

DESIGN OF INTERLOCAL TRUNKS

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1. GENERAL

1.01 This section discusses the specific design considerations pertaining to interlocal trunks. It supplements Section AB22.125 which outlines the more general transmission considerations common to the design of all types of exchange area trunks.

1.02 This issue replaces Issue 2 and reflects the present view that interlocal trunks may be designed to a transmission objective which is entirely independent of loop and trunk

studies. The basis for this view is that studies of subscriber loop transmission distributions have shown that the average transmission under current loop design practices will be about the same for all offices. Therefore, a trunk transmission objective may be established which is considered to provide a satisfactory grade of average over-all transmission and which is not dependent upon trading against loop losses for its determination. The former practice of determining the permissible trunk loss by subtracting the sum of the two loop losses from an over-all "standard" or "limiting" transmission had the detrimental effect of allotting too large a portion of the over-all loss to the trunk thus, in many cases, seriously degrading the average transmission. The permissible trunk losses set forth in this section will provide average transmission on interlocal calls which will be substantially the same for all offices and which, on the basis of laboratory judgment tests, would be rated as "good" by approximately 95 per cent of the subscribers.

2. TRANSMISSION REQUIREMENTS

(A) Permissible Trunk Losses

2.01 To avoid high concentration of trunked calls having near limiting transmission the permissible trunk loss, for a connection between two local offices, should not be permitted to exceed 8 to 10 db (effective) whether the trunk is direct or is switched through one or more tandem points. Tandem switching introduces problems which will be discussed later. The majority of trunks will have smaller losses, because of their moderate length, and there is no thought that they should be built out to any maximum loss. Also, as new instrumentalities are developed in the years ahead, which will permit further reductions in trunk loss with economy, the maximum values for permissible loss may be reduced.

2.02 The permissible trunk loss is composed of the following components encountered in the make-up of the trunk plant layout.

- (1) Effective trunk loss.
- (2) Terminal junction losses.
- (3) Intermediate junction losses.

- (4) Losses due to irregularities in loading spacing.
- (5) Equipment and office losses at intermediate switching points.
- (6) Losses due to other intermediate or auxiliary equipment.
- (7) Repeater gain.

References to transmission information required for trunk design are listed in Section AB22.125.

2.03 It has been the past practice of some Operating Companies to include in the permissible trunk loss those central office equipment and cabling losses which were not included in the loop loss. Others have regarded these losses as part of the "local terminal loss" which took into account all the losses associated with the station, the loop and all central office equipment at one end of a trunked connection. The average of these office losses as given in the data sections of the practices is approximately 0.5 db. In setting the limiting trunk loss at 10 db, local office losses can be neglected and need not be considered in the computations of the trunk loss. That is, if the sum of Items (1) to (7) in Paragraph 2.02 does not exceed 10 db, the limiting transmission objective will be attained.

2.04 For simplification in trunk design and facility assignment work the permissible 8 to 10 db effective trunk loss might be obtained by expressing it in terms of 1000-cycle loss (facility only), provided the permissible values are reduced by 1.5 or 2 db. In this way the design need only be concerned with actual facility length and db loss; it can disregard junction and other incidental losses.

(B) Effective Trunk Loss

2.05 The computation of effective trunk loss for loaded trunks has not in the past included the effects of loading end sections at the terminal offices which depart from half-section length. End sections in excess of a half section up to one and one-half sections were included in the terminal junction losses. The terminal junction losses are now covered in Section AB43.125.1 and are compromise values which, in the interests of simplified application, assume half-section termination of all loaded trunks. Therefore, the computation of the effective trunk loss should now take into account any such departures from half-section termination. This may be accomplished in the

following manner for end sections up to one and one-half sections.

