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SECURITY ARRANGEMENTS

INTERVALS AT WHICH SECURITY MEASURES ARE TO BE INVOKED

ITU-T Recommendation Q.293

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation Q.293 was published in Fascicle VI.3 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

8.5 INTERVALS AT WHICH SECURITY MEASURES ARE TO BE INVOKED

The following action points are defined:

T_0 = time when signalling fault indication starts,

T_w = time when warning of failure is issued (for example, to busy a nominated speech circuit reserve),

T_d = time when decision to change over is made,

T_u = time when signalling traffic is offered to the reserve link.

The intervals T_w - T_0 and T_u - T_d are not specified. It is recognized that these intervals will vary from one method or arrangement to another.

The interval T_d - T_0 does not include the time for the processor to react. Its value is determined in the case of:

- continuous failure, by all signal units being in error for 350 milliseconds;
- intermittent failure, by the instant the signal unit error rate monitor gives an output indicating that the signalling error rate has become unacceptable; or
- loss of block or multi-block synchronism, by the failure to achieve block resynchronization within about 350 ms.

8.6 CHANGEOVER AND CHANGEBACK PROCEDURES

8.6.1 *Changeover from faulty signalling links*

a) Consider two exchanges A and B with a fault in signalling link AB, *affecting both directions.*

Each exchange at time T_d initiates the synchronization procedure (Recommendation Q.278), where applicable, on the reserve signalling link. When both ends are in synchronism over the reserve link, the processors switch over without any proving period and use this link.

On detection of failure of a working link at time T_0 each terminal *starts sending faulty-link information* on the link just failed. This information consists of a number of changeover signals (completing the block being sent) plus ACU, followed by a continuous stream of alternating blocks of changeover signals and of SYUs (11 changeover signals + ACU, 11 SYUs + ACU, 11 changeover signals + ACU, etc.).

When a terminal is unable to accept a correctly received signal unit, the relevant bit in the ACU acknowledging the signal unit shall be set to **1**. If the terminal has lost synchronism, then the normal synchronization procedure is started (Recommendation Q.278, § 6.8.2).

With the reserve facility properly prepared, each exchange retransmits on the reserve facility all waiting signals marked for retransmission and all signals not acknowledged by the other exchange, followed by new signalling traffic from the failed link as specified in Recommendation Q.291, § 8.1.

b) Consider a fault affecting *only one direction* for example A to B. The fault will be detected at terminal B and at a time T_d this terminal will act as under § 8.6.1 a) above.

Upon receipt of two changeover signals on the working signalling channel within a period of 3 seconds, exchange A commences the synchronization procedure, when applicable, on the reserve signalling link. On the failed channel, exchange A will commence the resynchronization procedure as in Recommendation Q.278, § 6.8.2, allowing the block numbering sequence to be re-established. If exchange A has not itself lost synchronism on the failed channel,

it may skip over superfluous actions within the synchronization procedure, i.e. faulty-link information, the sending of all **1**s acknowledgement indicators, SYU search, and proving period. The detection and timing of the loss of block synchronization should be cancelled at this time. Exchange A will proceed to retransmit all the failed link messages as described in Recommendation Q.291, § 8.1, and transfer all subsequent signalling traffic destined for the failed link to the reserve link for the duration of the failure.

c) If more than one type of reserve is provided, the choice of reserve facility should be in accordance with Recommendation Q.292, § 8.4.5. Nominated speech circuits will be made busy to outgoing traffic at each end immediately, or as soon as free, until transfer to a nominated reserve signalling link has been accomplished. At time T_d, an operable reserve will be selected, by hunting through the available choices in a fixed predetermined order as specified by the Administrations concerned. Nominated direct circuits in use for speech are skipped over in the selection process.

If a synchronized reserve or quasi-associated route is selected, a later transfer to a non-synchronized full-time reserve link or a nominated direct circuit may be effected as described in § 8.6.3.2 below.

