A REPORT ON THE PERFORMANCE OF PERSONAL NOISE DOSIMETERS

Ronnie L. Fortner
Nick Blaskovich, Jr., Ph.D.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Appalachian Laboratory for Occupational Safety and Health
Division of Safety Research
Morgantown, West Virginia 26505

September 1978

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DHEW (NIOSH) Publication No. 78-186

ABSTRACT

This test report presents the results of a NIOSH evaluation of the current U.S. personal noise dosimeter market. Three units each of 9 personal noise dosimeter models were purchased. These units were subjected to acoustical, electrical and environmental evaluations in accordance with a proposed NIOSH certification program for such devices. The test methods are described and the test results with analysis are presented.

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INTRODUCTION

To accurately determine an individual's exposure to various hazardous agents in the occupational environment requires the use of instrumentation designed on sound scientific criteria to meet performance standards. The Testing and Certification Branch (TCB) of the Division of Safety Research (DSR) was established in Morgantown, West Virginia in the Appalachian Laboratory for Occupational Safety and Health (ALOSH) of the National Institute for Occupational Safety and Health (NIOSH) in order to evaluate those devices which measure or protect against occupational exposure to such hazardous agents. TCB has currently established such capability in developing techniques for gauging the performance of respirators, sound level meters, noise dosimeters, hearing protectors, protective eye-, foot-, and head-gear, gas detector tubes, and personal dust samplers. This report on the performance characteristics of personal noise dosimeters is one in a series of such reports designed to convey this information to those individuals concerned with providing the American worker a safe and healthful working environment.

A personal noise dosimeter is a device designed to be worn by a worker in order to measure and record the worker's exposure to noise during a work period. Unless these instruments are reliable and accurate, workers could be exposed to unsafe noise levels in the workplace. A personal noise dosimeter set consists of a device which computes, stores, and displays the accumulated noise dose, a compatible acoustic calibrator, and associated instruction manuals.

The majority of the personal noise dosimeters evaluated represent those devices commercially available in April, 1977 when purchases were made from distributer's stock. As the evaluations progressed, attempts were made to include new models as they appeared in the market to the extent feasible consistent with shipping schedules and program activity.

PURPOSE

NIOSH's specific purpose in publishing this technical report on personal noise dosimeters is two fold. The first is to supply to the buyer of personal noise dosimeters technical guidelines on which a purchase decision may be made. Secondly the report offers the manufacturers performance data. Such data shows the specific area in which a manufacturer may improve his product.

TESTING PROGRAM

A detailed discussion is given in this report for each of the tests performed. Many of the tests are patterned after tests suggested by the American National Standards Institute (ANSI) S1.4-1971. Although this standard applies to type 2 sound level meters certain sections are still applicable to personal noise dosimeters.

TEST AND RESULTS

Rapid Readout Procedure

Storage of the dosage in a personal noise dosimeter is accomplished in a variety of methods. Many units convert the RMS signal level to a pulse train whose frequency is proportional to the level of input. These pulses are then counted and stored either by a digital or electro mechanical counter. By measuring the time between these pulses one can obtain a rapid readout of the equivalent level. The only other alternative would be to wait for a dosage to accumulate over a specific time period then convert the dosage back to an equivalent level. This is a lengthy process involving hours of time for low signal levels.

For units that convert the RMS signal level to a voltage and use the voltage to charge a cell, the method of rapid readout merely involves measuring the charging voltage at specific levels of known input levels. Rapid readout measurements are made by comparing the measured voltage to a known reference.

Frequency Response Test

The accuracy of the A-weighted frequency response of the personal noise dosimeter was tested for conformance to the tolerance limits specified in Table 1 of this document. The relative response level is given at discrete frequencies in Table 1 but the desired response corresponded to a smooth curve passing through the particular discrete frequencies. The free field relative response level was determined with sufficient accuracy and number of frequencies to establish that the random incidence response level (as determined by the method detailed in Appendix A of ANSI S1.4-1971 "Specification for Sound Level Meters") of the personal noise dosimeter met the required frequency response characteristics and total tolerance limits as specified in Table 1. Testing was performed in an anechoic chamber with no observer present in the chamber. Tests to determine if the personal noise dosimeters met acoustic low frequency response tolerances (less than 250 Hz) were performed using a low frequency calibration chamber.

The random incidence responses of each personal noise dosimeter tested are shown in Figures 1 to 27. All the units except Tracoustics (SN 045) and and Bendix (SN 193) tested were inside the tolerance limits set forth in Table 1. The Tracoustics unit showed a large discontinuity between the 200 Hz point and the 250 Hz point. No explanation was apparent for the discontinuity. The other Tracoustics units did not exhibit this property. It should be noted that this unit failed to function for the duration of the testing program.

Acoustical Calibrator Accuracy Test

The acoustical calibrator accuracy test was designed to check, under minimal supply voltage conditions, the frequency, timed output, and sound pressure level accuracy of an acoustical calibrator of a personal noise dosimeter set (PND).

NIOSH requirements for acoustical calibrators for personal noise dosimeter sets are:

1. Each acoustical calibrator intended for use as part of a personal noise dosimeter set shall be of the pure-tone, coupler type and be compatible with the personal noise dosimeter with which it is to be certified as a set.

2. The acoustical calibrator shall generate at least one tone in the frequency range 200-1250 Hz, preferably at 1000 Hz. The frequency of each tone shall be marked on the acoustical calibrator and shall have an accuracy within ±5 percent of the nominal frequency stated by the applicant. If the acoustical calibrator operates at more than one frequency, means shall be provided to indicate which frequency is in use.

3. If the acoustical calibrator operates at more than one sound pressure level, means shall be provided to indicate which sound pressure level is in use. The accuracy of the calibration sound pressure level of the acoustical calibrator shall be within ±1 dB, utilizing any corrections for atmospheric pressure (see pressure test) specified by the instruction manual. In the case of multiple level acoustical calibrators, at least the preferred sound pressure level shall be tested.

4. If the acoustical calibrator is battery operated, means shall be provided to indicate whether battery voltage is adequate to maintain the performance specified for the acoustical calibrator. The requirements described in paragraphs (2) and (3) of this section shall be tested under minimally adequate battery voltage (i.e. the minimum battery voltage necessary to insure adequate operation).

5. The tests of frequency and sound pressure level shall be made with a compatible microphone whose calibration has been transferred from a laboratory standard microphone calibrated by the reciprocity technique described in ANSI S1.10-1966 "Method for the Calibration of Microphones".

6. If the output of an acoustical calibrator is controlled by a timing device, the accuracy of that timing device shall be within ±5 percent of the time period indicated. If more than one time period may be chosen, means shall be provided to indicate which time period is in use.

7. If the acoustical calibrator operates at multiple sound pressure levels, frequencies, or time periods, then the preferred sound pressure level,

frequency, and time period, if any, shall be specified by the manufacturer for use in calibrating the personal noise dosimeter for testing.

The test was performed in the following manner:

A reference sound pressure level equal to the manufacturers stated calibrator sound pressure level was established in a pressure cavity. The calibrator battery voltage was adjusted, using a series resistor, until the battery indicator showed minimally adequate battery voltage. The timed outputs if available, were measured using an electronic timer/counter. Using the PND as a measuring device, the calibrators sound pressure level and frequency were checked against the reference.

Table 2 shows the results of the tests on 8 different calibrator models. The Bendix calibrator showed the largest deviation in sound pressure level. The Bendix unit showed a large dependence on the battery voltage. As long as the battery was strong the sound pressure level was within tolerance. Once the battery approached minimal conditions the units frequency of the calibration signal distorted and the sound pressure level increased. The frequency of the Tracoustics calibrator was also outside the tolerances for the frequency set forth in this document. All the other units fell within the requirements.

Cutoff Level Test

This test was designed to find the decibel level dB(A, Slow) at which a personal noise dosimeter no longer accumulates a dosage. The cut off level of the personal noise dosimeter was tested as follows:

A sinusoidal signal (1000 Hz) was presented so as to produce an indicated level of 90 dB(A, Slow), as determined by rapid readout of the indicated noise level. The 90 dB(A, Slow) level was used as a reference only for those dosimeters with an 85 dB(A, Slow) threshold. For units with a 90 dB(A, Slow) threshold the reference level was set 5 dB higher i.e. 95 dB (A, Slow). The reference input signal was then reduced in 1.0 decibel steps until the level was reached at which the personal noise dosimeter no longer provided an output for the indicated level reading. The input was then increased in 0.1 decibel steps until the personal noise dosimeter began to give an output as determined by rapid readout. The input signal level at this point was called the measured threshold (see Table 3).

NIOSH requires that, with an input level 1 dB above the stated threshold level, the indicated level, as determined by rapid readout, should be such that a dosage of 100% or greater for units with a 90 dBA threshold or 50% or greater for units with an 85 dBA threshold would be accumulated in 8 hours. For units with a 90 dBA threshold the indicated level should be at least 90 dBA, and for units with an 85 dBA threshold the indicated level should be at least 85 dBA.

When the input signal is 3 dB below the stated threshold level the indicated level produced, for 90 dBA threshold units, should be such that a dosage of no greater than 10% would be accumulated in 8 hours. The indicated level for such a dosage is 73.4 dBA. For units with an 85 dBA threshold, the indicated level produced should accumulate a dosage of no greater than 10% in 16 hours. The indicated level for this dosage is 68.4 dBA.

The personal noise dosimeters which failed this test were one B&K unit at the 85 dBA threshold setting, two Bendix units and one Quest M-6 unit.

Shifting Levels Test

The shifting levels test was designed to verify proper operation of the detector circuit to levels of sound pressure that are constantly crossing the cut-off or threshold.

The response of the personal noise dosimeter to a quasi-steady waveform was tested as follows:

A 1000 Hertz sinusoidal signal, shifting between a level corresponding to 90 dB(A, Slow) as determined by rapid readout of the indicated noise level and a level which is 10.0 decibels lower, was applied across a resistor inserted in series with the acoustically isolated microphone (or equivalent electrical impedance). This 1000 Hertz signal was periodic with a 300 millisecond period. Its amplitude corresponded to a level of 90 dB(A, Slow) for 100 milliseconds and to a level 10.0 decibels lower for a period of 200 milliseconds. This periodic signal was applied for a duration of 2 hours. The dose at the end of the 2 hour period was converted to an indicated level. The true root-mean-square value (theoretical indicated level) of the signal was 86.0 decibels.

The above procedure was written for personal noise dosimeters with an 85 dB threshold. For units with a 90 dB threshold the input signal shifted between a level corresponding to 95 dB(A, Slow) and a level which was 10.0 decibels lower. The root-mean-square value of this signal was 91 decibels.

Two sets of personal noise dosimeters, B&K and Dupont, have a threshold switch allowing the operator an option of either 85 or 90 dB. These two sets were checked at each level.

Table 4 shows the results of the shifting levels test on 9 different models. NIOSH requires that the measured indicated level be within ±1.0 decibel of the theoretical indicated level. The units that failed this requirement were the three Tracoustics units, three Edmont-Wilson units, two B&K units, at the 90 dBA threshold, one Quest M6 unit, and two Columbia units.

Rise and Decay Time Test

The rise and decay time test was designed to check for the proper operation of the slow response circuitry. Ideal time constants for the response of the meter are approximately 1 second.

The rise and decay time of the averaging circuit of the personal noise dosimeter was tested as follows:

First, a sinusoidal signal was applied across a resistor inserted in series with the acoustically isolated microphone (or equivalent electrical impedance) so as to produce an indicated level of 115 dB(A, Slow) based on the rapid readout procedure. The signal was applied for 15 minutes to obtain a reference accumulated noise dose. The readout was then reset.

Next, a sinusoidal signal of alternating amplitude was applied across the resistor in series with the microphone (or equivalent electrical impedance). The amplitude alternated in the following manner: For 1 second, the amplitude was such that an indicated level of 115 dB(A, Slow) would be produced if applied continuously; for the next 8 seconds, the amplitude was reduced to a level that would produce an indicated level of 95 dB(A, Slow) if applied continuously. This alternating signal was applied for the same duration as the signal used to produce the reference accumulated noise dose (i.e., 15 minutes). NIOSH requires the accumulated dose so obtained to be 0.20 to 0.25 times the reference accumulated noise dose obtained previously. This test was performed at a frequency of 1000 Hz.

Test results listed in Table 5 show that one Bendix unit and all of the Columbia, Edmont-Wilson, Quest M-6 and Tracoustics units failed to meet the minimal requirements.

Exponential Formula Accuracy Test

This test was designed to check for the presence of a proper dose accumulating rate (i.e. double the dose per every increase in signal level of 5.0 decibels). The computation of the exponential formula was tested as follows:

A sinusoidal signal was presented so as to produce a reference indicated level of 95 dB(A, Slow) based on the rapid readout procedure. A precision attenuator was then used to decrease the input signal amplitude in 1.0 decibel increments until the dosimeter no longer produced an indicated level based on the rapid readout procedure. The input signal was then returned to the amplitude corresponding to the reference indicated level. The precision attenuator was then used to increase the input signal amplitude 21.0 decibels in 1.0 decibel increments. The test was performed at 63 Hz, 1000 Hz and 6300 Hz.

NIOSH requires that at each setting of the precision attenuator the indicated level should not vary by more than ±1.0 decibel from the corresponding input signal amplitude, i.e. a 5.0 decibel increase in the input signal should result in an increase of 5.0 decibels ±1.0 decibel in the indicated level.

Figures 28 to 54 show the deviation from the ideal level at the three frequencies. The Tracoustics, Quest M-7, Columbia, and Bendix units had excursions outside the ±1.0 decibel tolerance required by NIOSH. Figures 28 to 54 also show the cutoff or threshold for the required 1000 Hz frequency.

Foldover Test

The foldover test was designed to insure that a personal noise dosimeter would read at least 115 dB(A, Slow) and not less when the input signal is over 115 dB(A, Slow). This was confirmed as follows:

A sinusoidal signal was electrically presented to the personal noise dosimeter so as to produce an indicated level of 115 dB(A. Slow) as determined by the rapid readout procedure. The signal was then increased in 1.0 decibel increments and the indicated level produced noted. The input was increased a total of 5.0 decibels.

Figures 55 to 63 illustrate that none of the units fell below the 115 dB (A, Slow) indicated level.

Integration Accuracy Test

The integration accuracy test was designed to assure the accuracy of projecting a dose accumulated after a portion of the day over a whole day. The test also provides the means for a quick field calibration.

The personal noise dosimeter was checked for an accurate integration scheme in the following manner:

A 1000 Hz, 114 dB(A. Slow) tone as determined by rapid readout was applied to the personal noise dosimeter for a one minute period. The dose at the end of the one minute period was then recorded and the personal noise dosimeter reset to zero. The same tone was then applied for 15 minutes and the dose recorded. The 1 minute dose was then multiplied by 15 and subtracted from the 15 minute dose.

NIOSH requires that the difference between fifteen times the projected 1 minute dose and the actual 15 minute dose should be less than 5 percent.

From Table 6 it is evident that all of the units tested fell well within the limits set forth by NIOSH. Note: The test was modified for the B&K dosimeters since the readout does not allow an indication of tenths of a percent.

Crest Factor/Square Law Test

The crest factor/square law test was designed to check the ability of a personal noise dosimeter to accurately measure pulsating or rapidly changing noise levels.

The crest factor and square law capacity of the amplifier of the personal noise dosimeter were tested simultaneously as follows:

The steady state accuracy of the square law and averaging circuits were tested by comparing the indication for tone bursts with that for a reference sine wave signal. A 1000 Hz sinusoidal signal was applied across a resistor inserted in series with the acoustically isolated microphone (or equivalent electrical impedance) so as to produce a reference indicated level of 114 dB(A, Slow) based on the rapid readout procedure. Then a tone burst having a frequency of 1000 Hz with 5 cycles on, starting and ending at zero crossings, and 17 cycles off was applied. (This burst has a crest factor of approximately 3, after passing through an A-weighting network). Because of the effect of A-weighting on this tone burst, the signal was set to have an rms value 0.1 dB higher than that of the 1000 Hz continuous signal. NIOSH requires that the indicated level produced by the tone burst signal be within ±1.5 dB(A, Slow) of the reference indicated level produced by the sinusoidal signal. This test was repeated for a reference indicated level of 95 dB(A, Slow).

The results of the crest factor test are shown graphically in Figures 64 to 72. Figure 72 shows the poor performance of the Tracoustics units. The plotted points show the indicated levels at crest factors of 1.414, 2, 3 and 4.

Battery Life Test

This test requires at least 16 hours of accurate operation from the dosimeter. Such a requirement allows for the use of the dosimeter on shifts of 8 hours or more with a large margin of safety for calibration before the shift and readout after the shift. Since the battery life test is performed at room temperature, it does not determine the effect of hot or cold environments which could reduce the battery life; however, the safety margin certainly should be sufficient for eight hours of use. The test is performed in two successive eight hour periods so as to coincide with a normal work day. The 100 dB(A, Slow) level was chosen because it is midrange. The dosimeter must be reset at 4 hour intervals because after exposure to a 100 dB(A, Slow) signal for this period of time it should have accumulated a dose of 200 percent.

The personal noise dosimeter battery life was tested in the following manner:

A 1000 Hz sinusoidal tone was applied so as to produce an indicated level of 100 dB (A, Slow) as determined by the rapid readout procedure. The same input was applied for 16 hours; after 16 hours the indicated level was noted for deviation. The test was performed in two successive 8-hour periods. During each 8-hour period, the storage device was reset to zero at 4 hour intervals. The personal noise dosimeter was turned off in the interval between test periods. NIOSH requires a deviation of less than ±0.5 dB (A, Slow) for this test.

Table 7 shows the results of the battery life test. Of all the dosimeters tested 1 unit each of B&K, Dupont, Edmont-Wilson and Quest M-6 did not meet the requirement.

Battery Indicator Test

This test determines if the battery indicator of a personal noise dosimeter shows the minimum voltage necessary for proper operation. The battery indicator was checked as follows:

With normal battery voltage, a sinusoidal signal was presented so as to produce a reference indicated level of 105 dB(A, Slow) as determined by the rapid readout procedure. Then, with minimally adequate battery voltage, the same signal was applied. Any deviation from the indicated level of 105 dB (A, Slow) was recorded. If the personal noise dosimeter had more than one battery, the various combinations of minimally adequate battery voltage were used to perform the test. The test was performed at a frequency of 1000 Hz. NIOSH requires that the indicated level vary less than ±0.5 dB (A, Slow).

Table 8 shows the deviations for each battery condition. The Tracoustics dosimeter fails to meet a basic NIOSH design requirement since it lacks a battery indicator. The following dosimeters failed to meet the minimum requirements of this test: three of the Dupont units, two of the Quest M-6 units, and one of the Edmont-Wilson units.

Dose Storage Test

NIOSH believes the following dose storage requirement should be met:

If the accumulating function of the personal noise dosimeter may be turned off without erasing or destroying the accumulated noise dose N, then it shall be capable of holding and displaying, with the readout device, the accumulated noise dose for at least 24 hours with no change in the value of the stored accumulated noise dose of more than 0.03XN for values of N>100 percent.

Table 9 shows the results of this test. The data is presented for only those units capable of storing a dose with the unit off. All units were well within the 3 percent variation in dose allowed.

Temperature Sensitivity Test

The effect of temperature on the electronic circuitry of the personal noise dosimeter during operation was tested as follows:

The personal noise dosimeter was placed in a temperature controlled chamber at room temperature (approximately 20°C) and a sinusoidal signal of 1000 Hertz was applied across a resistor inserted in series with the microphone so as to produce a reference indicated level of 105 dB(A, Slow) as determined by the rapid readout procedure. The temperature was then varied over the range -10°C to 50°C. The indicated level was monitored for deviations from the reference indicated level.

NIOSH requires that the indicated level should not deviate more than ±0.5 dB (A, Slow) from the reference indicated level as the temperature is varied over the specified range. The results of the test are presented graphically in Figures 73 to 81. The only dosimeters which passed this test were three of the Edmont-Wilson units, two of the Dupont units, one Columbia unit, and one Bendix unit.