- (1) Compute the trunk attenuation as the product of actual length and effective attenuation per unit length.
- (2) Determine the length of the end section departure from half section.
- (3) Compute the difference between loaded and non-loaded attenuations for the length in Step (2).
- (4) For a deficient end section subtract the value in Step (3) from the value in Step (1).
- (5) For an excess end section add the value in Step (3) to the value in Step (1).

The foregoing procedures applied at each end will adjust the trunk attenuation for application of the terminal junction losses.

2.06 A loaded trunk having an end section longer than one and one-half sections should be considered as made up of a loaded trunk terminated in a half section and extended by a length of non-loaded trunk. The applicable terminal junction loss is that for the non-loaded trunk. To this is added the intermediate junction loss between the loaded trunk and the non-loaded trunk as given in Section AB43.176. If the non-loaded portion of the trunk is short this procedure may introduce some error as the terminal and intermediate junction losses apply to electrically long trunks. They do not take into consideration the interaction effects due to electrically short separation between the terminal and intermediate junctions. However, the error is not large and may usually be neglected in the design of interlocal trunks.

(C) Terminal Junction Losses

2.07 The terminal junction losses which apply to the local office ends of trunks are given in Section AB43.125.1. They are shown as functions of (1) the type of trunk facility or loading regardless of gauge, (2) the ratio of the repeating coil between the loop and the trunk and (3) the loop gauge representative of the office. The selection of the last factor is discussed in that section.

(D) Intermediate Junction Losses

2.08 An intermediate junction loss will occur where the trunk facility is not of the same make-up throughout its length. Since it

is generally the practice to provide facilities of uniform make-up and loading between main frames the points of discontinuity resulting in intermediate junction losses will usually occur at the main frames of an intermediate office on a through route. In order to keep the intermediate junction losses as low as possible and to avoid impedance irregularities which may seriously reduce the return losses on repeatered trunks it is always advisable to use like facilities on both sides of an intermediate cross-connect point. Values of intermediate junction loss may be obtained from Section AB43.176.

2.09 At these intermediate points, it may frequently be necessary to determine the effect of load spacing irregularities in addition to the junction loss due to unlike facilities. In some offices in a metropolitan area where there are several converging routes and a large number of cables, it is not usually feasible to provide ideal end sections on all of the cables and allowance should be made for the irregularities. However, should the layout result in all trunk routes having end sections between .4 and .6 length, losses for spacing irregularities may be disregarded. Refer to Section AB43.175 for data on adjacent section irregularities and calculation of the resultant loss. In specific instances of repeatered trunks or those requiring high return losses, measures to remove or minimize the effect of the irregularity may be required.

(E) Losses at Intermediate Switching Points

2.10 Although the largest part of exchange area calls which involve trunks are completed over interlocal trunks directly connecting the terminal offices involved, the remainder, because of particular traffic, geographical or operating conditions, are routed through an intermediate switching point, such as (1) a DSA board or operator office, (2) an office selector tandem system or (3) through a full selector tandem office.

2.11 When an intermediate switch is required to complete an interlocal connection, the intermediate junction loss, the loss due to a load spacing irregularity, if present, and the switchboard or switching equipment and other office loss at the switching point should be included in the trunk loss. Where the design of interlocal trunks is handled on an office selector or similar tandem basis, one half the sum of these losses and one half of the permissible 10 db terminal-to-terminal trunk loss may be assigned to each side of the switching point. In particular cases, discussed later, it may be desirable to divide the permissible trunk loss into other proportions such as 6 db incoming and 4 db outgoing.

2.12 When a group of tandem trunks is used for both toll completion and interoffice via tandem trunks, the design requirements of toll trunks including return loss objective must be met. In these cases refer to Section AB22.128.1 for design requirements.