When a failure is encountered on a reserve signalling link, faulty-link information is sent in the same manner as on a regular signalling link encountering a failure. If the reserve link is carrying signalling traffic, the procedure as covered in Recommendation Q.291, § 8.2, will be initiated.

d) When a changeover is to another link in the same linkset, Signalling System Control Signals (SCUs) waiting on the faulty link are not retransmitted on the new link. When a changeover is to one or more quasi-associated routings, the telephone signal units, network maintenance signals and network management signals are retransmitted on their respective routings after band translation where necessary. SCUs and signalling network management signals are not retransmitted on quasi-associated routings.

When a link becomes faulty and no reserve facility is available for some or all bands on the link, then any waiting signal units for such bands will not be able to be retransmitted as described above. Where such signals refer to remote routes and are using the System No. 6 exchange as a signal transfer point, these signals should be deleted and a message-refusal signal returned for each telephone signal and a transfer-prohibited signal returned for each network maintenance signal (see Recommendation Q.266, §§ 4.6.2.1 and 4.6.2.3).

8.6.2 *Changeback to the regular link*

When either terminal has regained synchronism on the failed regular link, it will begin both its one-minute and emergency proving periods. However, if synchronism had been continuously maintained at one end during the failure, this exchange need not start a new proving period. When the received signal unit error rate has remained acceptable for the one-minute proving period, the exchange will *cease sending faulty-link information* by replacing the changeover signals (if it is sending changeover signals) with SYUs (plus ACUs).

To return to the regular link, the exchange A initiating the changeback sends two load-transfer signals on the regular link. From this time until changeback is either completed or abandoned, exchange A must be in a position to receive and process all signals on both the regular link and the reserve in use. When exchange B receives a load-transfer signal and knows the regular link is operational, it responds with a load-transfer acknowledgement signal on the regular link, then immediately transfers its signalling traffic from the reserve to the regular link. When exchange A receives one load-transfer-acknowledgement signal, it transfers its signalling traffic from the reserve to the regular link. Should an exchange receive a load-transfer signal on the link that is carrying traffic, then this signal shall be acknowledged.

Until the load-transfer and acknowledgement signal sequence has been satisfactorily completed as described above, signalling continues over the reserve link. After this signal sequence is completed, exchanges A and B continue to monitor the reserve link until all signals initially transmitted on the reserve link have had the opportunity to be acknowledged. Signals sent on the reserve link acknowledged as having been received in error are retransmitted on the reserve link. After 5 ± 1 seconds, when all signals have had the opportunity to be acknowledged as correctly received, each end will return reserve voice-frequency links with switched terminals and modems to their original status. A nominated speech circuit must be returned to service for outgoing traffic without delay by completing an unblocking sequence even though blocking signals have not previously been exchanged for the circuit. This unblocking sequence will remove any previous circuit state at both ends and return the circuit to the idle state. Any resultant failure indications occurring on the reserve link during the 5 ± 1 second time interval may be ignored. (See also § 8.9.)

In the event exchange B decides not to change back when it receives a load-transfer signal, it withholds the load-transfer-acknowledgement signal. Exchange A must therefore time for an interval of approximately 2 minutes for the receipt of a load-transfer-acknowledgement signal. If the time interval elapses without receiving a load-transfer-acknowledgment signal, exchange A will transmit two more load-transfer signals and recycle the timing.

If exchange A decides to terminate the changeback procedure at any time before the process is completed, it will interrupt the changeback procedure and transmit faulty link information as for a normal changeover. Exchange B will respond to the faulty-link information even though it has agreed to changeback and has started sending messages on the regular link. In the event of changeover before the load-transfer signalling sequence is completed, both exchanges will remain on the reserve link which the changeback commenced.

If the changeback procedure is interrupted or terminated as above before the procedure is completed, the regular link should continue to meet the one-minute proving period requirement.

In the event that both exchanges A and B start changeback procedures at about the same time, either exchange, having transmitted two load-transfer signals, shall respond to a received load-transfer signal with a load-transfer-acknowledgement signal and shall transfer signalling traffic to the regular link on the receipt of either a load-transfer signal or a load-transfer-acknowledgement signal.

