IMPULSE NOISE

REQUIREMENTS AND MEASUREMENT

CONTENTS PAGE

1. GENERAL

1.01 This section presents requirements and techniques used in the measurement of impulse noise. Its purpose is to provide the objectives that will achieve the capability of transmitting data which is reasonably free of errors caused by impulse noise when dedicated or switched facilities of the telephone network are used as the transmission medium.

1.02 ◗This section is reissued to make minor changes to the text and Table A and to extend Table B.◖

1.03 General information about impulse noise is presented in Section 331-100-101.

1.04 Other sections will define intervals at which impulse noise measurements are to be made.

2. REQUIREMENTS

A. General

2.01 Impulse noise measurements on trunks need not be made at the time circuit order tests are made; and, therefore, no circuit order limits are specified. Impulse noise measurements will be required at the time of initial lineup of trunk facilities when so specified in the trunk facilities sections of the Bell System Practices. Actual line-up requirements are given in Table A.

B. Impulse Noise Requirements

2.02 Impulse noise requirements are presented in Table A. The requirements are to be met using a 6-type impulse noise measuring set. The reference level (presented in the LEVEL column) is used to determine the threshold setting on the impulse noise measuring set. The various impulse noise requirements are discussed in the following paragraphs.

2.03 ***Loops:*** Measurements are to be made from the central office or referred to another point through the 1000-Hz loss to the central office.

2.04 ***Connections:*** Customer-to-customer connections include 2 loops and any number of trunks in tandem. These connections make up the transmission path encountered by a customer. The requirement for connections is specified as 5 dB below the receive level of the data signal. This level is determined by transmitting a 0-dBm0 test tone at 1000 Hz from the far end. Since the receive level of the data signal is −13 dBm0, the level to be set on the impulse noise counter should be 18 dB below the receive level of the test tone.

2.05 ***Switching Offices:*** All switching offices contribute to impulse noise. The degree of

contribution varies with the type of office. A consideration of switching offices follows:

(a) ***Panel Offices:*** No impulse noise requirement is given. The impulse noise level in these offices is high and the cost of making them satisfactory for data transmission, if that is possible, is considered prohibitive. Data customers who would normally be served from panel offices should be served with foreign exchange lines.

(b) ***Step-by-Step (SXS) Offices:*** "Contact noise" in SXS offices has been a known impairment to voice communication for many years. Impulse noise in SXS offices as measured with 6-type impulse noise measuring sets is usually contact noise. Impulse noise in SXS offices varies considerably from office to office and from call to call within an office. Higher levels of impulse noise are encountered in SXS offices than in crossbar offices. Nevertheless, in most cases, the expected data transmission performance is still good. The impulse noise requirements are referred to the level at the switching office.

(c) ***Rotary-Out Trunk Switches (SXS Offices):*** It has long been known that some SXS switching offices equipped with rotary-out trunk switches (ROTS) generally have impulse noise levels in excess of offices without ROTS. A modification is available which improves the performance of ROTS offices. This modification involves equipping each ROTS with a multiple cutoff (MC) relay. The MC relays operate whenever the ROTS rotates to locate idle terminals. When operated, the MC relay opens the tip and ring leads back toward the selector multiple. By opening these leads, the total capacitance of the ROTS wipers is reduced. The charge transferred to the busy terminals as the wipers rotate is, therefore, reduced, resulting in improved impulse noise performance. The impulse noise requirements given in Table A for an SXS office apply from MDF (main distributing frame) to MDF and, therefore, do not serve to determine whether or not the ROTS-generated impulse noise is excessive. To account for the noise due to the ROTS, a test has been devised to ascertain whether the ROTS-equipped offices are suitable for serving subscribers to DATAPHONE® service or data-access arrangements (DAA).* The test criteria are based on having the error performance from ROTS offices lie reasonably close to that of non-ROTS offices.

*This test is described in detail in E.L. 1379/P.L. 2510.

(d) ***Crossbar (CSBR) Offices:*** There is no reason to believe that the impulse noise in CSBR offices contributes significantly to errors in data transmission. The impulse noise requirements are referred to the level at the switching office.