2.13 The incoming and outgoing trunk groups at an intermediate switching point may involve a variety of trunk facilities and their interconnection may present a rather wide range of intermediate junction losses as well as varying loading irregularities due to different end sections. Because of the obvious difficulty of administering design and layout on the basis of the individual variables it is more practicable and desirable to develop an average figure applicable at the switching point for all combinations. Such an average value of intermediate junction loss for the office may be estimated by weighting the sum of the intermediate junction loss and the loading irregularity loss for each combination in proportion to the frequency of occurrence of the various interconnections. The weighted figure thus obtained may be combined with the switchboard or switching equipment and office wiring losses to obtain a total average intermediate loss. This figure may then be applied in the manner suggested in Paragraph 2.11. Where this procedure is adopted it would appear desirable to check the value of the weighted figure at intervals depending on the amount of construction and trunk rearrangement work affecting the facilities terminating in the office.

2.14 Incoming trunk circuits at tandem switching points may or may not be equipped with repeating coils, depending upon the type of office. Outgoing trunk circuits at these offices, except those employing composite or simplex signaling, are seldom so equipped. Trunk circuits which include repeating coils generally have standard provisions for either 1:1 or 1.5:1 ratios. With the trend toward lower impedance loading systems it does not appear generally advisable to specify coils of higher ratios, even though small transmission penalties are incurred with the standard ratio coils and existing high impedance facilities. The use of other than standard coil ratios complicates the assignment practices and reduces the flexibility of the equipment to an extent which may offset the small transmission advantage.

(F) Contrast Limits

2.15 As mentioned in Section AB22.125 the magnitude of the transmission contrast problem should be reduced by adherence to the design objectives described in this section. If

the over-all trunk loss between two terminal local central offices, whether direct or tandem switched, does not exceed 10 db, the various contrasts which may occur should seldom exceed 5 db. With the average transmission so provided, a 5 db contrast will rarely provoke unfavorable customer reaction. In cases where computations indicate that any contrast (except certain cases of automatic routing as discussed below) will exceed 5 db suitable measures should be considered to bring the contrast within this limit.

2.16 It sometimes becomes necessary, due to cutovers or rearrangements, to increase the loss of the trunks between two offices by more than 5 db. Where it is desired to avoid unfavorable subscriber reaction the change can be made in steps over a period of time prior to the final change. Pads in the trunk circuits increased in 3 or 4 db steps at intervals of about three months will usually care for such a situation.

2.17 As a permanent means of correcting contrasts pads are not desirable. Neither is it generally desirable to deliberately degrade the better trunks in order to avoid contrast.

2.18 In cases where busy-hour overflow traffic is handled by automatic alternate routing the probability that successive calls between two subscribers during a short interval will follow different routes is rather small. Therefore, if it becomes necessary, the contrast between the direct and alternate routes may be allowed to go as high as 7 db. The contrast between this alternate route and any route in the reverse direction also should not exceed 7 db.

3. SIGNALING REQUIREMENTS

3.01 The resistance limits for the various types of signaling over the trunk plant vary materially depending upon the types of offices and associated terminal equipment. These limits are indicated on the standard drawings for each central office circuit and reference should be made to the circuit drawings for both ends of the trunk to determine which is the controlling value. The design limit for each group should be checked with the equipment engineer. The limiting values are expressed as the total permissible resistance between the main frames of the originating and terminating offices.

3.02 Over-all trunk resistance for signaling purposes is usually computed from unit values given for a temperature of 68° F. In underground trunk plant the amount of resistance

change with temperature will usually be in the order of three per cent for extreme summer temperatures and this variation may be disregarded. However, in aerial cable the corresponding temperature change may be as high as ten to twelve per cent. In cases where a substantial portion of the trunk is in aerial cable and the computed resistance at 68° F. approaches the signaling limit it will be advisable to check the hot weather resistance to be sure that it does not exceed the limiting value. The 68° F. resistances of standard exchange type facilities are tabulated in Section AB43.521 in a form which permits rapid computation. Included also in the section is a formula for converting the 68° F. values to any other temperature.