Magnetic Field Sensitivity Test

The personal noise dosimeter was tested in an alternating magnetic field strength of 80 amperes/meter at the frequencies of 60 Hz and 400 Hz. None of the units tested showed any noticeable change in the indicated level as determined by rapid readout when placed in the field.

115 dB(A, Slow) Latch Test

This test was designed to insure that the personal noise dosimeter records the presence of an input signal of over 115 dB(A, Slow). The holding upper limit indicator of the personal noise dosimeter was tested as follows:

A 1000 Hz sinusoidal signal was applied across a resistor inserted in series with the acoustically isolated microphone (or an equivalent electrical impedance) so as to produce an indicated level of 115 dB(A, Slow) based on the rapid readout procedure. The input signal was increased by 2.0 decibels. NIOSH requires that the indicator not trigger at 115 dB (A, Slow) but should trigger within two seconds after the application of 117 dB(A, Slow).

Table 10 shows the results of the 115 dB(A, SLow) Latch Test.

Three units each of the B&K, Columbia, and GenRad, and one unit of the Edmont-Wilson and Bendix failed the test since their latch triggered prematurely with the application of the 115 dB(A, Slow) continuous signal. Three units of the Quest M-7 failed since their latch did not trigger after the two-second application of the 117 dB(A, Slow) signal.

Atmospheric Pressure Variations Test

The effect of the variation in atmospheric pressure on the calibration of the personal noise dosimeter was checked as follows:

The personal noise dosimeter and acoustical calibrator were placed in the recommended calibration position in a pressure controlled chamber. A reference indicated level, based on rapid readout, was obtained at a barometric pressure of 760 mm of mercury. This corresponds to sea level conditions. The barometric pressure was then varied over a range corresponding to -2000 ft. to 13,000 ft. above sea level. The indicated level was recorded for each 1000 ft. change in elevation.

Figures 82 to 88 show the results of the test. These plots also contain corrections to calibrator sound pressure level provided by the manufacturer's instruction manual. NIOSH requires that the indicated level remain within ±1.0 decibel of that predicted by the corrections of the instruction manual for a variation in barometric pressure corresponding to altitudes of sea level to 6000 feet. If no corrections are provided by the instruction manual then the indicated level shall remain within ±1.0 decibel of the reference indicated level for an increase in barometric pressure corresponding to an altitude of 6000 feet.

The Columbia unit failed to meet the minimum requirement of this test. The test was not run on the B&K unit since all three dosimeters were damaged due to battery acid leakage.

Drop Test

One unit of each personal noise dosimeter model (except Tracoustics) was dropped from a height of 36 inches. Each unit was dropped 10 times on to a concrete slab. The dosimeters were oriented at different angles before each drop. Data sheets 1 thru 8 present the results of this test.

NIOSH requires that the manufacture state the height from which his dosimeter (less microphone) can be dropped ten times onto a concrete surface and remain operational. Since most operating manuals did not specify a drop height, a belt carrying a height of 36 inches was chosen. The B&K, Dupont, GenRad and Bendix units were inoperable after this test.

Cable Integrity Test

A cable integrity test was performed in the following manner:

A 15 pound weight was attached at the approximate midpoint of the cable with the personal noise dosimeter and microphone unit arranged so that approximately 45-degree angles were formed between a horizontal line through the weight attachment point and the cable leading to the personal noise dosimeter and to the microphone unit. The weight was applied for 1 minute.

Data Sheets 9 thru 16 present the condition of the dosimeters after the test. NIOSH requires the microphone cable to remain intact and not cause the PND to fail to operate after the test. The test was run on 1 unit of each dosimeter Model. The B&K unit was not operational after test.

Temperature Endurance Test

The following temperature endurance test was run on one unit of each personal noise dosimeter model (except Tracoustics):

The PND was cycled between -20°C and 60°C while the unit was turned off. The battery(ies) remained in the PND during the temperature cycling. The PND was placed in a -20°C environment for 3 hours, removed to room temperature (approximately 20°C) for 1 hour, placed in a 60°C environment for 3 hours, and then removed to room temperature.

NIOSH requires the PND to operate after the temperature endurance test. The results of the test are shown on data sheets 17 through 24. The Bendix unit would not operate after the test and the GenRad unit was out of calibration.

CONCLUSIONS

The tests performed on the personal noise dosimeters listed in this publication were extensive. Table 11 gives a detailed summary of whether or not the units tested met the NIOSH minimum requirements. The units are labeled pass/fail (P or F) for each of the tests performed. Some units failed to operate for the entire length of the testing program. The Temperature Endurance, Cable, Drop and Pressure Tests were run on only one unit of each model.

No single unit passed all of the tests. The last column in Table 11 shows the percentage of tests passed by each single unit. No attempt was made to put a degree of importance on each test performed, but depending on the users requirements certain test results are more critical than others. Manufacturers and users as well should look at each test on an individual basis. Specific requirements will designate which tests carry the most impact.

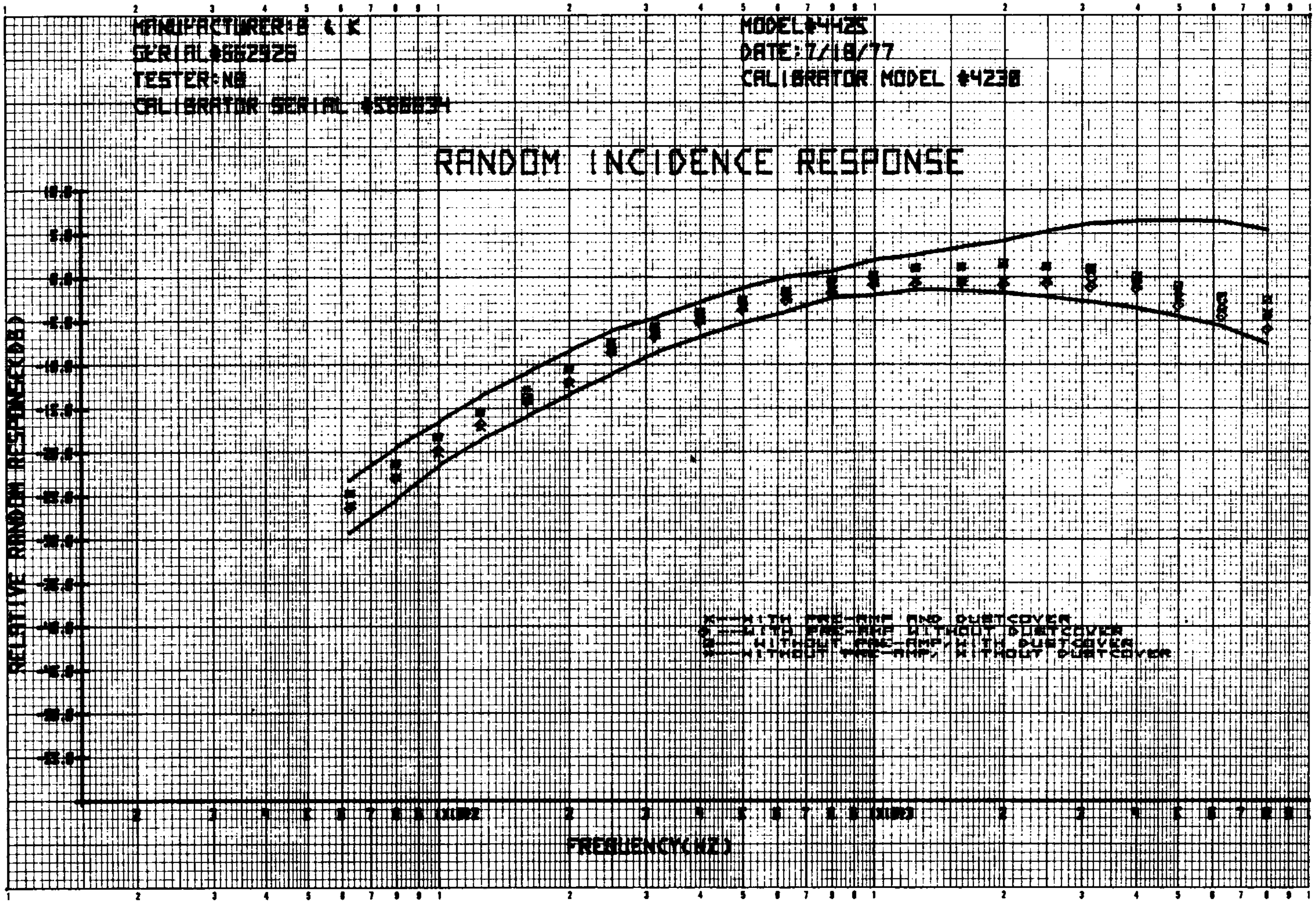

Figure 1. Random Incidence Response of B&K Model 4425
Personal Noise Dosimeter SN 662926

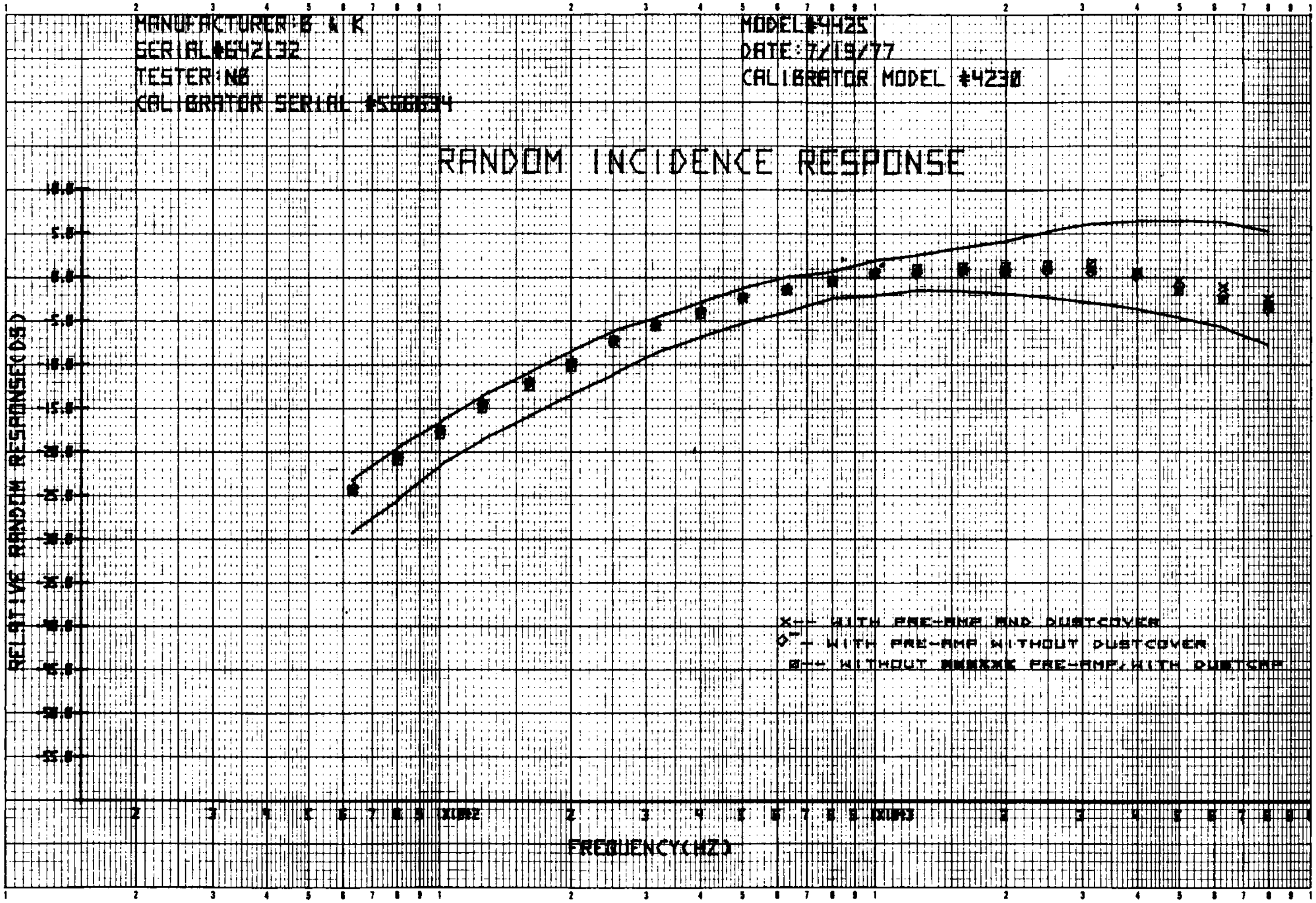

Figure 2. Random Incidence Response of B&K Model 4425
SN 642132

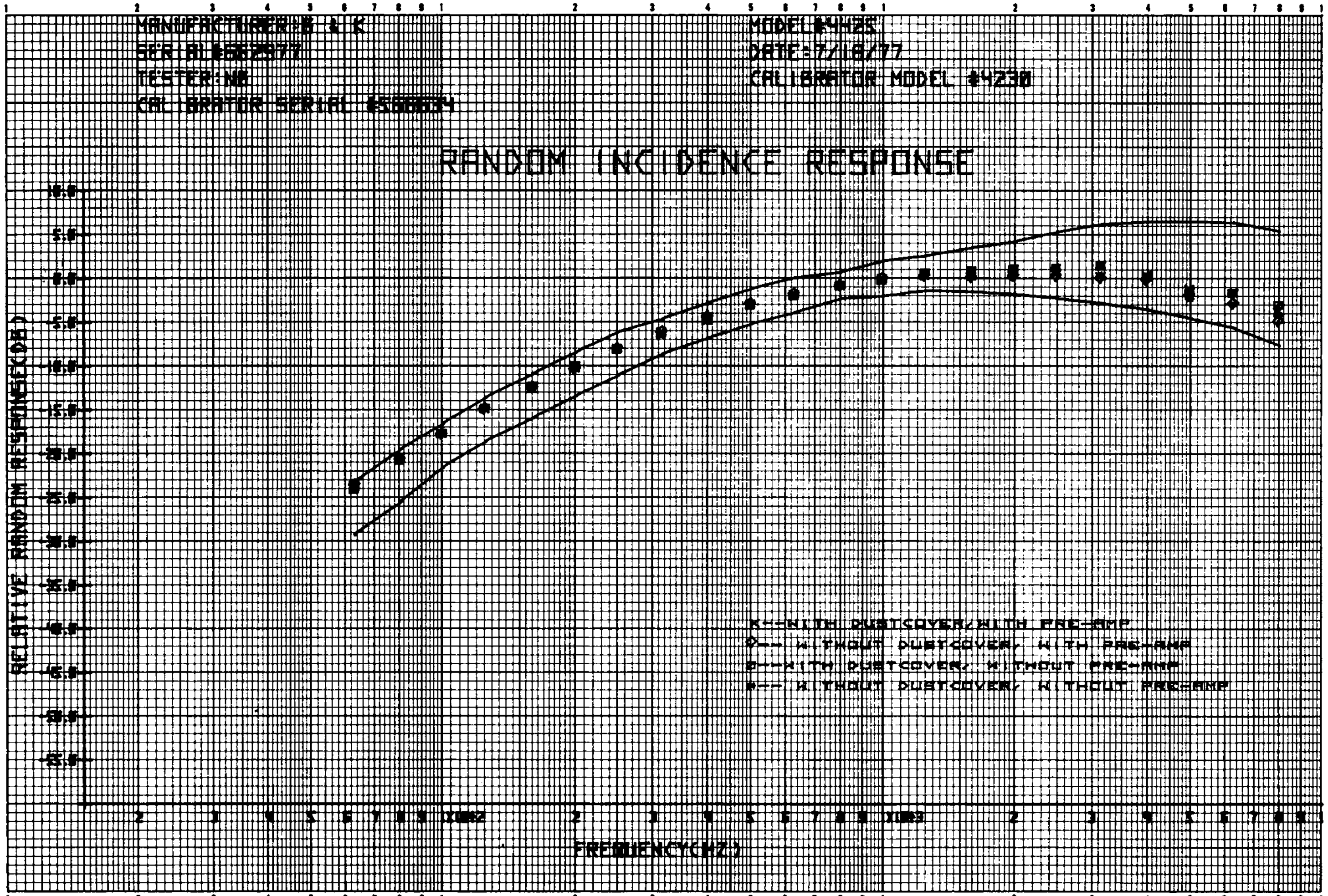

Figure 3. Random Incidence Response of B&K Model 4425
Personal Noise Dosimeter SN 662977

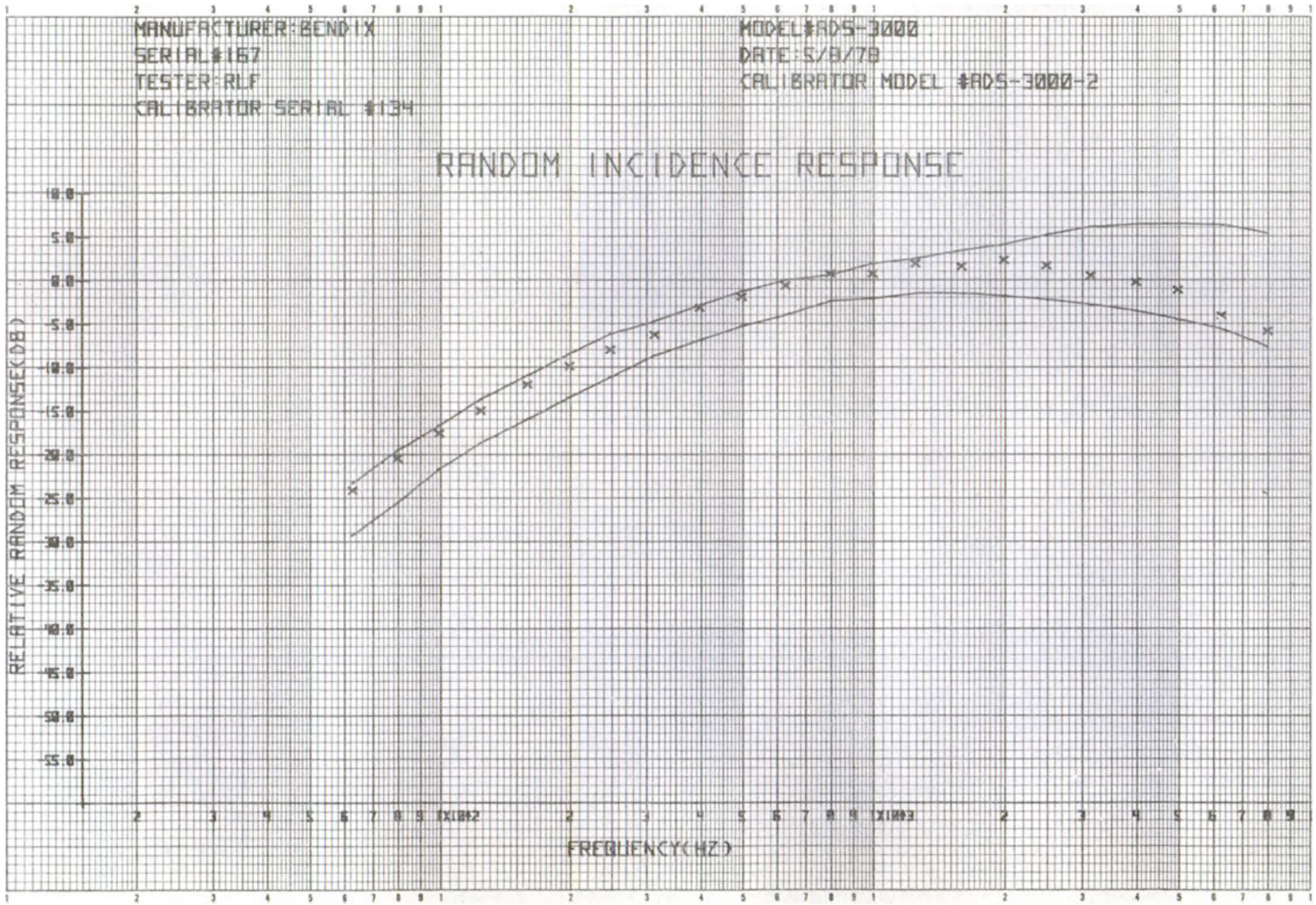

Figure 4. Random Incidence Response of Bendix Model ADS-3000 Personal Noise Dosimeter SN 167

