

**NOISE ENGINEERING**  
**CONTROL OF**  
**CENTRAL OFFICE NOISE**  
**MEASUREMENT OF**  
**CROSS-OFFICE NOISE**

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**1. GENERAL**

**1.01** This section describes the engineering considerations necessary for measuring and controlling cross-office noise. The information in this section concerns local offices. Methods of reducing noise in toll-office equipment are described in Section 870-700-102.

**1.02** In this practice, the term cross-office noise refers to noise appearing in a single connection through a specific switching machine and is identifiable as a central office code or group of codes. A group of codes is applicable where a machine is common to several units such as those in urban areas served by panel or step-by-step (SXS) offices. In these cases as many as five or six office codes may use common originating equipment. In such offices, only the terminating equipment can be identified with a single code. In sampling paths through such a machine, do not make more than one test call from the same line group. Spread the called numbers as equally as possible over all the terminating equipment associated with the machine. In no case should a test call include more than one type of equipment.

**1.03** The procedures and limits described in this section apply to all class 5 offices. The same procedures may be applied in most private branch exchanges where a combination distributing frame (CDF) or its equivalent is available for making measurements. The noise limits may be used as a guide for evaluating noise arising in PBX equipment although PBX noise, particularly in older installations, may vary more widely due to differences in equipment quantities, poorly controlled environmental conditions, older type apparatus with poorly controlled balance, and other conditions less susceptible to control.

**1.04** Section 870-700-500 discusses noise related to battery supplies and the effects of decentralized battery filters. This section, therefore, does not discuss either these or related topics.

**1.05** Telecommunications nomenclature attaches somewhat specialized meanings to many terms used to describe noise. Other practices define these terms as they apply in telecommunications practice. Section 870-200-100, Appendix 1 contains a list of terms describing noise as heard by the telephone user, and 870-700-500, Appendix 1 lists terms relating to power supplies.

**2. CROSS-OFFICE NOISE CHARACTERISTICS**

**2.01** The character and magnitude of cross-office noise varies somewhat with the type and arrangement of switching equipment. However, certain types of noise tend to be common to most types of switching apparatus. In this category are the various tones and signals generated by ringing apparatus, howling generated by negative impedance repeaters, and battery supply noise described in Section 870-700-500. Thermal noise is common to

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all types of dial equipment, but is usually too low in level to be of concern.

**2.02** In addition to the noise categories listed in 2.01, step-by-step dial equipment tends to produce (a) recognizable dial-pulse noise trains, clicks and pops, or impulses, generated by the release function of the step-by-step switches, (b) series of clicks related to the hunting or spinning of rotary-type selector switches, and (c) some microphonic sounds generated at the wiper contacts of step-by-step selectors.

**2.03** Both No. 1 and No. 5 crossbar equipment tend to be quieter than step-by-step. In general, the common noise characteristics listed in 2.01 tend to predominate in crossbar offices. This equipment may add microphonic noise caused by the crossbar switches. This banjo noise is a twanging sound, most likely produced by switch springs under light pressure responding to structural vibration. The vibration is caused by frequent operation and release of many massive switch elements. The No. 1 crossbar uses revertive pulsing to transfer called number information from originating to terminating equipment. Likewise, No. 5 crossbar may be equipped with revertive pulsing outgoing senders to function with both panel and No. 1 crossbar. Such revertive pulsing operation may contribute to cross-office noise in central offices so equipped.

**2.04** The No. 1 electronic switching offices contribute the least noise to circuits traversing such equipment. This equipment utilizes ferreed crosspoints with sealed contacts, employs few conventional relays, presents good balance to connected line and trunk equipment, and includes more battery filtering than earlier central office equipment. The noise that can be observed in the monitoring receiver of a 3-type noise measuring set consists mainly of scratchy sounding pops, very low crosstalk, and occasional chirpy sounds.

**2.05** Cross-office noise, though always present, is not usually a major contributor to the total noise on a telephone connection. Panel dial equipment may contribute significantly to the noise on a typical connection. However, the mean noise contribution tends to vary greatly from office to office, depending on the extent and quality of maintenance.

## 3. CROSS-OFFICE NOISE REQUIREMENTS

**3.01** If noise measurements are made on many cross-office connections randomly selected in a well maintained office, the average noise level will be low, and the highest noise levels will not affect a telephone connection. If the average noise level is high, as may be the case with defective battery supply filters, then all connections may be affected.