3.03 The resistances of exchange type loading coils are given in Section AB45.085.

4. GENERAL LAYOUT CONSIDERATIONS

4.01 Due to, (1) signaling limitations, (2) the short distances involved in some instances, (3) the limited number of types of facilities which it is economical to provide in exchange plant and (4) the undesirability of providing other than uniform gauges between central office main frames, it is impractical to design a trunk plant in which all groups conform closely to their respective permissible trunk losses. The objective should be to provide the most economical trunk plant, usually the finest gauge which will meet the signaling requirements and which at the same time, with proper loading, will meet the transmission requirements.

4.02 Because of the differences in signaling limits for the various types of central offices, which range from about 600 ohms for some manual offices to about 3000 ohms for crossbar offices, it may be found in some instances that heavy gauge facilities will be required in one direction between two offices while fine gauge will be permitted in the other direction. This may result occasionally in reverse direction transmission contrasts which exceed 5 db even though each group meets its permissible loss. Use of auxiliary trunk circuit equipment which increases the resistance limit of the short range group may permit the same facility in both directions.

4.03 In planning reinforcements to an existing manual office which may be either scheduled or contemplated for conversion to dial in the near future the requirements of the new office should be considered carefully in order to avoid overgauging the cable to meet a

short term need which could be met more economically with auxiliary trunk equipment.

5. TANDEM SWITCHING OF INTERLOCAL CALLS

(A) Office Selector Tandem Systems

5.01 Office selector tandem systems (also known as 2-wire distant office frames or office tandem centers) are often used in large metropolitan areas instead of direct trunks where a number of trunk groups follow the same route and also as a means for handling economically many small items of dialed interlocal traffic. These one-way arrangements permit trunk plant economies in the same manner as in a regular two-way tandem system. Traffic from an originating office to a number of distant offices is handled over a common trunk group to an OST at an intermediate office and distributed over individual completing groups from the OST to the called offices. Several originating offices may use the same OST for completion to a common group of called offices. A schematic of such an arrangement is shown in Fig. 1.

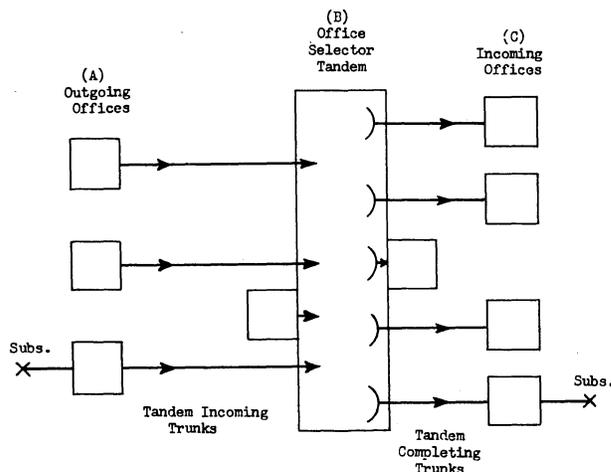


Fig. 1 - Trunk Layout Schematic - Office Selector Tandem System

5.02 The design of the incoming and outgoing trunks of an office selector tandem or other type of intermediate switching point should be such that the sum of the two trunk losses including the office losses at the switching point does not exceed, for any combination, the 10 db permissible loss for direct trunks. If the permissible loss is divided equally between incoming and outgoing trunks then the design maximum loss between "A" and

"B" offices and between "B" and "C" offices will be 5 db with 10 db for switched "A" to "C" traffic. With 10 db for reverse direction direct trunks, contrasts between the two directions would not exceed 5 db on a design basis.

5.03 Because the trunk plant layout is such that trunk losses are usually somewhat less than the design maximum, it will be necessary to check the losses actually obtained from the layout with available facilities to determine the resulting contrasts. If contrasts in excess of 5 db are indicated, means for their reduction should be considered.