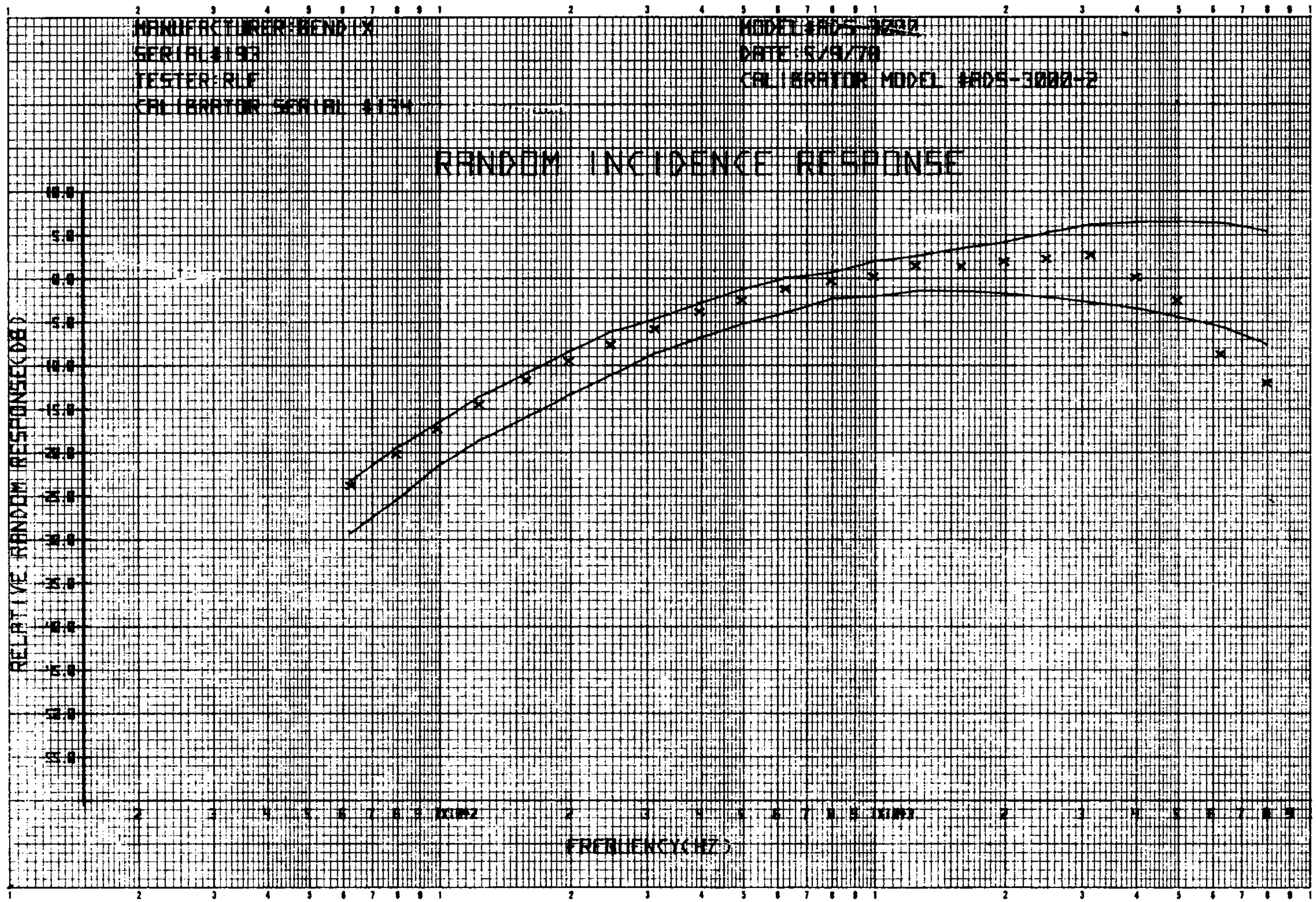

Figure 5. Random Incidence Response of Bendix Model ADS-3000 Personal Noise Dosimeter SN 193

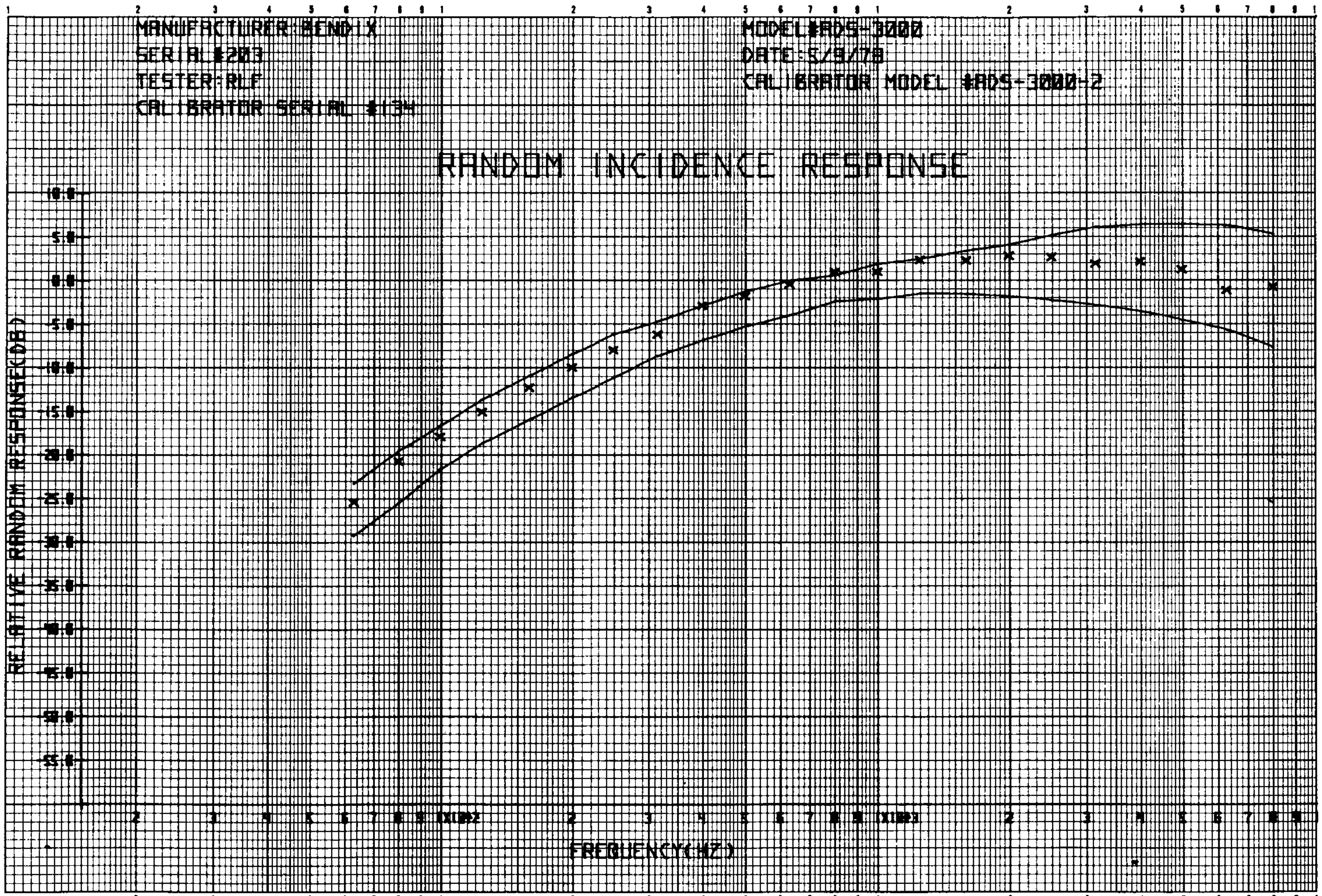

Figure 6. Random Incidence Response of Bendix Model ADS-3000
Personal Noise Dosimeter SN 203

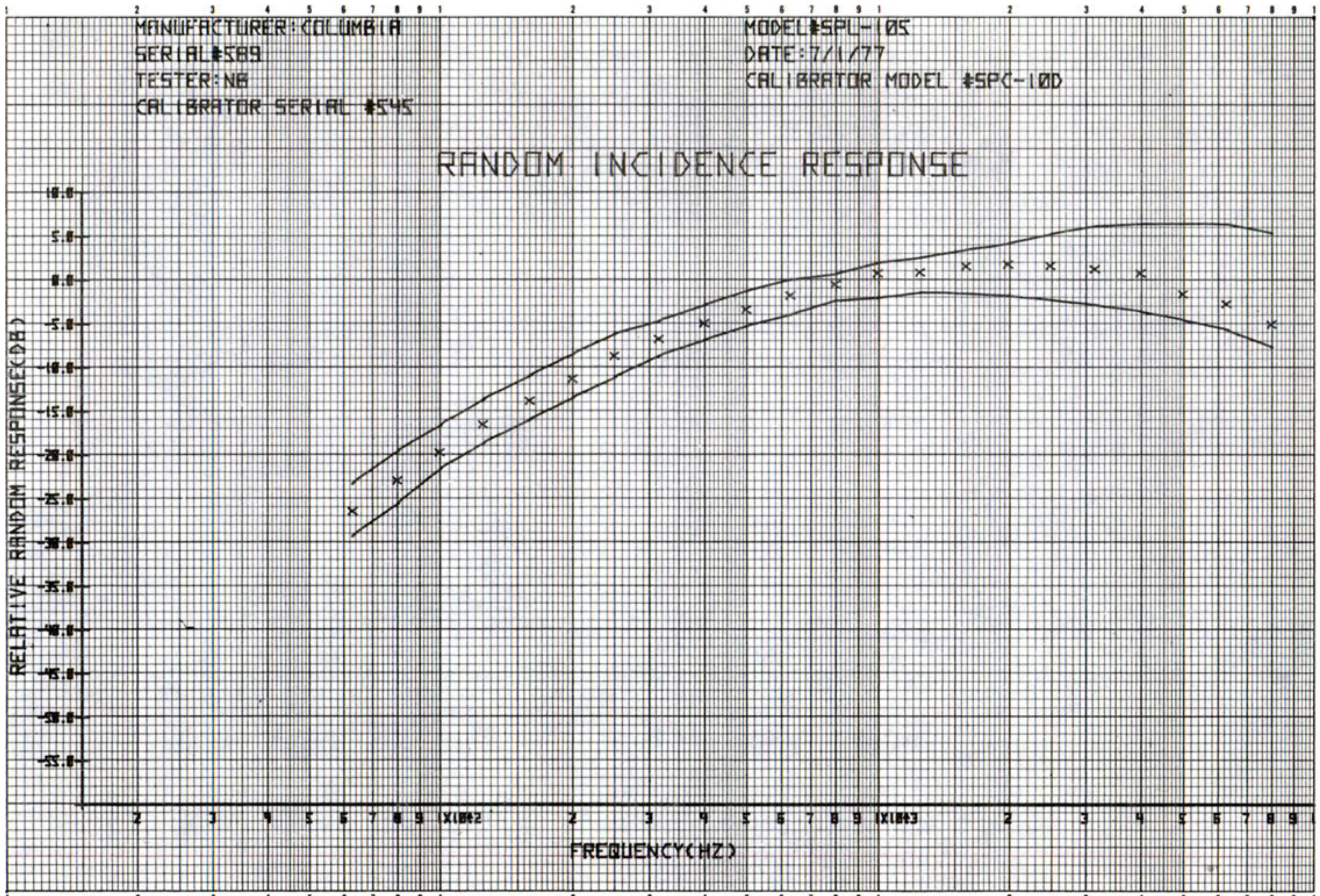

Figure 7. Random Incidence Response of Columbia Model SPL-105
Personal Noise Dosimeter SN 589

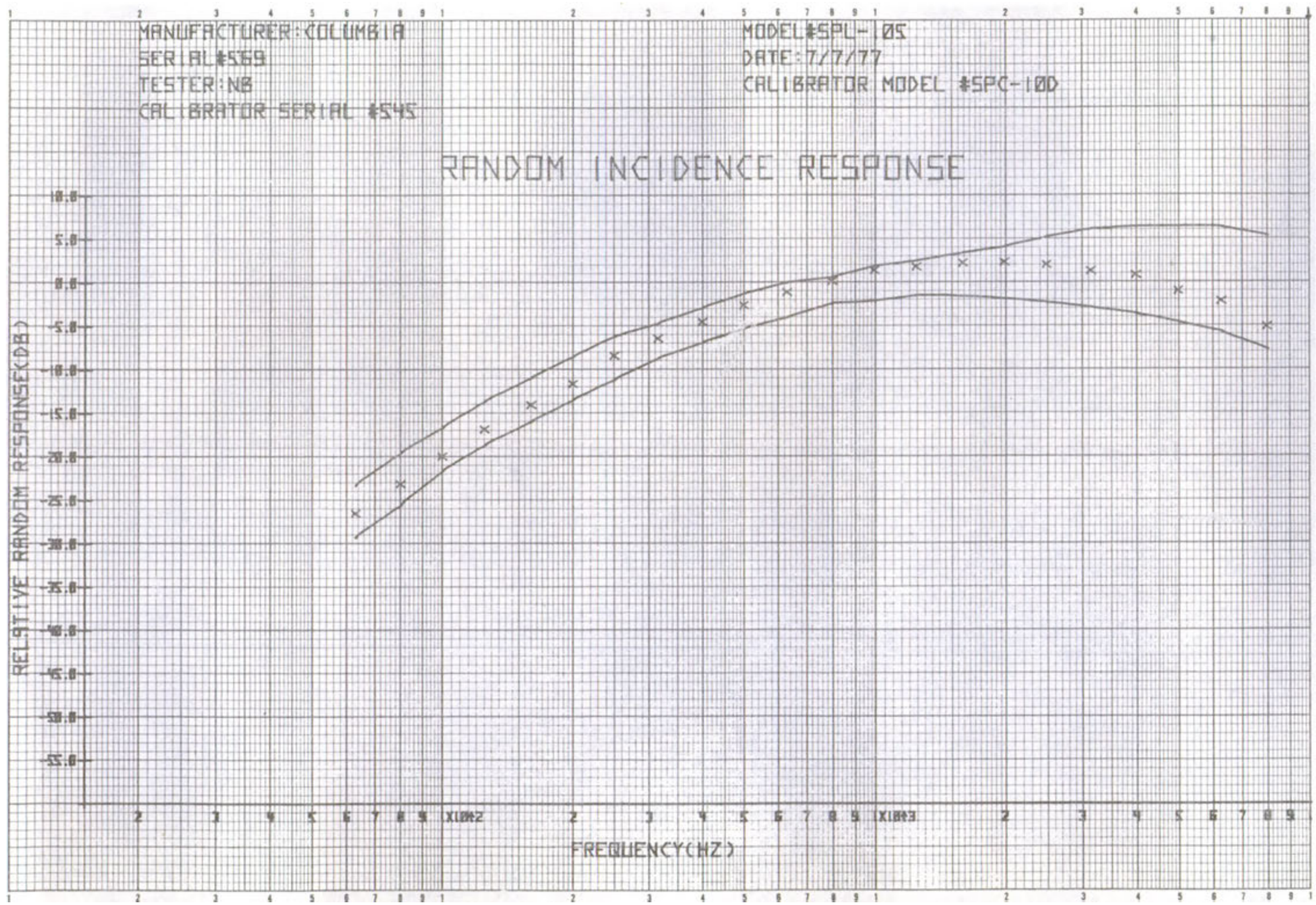

Figure 8. Random Incidence Response of Columbia Model SPL-105 Personal Noise Dosimeter SN 569

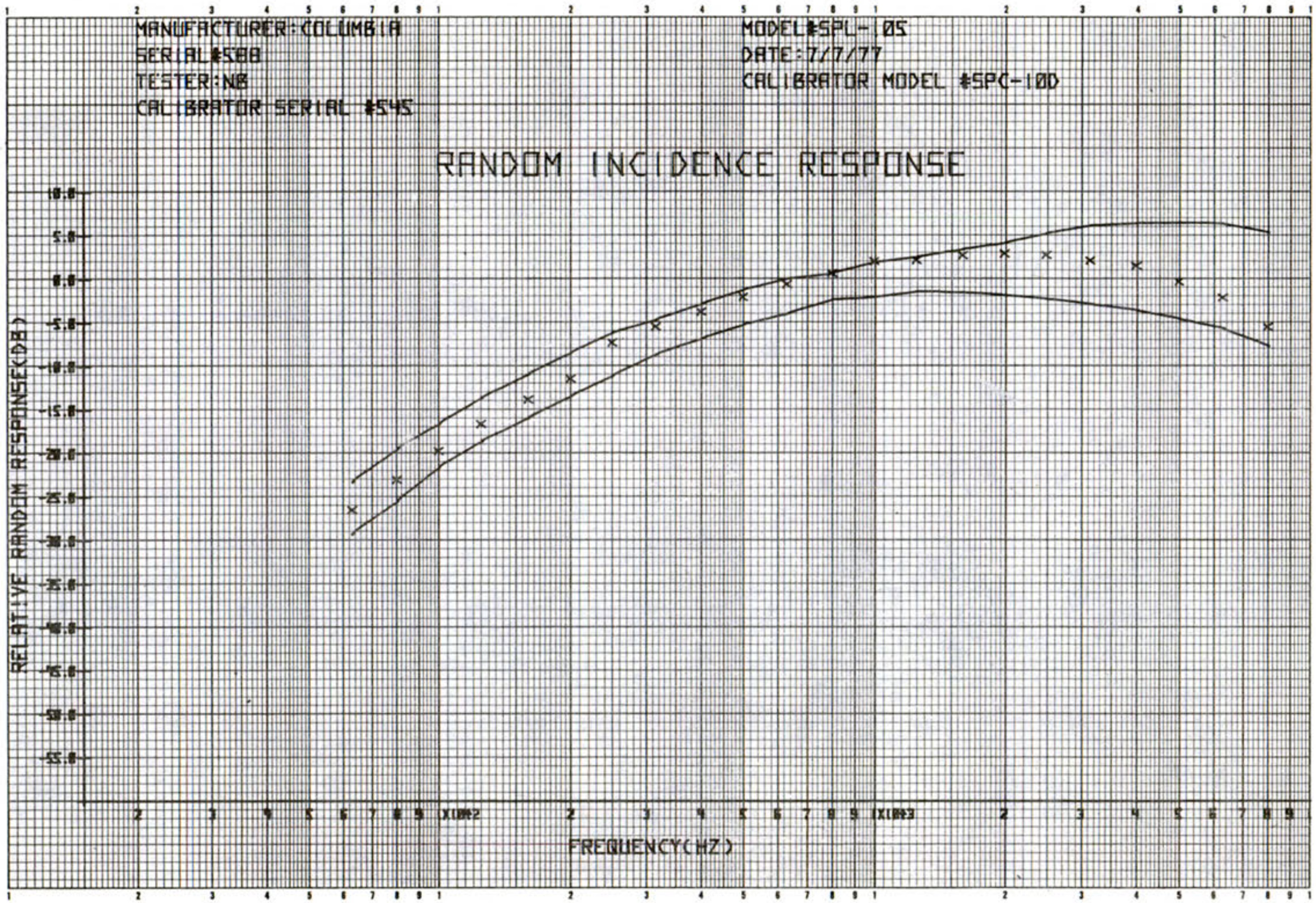

Figure 9. Random Incidence Response of Columbia Model SPL-105 Personal Noise Dosimeter SN 588

Figure 10. Random Incidence Response of Dupont Model D-376
Personal Noise Dosimeter SN CD-4232