8.6.3 *Changeover from working signalling links*

8.6.3.1 *Manual changeover procedure*

a) In the event that it is desired to change over to a reserve link for rearrangements, changes, maintenance, etc., on a link currently carrying the signalling traffic for the link set, the exchange A desiring the changeover will send a manual-changeover signal on the working link. This working link may be the regular link, a full-time synchronized reserve link, or one link of a load shared pair. When exchange B receives this signal, the selection of a reserve link is initiated by both exchanges. The selection order for this reserve differs from that for the normal changeover (described in § 8.4.5 above) in that quasi-associated routings are excluded from the search if one-or more non-synchronized reserve links are provided in the link set. This is specified in order to transfer the signalling load directly to a non-synchronized reserved link, thus preventing a possible double load transfer due to the load transfer procedure (automatic) as specified in § 8.6.3.2 being initiated on a quasi-associated routing subsequent to the manual changeover. When a transfer to a non-synchronized reserve link is indicated, the cyclic procedure described in § 8.6.3.2 below will be used as appropriate. When exchange B has selected a quasi-associated route or other synchronized reserve link or has gained synchronism on a non-synchronized link, a manual-changeover-acknowledgement signal is sent back on the original working link.

Exchange A must not send a manual-changeover signal or exchange B send a manual-change-over-acknowledgement signal if the desired changeover would cause the complete failure of a signalling route set. That is, the signalling for a group of bands would be lost. However, these signals will not be inhibited if the affected signalling route set is for bands for which the exchange is acting as a signal transfer point.

If a quasi-associated route or other synchronized reserve link is selected for the changeover, the exchanges A and B transfer their signalling traffic subsequent to the exchange of the manual-changeover-acknowledgement signal.

If a non-synchronized reserve signalling link is selected and the manual-changeover-acknowledgement signal has been received, two load transfer signals are sent by exchange A on this link when the link is in synchronism and has passed the one-minute proving period. On receipt of one load-transfer-acknowledgement signal, exchange A will transfer its signalling traffic.

For all cases, both exchanges A and B continue to monitor the original working link for 5 ± 1 seconds, until all signals initiated on this link have the opportunity of being acknowledged as correctly received. Signals acknowledged as having been received incorrectly are retransmitted on the original working link. Subsequent to this timing period, the exchange initiating the manual changeover may continue to transmit SYUs + ACUs in the normal manner or may remove the link from service. The exchange acknowledging the manual changover should maintain synchronism and, should the link be removed, detect loss of synchronization.

b) If exchanges A and B simultaneously send manual-changeover signals, both exchanges must send manual-changeover-acknowledgement signals. In the quasi-associated route or other synchronized reserved link case, exchanges A and B transfer their signalling traffic subsequent to the receipt of the manual-changeover-acknowledgement signal. For all other cases, each end, subsequent to receipt of a manual-changeover-acknowledgement signal on the original

working link, will transmit two load-transfer signals on the selected reserve which will be acknowledged by the other end.

When either end receives a load-transfer signal, while expecting a load-transfer-acknowledgement signal from the other end after sending two load-transfer signals, it may transfer its signalling traffic from the original working link to the reserve link after sending a load-transfer-acknowledgement signal.

c) In the event that a manual-changeover signal is not acknowledged by the other exchange, a suitable interval shall elapse (e.g. one minute), before the request is repeated. If the second manual-changeover signal is not acknowledged, the maintenance staff at the exchange requesting changeover should be alerted.

d) Changeback from the reserve link will always be to the regular link and is initiated by the end which previously initiated the manual changeover. The procedure used is the same as the normal changeback as described in § 8.6.2 above. In the event of simultaneous manual changeover, or in the case where the regular link is not the link from which manual changeover had originally taken place, either end can initiate the changeback to the regular link.