(e) ***Electronic Switching Systems (ESS):*** In keeping with technical changes and the continuing effort to suppress impulse noise in new equipment, the design objectives for such noise in ESS offices are tighter than the maintenance objective proposed for older switching machines. Past measurements of impulse noise in ESS offices indicated that levels were below those that impair data transmission. The requirements are referred to the level at the switching office.

2.06 ***Trunks:*** Impulse noise requirements for voice-frequency and carrier trunks are referred to the zero transmission level point (0 TLP). Requirements for trunks consisting of compandored facilities of mixed compandored and noncompandored facilities are stated separately in Table A. Compandored and mixed compandored and noncompandored facilities are measured with a −13 dBm0 holding tone to operate the expandor. The requirements are based on the statistical behavior of impulse noise across trunk groups and are not to be used for individual trunk measurements. Measurements made on any ***single*** trunk may be made at the same level but for a 15-minute interval.

2.07 ***Facilities:*** Requirements for impulse noise for facilities are applicable from voice-frequency patch to voice-frequency patch (or equivalent) and are referred to 0 TLP. Requirements for compandored facilities are stated separately in Table A and are measured with a −13 dBm0 holding tone to keep the expandor operating at a fixed loss. The requirements are based on the statistical behavior of impulse noise as it affects facility groups and are not to be used for individual facility measurements. Measurements made on any ***single*** channel may be made at the same level but for a 15-minute interval.

3. MEASUREMENT OF IMPULSE NOISE

A. General

3.01 Several things must be considered in making impulse noise measurements. The characteristics of impulse noise (discussed in Section 331-100-101) are such that the instruments which were designed to measure message circuit noise could in no manner produce an intelligent measure of impulse noise. The 6-type impulse noise measuring sets were designed so that measurements of impulse noise could be performed with satisfactory results.

3.02 Other factors must be applied to impulse noise measurements. These factors are discussed in the following paragraphs.

B. Level Correction

3.03 Levels specified for measurements with the 6-type noise measuring set are referenced to 0 TLP. Points other than 0 TLP are referred to 0 TLP using the loss experienced by a 1000-Hz dBm0 tone transmitted from the far end to the point of measurement.

C. Holding Tone—Compandored Carrier

3.04 Measurements made on compandored carrier systems or mixed compandored and noncompandored systems are made with application of a 2800-Hz holding tone at −13 dBm0 applied at the ▶distant◀ end. Since present testing procedures do not provide this tone, two people are required to perform the tests on compandored facilities. A 2800-Hz notched filter (497G) is used with the 6-type noise measuring set to block the tone at the set. The 6F, 6FR, 6H, and 6HR impulse noise measuring sets have provision for this filter.

3.05 ▶Holding tone should be applied and measurements made at test points that will include compandor action. The DO-DG jacks on N2 and N3 carrier do not include the compandor and should not be used as test points for this measurement.◀ The expandor is operated at a fixed loss by application of the holding tone. The requirements specified for compandored systems account for the fixed expandor loss and are not valid if the holding tone is not applied.

D. Measurement Time

3.06 The permissible time for measuring is any time in the normal working day (from 9:00 am to 4:30 pm). However, in the event that measurements are being made because of a particular subscriber's complaints, the measurements should be made during the hours that the subscriber observes the trouble condition.

E. Slope

3.07 If impulse noise counts versus threshold level is plotted on semi-log graph paper, the curve approximates a straight line (constant slope). Figure 1 illustrates two such plots: an "average" distribution of 7 dB/decade and a "bad" distribution of 20 dB/decade.

3.08 The curves of Fig. 2 illustrate the 7 dB/decade curves which may be used to convert from a given count and threshold to another count or level. An example is provided in Section 331-100-101 using this same figure.

F. Measurement Techniques—Sampling

General

3.09 Impulse noise is time variable and ordinarily requires long intervals of testing to establish its existence at impairment levels. It is also facility-oriented rather than channel-oriented: that is, impulse noise induced in lines from external sources ▶is most likely to affect facility groups as measured at the channels rather than affecting individual channels alone.◀ To shorten test intervals, methods of sampling have been developed that take into account these characteristics. By these methods, several relatively short tests are made on several channels rather than long tests on single channels.