**3.02** The discussion here assumes that battery supplies have been checked and found in satisfactory condition, as described in Section 870-700-500; therefore, it is appropriate to define only the upper limits for cross-office measurements.

**3.03** The distributions of measurements for five panel offices are shown in Fig. 1. Distributions for 20 step-by-step offices are shown in Fig. 2, and for 14 crossbar offices in Fig. 3. Note that the majority of measurements in each case are low enough to have little or no effect on a telephone connection but in a few cases the levels are definitely excessive. Therefore, the cross-office noise requirements are stated in terms of the upper limit.

**3.04** The requirements are based on a 2-stage sampling plan. If 20 different cross-office connections are selected at random and measured, an office is considered to be satisfactory if no measurements exceed 18 dBrnc for all offices except panel and 24 dBrnc for panel offices.

**3.05** An office is considered unsatisfactory if four or more measurements exceed the requirements given in 3.04 or if any measurement exceeds 22 dBrnc for all offices except panel and 28 dBrnc for panel offices.

**3.06** If 1, 2, or 3 measurements exceed the requirements of 3.04 but not those of 3.05, then 20 more measurements must be made and the requirements of 3.04 and 3.05 must then apply to all 40 measurements.

**3.07** The noise requirements listed and described in 3.01 through 3.06 are for steady-state noise. Noise of this character is usually described by customers as hum, buzz, growl, crackling, frying sounds or simply noise. There is another category reported often which includes clicks, pops or bangs. This latter category is believed to be the most

objectionable type of noise. When making cross-office noise measurements, clicks and bangs appear on the noise meter as large needle excursions. These excursions should be observed and an average value determined. This average peak value should be entered on the study form in the peak column when the steady reading is recorded. When the required number of test calls have been completed, the results should be examined to determine the office condition.

**3.08** In addition to the steady-state requirements listed in 3.07, the average peak limits are 26 dBrnc in all offices except panel offices and 32 dBrnc in panel offices.

**3.09** An office is considered unsatisfactory if four or more average peak measurements exceed the requirements given in 3.08, or if any measurement exceeds 30 dBrnc in all offices except panel offices and 36 dBrnc for panel offices.

**3.10** If 1, 2, or 3 measurements exceed the requirements of 3.08 but not those of 3.09, then 20 more measurements must be made and the requirements of 3.08 and 3.09 applied to all 40 measurements.

**3.11** In the field trials of this method, average peak measurements were found as high as 30 dB above satisfactory steady-state levels of 9 to 13 dBrnc in both panel and SXS offices.

#### 4. SAMPLING TECHNIQUE

**4.01** Methods for selecting and testing cross-office connections are described in Section 331-700-100 and associated sections. The sampling is done in two stages.

**4.02** The sample size of 40 connections taken in two stages of 20 each represents a compromise between a high degree of certainty that all bad central offices will be identified and that a reasonable number of measurements per office have been made. Figure 4 shows the probability that an office will be accepted if no paths are measured with noise exceeding 18 dBrnc out of the first 20, and the probability that an office will be rejected if 3 paths are found to exceed the 18 dBrnc limit. Both are plotted against the true proportion of bad paths which is the percentage of the total number of possible paths through the office that are actually bad. Likewise, the curve in Fig. 5 gives the

probability of accepting an office when 3 paths out of 40 measured have noise levels above 18 dBrnc derived as a function of the actual percentage of bad paths.

**4.03** The dashed curves in Fig. 5 show the effect of doubling and halving the sample size. The improved certainty of accepting an office when the sample size is doubled is not sufficient to justify the added measurement time and effort. Halving the sample size seriously impairs the chances that a poorly performing office will be indicated or rejected.

#### 5. EVALUATION OF MEASUREMENTS

**5.01** The characteristics of the noise as heard in the monitoring receiver of the noise measuring set will provide the most useful clues as to the source of specific central office noise troubles. The actual noise level as measured in dBrnc gives little indication of the source of trouble, if any. Therefore, every measurement must be monitored and the characteristic sound noted along with the measured value.