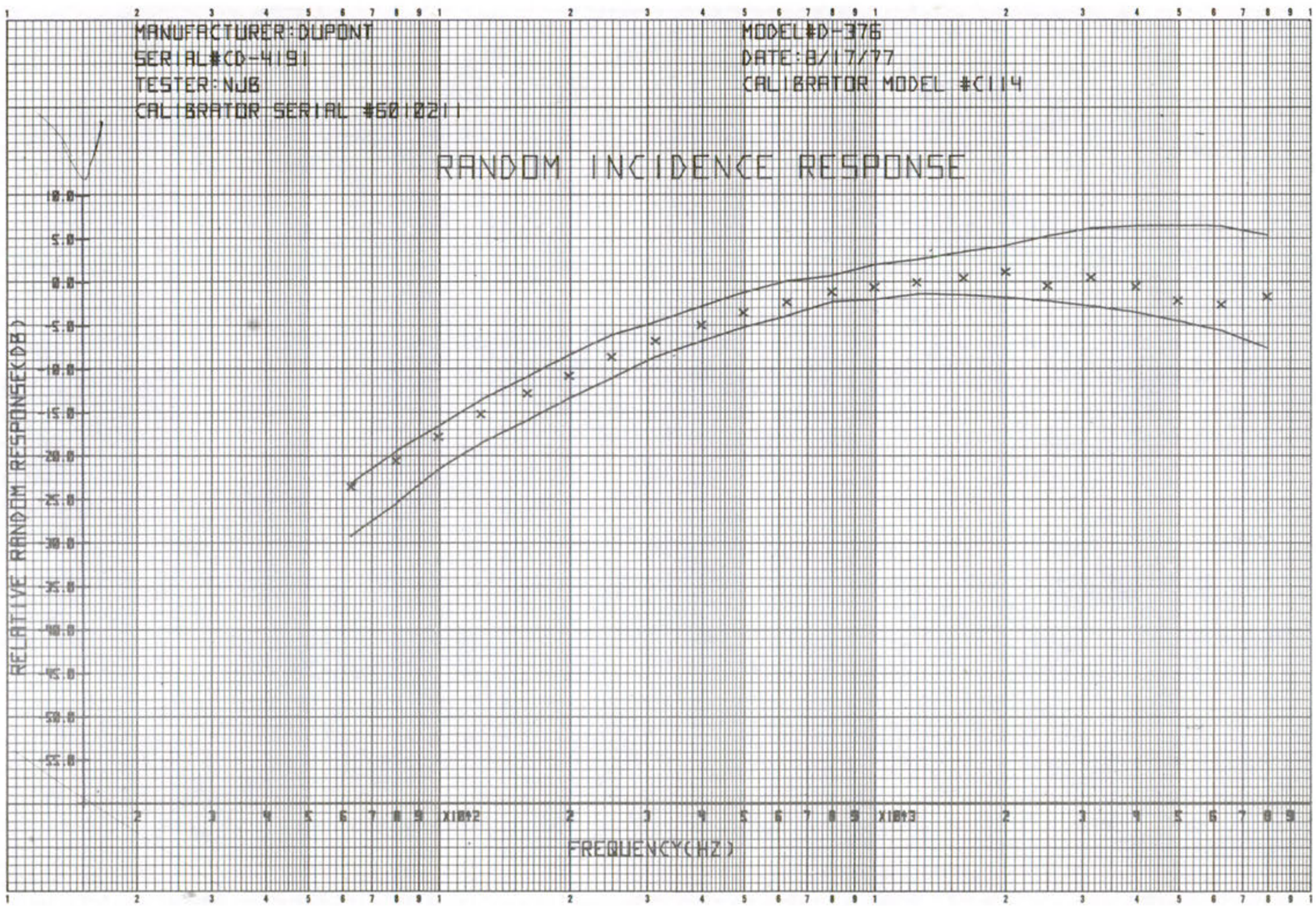

Figure 11. Random Incidence Response of Dupont Model D-376
Personal Noise Dosimeter SN CD-4191

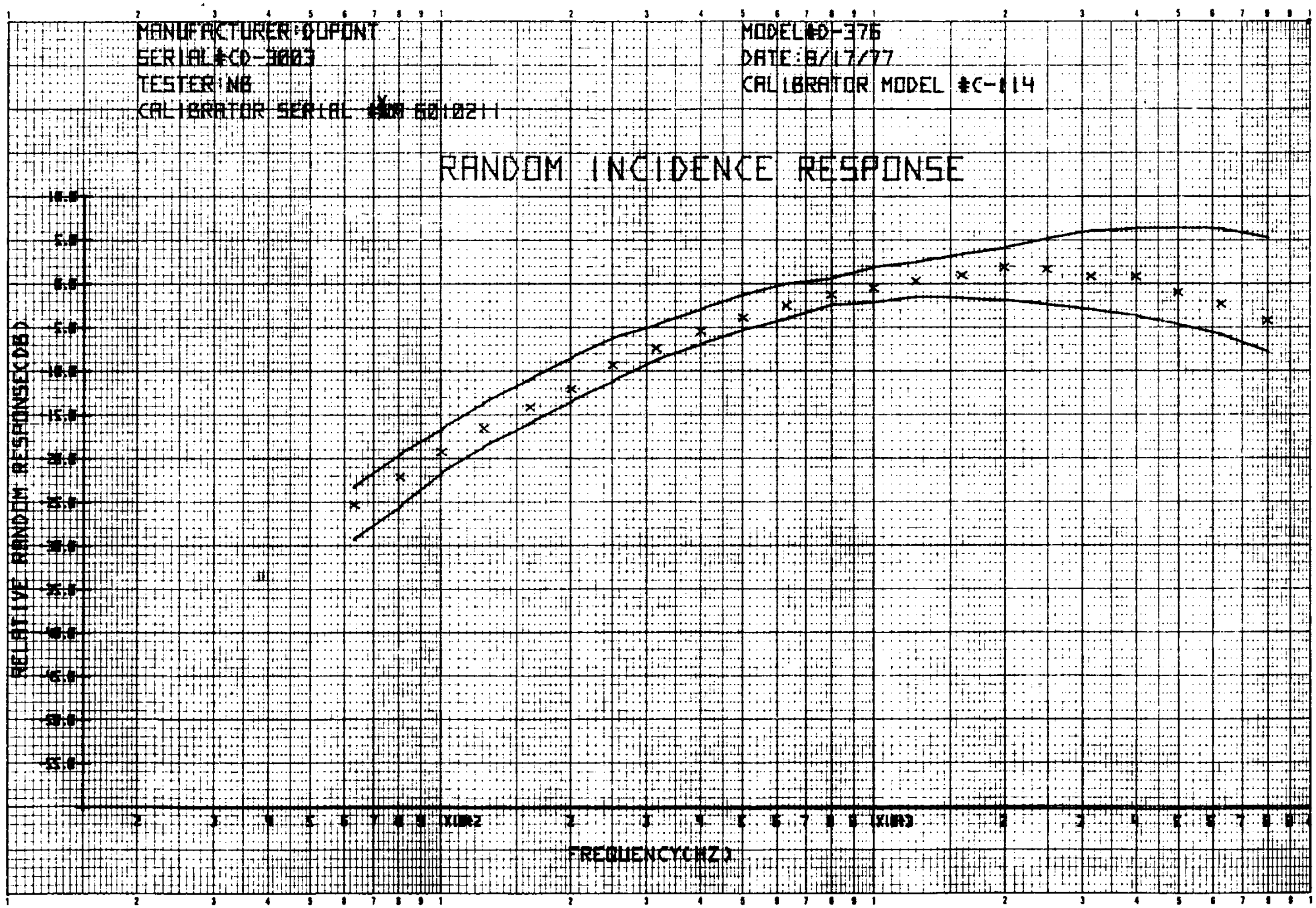

Figure 12. Random Incidence Response of Dupont Model D-376 Personal Noise Dosimeter SN CD-3003

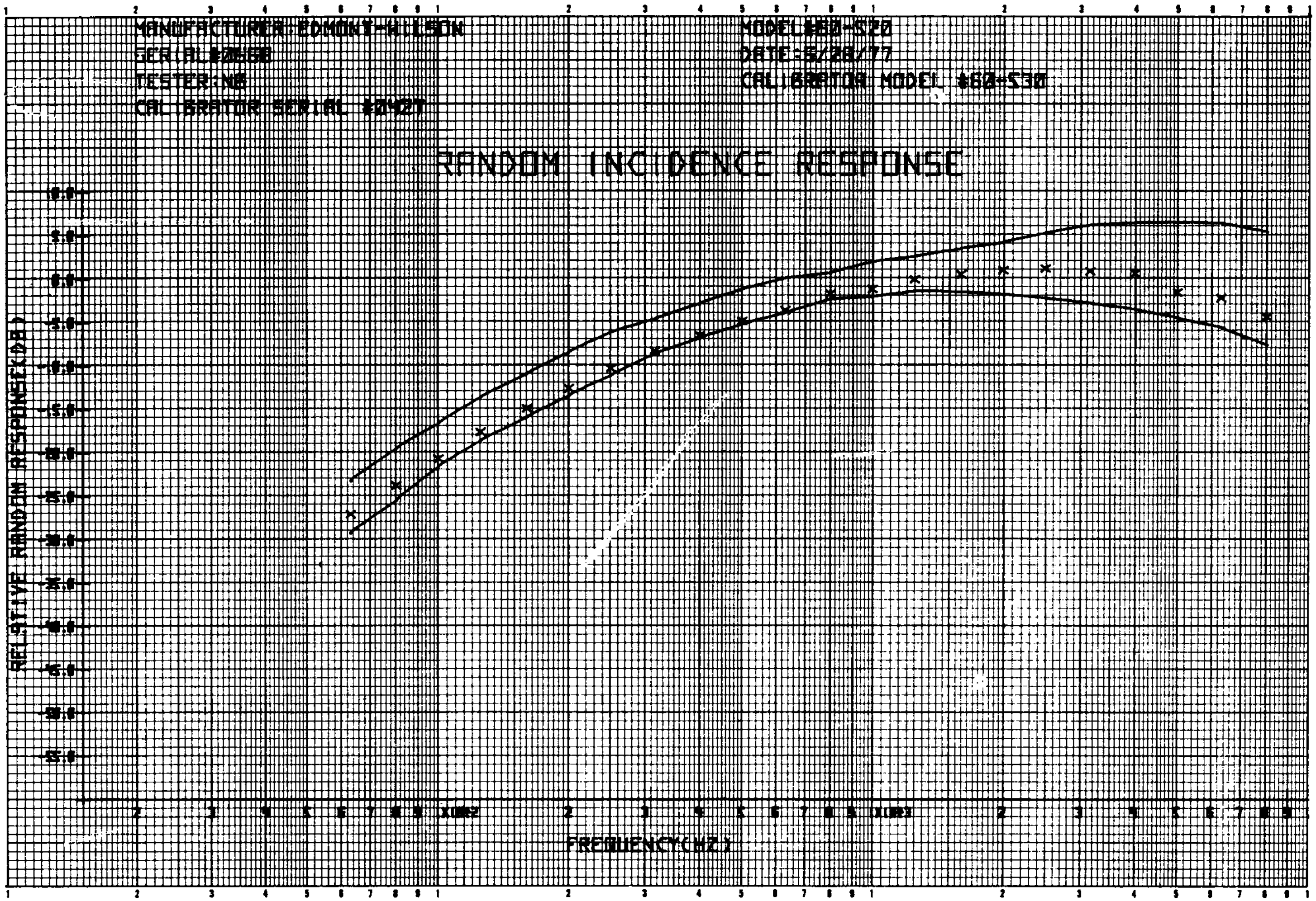

Figure 13. Random Incidence Response of Edmont-Wilson Model 60-520 Personal Noise Dosimeter SN 0668

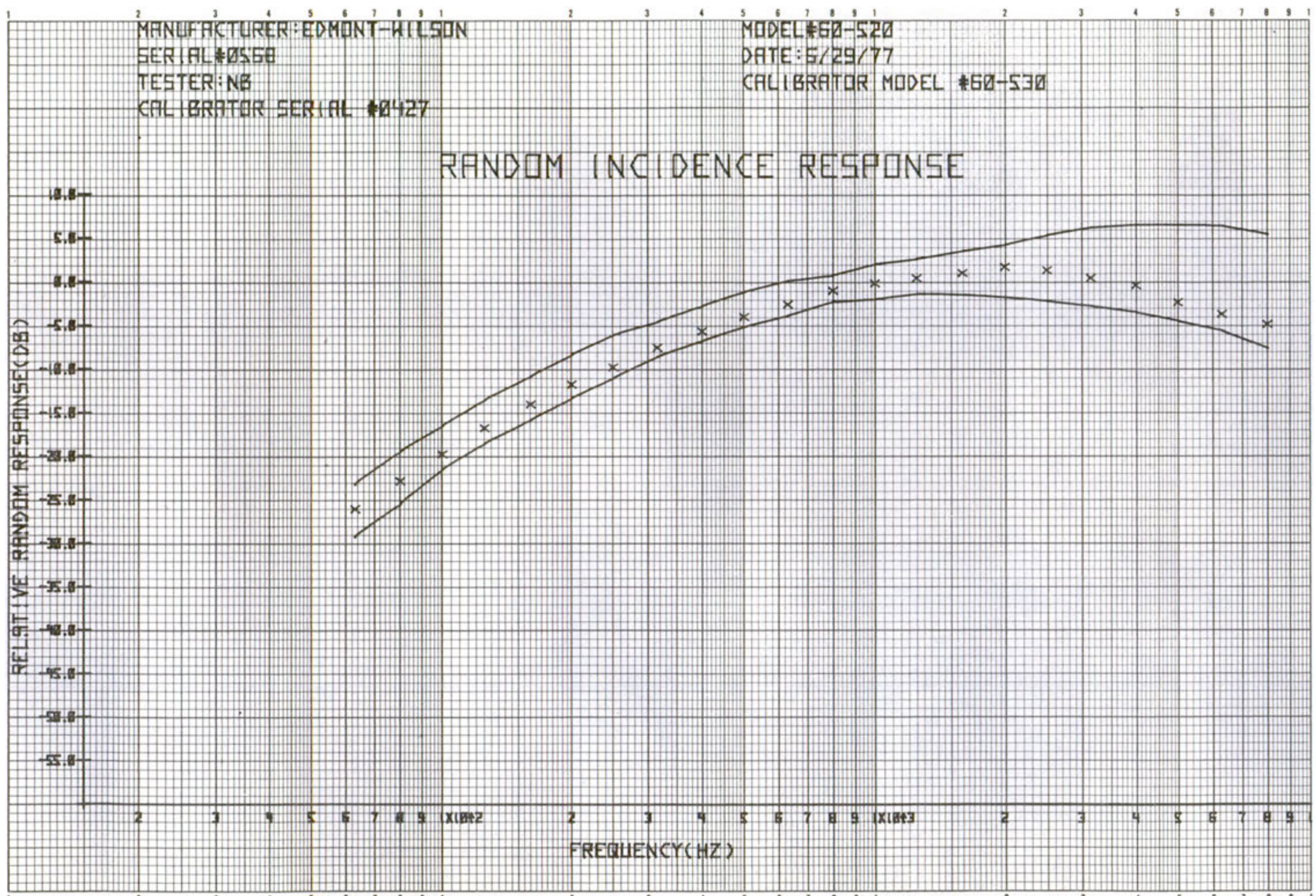

Figure 14. Random Incidence Response of Edmont-Wilson Model 60-520 Personal Noise Dosimeter SN 0568

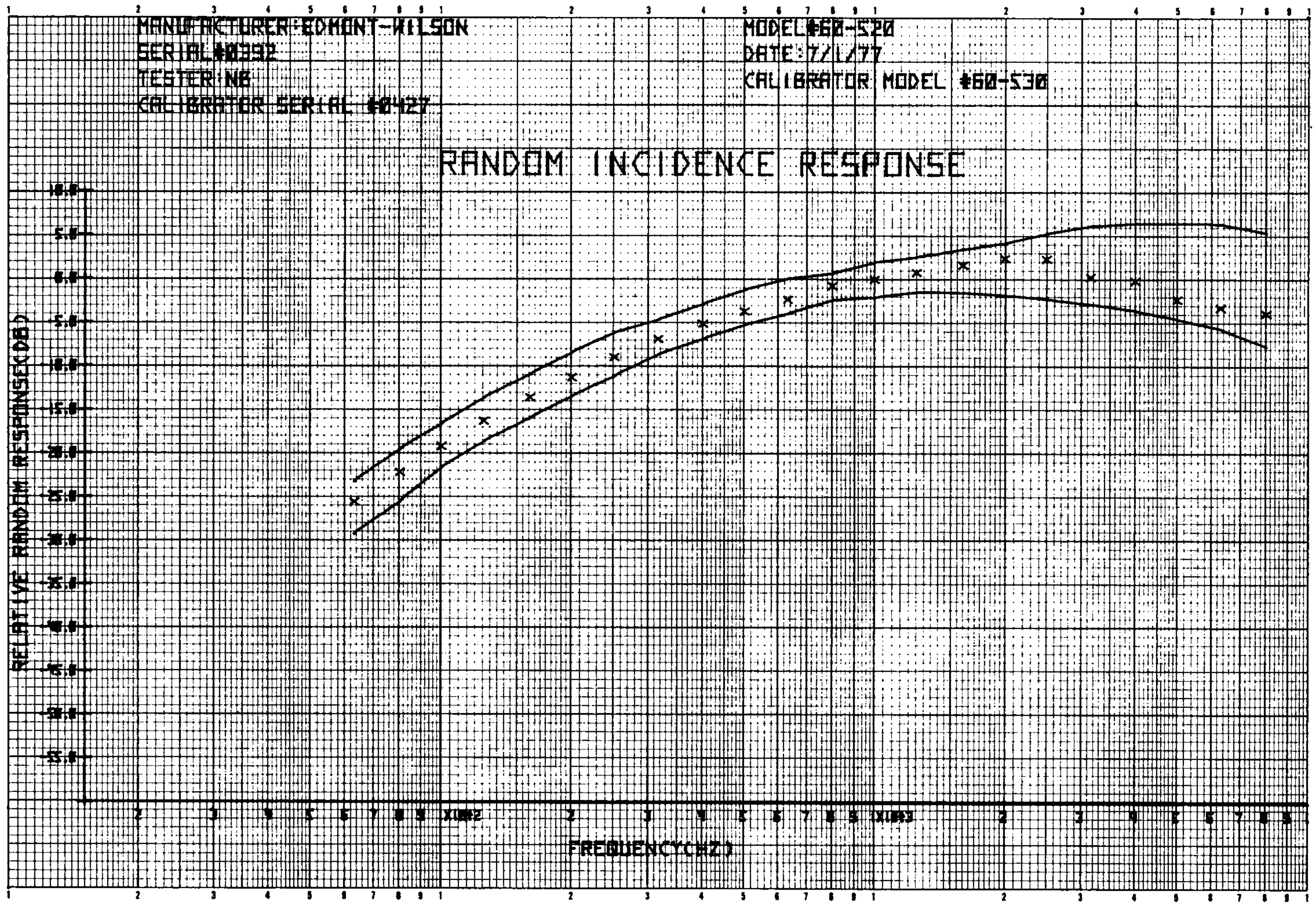

Figure 15. Random Incidence Response of Edmont-Wilson Model 60-520
Personal Noise Dosimeter SN 0392