3.10 The following paragraphs describe procedures for measurements on trunks, facilities, and central office switches. The sampling technique adaptable to trunk and facility measurements is ***sequential sampling,*** a procedure of successive tests in which a decision is made after each test on the basis of the cumulative results. The central office measurements are made on a small sample of the many possible combinations of paths, and a decision is made on the test results of this sample.

Trunk and Facility Measurements—Sequential Sampling

General

3.11 The basic procedure for evaluation of impulse noise on trunks and facilities using sequential sampling is to look at the cumulative value of some parameter after each test or measurement is completed. On the basis of the cumulant, one of three possible actions may be taken: one may either accept the lot under test, reject the lot, or make another test.

3.12 This method of testing has the advantage of requiring a minimum number of measurements if the population under test meets or fails the acceptance criterion by a considerable margin. Thus a very good system would be accepted or a very poor system rejected after a fairly small number of measurements. However, systems which are borderline may require a relatively large number of tests. By performing the tests, the answer to the question as to whether the median noise count is above or below 5 can be obtained. (The objective for trunks is 5 counts in 5 minutes at the levels given in Table A.) Testing terminates as soon as it has been reasonably well determined that the median is 5 or less (accept the system) or 6 or more (reject the system).

3.13 Two kinds of errors can be made: one may accept a system which is actually bad or reject a system which is actually good. It is, of course, highly desirable to minimize the probability of either kind of error. These probabilities can be made arbitrarily small but at the expense of additional testing. In the procedure established ▶in this section, the choice of a 10-percent probability of error in the acceptance or rejection of a system has been made.◀ Once the choice has been made, the procedure described determines an upper bound on the number of tests (or the sample size) required. However, as stated in 3.12, the testing may terminate before the maximum sample size is achieved. Such a termination in no way affects the error probability; it simply means that the performance of the system being tested is somewhat better (or worse) than the objective.

Procedure

3.14 The sampling procedure is as follows:

(a) A trunk group is defined as all trunks between common test points: for example, all those trunks between two testboard appearances would comprise an intertoll trunk group.

(b) Use a test sheet similar to the sample form supplied at the end of this section, which may be reproduced locally if desired. List in the column designated CUMULATIVE NUMBER OF TRUNKS MEASURED numbers according to the number of trunks being measured (see Fig. 3 or sample form). Enter "compandored" opposite the trunk number for those trunks using compandored facilities. Use Table A to obtain the test level for each trunk and enter this value in the column designated TEST LEVEL. Enter the decision number from Table B. Note that this value starts with the fourth trunk to be tested. ▶Note also in Table B that all trunk groups containing 44 or more trunks (regardless of the size of the group) will use 26 as the decision number for determining whether a group is good or bad.◀

(c) Terminate the far end of the trunk (code 101 or equivalent) and connect a 6-type impulse noise measuring set to the trunk at the near end. (See 3.04 for compandored trunks.)

(d) Set the test level on the 6-type set, using the DBRN switch, to the value listed in the column designated TEST LEVEL on the test sheet opposite the first trunk. (See references in 4.01 for operation of impulse noise measuring set.) Set the counter to zero and the timer for 5 minutes.

(e) At the end of the 5-minute test interval, observe the counter reading. If the counter reads 5 or less (designated as 0's), enter a 1 in the column designated CUMULATIVE 0's opposite the 1 in the column designated CUMULATIVE NUMBER OF TRUNKS MEASURED. If the counter reads more than 5 (designated as 1's), enter a 1 in the column designated CUMULATIVE 1's opposite the 1 in the column designated CUMULATIVE NUMBER OF TRUNKS MEASURED.

(f) In the same manner as that described in (d), measure the remaining trunks of the group in a random manner. The next trunk measured will be entered in either the CUMULATIVE 0's or the CUMULATIVE 1's column (depending on the count level) and a cumulative number for that column will be shown. For example, in Fig. 3, the third trunk was the second trunk with 5 or less counts to be tested

and the fifth trunk was the second trunk with more than 5 counts. Continue testing until either the cumulative 0's or 1's exceed the decision number. If the exceeding cumulative number appears in the 0's column, accept the group. If the exceeding cumulative number appears in the 1's column, reject the group. If neither 0's nor 1's exceed the decision number after the maximum number of tests and there are equal 0's and 1's, accept the group.