**5.02** Noise in a cross-office connection may result from three different conditions:

- (a) Relay and/or switch contacts in series with the transmission path of the circuit itself frequently contribute noise resulting from dirt, light contact pressure, corrosion, pitting, and other defects. Such contact problems also tend to unbalance the transmission path making it more susceptible to noise from outside disturbers.
- (b) Magnetic or electrostatic couplings to nearby circuits introduce noise into the cross-office connection.
- (c) The talking battery supply, in some cases, may introduce noise into the cross-office connection. Item (a) is common in step-by-step and, to an even greater degree, in panel offices. Because contact impedance also tends to unbalance the transmission path, Item (a) tends to grade into Item (b). Such circuit unbalance increases susceptibility to noise induced from adjacent circuits via magnetic and electrostatic couplings. Section 870-700-500 covers Item (c). Noise in No. 1 and No. 5 crossbar offices most likely results from the effects suggested in Item (b),

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although light contact pressure in crossbar switches may permit generation of some noise.

**5.03** In central offices where trouble is suspected in a particular line group or line finder, including the associated first selector, district selector, or district junctor, subscriber trouble reports may direct attention to the particular apparatus in trouble. The local test desk people usually maintain a file of such reports. In situations where neither subscriber trouble reports nor trouble indicator cards are available, the central office trouble records may show up equipment or apparatus likely to contribute excessive noise to cross-office connections.

**5.04** A review of subscriber trouble reports or central office trouble records might reveal repeated references to a particular switch frame, circuit group, central office cable exposure, or a combination of these that might be introducing noise into or contributing noise to the cross-office connection. Reviews of the various trouble record sources may be helpful or useless. It will depend entirely on how well the records are kept.

**5.05** Where the various trouble records described fail to implicate any specific frames, apparatus or cabling that might introduce noise into cross-office connections, a valid conclusion might be that noise production is fairly generally distributed throughout the office. If noise troubles in specific apparatus, frames, or cabling are still suspected, extended cross-office noise measurements might be useful. The trend of the noise levels should, if they are higher for a specific originating frame or location or for some specific group of interconnecting circuits, lead to localization of the trouble. In making extended cross office-noise measurements, the procedures suggested in this section should give the most reliable results. This is so because no permanently cross-connected originating or terminating locations are involved as would be the case if the regular test frames, call-through test boxes, or balance test lines were to be used. However, such permanently wired test apparatus should be useful in conjunction with either the originating or terminating testing arrangements described in 870-700-501 and as supplemental testing apparatus. Permanently wired testing arrangements are of limited value for general central office noise analysis as they do not have access to a large enough sample of lines on the originating or terminating frames.

**5.06** The most useful procedure, yielding quickest results, for reducing noise in offices failing to meet the tests outlined in this section, is to arrange for a detailed study of the specific causes of noise found in a properly selected sample of intraoffice test calls. When excessively noisy test calls are found, trace the calls through the machine. Inspect each pair of contacts for conditions, position, and tension. If a noise causing contact condition exists throughout an office or in some equipment groups, it will be shown by an analysis of test results. If noise is entering the voice paths through improper filtering on some frames or distributed exposure, the sample analysis will show this also.

**5.07** When the noise source has been identified, (for example, worn wipers in SXS offices, corroded cams in panel offices, weak spring tension in crossbar switches, weak relay spring tension, or certain combinations of these in any system) applicable BSPs will be found to prescribe proper corrective action. The difficulty lies in identifying the source, not in determining action required once the cause is known.

**5.08** The cost of corrective action and the remaining life expectancy of a specific machine in trouble should be considered when planning large scale noise reduction programs in older offices. In panel offices, cleaning of sequence switch cams might be all that is required to reduce noise to acceptable levels. In step-by-step equipment, bank cleaning and corrosion removal will often be all that is required. In panel and SXS offices, undesirable wear conditions in contact springs can often be tolerated **if the flat surfaces** they contact are clean and free of corrosion.

**5.09** In general, large scale readjustment or replacement of talking path components in older machines should not be considered until after cleaning of such surfaces has failed to reduce noise to acceptable levels. In crossbar offices where test call tracing and analysing discloses relay or switch contact wear or tension problems, readjustment or replacement (perhaps on a very large scale) will be necessary.