If the link from which manual changeover originally took place is not the regular link but is a synchronized reserve, the end initiating the manual changeover will initiate the restoration of the link to the standby ready-state as described in § 8.8 c) below. This will commence when the link is considered serviceable again and may occur independently of the load transfer to the regular link.

8.6.3.2 *Load-transfer procedure (automatic)*

a) An automatic load-transfer from a quasi-associated routing or other synchronized reserve to a prepared non-synchronized reserve may be provided by agreement if desired by the Administrations concerned. This procedure may be used to limit the signalling traffic load at the signal transfer point or to maintain two synchronized links within the link set. Three types of automatic load-transfer are possible. In the first type, the signalling traffic for a group of bands using a signal transfer point is transferred back to the associated link set. In the second type, the signalling traffic in a link set is transferred from a synchronized reserve to a prepared non-synchronized reserve allowing the synchronized reserve to remain as a standby link. In the third type the signalling traffic from a failed load sharing link in a link set is transferred from the other load sharing link to a prepared non-synchronized reserve allowing the working load sharing link and the prepared reserve to remain as mutual reserves.

b) Subsequent to the initial transfer of signalling traffic to a synchronized reserve, both exchanges attempt to achieve synchronization on a secondary reserve facility. If more than one facility is provided, the two exchanges use the following selection procedure to establish synchronization on a secondary facility.

Each exchange will select the first choice non-synchronized reserve and will attempt to synchronize for a prearranged time interval of 5 +/- 0.25 seconds at one exchange and 7.5 +/- 0.25 seconds at the other. The selection sequence and the time interval will be fixed by bilateral agreement. If synchronization is not accomplished within the specified time interval, an attempt is made to synchronize on each of the available reserves in turn. If unsuccessful on the last choice non-synchronized reserve, the selection cycle is repeated unless the regular link has become operative. The difference in timing at the two exchanges ensures that even in the event the exchanges do not attempt synchronization on the same reserve initially, both exchanges will ultimately meet on the reserve for a minimum interval of 2 seconds.

When synchronism is established on the reserve and the error rate has been acceptable during the one minute proving period, load-transfer and load-transfer-acknowledgement signals are interchanged on the selected reserve prior to transfer of the traffic as described in § 8.6.3.1 above. Signal units originally transmitted on the synchronized reserve are retransmitted as necessary on the same reserve.

8.7 EMERGENCY RESTART PROCEDURE

a) The emergency restart procedure is intended to re-establish signalling communication on a link set between two exchanges without waiting for the one-minute proving period, whenever the regular, and all synchronized links in the link set of lower priority than the last working links, have failed, or non-synchronized reserve links cannot be synchronized within 2 to 3 seconds of failure of the working link. Any link between the two exchanges which has achieved synchronism and has passed the emergency proving period (see Recommendation Q.291, § 8.3.3) will be selected to re-establish signalling communication. Maintenance personnel are alerted whenever an emergency restart condition exists. Either exchange may unilaterally commence the emergency restart procedure and the other exchange must respond even though it is unaware of an emergency signalling situation. The emergency restart procedure will be

initiated on a link set even though all the signalling traffic may have successfully transferred to quasi-associated reserves. However, the emergency restart procedure will not be initiated on a link set, if after termination of link set signalling a manually changed-over link remains in the link set. In this case, the link set carries out the emergency restart procedure only if the subsequent failure of a signalling route set occurs [except STP signalling route sets, see § 8.6.3.1 a)]. This failure would be for signalling traffic transferred from the link set to a quasi-associated routing at the manual changeover. Therefore, the manually changed-over link can be included in the emergency restart procedure if it is capable of being synchronized and emergency proved.

b) If faulty-link information is being sent on a previously failed link, it will continue to be sent until that link has passed its emergency proving period.

If at any time after the emergency proving period the signal unit error rate monitor indicates an unsatisfactory performance of the link, faulty-link information is again sent on the link and the change-over or emergency restart procedure is begun.