(B) Alternate Routing via Regular Tandem Offices

5.04 Where alternate routing of interlocal traffic through regular tandem offices is employed, a similar problem of the division of losses between tandem incoming and outgoing trunks exists, but with certain differences. In the case of tandem offices in which the completing trunks may be used primarily for the completion of either short haul toll or inter-toll traffic or both, the permissible loss of these trunks is usually fixed by the toll requirements. This is covered in detail in Section AB22.128.1. If this loss is set at 4 db by the toll completing requirement then the incoming trunks may be 6 db. Both of these values include their proportionate allowances for tandem office losses.

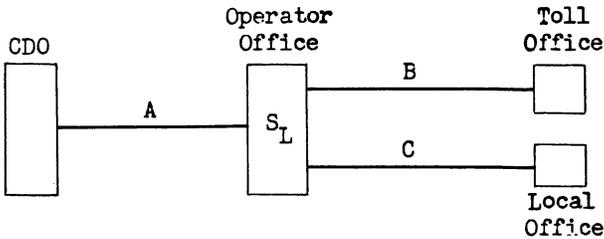
6. ASSISTANCE TRUNKS

6.01 Assistance or "OPERATOR" trunks from a dial office which has no operators to an operator office usually serve two purposes: (1) completion by the operator of interlocal calls normally dialed by the subscriber and (2) completion of interlocal (in the case of CDO's), interzone and short haul toll calls which the subscriber can not dial directly. Trunks from community dial offices to their respective operator offices and trunks from dial offices to centralized DSA boards are the two common types of trunks in this class. In some instances the operator office or DSA board may be combined with an outward toll board.

(A) Community Dial Office to Operator Office

6.02 In the case of a small CDO having trunks only to the operator office all traffic outside the CDO is switched at the operator office. The outgoing trunks from the operator office, both local and toll, over which the CDO traffic will be handled are, for economical reasons, usually designed to meet the requirements of that office. Therefore, the loss in

the CDO trunks plus the switching loss, less any margin which may exist in the interlocal or toll trunks represents an excess loss for the CDO. See Fig. 2.



S_L - Switching loss.

A - Toll and local trunks as common trunks.

B - Toll trunks designed for 4.0 db.

C - Local trunks designed for 10 db.

(1) Toll Connection: $A + B + S_L$ should be 4.0 db or less. Therefore any loss in " $A + S_L$ " may be excess loss unless "B" has less than design requirement loss.

(2) Local Connection: $A + C + S_L$ should be 10 db or less, therefore any loss in " $A + S_L$ " may be excess loss unless "C" has less than design requirement loss.

Fig. 2 - Trunk Layout Schematic - Community Dial Office to Toll or Local Office via Operator Office

6.03 It may not be economically feasible to shorten the large number of interlocal trunks serving the local office to compensate for the loss of the CDO trunks because of the relatively small amount of CDO traffic. To minimize the resulting transmission penalty on the CDO it is desirable to hold the operator office trunk loss to the lowest value obtainable. E-type repeaters at one or both ends of the CDO trunks may provide the solution to this problem.

6.04 A relatively large CDO, in addition to operator trunks, may have trunks to the operator office equipment over which calls may be dialed to that office and through it to other local offices. The transmission problem is essentially similar to that in the foregoing paragraph except that in this case repeaters on

calls extending beyond the operator office may prove more economical, especially where they are available to other CDO's served by the operator office.

(B) Dial Office to Central DSA Board

6.05 In many instances it has been found economical to centralize DSA operations in one office and serve one or more remote dial offices. As in the case of the CDO operator office trunks, the trunks to the DSA board from the remote dial office represent an excess loss. For interlocal assistance calls which are only a small percentage of the direct dialed traffic the additional loss penalty may be tolerated if it does not exceed about 3 db. However, if the same "OPERATOR" trunks are used for toll completion as well as local assistance the excess loss becomes important and should be held to the lowest possible value. If the toll traffic is completed by the DSA operator through a tandem office it may be possible to reduce the loss of the tandem trunks so that no penalty to the remote office is incurred. This phase of the problem is covered more fully in Section AB22.128.1.