**5.10** In crossbar offices where measured noise levels are acceptable, but approach the limit, a study should be made to determine the cause. If switch contact wear or tension is heavy contributors, preference strapping where provided, should be changed to reduce usage on the worn

channels and increase usage of previous middle or last choice paths. This will postpone, perhaps for the life of the equipment, the need for very expensive replacement of crossbar switches.

**5.11** Contact noise in No. 1 ESS offices is likely to be very specific. Some of the talking path contacts are on wire spring relays. The majority, however, are sealed ferreeds. Very little is known about how either of these devices will react to prolonged usage in various environments.

**5.12** Specific cross-office noise troubles, particularly those that occur in a connection that can be held and traced, are fairly easily located. In such cases, the various contacts in the transmission

path are identifiable and their condition can be checked by inspection. Inductive noise couplings within the office cabling are less easily identified. Sleeve and other supervisory and control leads working to central office battery and ground are likely sources of inductive noise as they are, in effect, highly unbalanced disturbers. However, their influence is limited because of the short length of the exposure and the usually fairly good balance in the transmission path. Battery supply leads, too, where not closely paired with their associated ground leads, may be sources of induced noise. Section 870-700-500 discusses this problem, as well as the role of battery wiring as a common coupling impedance between circuits.

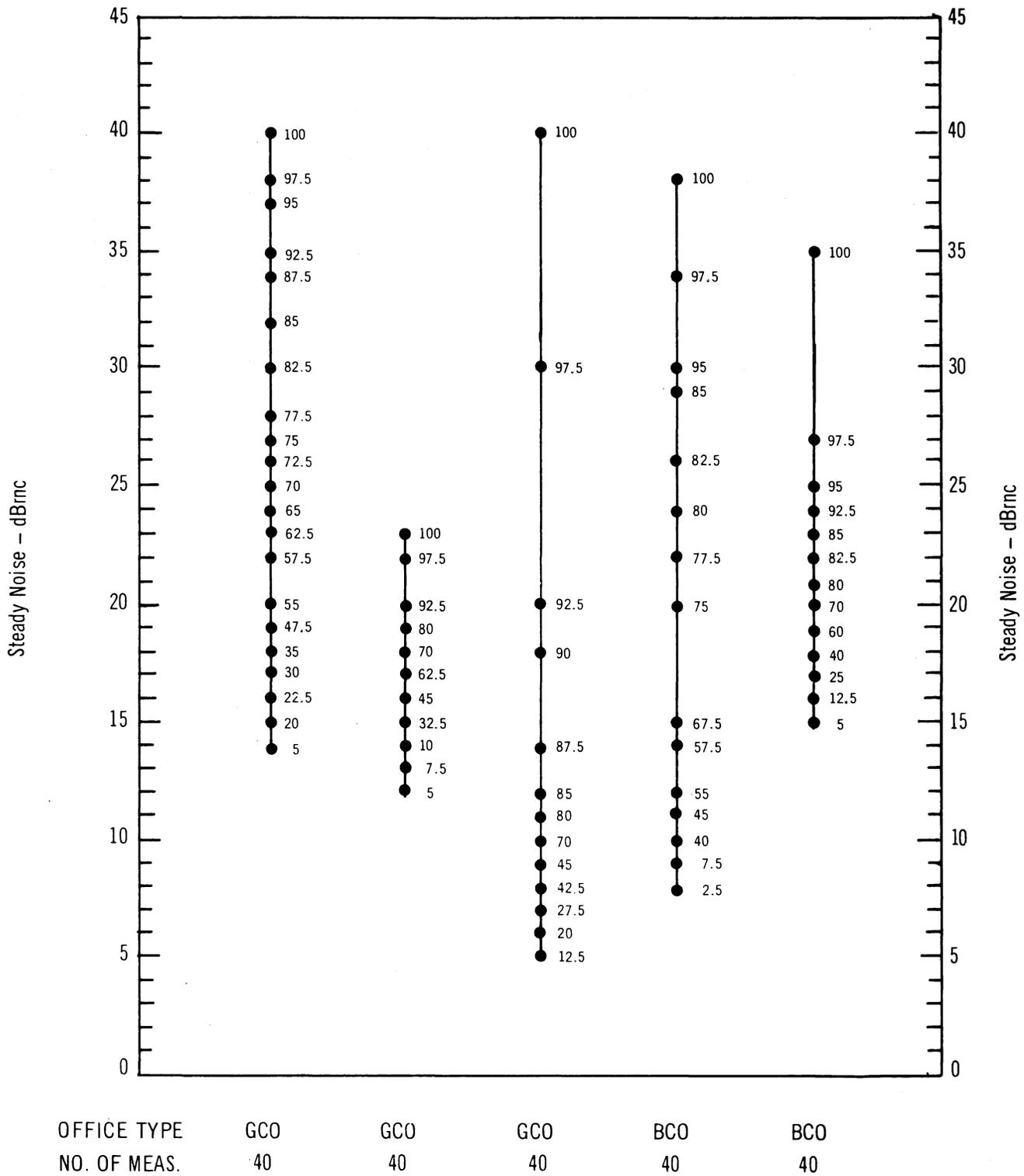


Fig. 1—Panel Office Noise Data (Cumulative Distributions)



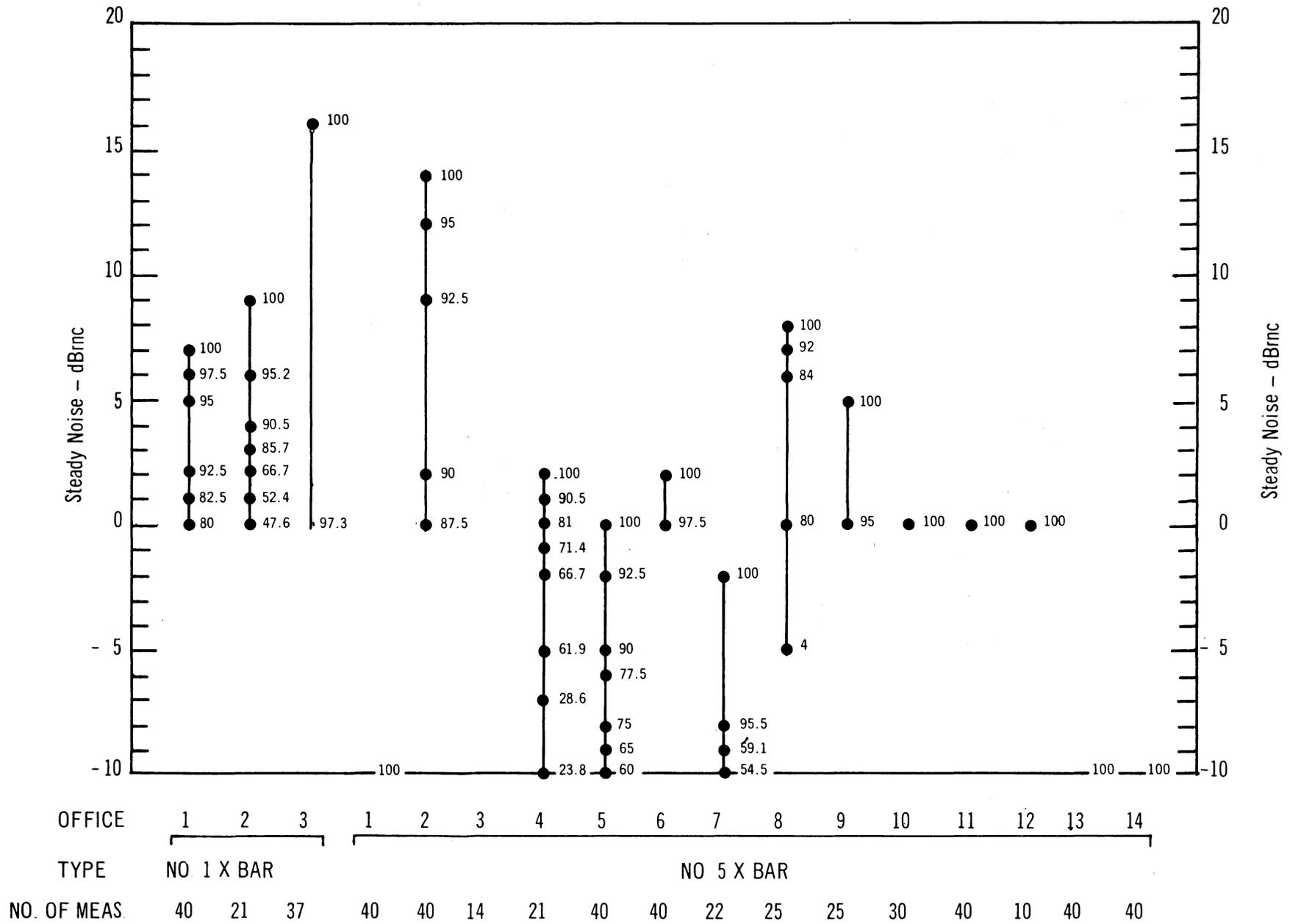


Fig. 3—Crossbar Office Noise Data (Cumulative Distributions)