To minimize the number of calls affected by the emergency restart condition, Recommendation Q.291, § 8.1 should be followed, particularly the recommendation to remove free speech circuits from service. However, this will only be necessary when the link-set failure has caused the failure of an entire signalling route set, and hence no quasi-associated routings are available.

The following procedure is designed to attempt emergency restart on as many signalling links as possible at the same time. Both exchanges will simultaneously connect terminals to as many voice-frequency links as possible between the two exchanges. Quasi-associated signalling routes are excluded from this procedure. The regular link and all synchronized reserve links have terminals permanently assigned to them. Terminals for non-synchronized reserve links will be assigned from a pool of reserve terminals. Assume that the total number of links is n and the available number of reserve terminals is T. If $T \geq n$, then a reserve terminal is assigned to each of the n non-synchronized reserve links and synchronization is simultaneously attempted on all links. If $T < n$, then T - 1 reserve terminals are assigned to as many non-synchronized reserve links, and one terminal will be cycled through the remaining non-synchronized reserve links following the procedure described in § 8.6.3.2 b) above.

Idle status of previously engaged nominated speech circuits at each exchange during the emergency restart procedure is recognized either by reception of a clear-forward signal from a preceding exchange or by reception of a clear-back signal from a succeeding exchange.

c) When one or more links have passed the emergency proving period, two emergency-load-transfer signals are sent periodically (at 2-3 seconds intervals) over each link. Each exchange may receive signals on the links during the emergency restart procedure and must take steps either to process these signals or deliberately reject them by setting the relevant ACU indicators to **1**. However, after sending ELT signals on any link, all signals received on the link must be processed. Although both exchanges may send emergency-load-transfer signals, only one exchange (designated the emergency restart control exchange by mutual agreement of the two Administrations) will acknowledge these signals. The non-control exchange must respond by sending emergency-load-transfer signals over the same signalling link, whenever it receives these signals and the link has passed the emergency proving period.

Both exchanges continue sending pairs of emergency-load-transfer signals at 2-3 seconds intervals over links which have passed the emergency proving period until the control exchange has sent two load-transfer-acknowledgement signals and one has been received by the non-control exchange.

Upon receiving two emergency-load-transfer signals within 3 seconds on one or more links, the control exchange will select one of these links which has passed the emergency proving period and respond with two load-transfer-acknowledgement signals. The control exchange may now start sending signalling traffic over this link. The non-control exchange may also commence signalling traffic when it receives a load-transfer-acknowledgement signal. The signalling traffic that is restarted (or allowed for STP traffic) will be for bands where no working signalling path is at that time available via this exchange. Other signalling traffic may only be transferred from working links after the one-minute proving period using the normal changeback or automatic load transfer procedures.

This interchange of signals will take place even if the selected link had previously been manually changed-over, and irrespective of whether or not the control exchange had initiated the manual change-over. Once the link is selected the manual change-over condition will be removed at both ends.

A guard period of 5 ± 1 seconds shall be commenced on transfer of traffic to the selected link. During this guard period, any emergency-load- transfer signals, received at the control exchange on the link on which traffic has been resumed, shall be acknowledged. Emergency-load-transfer signals received on any other link, between the two exchanges, or received by the non-control exchange on any link, shall be ignored. If, during the guard period, the signal unit error rate monitor indicates an unsatisfactory performance of the link carrying traffic or if faulty-link information is received on that link, then the guard period is terminated and § 8.7 b), second paragraph applies.

After the emergency restart procedure has been terminated, subsequent failures are treated in the normal manner. The load-transfer or standby-ready signalling sequences are not initiated on the selected link during the emergency restart procedure, although they shall be sent after the one-minute proving period in order to carry out the normal changeback and automatic load transfer procedures or to confirm the proving status of the link for subsequent link security procedures.

If an exchange receives two emergency-load-transfer signals, it must respond in the manner described and transfer signalling traffic to the indicated signalling link, even though it may not be in the emergency restart state.