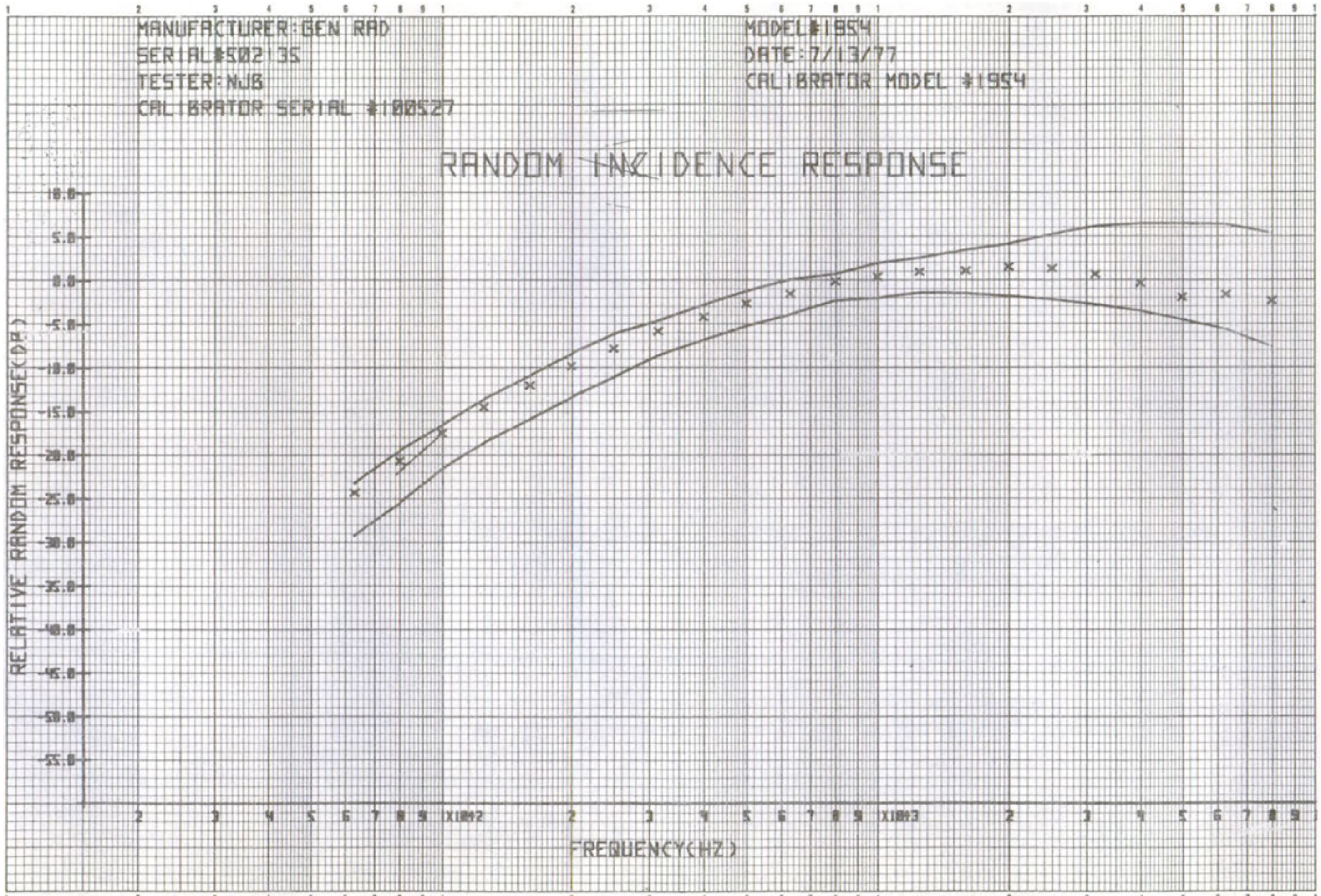

Figure 16. Random Incidence Response of GenRad Model 1954 Personal Noise Dosimeter SN 502135

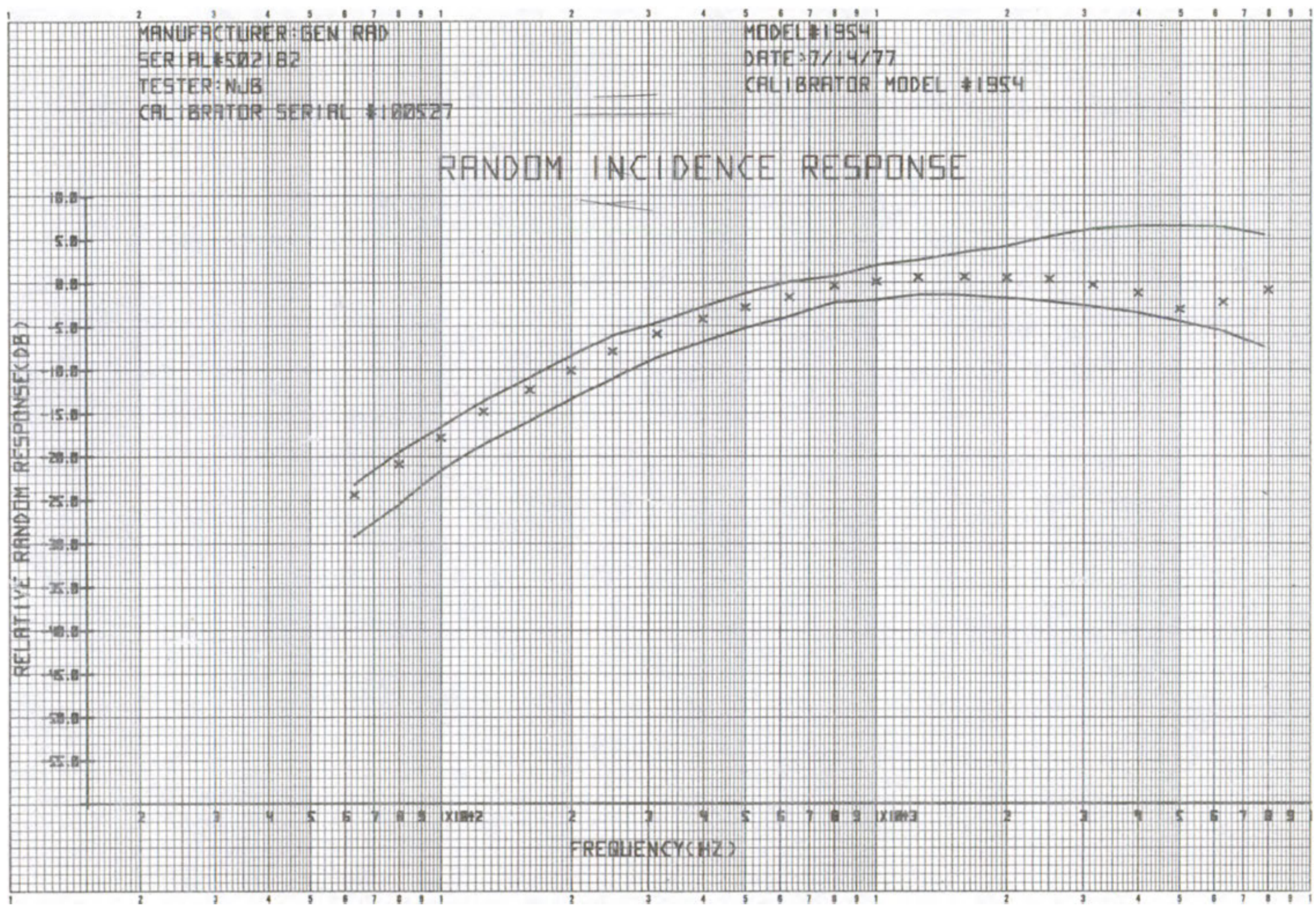

Figure 17. Random Incidence Response of GenRad Model 1954 Personal Noise Dosimeter SN 502182

Figure 18. Random Incidence Response of GenRad Model 1954 Personal Noise Dosimeter SN 501819

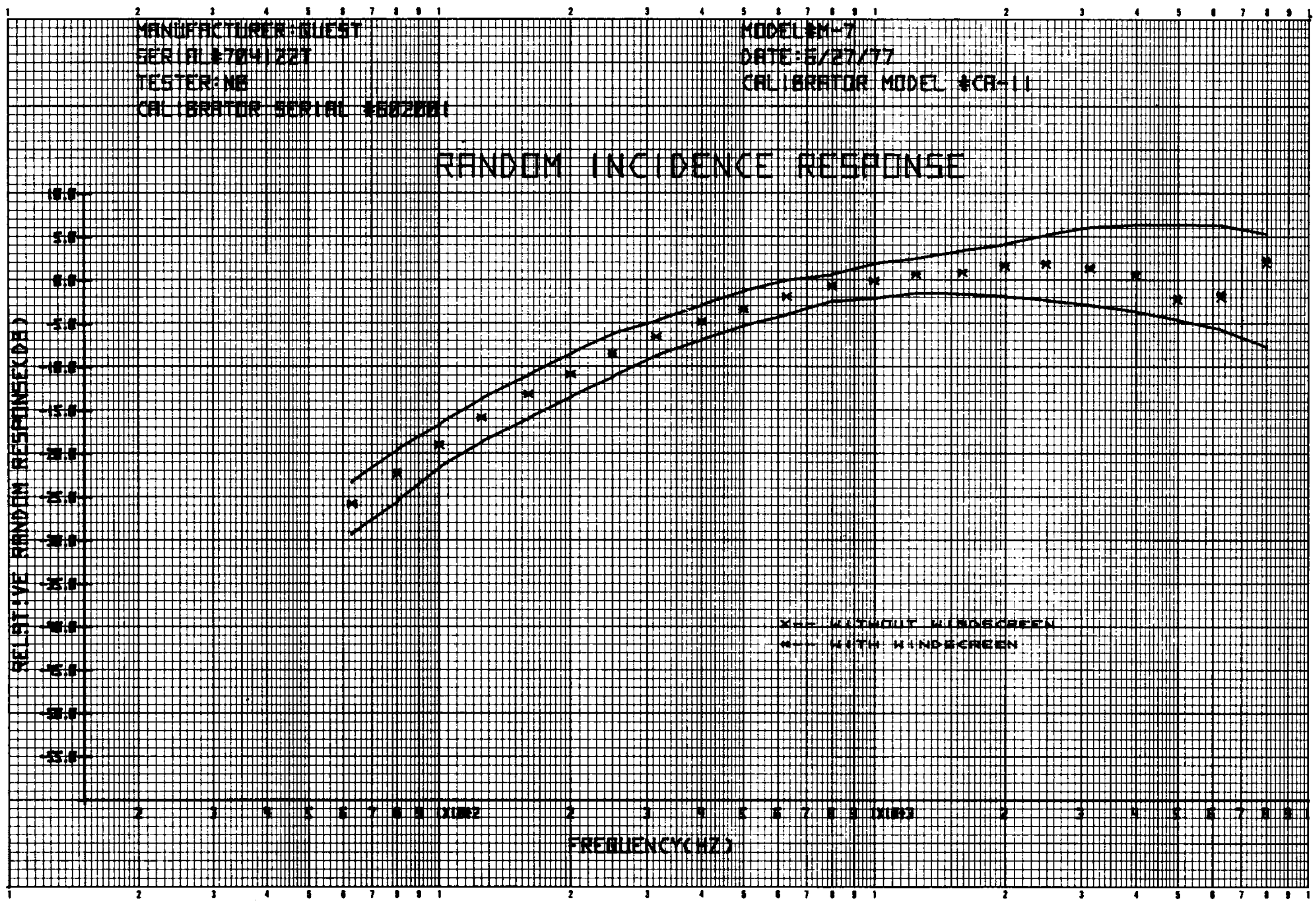

Figure 19. Random Incidence Response of Quest Model M-7 Personal Noise Dosimeter SN 704122T

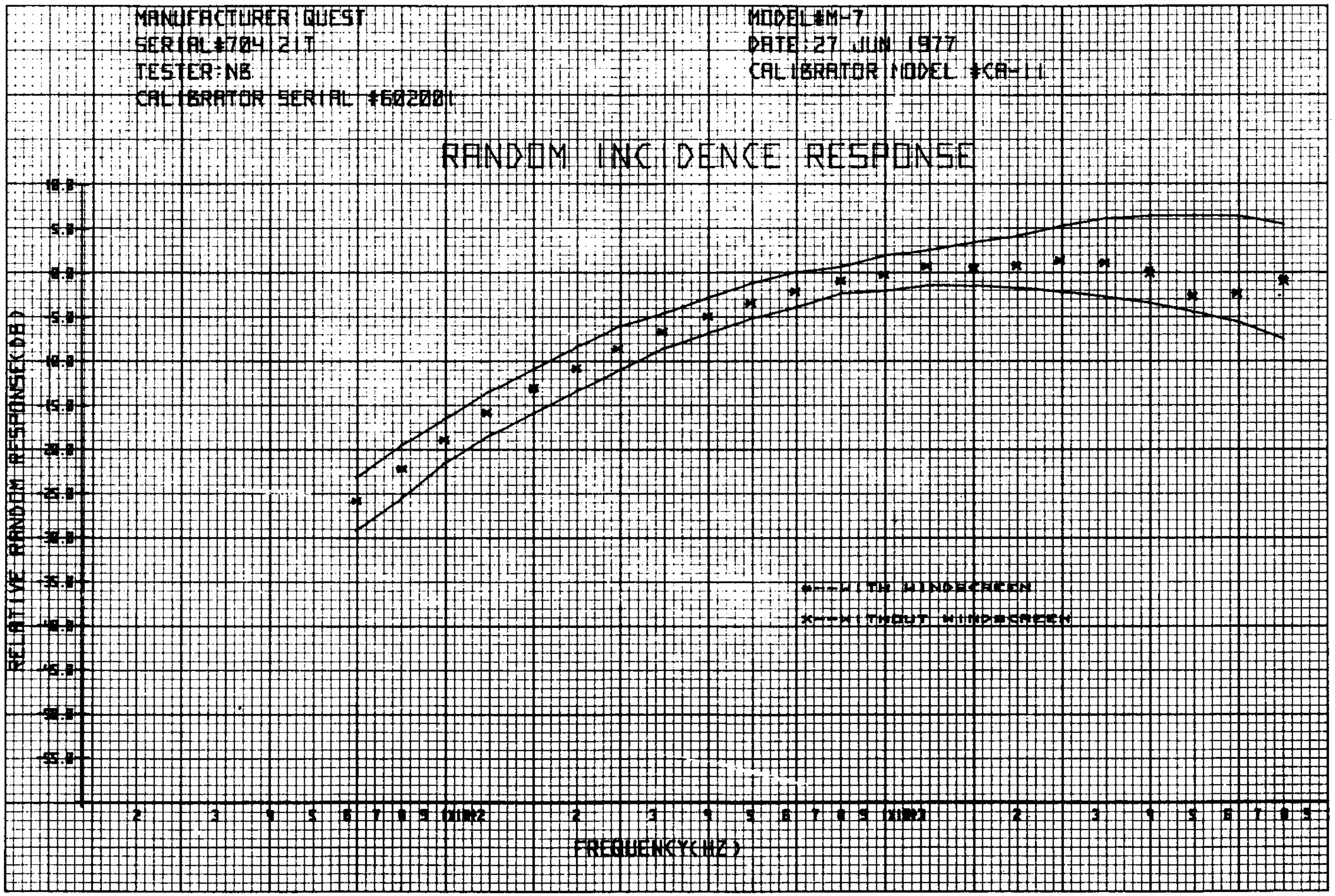

Figure 20. Random Incidence Response of Quest Model M-7 Personal Noise Dosimeter SN 704121T

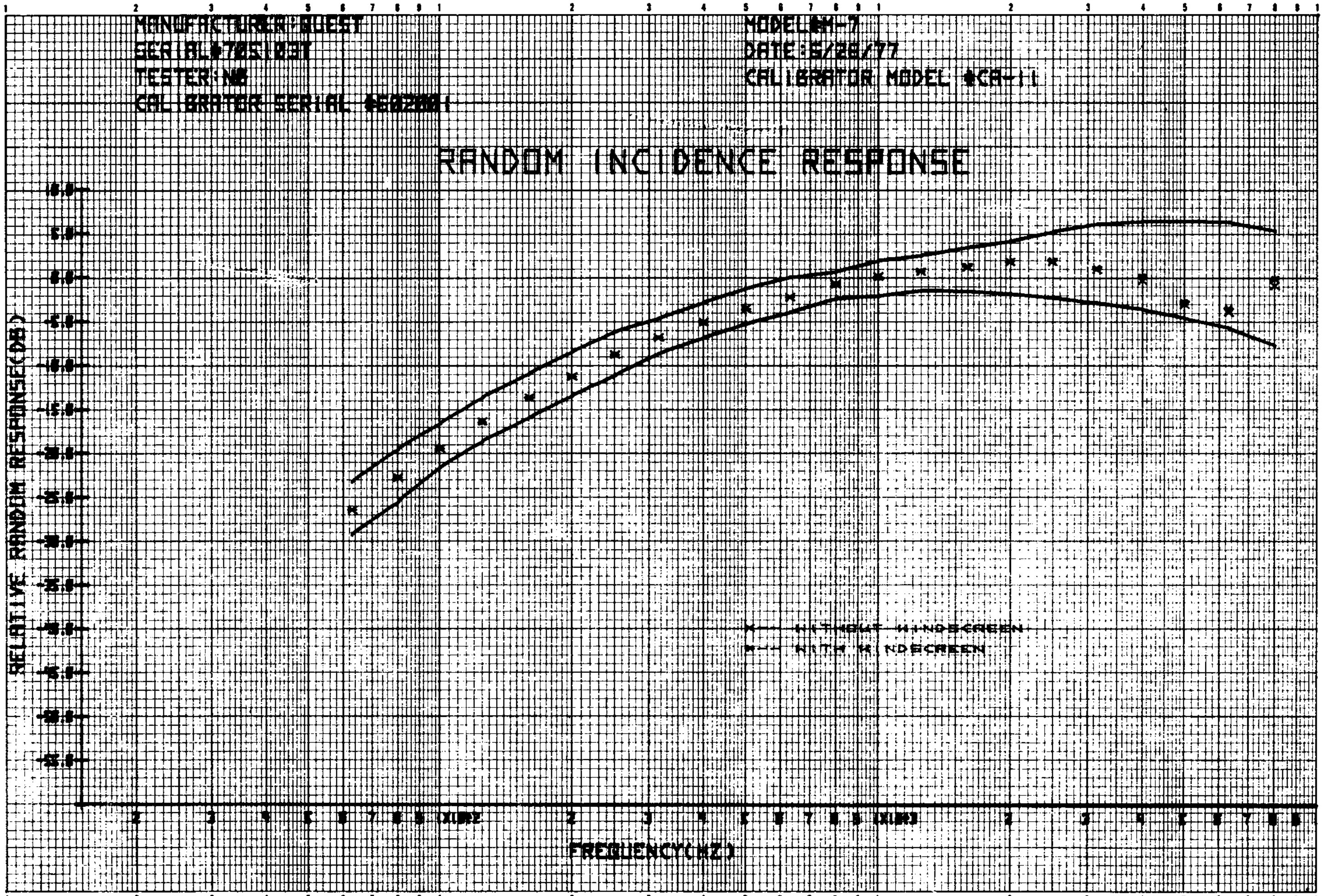

Figure 21. Random Incidence Response of Quest M-7 Personal Noise Dosimeter SN 705103T