6.06 Where centralized DSA boards are combined with outward toll boards and separate groups of trunks are provided for the "OPERATOR" code and for the "LD" code, the operator trunks may be designed in accordance with Paragraph 6.04. The LD trunks would be designed to meet the requirements for toll connecting trunks. However, if a common group is provided for a combined DSA and outward toll board, the design of the group would then be dependent upon the most severe requirements, interlocal, tandem or toll connecting.

7. TRUNKS FROM MANUAL TO DIAL OFFICES

7.01 Incoming calls to dial offices from manual local offices and from DSA and toll boards not arranged for operator dialing or key pulsing are completed through a DSB board which may be either individual to the incoming office or may be a centralized board common to several local dial offices in an exchange district. The different operating and routing features involved and their effect on interlocal trunk design for the various types of incoming dial offices are discussed in the following paragraphs.

(A) Incoming to Step-by-Step Offices

7.02 Interlocal trunks from manual to step-by-step offices usually terminate directly on the incoming equipment and do not require the services of a DSB operator for completion. No special features are involved in the design of these trunks.

(B) Incoming to Panel Offices

7.03 Calls to panel offices from manual offices usually are not dialed but are passed verbally to a DSB operator who completes the call through the equipment. In a few areas where manual offices are equipped for dialing or key pulsing to panel offices no DSB board is required as the trunks are direct and no special design is involved.

7.04 Where the incoming panel office is in the same building as the DSB board which serves it, the trunks are also direct and require no special considerations since the repeating coil in the DSB board trunk circuit also serves as the called subscriber battery supply coil and no intermediate switching loss is incurred.

7.05 Where the incoming panel office is served from a centralized DSB board in a different building the trunks from the manual office are routed via the DSB board. Unless the DSB office happens to be on the main route between the two terminating offices these trunks may be considerably longer than the direct trunks in the reverse direction. In order to meet the same transmission objective as for direct trunks those via the DSB board will probably require somewhat better grade facilities even though the signaling limits may be higher because of the repeated supervision feature at the DSB board. Intermediate office loss is incurred in the repeating coil and cabling in the DSB office.

7.06 The centralized DSB board trunk circuit is of the repeating coil type and where the trunk facilities on each side of the DSB office are of sufficiently dissimilar impedances, repeating coils of proper ratio may be specified to reduce the reflection loss. However, unless the facility arrangement is such that the same ratio can be used in all of the DSB trunk circuit coils, it may be advisable

to provide only unity ratio coils rather than to impair assignment flexibility with more than one ratio.

7.07 Because the section of the trunk from the DSB office to the terminating office is not connected to the originating part of the trunk until after the DSB operator completes the connection no bridging loss occurs and there will usually be ample transmission margin in the operator-to-operator condition.

(C) Incoming to Crossbar Offices

7.08 As in the case of panel offices, trunks from manual to crossbar offices are usually completed through a DSB board. In the few cases where calls are dialed or key pulsed by the manual operator the trunks are direct and require no special consideration.

7.09 Trunks from manual to crossbar offices differ from those to panel offices in that they are routed direct to the crossbar office rather than through the DSB office. At the crossbar office an incoming manual trunk is routed through a B operator sender circuit over a trunk to the DSB board. After key pulsing is completed by the B operator the B sender and trunk are disconnected at the crossbar office.

7.10 With this type of layout the interlocal trunk may be designed to the full permissible trunk loss of 10 db. However, this requires that the loss of the B sender trunks from the crossbar office to the centralized DSB board be held as low as possible to avoid poor operator-to-operator transmission. They should not in any case exceed 5 db.

7.11 The auxiliary incoming trunk circuit at the crossbar office on incoming trunks from manual offices will increase the crossbar office loss by approximately 0.5 db above that for incoming dial trunks.