8.8 FULL-TIME SYNCHRONIZED RESERVE LINKS

8.8.1 *Failure of a synchronized reserve link*

On detection of failure of a synchronized reserve link, the terminal starts sending faulty-link information as described in § 8.6.1 a) above. Receipt of faulty-link information indicates that the link is not suitable for use as a reserve.

8.8.2 *Removal of a full-time synchronized reserve link from service availability*

It may be necessary, for reasons of rearrangements, changes, maintenance, etc., to remove a full-time synchronized reserve link, which is not currently carrying the signalling traffic for the link set, from service availability.

In this case the Exchange A desiring the removal will send a manual-changeover signal on the reserve link. On receipt of this signal Exchange B will mark the reserve as unavailable for service and respond with a manual changeover-acknowledgement signal. Exchange A, on receipt of the acknowledgement signal, will also mark the reserve as unavailable for service and may then continue to transmit SYUs or ACUs in the normal manner or may remove the link from service. Exchange B acknowledging the removal should maintain synchronism and, should the link be removed, detect loss of synchronization. Subsequent to these actions the provisions for inclusion of the reserve link in an emergency restart procedure apply as specified in § 8.7 a).

In the event that the manual-changeover signal is not acknowledged by the other exchange, a suitable interval shall elapse (e.g. one minute), before the request is repeated. If the second manual-changeover is not acknowledged the exchange initiating the removal may unilaterally remove the link from service (provided that it is still acting as a reserve and is not carrying signal traffic) by sending faulty link information or disconnection of the carrier but may not mark the link as unavailable and continue to transmit SYUs + ACUs in the normal manner.

Restoration of the reserve link from unavailable to available (standby ready) status will be initiated by the end which previously initiated the removal using the procedure described in § 8.8.3) below.

8.8.3 *Restoration of a synchronized reserve link*

When both terminals are again in synchronism over the reserve link and the error rate has met the requirement for the one-minute proving period (see Recommendation Q.291, § 8.3.3), the faulty-link information will be replaced with blocks of SYU (plus ACU) to indicate that the proving period has been completed.

To confirm that the proving period has been completed at both exchanges, the exchange A finishing the proving period sends two standby-ready signals on the reserve link.

When exchange B receives a standby-ready signal and knows the reserve link is usable, it responds with a standby-ready-acknowledgement signal on the reserve link. When exchange A receives one standby-ready-acknowledgement signal, it has confirmation that the reserve link is available for use.

8.9 LOAD SHARING METHOD

The load sharing method is described in § 8.4.2 a). The method implies that the total signalling load on the link set is shared between two working links. Steps should be taken to ensure that the load is approximately equalized between the two links. This will normally be done by allocating each circuit to one of the signalling links as its regular link, and arranging for half of the total number of circuits to be allocated to each link. Although not mentioned in § 8.4.2 a), other allocation methods are possible such as allocating each circuit to one of the signalling links on a per-call basis. This follows from the fact that under failure conditions on one link the signalling traffic will be transferred to the remaining link and hence each exchange must be capable of accepting signalling traffic for all labels on either link. It is therefore unnecessary for both exchanges to use the same allocation method for their outgoing signalling traffic and each Administration will decide on a suitable method. (For example, free option for each label, an odd-even label basis, a per-band basis or a per-call basis.)

It must be ensured that one signalling link can handle all the signalling traffic without unacceptable queueing delays. Load sharing should not, therefore, be used to increase the signalling capacity of a link set. If extra capacity is required, then a second link set with separate links should be provided.

When a faulty link within a load-shared pair becomes workable again, the procedure used is the changeback procedure of § 8.6.2 (and not the procedure of § 8.8). The signals standby-ready and standby-ready-acknowledgement are not used. As both links remain in use, the 5 ± 1 second guard timing is not used.

In general, any link set will probably contain a maximum of two synchronized links, although more may be provided by agreement between Administrations. Normally there will be no mixing between different security arrangements (i.e., a load shared pair with full-time synchronized reserves, etc.) although it may be provided by agreement between Administrations.