established and available for carrying traffic and the ANSWER and CONNECT ACKNOWLEDGEMENT messages have been passed to the appropriate signalling systems.

The values in Table 32/Q.543 are recommended.

TABLE 32/Q.543

Reference load A

Reference load B

Mean value

£ 250 ms

£ 400 ms

0.95 probability of not exceeding

300 ms

600 ms

2.4.5 incoming call indication sending delay – (for terminating and internal traffic connections)

The incoming call indication sending delay is defined as the interval from the instant at which the necessary signalling information is received from the signalling system to the instant at

which the SETUP message is passed to the signalling system of the called subscriber line.

In the case of overlap sending in the incoming signalling system, the values in Table 33/Q.543 are recommended.

TABLE 33/Q.543

	Reference load A	Reference load B
Mean value	£ 400 ms	£ 600 ms
0.95 probability of not exceeding	600 ms	1000 ms

In the case of en–bloc sending in the incoming signalling system, the values in Table 34/Q.543 are recommended.

TABLE 34/Q.543

	Reference load A	Reference load B
Mean value		

£ 600 ms

£ 800 ms

0.95 probability of not exceeding

800 ms

1200 ms

2.4.6 **connection release delay**

Connection release delay is defined as the interval from the instant when DISCONNECT or RELEASE message is received from a signalling system until the instant when the connection is no longer available for use on the call (and is available for use on another call) and a corresponding RELEASE or DISCONNECT message is passed to the other signalling system involved in the connection.

The values in Table 35/Q.543 are recommended.

TABLE 35/Q.543

Reference load A

Reference load B

Mean value

£ 250 ms

£ 400 ms

0.95 probability of not exceeding

300 ms

700 ms

2.4.7 *Call clearing delay*

Disconnect and call clearing will usually be performed at the same time. However, on certain calls it may be necessary for an exchange to retain call references after disconnect has occurred, until a clearing message is received. The exchange may then discard the call reference information. The corresponding RELEASE message must be passed on to other involved signalling systems in the interval allowed for signalling transfer delay (see § 2.4.2).

2.4.8 *Timing for start of charging (circuit switched calls)*

When required, timing for charging at the exchange where this function is performed, shall begin after receipt of an ANSWER indication from a connecting exchange or the called user. The start of timing for charging should occur within the intervals recommended in Table 36/Q.543.

TABLE 36/Q.543

	Reference load A	Reference load B
Mean value	£ 100 ms	£ 175 ms
0.95 probability of not exceeding	200 ms	350 ms

2.5 *xe ""§Call processing performance objectives*

2.5.1 *64 kbit/s switched connections*

2.5.1.1 *xe ""§Premature release*

The probability that an exchange malfunction will result in the premature release of an established connection in any one minute interval should be:

$$P \pounds 2 \times 10–5$$

2.5.1.2 *xe ""§Release failure*

The probability that an exchange malfunction will prevent the required release of a connection should be:

$$P \pounds 2 \times 10–5$$

2.5.1.3 *xe ""§Incorrect charging or accounting*

The probability of a call attempt receiving incorrect charging or accounting treatment due to an exchange malfunction should be:

$$P \pounds 10–4$$

2.5.1.4 *xe ""§Misrouting*

The probability of a call attempt misrouted following receipt by the exchange of a valid address should be:

$$P \leq 10^{-4}$$

2.5.1.5 *xe ""§No tone*

The probability of a call attempt encountering no tone following receipt of a valid address by the exchange should be:

$$P \leq 10^{-4}$$

2.5.1.6 *Other failures*

The probability of the exchange causing a call failure for any other reason not identified specifically above should be:

$$P \leq 10^{-4}$$

2.5.2 *64 kbit/s semi–permanent connections*

This requires further study taking into consideration:

– need to recognize an interruption;
– probability of an interruption;
– requirements for re–establishment of interrupted connection;
– any other unique requirements.

2.5.3 *n × 64 kbit/s switched connections*

To be recommended if/when specific services are defined.

2.5.4 n × 64 kbit/s semi–permanent connections

To be recommended if/when specific services are defined.