3.15 Table B is based on a 10-percent or less probability of making the wrong decision. In the example in Fig. 3, the group passed after making seven tests. If the actual noise level for the group is at least 2.5 dB from the objective (either below or above) the chance that testing sequences will produce an erroneous conclusion is less than 1 percent.

Central Office Measurement Plan

General

3.16 The sampling plan for measuring impulse noise in central offices requires that the office be defined as being inclusive of all of the equipment and cable that is required to complete a connection from one termination on the main distributing frame (MDF) to some other termination on the MDF. For ease of administration, a single office is defined as including only those MDF terminations assigned to a single exchange number, even though more than one such number may exist for a given switching machine.

3.17 Since there is an extremely large number of possible paths that may be taken for a connection between two arbitrary MDF terminations and since there are $n(n-1)$ possible termination pairs, where n is the total number of such terminations, a sampling plan is required to evaluate the noise encountered on connections through an office.

Procedure

3.18 The population from which a test sample is to be drawn is all of the spare MDF terminations included in a single exchange number. Two line-finder groups or two trunk link frames are picked at random. One spare terminal in each group is assigned a directory number and designated as the called terminal. Ten other spares are picked arbitrarily (strict random sampling is not necessary) within each group. In offices with a high fill, eleven spares may not be available in any one group. In these cases, any 22 spares may be used. Calls are established sequentially from each of the ten spares within each group to the called terminal within the group.

3.19 Using locally fabricated test boxes (see BSP Section 331-700-130), make measurements of C-message noise and impulse noise as follows:

(a) Connect one test box to the calling line and one to the called line. Connect the ▶6F impulse counter◀ to the test box, and establish a connection to the called line. When the connection has been completed, make impulse noise measurements with the 6F selector switch placed in the MEAS position.

(b) The 6F timer is set for 5 minutes, and the threshold level is set to the level given in Table A for the type of switching office. The impulse noise count after 5 minutes is recorded.

(c) Using ▶a 3C measuring set,◀ a measurement is also made of message circuit noise. No measurement of C-message noise should exceed ▶18 dBrnc on trunks or 20 dBrnc on loops.◀

(d) For impulse noise measurement, if the count at the end of 5 minutes is 5 or less, a zero is recorded for that measurement; otherwise, a one (1) is recorded. Twenty measurements (10 in each of the groups or other available spares) are made. The office is acceptable from an impulse noise standpoint if no more than six 1's are accrued in either of the 2 groups of 10 measurements. This criterion ensures that 50 percent of calls through the office will have 5 counts or less in 5 minutes with 90-percent confidence.

3.20 Since it is proposed that an office be evaluated only after a specific noise complaint has been traced to the office, the results of the measurements should be forwarded to the appropriate evaluation group for follow-up action.

3.21 Impulse noise problems in other than SXS offices will probably require engineering assistance for mitigative measures. In SXS offices, cleaning and adjusting of the switches according to standard practices usually results in improved

performance. If background noise is out of limits, the office should be investigated according to prescribed procedures in the sections covering cross office noise (Sections 331-700-100, 331-700-130, and 331-700-501).

4. IMPULSE NOISE COUNTERS

4.01 The following instruments and their related sections can be used for measuring impulse noise:

(a) J94006A (MD) Impulse Counter
Section 103-620-100

(b) J94006E (A&M Only) Impulse Counter
Section 103-620-100

(c) J94006F Voiceband Noise Measuring Set
Section 103-626-100

(d) J94006H Impulse Counter
Section 103-620-101

(e) ▶J94003C Noise Measuring Set
Section 103-611-101◀

◗TABLE A◖

IMPULSE NOISE REQUIREMENTS (6-TYPE COUNTER)