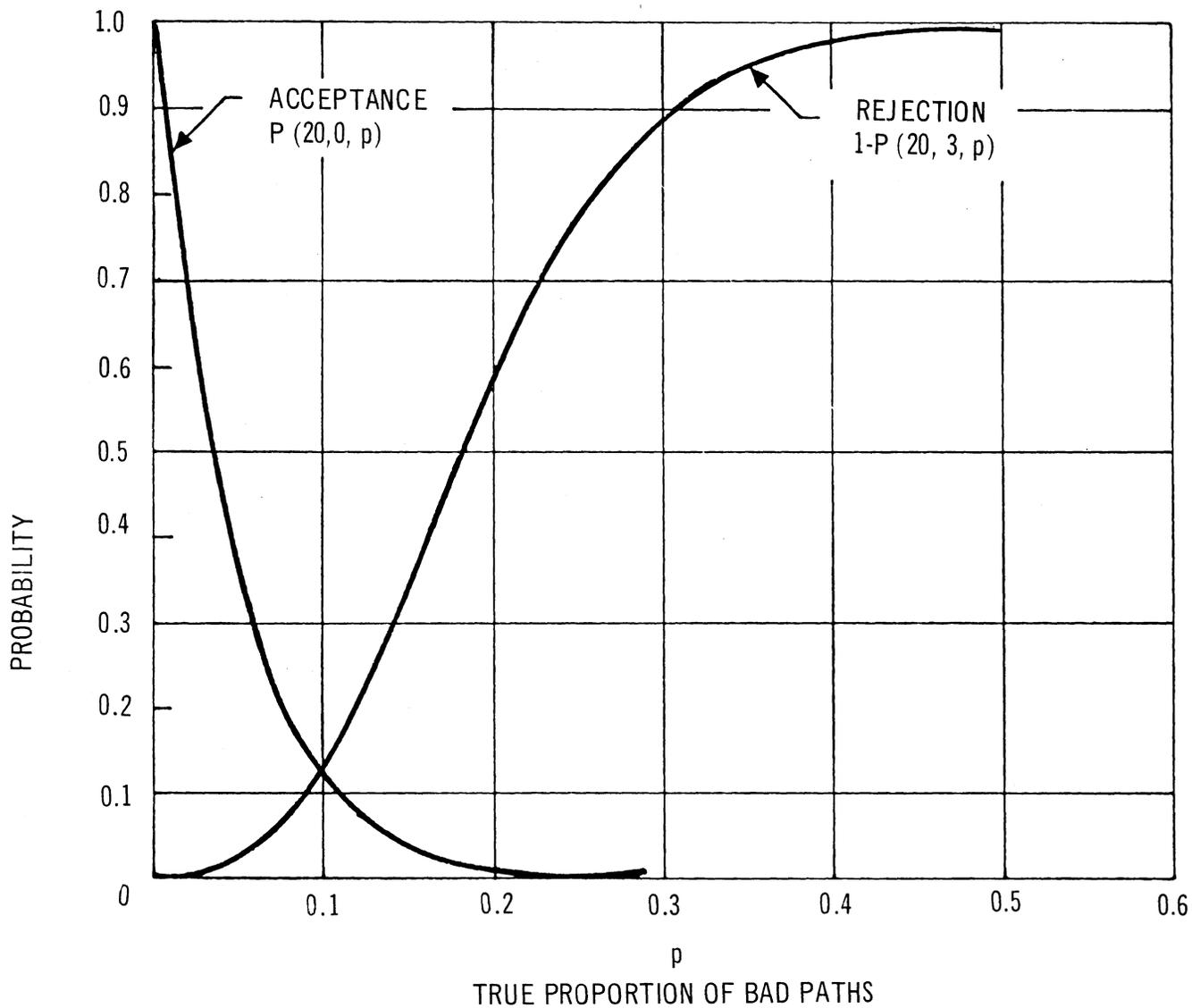


Fig. 4—Step 1 Probability

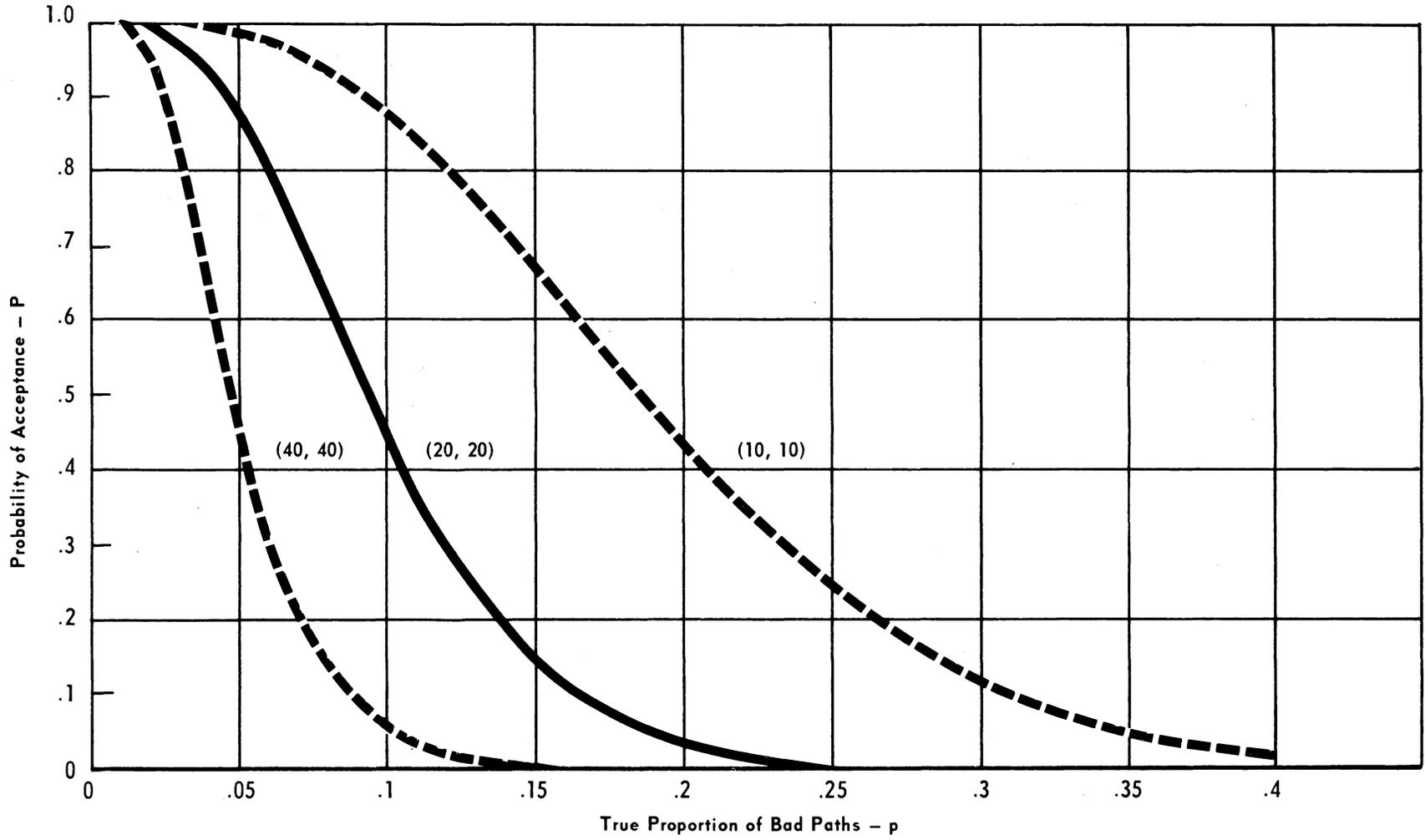


Fig. 5—Acceptance Probability,  $P_t$ , for Three Sample Sizes (a,b) = Sample Size a for Step 1, b for Step 11