2.6 *Transmission performance*

2.6.1 *64 kbit/s switched connections*

The probability of a connection being established with an unacceptable transmission quality across the exchange should be:

P(Unacceptable transmission) £ 10–5

The transmission quality across the exchange is said to be unacceptable when the bit error ratio is above the alarm condition.

Note – The alarm condition has yet to be defined.

2.6.2 *64 kbit/s semi–permanent connections*

To be recommended.

2.6.3 *n × 64 kbit/s switched connections*

To be recommended, if/when specific services are defined.

2.6.4 *n × 64 kbit/s semi–permanent connections*

To be recommended if/when specific services are defined.

2.7 *Slip rate*

2.7.1 *Normal conditions*

The slip rate under normal conditions is covered in Recommendation Q.541.

2.7.2 *Temporary loss of timing control*

The case of temporary loss of timing control corresponds to the “holdover operation” defined and recommended in Recommendation G.812. The allowable slip rate will correspond to the maximum relative TIE also recommended therein.

2.7.3 *Abnormal conditions at the exchange input*

The slip rate in case of abnormal conditions (wide phase diviations, etc.) at the exchange input is the subject of further study taking into account the requirements of Recommendation G.823.

3 xe ""§Exchange performance during overload conditions

This section applies to digital exchanges operating during periods when the number of call attempts presented to the exchange exceeds its call processing capacity for a significant period of time, excluding momentary peaks. Under these conditions the exchange is said to be operating in an overload condition.

This Recommendation identifies requirements for exchange performance during overload and for overload mechanisms in the exchange. Network management functions to be supported by an exchange are defined in Recommendation Q.542, § 5.

3.1 *Explanation of terms used in definition of overload parameters*

– **load**: the total number of call attempts presented to an exchange during a given interval of time (i.e. offered load)

– **overload**: that part of the total load offered to an exchange, in excess of the engineered traffic processing capacity of the exchange. Overload is usually expressed as a percentage of engineered capacity.

– **throughput**: the number of call attempts processed successfully by an exchange per unit time.

– **engineered capacity**: the mean offered load at which the exchange just meets all grade of service requirements used by the Administration to engineer the exchange.

3.2 *Call processing performance during overload*

An exchange must continue to process a specified load even when the offered call attempts exceed its available call processing capacity. The number of call attempts handled during an overload condition should not be significantly lower than the engineered capacity of the exchange for a specified Grade Of Service (GOS), as noted in § 3.7.

Two basic requirements for exchange performance during overload are:

– to maintain adequate exchange throughput in sustained overload

– to react sufficiently quickly to load peaks and the sudden onset of overload.

As the offered load increases beyond the engineered attempt capacity of the exchange, the throughput or the carried attempt load may exhibit a behaviour shown by curve A in Figure 1/Q.543, i.e. processor throughput may be reduced drastically if the offered load increases well beyond the engineered load. Curve B in Figure 1/Q.543 represents the maximum throughput, where the throughput remains at the nominal design level under overload. Appropriate overload protection mechanisms should be included in the overall exchange design so that the throughput performance of the processor under overload resembles the curve C in Figure 1/Q.543.
Figure 1/Q.543 - T1106950-87

3.3 *xe ""§Engineered exchange capacity*

Exchange engineered capacity is the maximum load that the exchange can handle while operating in a “normal” mode (i.e. performing all required operating and administrative functions) while meeting performance requirements specified in § 2 or those specified by the Administration. It is not necessarily the point of maximum throughput (see Figure 1/Q.543).

Overload controls, when applied, may have a significant effect on exchange capacity. Overload throughput performance should be specified relative to the engineered capacity of the exchange when overload controls are operating.

3.4 *xe ""§Overload control strategy*

An effective overload control strategy will prevent the rapid decrease in processed call attempts with increasing overload (see Curve A in Figure 1/Q.543); the relatively gradual decrease with overload controls enabled (Curve C in Figure 1/Q.543) is due to the increasing processing overhead in exercising the overload controls.

Overload is defined as the level of call attempts offered to the exchange in excess of the exchange engineered capacity. For example, when the exchange is offered call attempts at a rate of 10% greater than the engineered capacity, the exchange is said to have 10% overload.