	CONDITIONS	LEVEL	
LOOP	No more than 15 counts in 15 minutes on all loops. Level at CO, or referred to CO through 1,000-Hz loss.	59 dBrnc	
CONNECTION	No more than 15 counts in 15 minutes on at least 50% of calls.	5 dB below signal level	
SWITCHING OFFICE	No more than 5 counts in 5 minutes on 50% of test calls (use sampling plan). Immediate action limit: 100 counts or more in 5 minutes. Level at CO.	Crossbar	54 dBrnc
		Step-by-Step	59
		ESS	47
VF AND CARRIER TRUNK	No more than 5 counts in 5 minutes on 50% of trunks in group (use sampling plan). Immediate action limit: 100 counts in 5 minutes. *With −13 dBm0 holding tone.	Voice Frequency	54 dBrnc0
		Compandored or Mixed	66 dBrnc0*
		T-Carriers	62 dBrnc0 (See Note)
		Noncompandored	
		0-125 Miles	58 dBrnc0
		125-1000	59
		1000-2000	61
		Over 2000	64
FACILITIES	No more than 5 counts in 5 minutes on 50% of ◗channels◖ (use sampling plan). Immediate action limit: 100 counts in 5 minutes *With −13 dBm0 holding tone.	Voice Frequency	52 dBrnc0
		Compandored or Mixed	64 dBrnc0*
		T-Carriers	67 dBrnc0*
		Noncompandored	
		0-125 Miles	56 dBrnc0
		125-1000	57
		1000-2000	59
		Over 2000	62
PRIVATE LINES	See Section 314-410-500.		

Note: ◗Do not use holding tone when measuring trunks on T-carrier facilities.◖

◗ TABLE B ◖

DECISION NUMBERS OF 0's AND 1's
(For Various Trunk Group Sizes)

Note: Accept group if 0's exceed decision number.
Reject group if 1's exceed decision number.
Accept group if equal 0's and 1's after maximum tests.

CUMMULATIVE NUMBER OF TRUNKS TESTED	SIZE OF TRUNK GROUP					
	5-12	13-18	19-24	25-30	31-43	44 UP
4	3	3	3	3	3	—
5	3	4	4	4	4	5
6	4	4	4	4	4	6
7	4	5	5	5	5	6
8	5	5	5	5	6	7
9	5	6	6	6	6	7
10	6	6	6	6	6	8
11	6	7	7	7	7	9
12	6	7	7	7	8	9
13		7	8	8	8	10
14		8	8	9	9	10
15		8	9	9	9	11
16		9	9	10	10	12
17		9	10	10	10	12
18		9	10	11	11	13
19			10	11	11	13
20			11	12	12	14
21			11	12	13	14
22			12	12	13	15
23			12	13	14	16
24			12	13	14	16
25				14	14	17
26				14	15	17
27				15	15	18
28				15	16	18
29				15	16	19
30				15	17	19
31					17	20
32					18	21
33					18	21
34					19	22
35					19	22
36					20	23
37					20	23
38					20	24
39					21	24
40					21	25
41					21	26
42					21	26
43					21	26

◗ TABLE B (Cont) ◖

DECISION NUMBERS OF 0's AND 1's
(For Various Trunk Group Sizes)

CUMMULATIVE NUMBER OF TRUNKS TESTED	SIZE OF TRUNK GROUP					
	5-12	13-18	19-24	25-30	31-43	44 UP
44						26
45						26
46						26
47						26
48						26
49						26
50						26