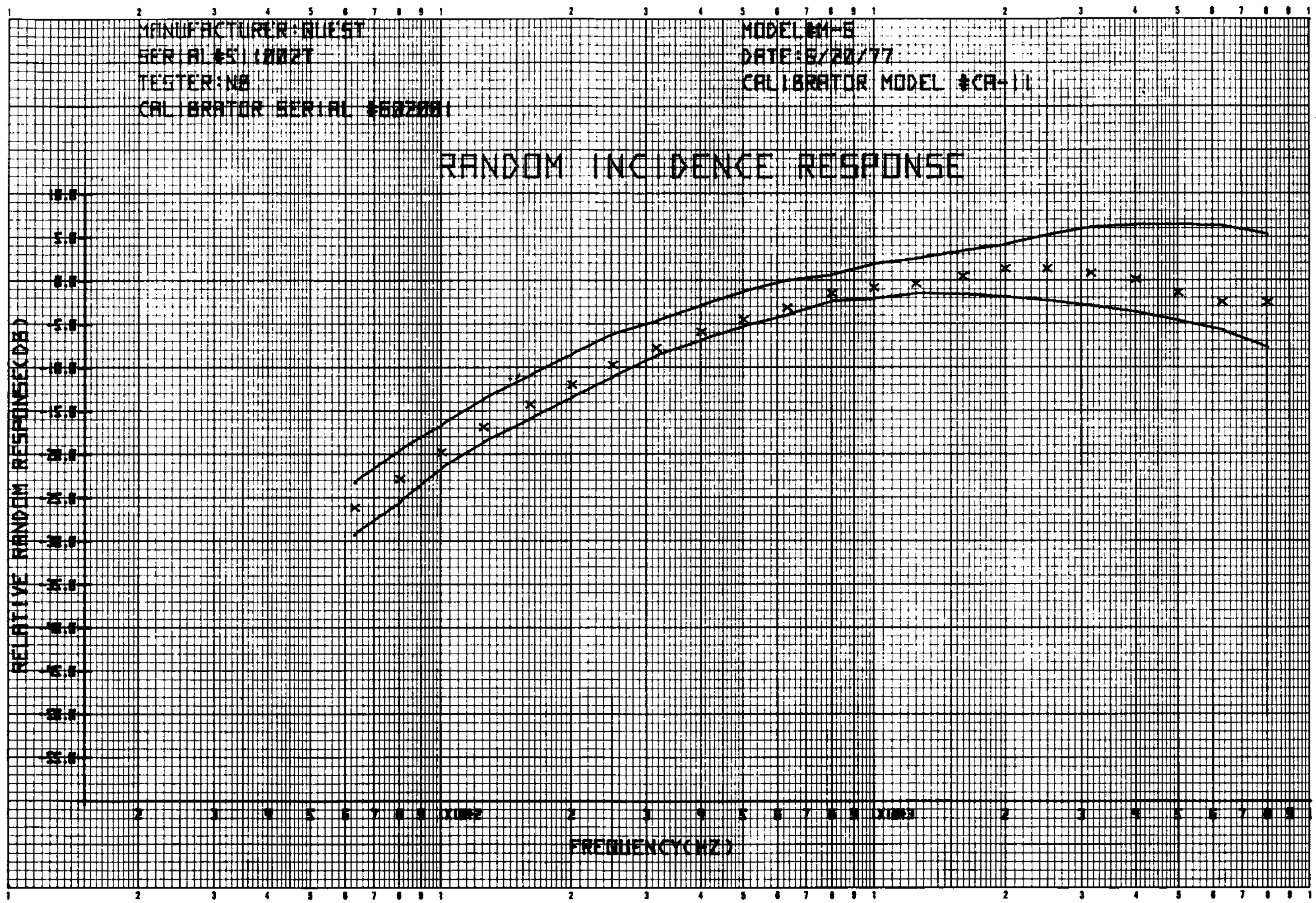

Figure 22. Random Incidence Response of Quest Model M-6 Personal Noise Dosimeter SN 511002T

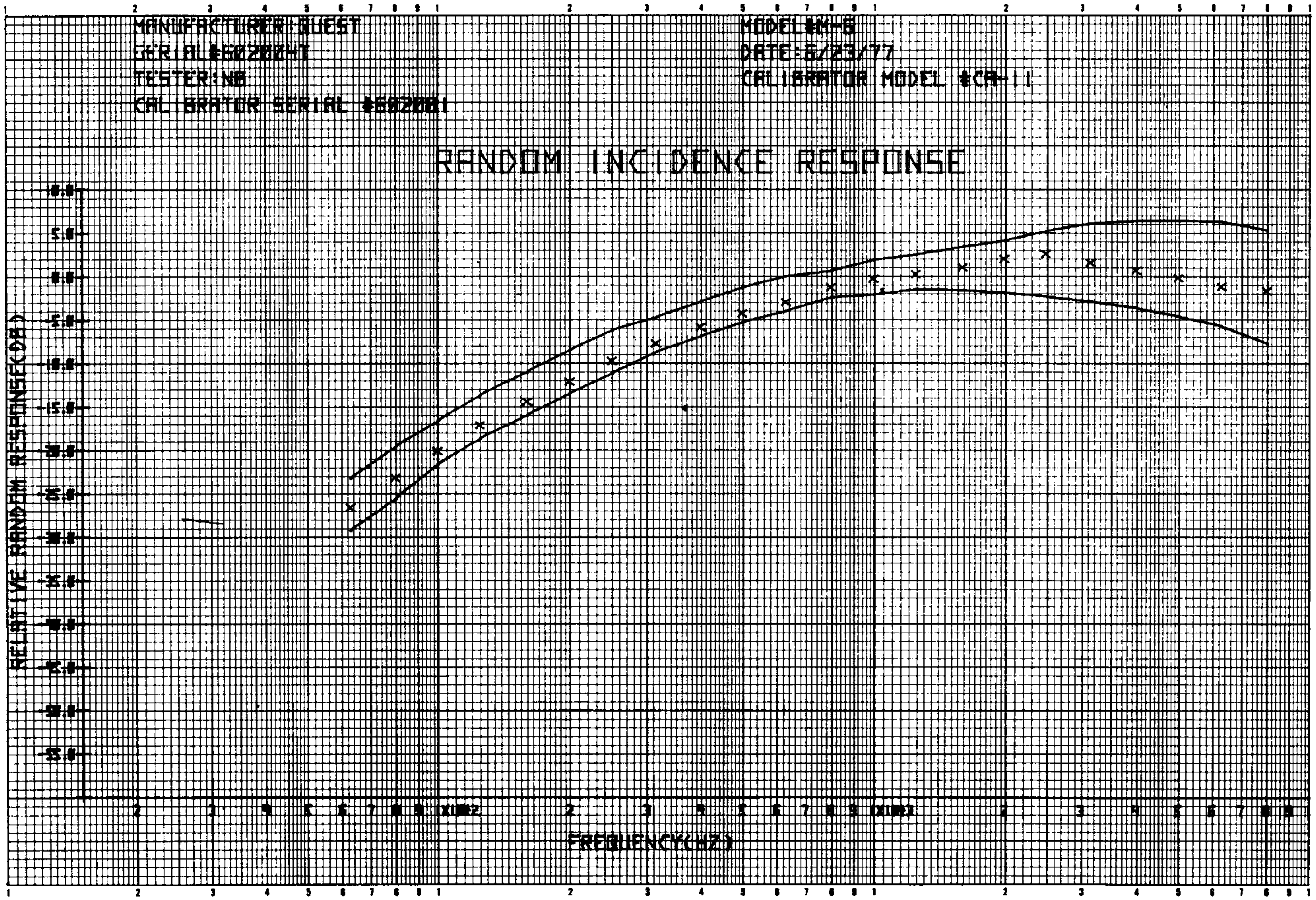

Figure 23. Random Incidence Response of Quest Model M-6 Personal Noise Dosimeter SN 602004T

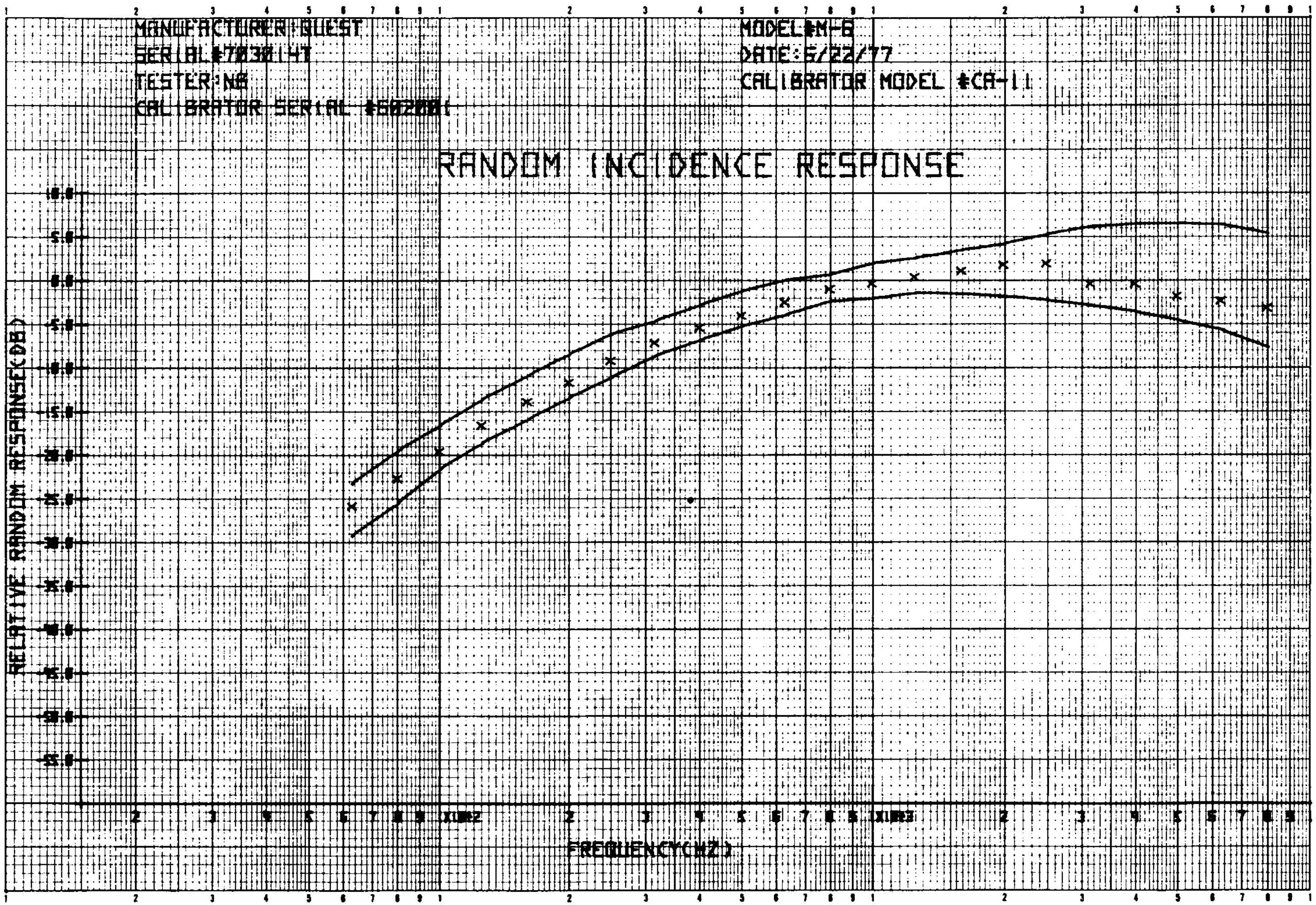

Figure 24. Random Incidence Response of Quest Model M-6 Personal Noise Dosimeter SN 703014T

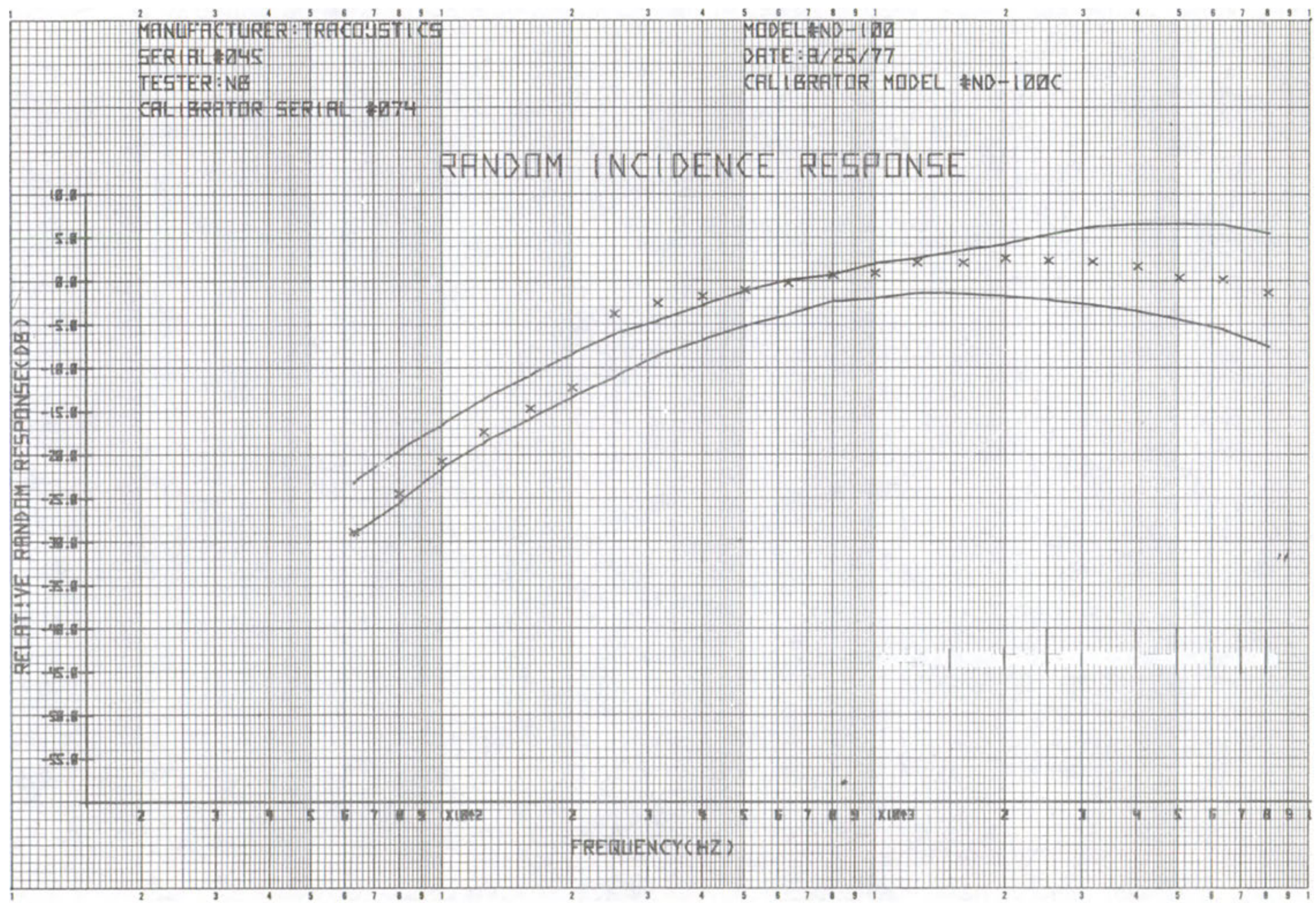

Figure 25. Random Incidence Response of Tracoustics Model ND-100 Personal Noise Dosimeter SN 045

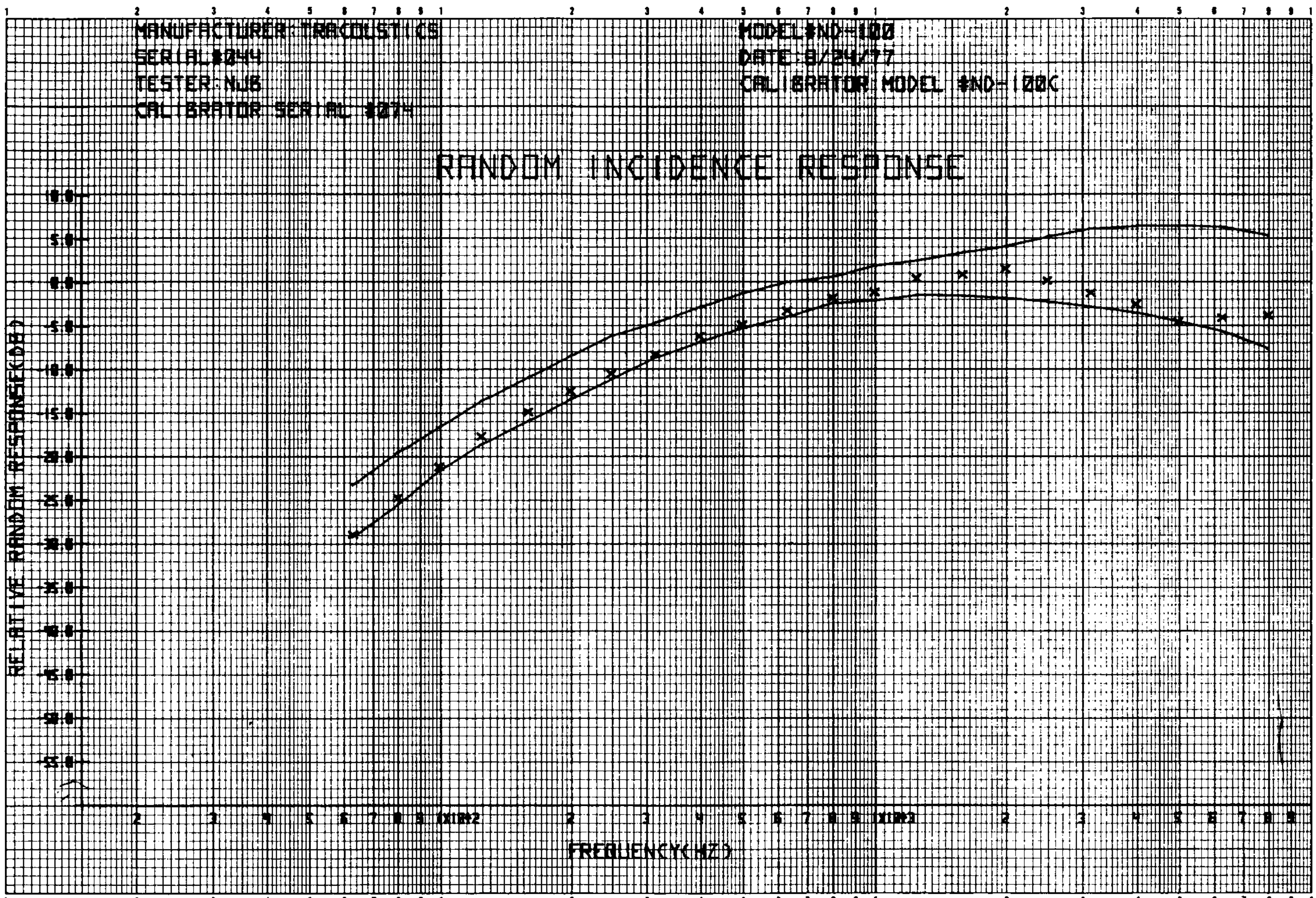

Figure 26. Random Incidence Response of Tracoustics Model ND-100
Personal Noise Dosimeter SN 044

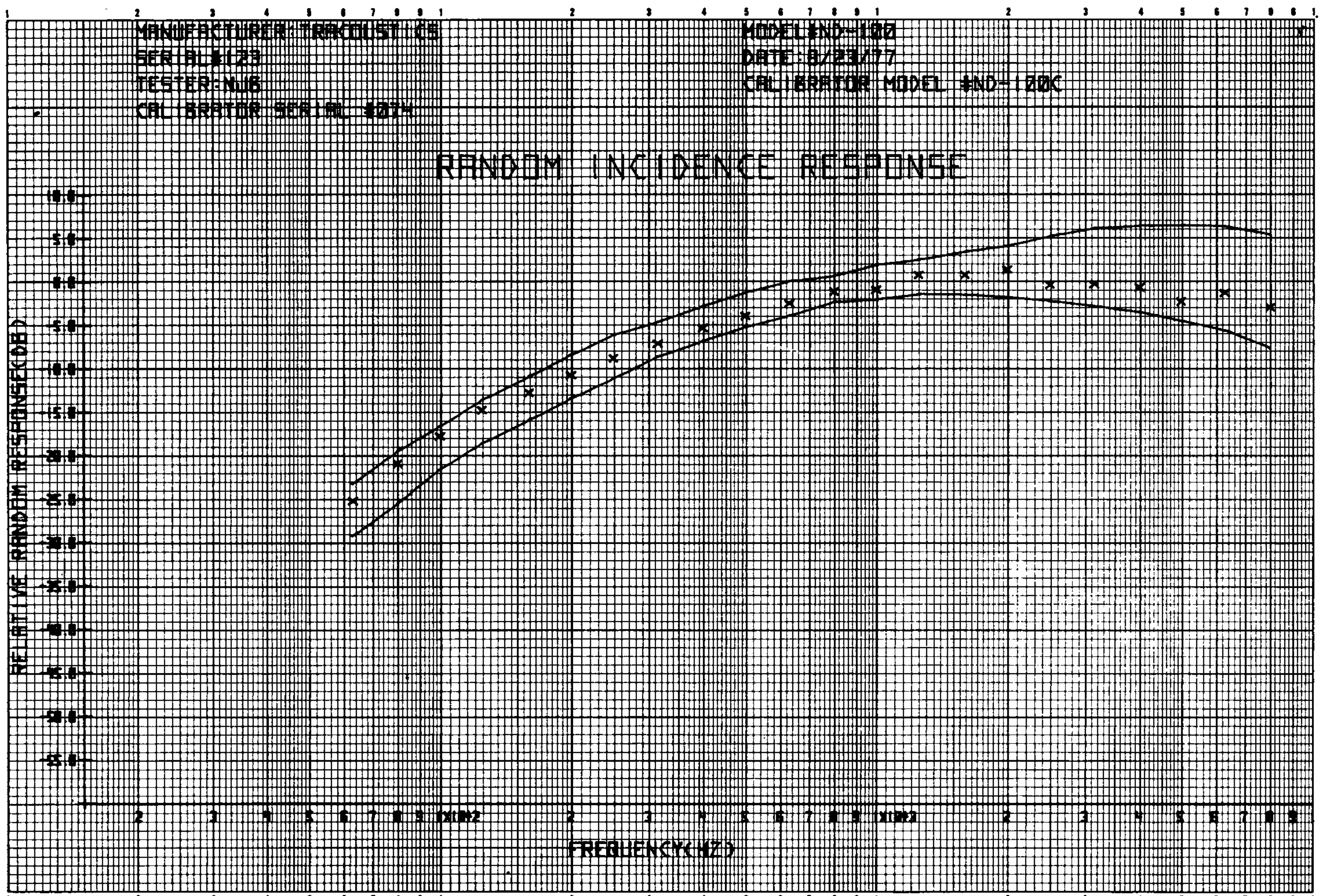

Figure 27. Random Incidence Response of Tracoustics Model ND-100 Personal Noise Dosimeter SN 123