The exchange throughput at an overload of Y% above the engineered capacity load should be at least X% of the throughput at engineered capacity. This concept is shown in Figure 2/Q.543 which shows the region of unacceptable throughput performance. Any throughput curve which remains above the X% level until reaching the point of Y% overload is acceptable. The recommended values are Y = 50% and X = 90%. Beyond Y% overload the exchange should continue to process calls in an acceptable manner.

As long as the level of overload does not exceed Y% above the exchange engineered capacity, then the exchange throughput should be no less than X% of engineered capacity, as depicted in Figure 2/X.543.

Measurements that can provide data as the basis for calculation of X and Y, are identified in § 3.8.

Figure 2/Q.543 - T1106960-87

3.5 *Detection of overload*

The exchange should incorporate suitable means for detecting overload conditions.

The onset of an overload state should be recognized by the exchange processing logic which in turn will invoke strategies to avoid a severe degradation in throughput load. During overload, both severe delays and processing delays will increase and will normally exceed the performance objectives given for Reference load B.

Overload indications may, for example, be provided by: a continuous measurement of the occupancy of the resources used for call handling over short periods (e.g. a few seconds); monitoring the queue lengths for the various call handling processes, etc. Overload control activation indications should be given to the administration staff.

3.6 *Overload protection*

The internal overload control methods used in an exchange are dependant on the particular technical arrangement of the switching system, and are not subject to CCITT Recommendations. Overload controls used in conjunction with adjacent exchanges are discussed under “Network management design objectives” in Recommendation Q.542, § 5.

In order to reduce the load on the exchange caused by calls that cannot be processed during overload, it may be necessary to discourage further attempts by customers during this situation. Methods used to achieve this reduction should not significantly increase the load on exchange processors, as for example, routing calls to recorded announcements.

Overload controls, once applied, should be removed as quickly as possible when the degree of overload reduces, consistent with the need to avoid oscillatory behaviour which might prolong the period of degraded service.

As a guideline to providing service during overload conditions, the following general principles are applicable:

– give preference to the processing of terminating calls,

– give preference to priority class lines, calls to priority destinations based on digit analysis and incoming calls with priority indications in, for example, the Initial Address Message of a call using CCITT Signalling System No. 7, if an essential service protection capability has been invoked,

– defer some or all activities non–essential to handling offered traffic; examples are some administration and maintenance processes in the exchange. (Nevertheless the man–machine communications essential for priority operational tasks should always be preserved. In particular, network management terminals and functions associated with interfaces to network management support systems should be afforded high priority, since network management actions can play an important role in reducing exchange overloads),
– maintain normal charging and supervisory functions, and established connections until the receipt of the appropriate release signal,
– assign priorities to specific exchange measurements, such that low priority measurements cease at a predetermined level of congestion. Higher priority measurements may be ceased at a higher level of congestion, or may be run continuously, depending on their importance to the call handling functions,
– give preference to calls already being processed, before accepting new calls.

3.7 *Grade of service during overload*

In general the overall grade of service seen by the subscribers will deteriorate when the exchange experiences severe overload conditions and the overload protection mechanisms have been invoked. This may be due to the fact that the overload protection procedures may require that the exchange not accept all the call attempts offered.

Accepted calls may or may not receive a grade of service equal to that received by calls at Reference load B of § 2. In terms of the exchange overload performance, it is sufficient that calls be accepted in such a way that throughput is maximized.

3.8 *Performance monitoring during overload control activation*

The operational measurements in the exchange should be sufficient to determine the number of call attempts accepted by the exchange, and the number that are successfully being completed, from the exchange point–of–view. Separate measurements should be available to count the number of attempts rejected by the exchange during overload, so that the total load can be estimated.

An accepted call attempt is defined to be a call attempt which is accepted for processing by the exchange. This does not necessarily mean that an accepted call attempt will complete or receive an acceptable grade of service.

The call completion rate can vary statistically with time, according to the specific call attempt acceptance process invoked by the overload controls. Therefore the call completion rate estimated from the operational measurements needs to be taken over a sufficiently long period of time to verify conformance to the X% throughput requirement.