◗ ***Note:*** See 3.14 (b). ◖

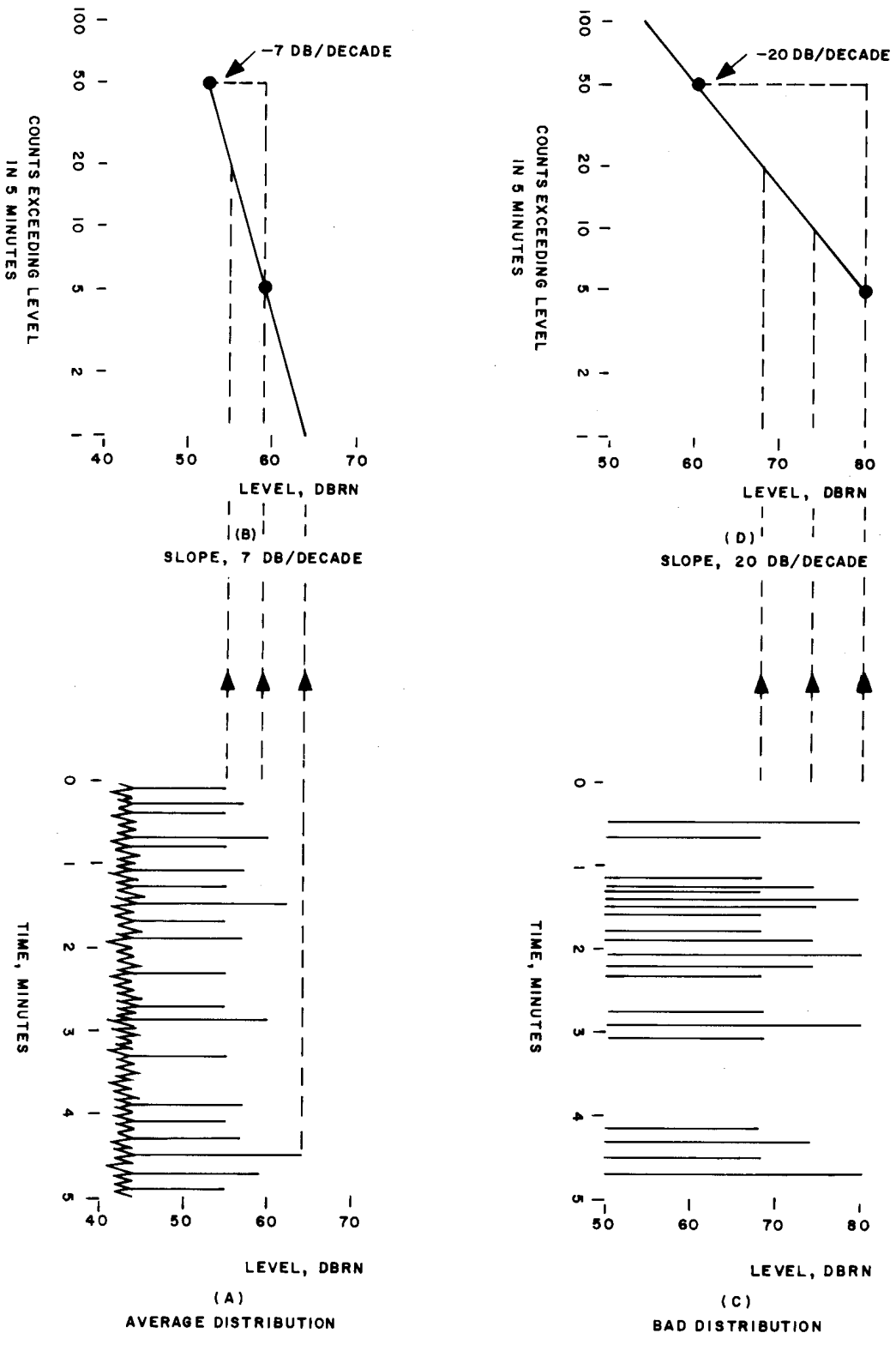

Fig. 1—Relationship Between Distribution and Slope

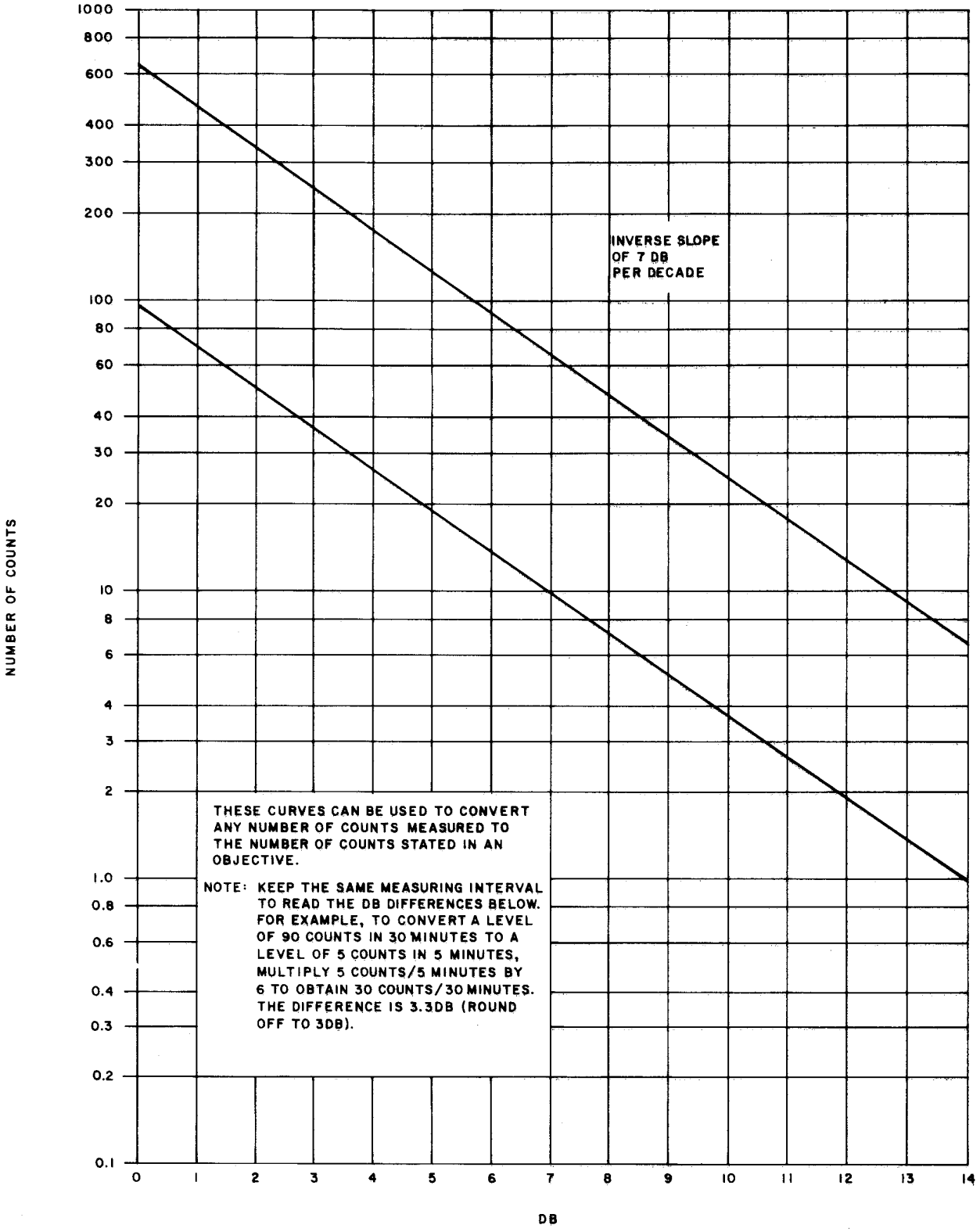

Fig. 2—Conversion Chart

IMPULSE NOISE
SAMPLE TEST SHEET–TRUNK GROUPS

TRUNK GROUP JONESTOWN - SMITHVILLE DATE 11-1-73

OFFICE ANYTOWN ACCEPT ☑ REJECT ☐

CUMULATIVE NUMBER OF TRUNKS MEASURED	REMARKS	TEST LEVEL	DECISION NUMBER OF 0'S OR 1'S	CUMULATIVE 0'S	CUMULATIVE 1'S
1	COMPANDORED	64	–	1	–
2	COMPANDORED	64	–	–	1
3	COMPANDORED	64	–	2	–
4	NON-COMPANDORED	52	3	3	–
5	NON-COMPANDORED	52	3	–	2
6	NON-COMPANDORED	52	4	4	–
7	COMPANDORED	64	4	5	–
8			5	–	–
9			5	–	–
10			6	–	–
11			6	–	–
12			6	–	–

ACCEPT IF 0'S EXCEED DECISION NO.

REJECT IF 1'S EXCEED DECISION NO.

ACCEPT IF EQUAL 0'S AND 1'S AFTER MAXIMUM NO. OF TESTS

Fig. 3—Example Test Sheet for a Group of Twelve Trunks

IMPULSE NOISE
SAMPLE TEST SHEET–TRUNK GROUPS

TRUNK GROUP _____ DATE _____

OFFICE _____ ACCEPT ☐ REJECT ☐

CUMULATIVE NUMBER OF TRUNKS MEASURED	REMARKS	TEST LEVEL	DECISION NUMBER OF 0'S OR 1'S	CUMULATIVE 0'S	CUMULATIVE 1'S

ACCEPT IF 0'S EXCEED DECISION NO.

REJECT IF 1'S EXCEED DECISION NO.

ACCEPT IF EQUAL 0'S AND 1'S AFTER MAXIMUM NO. OF TESTS

Fig. 4—Sample Form