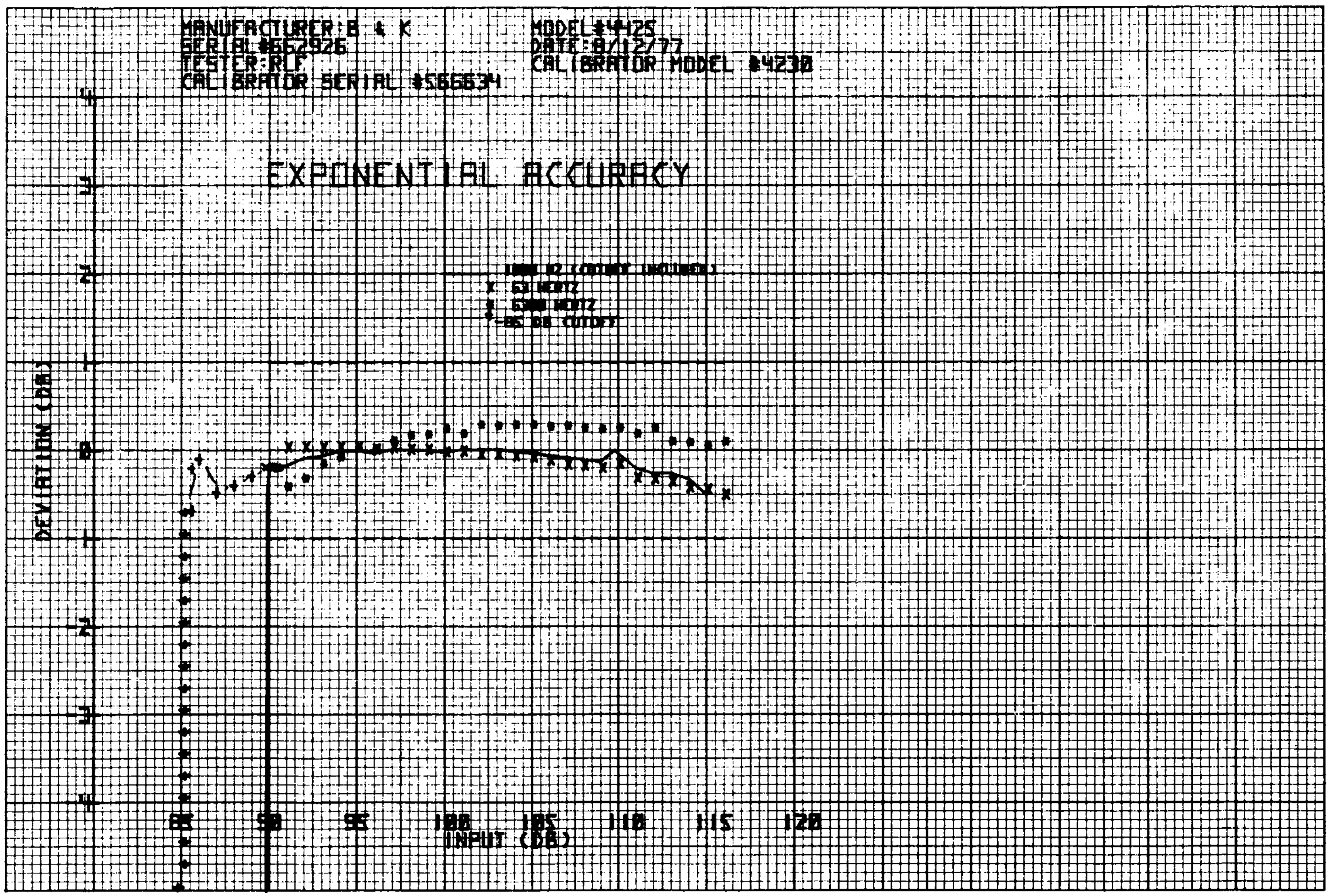

Figure 28. Exponential Accuracy Plot for B&K Model 4425 Personal Noise Dosimeter SN 662926

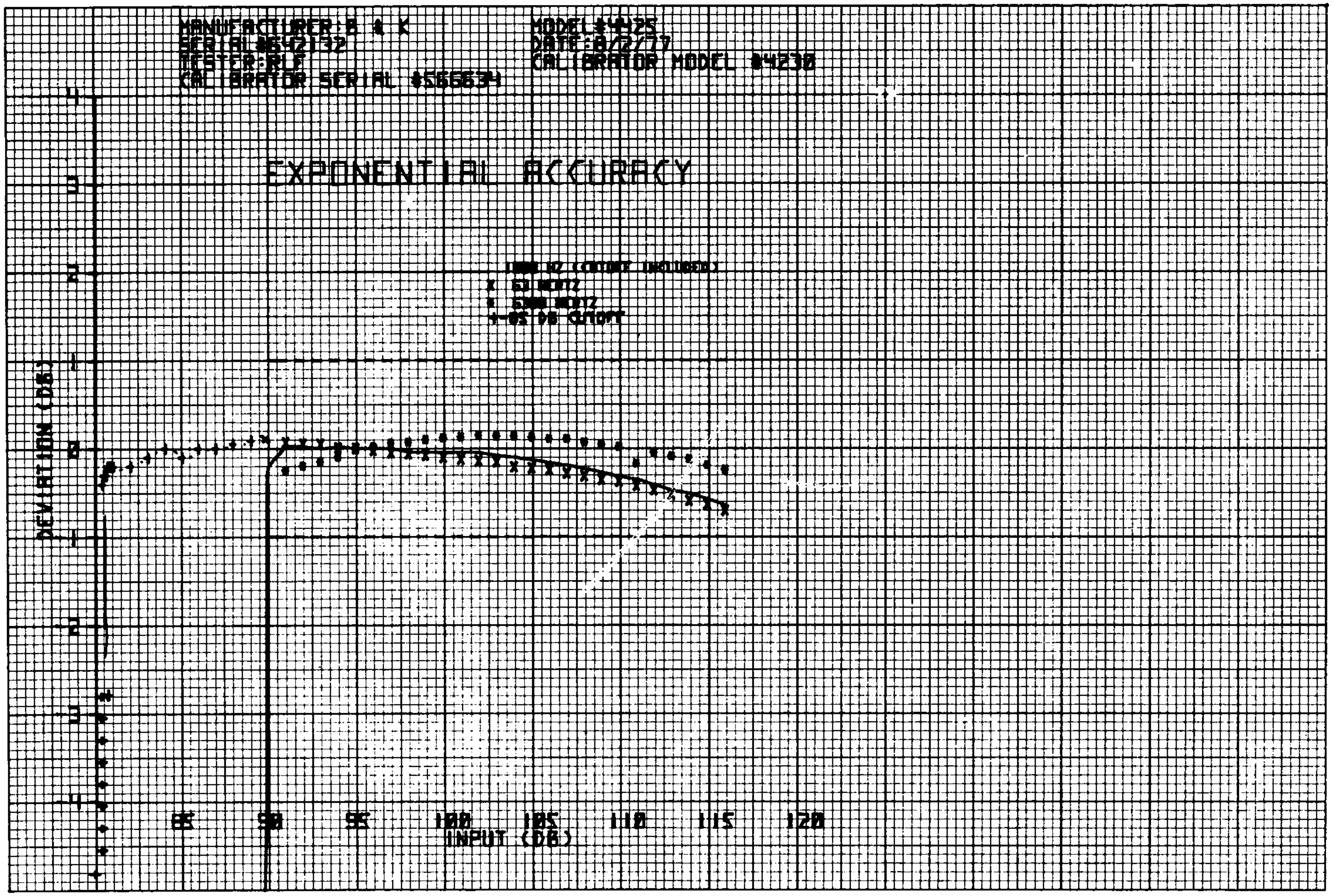

Figure 29. Exponential Accuracy Plot for B&K Model 4425 Personal Noise Dosimeter SN 642132

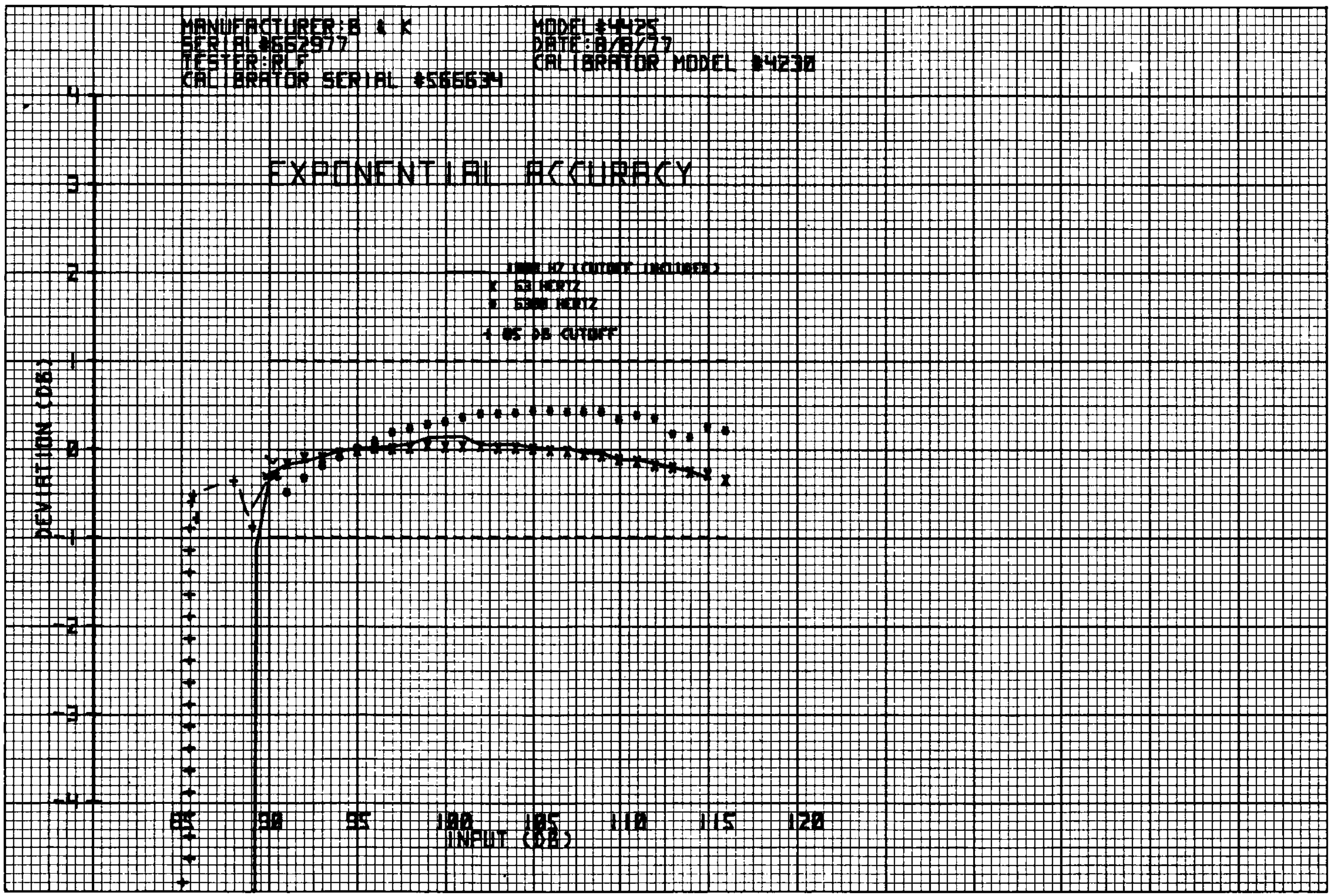

Figure 30. Exponential Accuracy Plot for B&K Model 4425 Personal Noise Dosimeter SN 662977

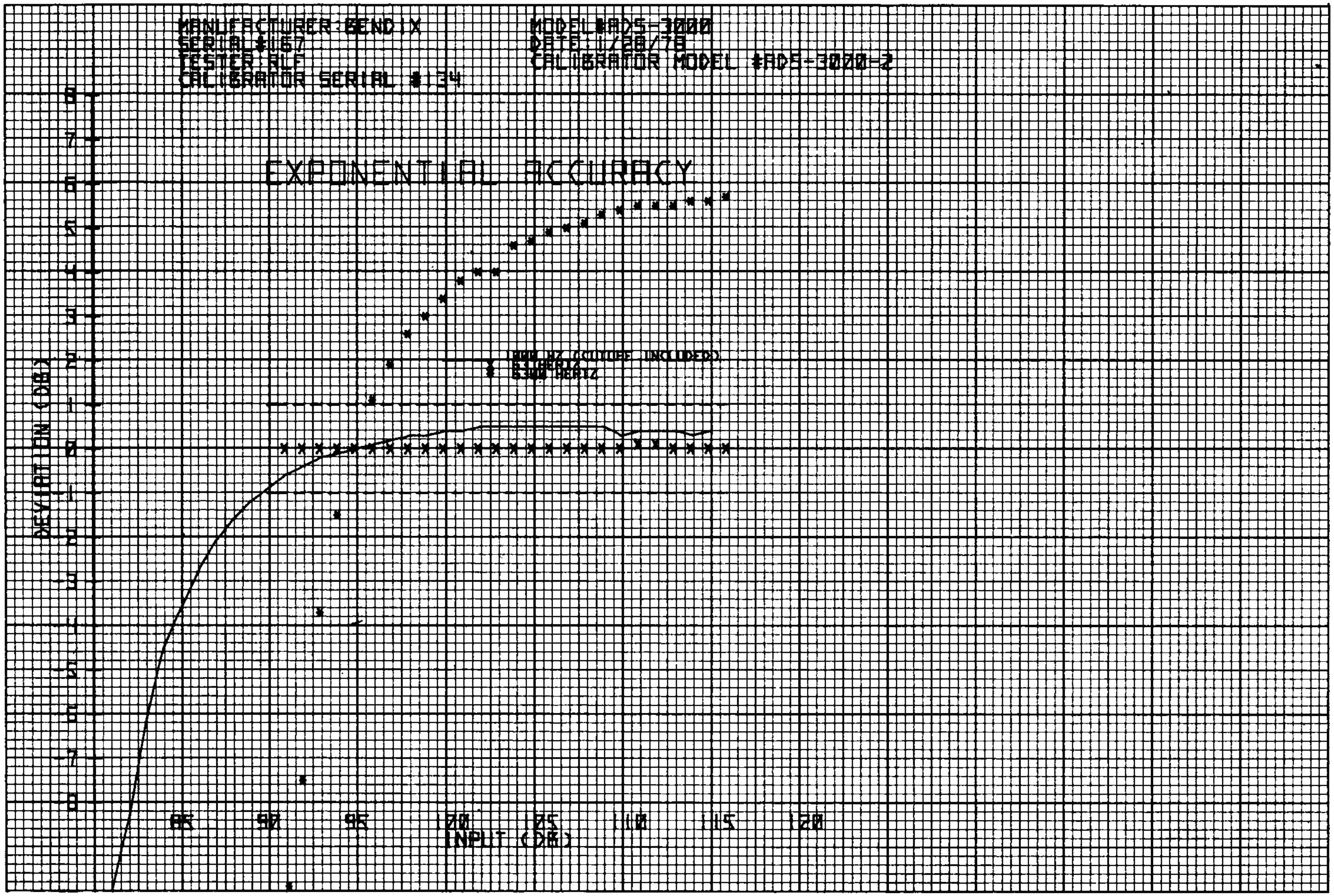

Figure 31. Exponential Accuracy Plot for Bendix Model ADS-3000 Personal Noise Dosimeter SN 167

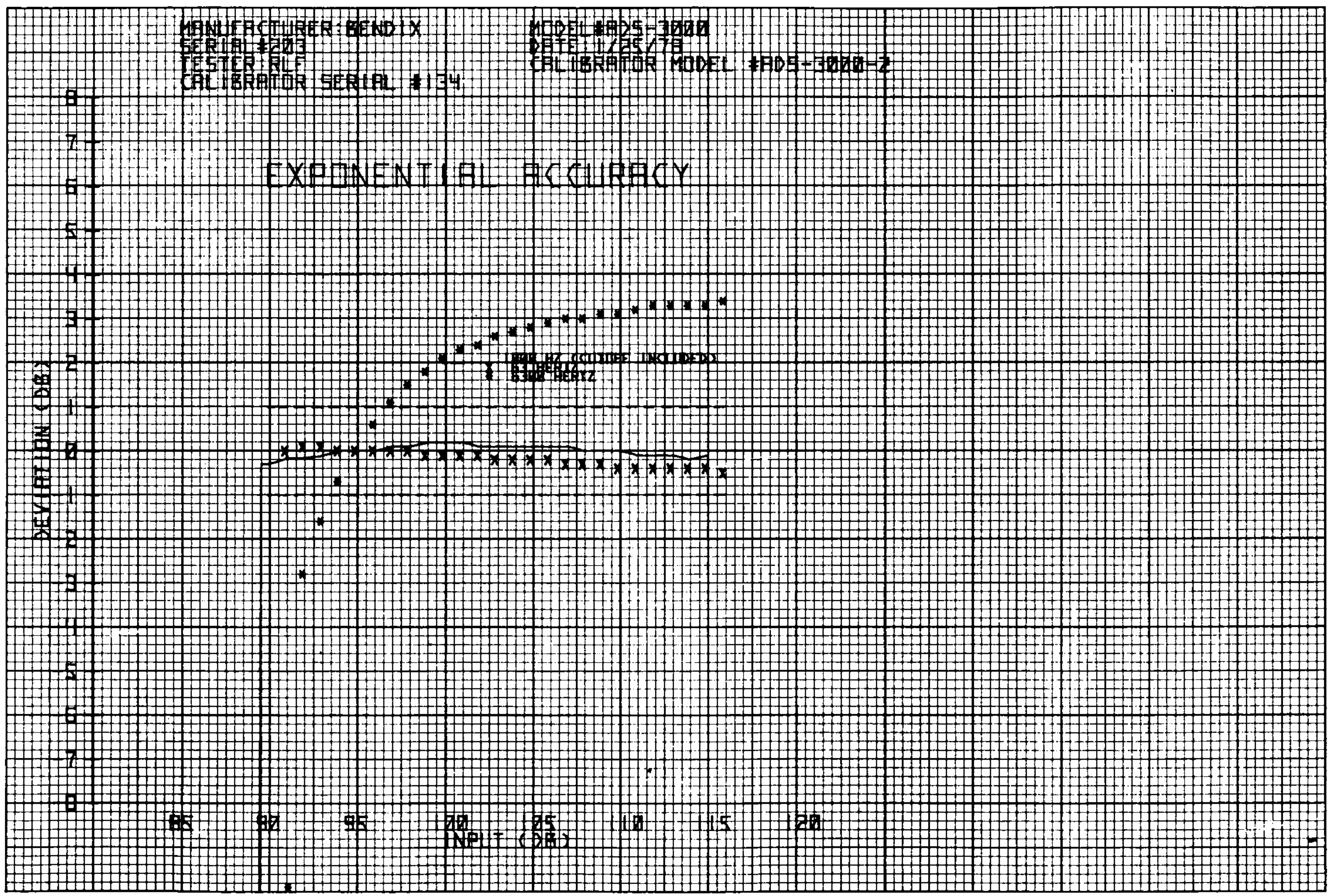

Figure 32. Exponential Accuracy Plot for Bendix Model ADS-3000
Personal Noise Dosimeter SN 203

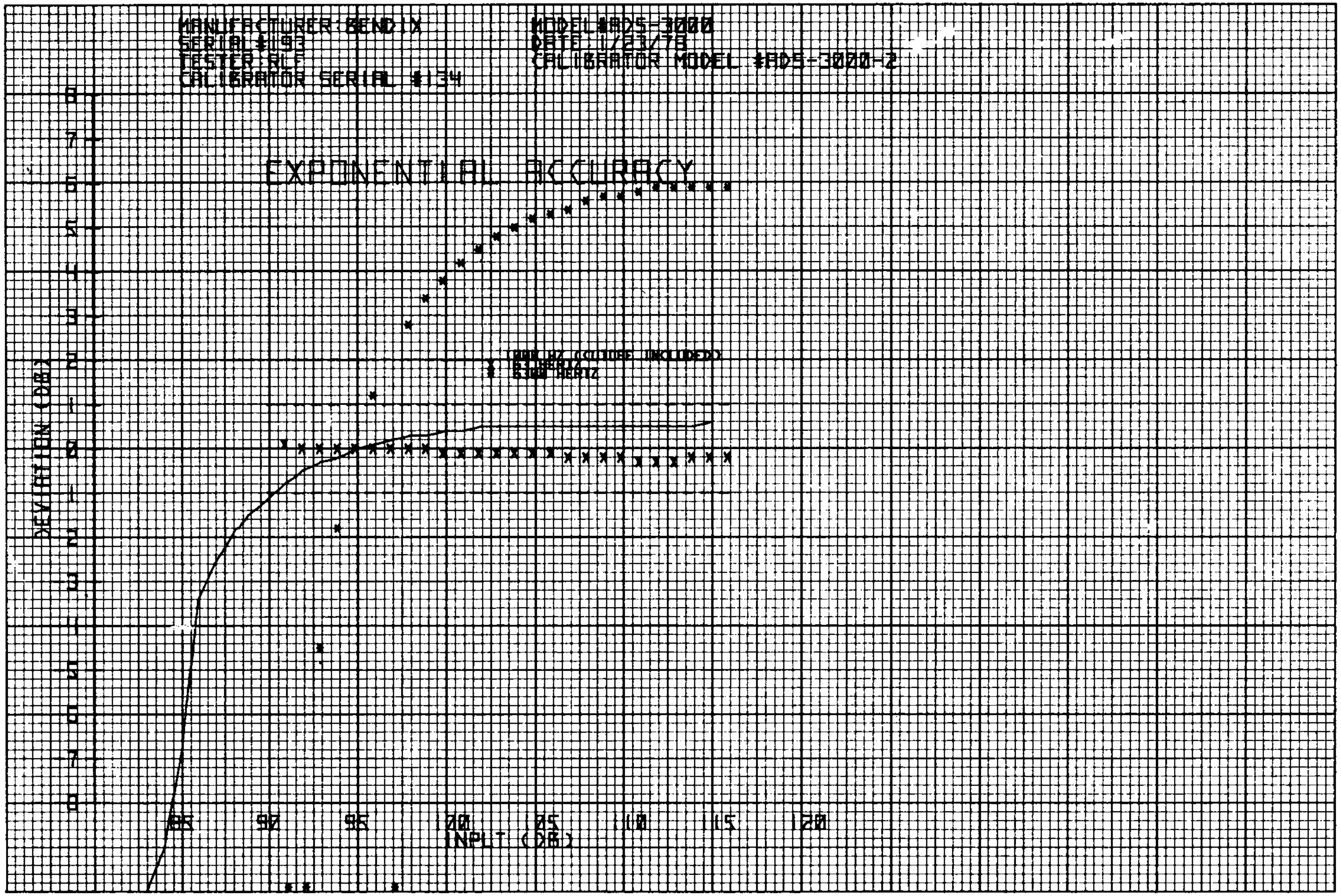

Figure 33. Exponential Accuracy Plot for Bendix Model ADS-3000 Personal Noise Dosimeter SN 193

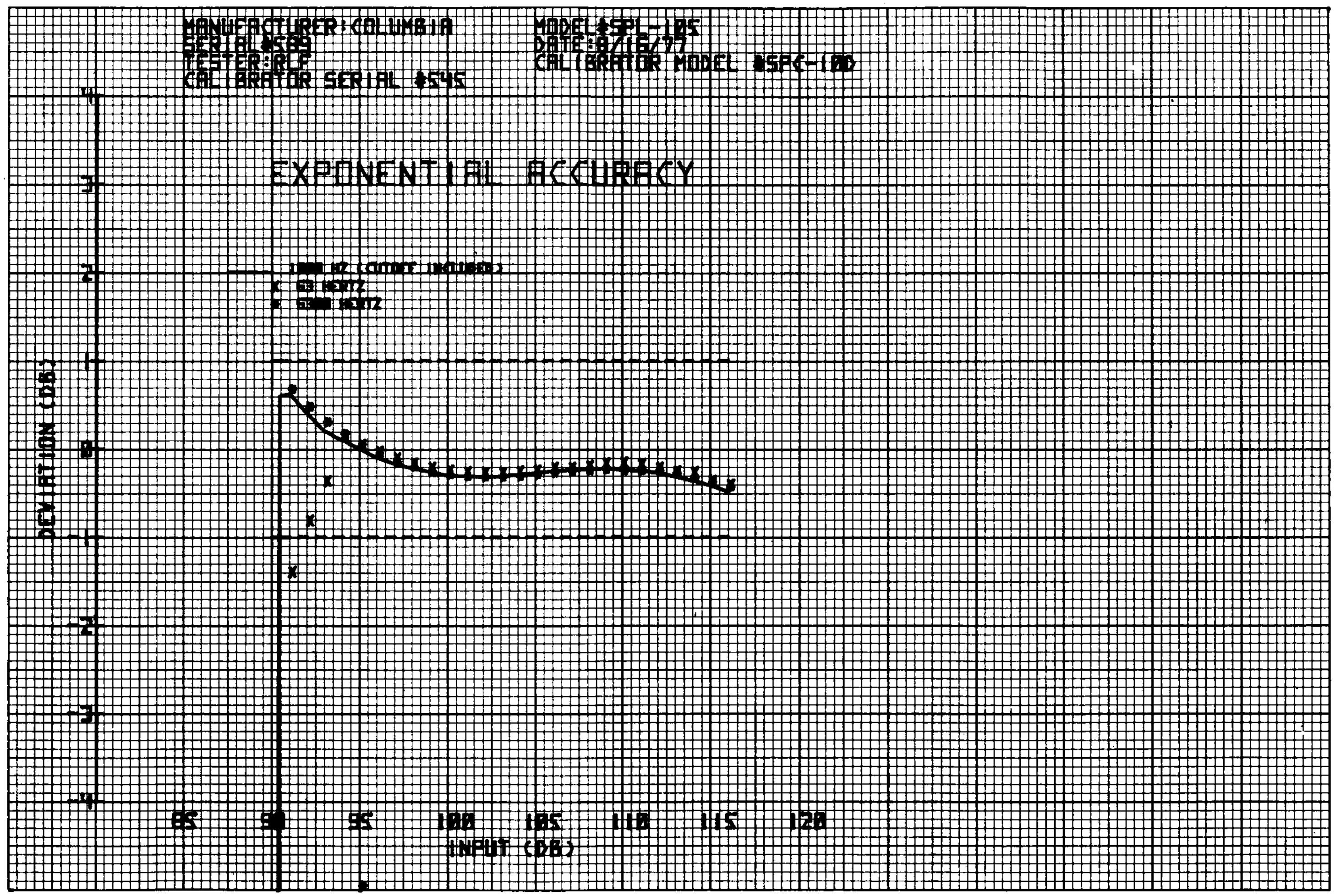

Figure 34. Exponential Accuracy Plot for Columbia Model SPL-105 Personal Noise Dosimeter SN 589

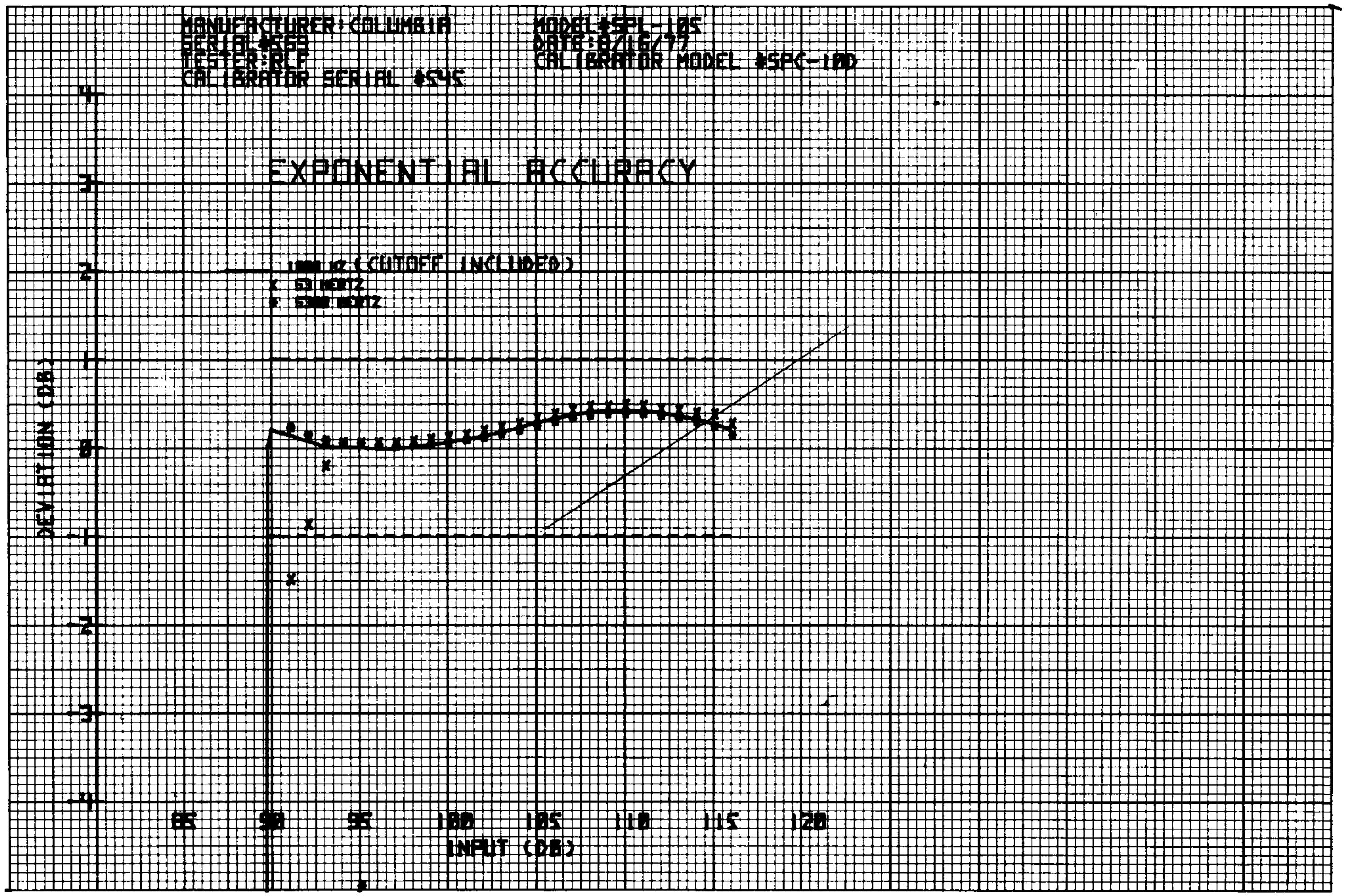

Figure 35. Exponential Accuracy Plot for Columbia Model SPL-105 Personal Noise Dosimeter SN 569

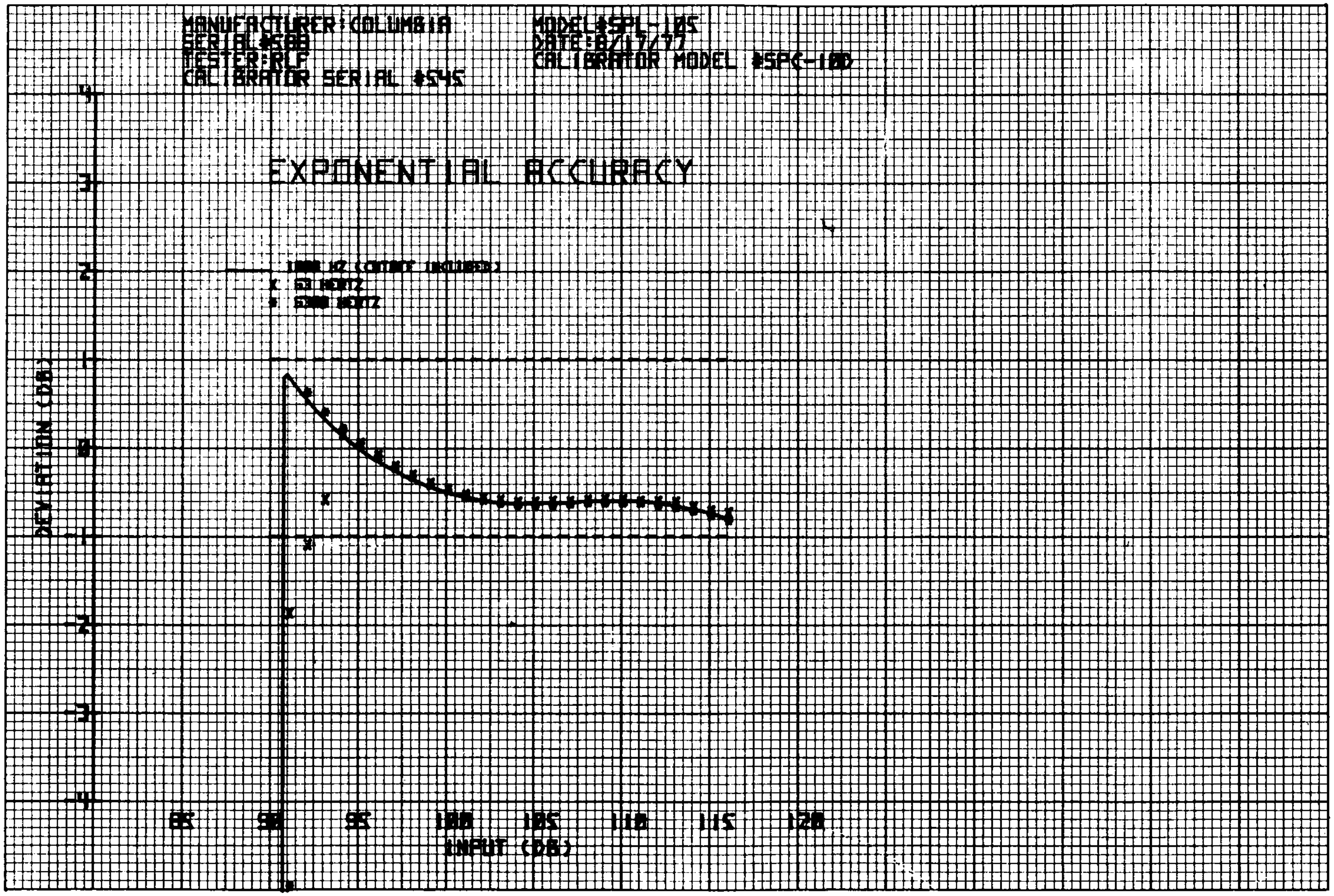

Figure 36. Exponential Accuracy Plot for Columbia Model SPL-105 Personal Noise Dosimeter SN 588

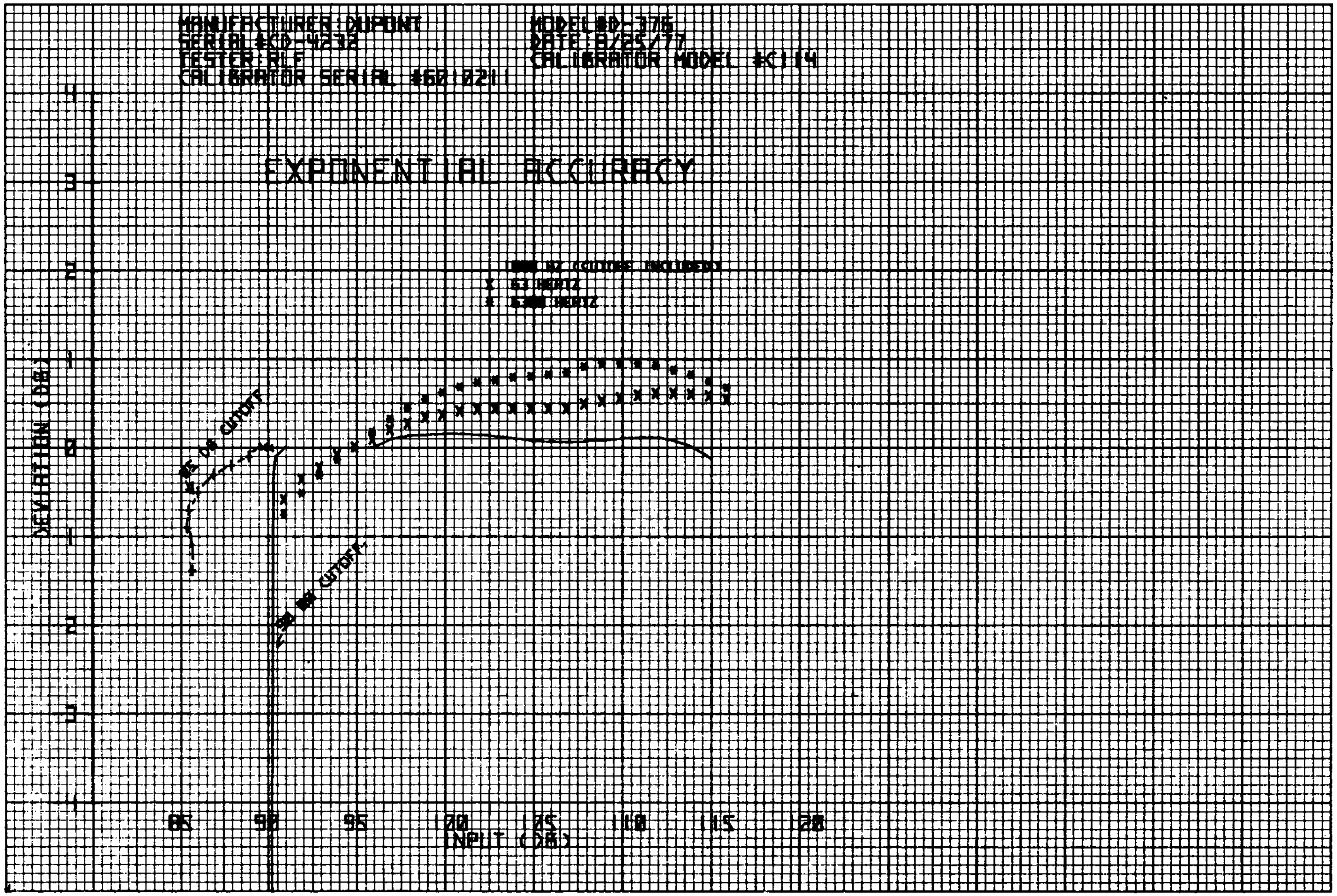

Figure 37. Exponential Accuracy Plot for Dupont Model D-376 Personal Noise Dosimeter SN CD-4232

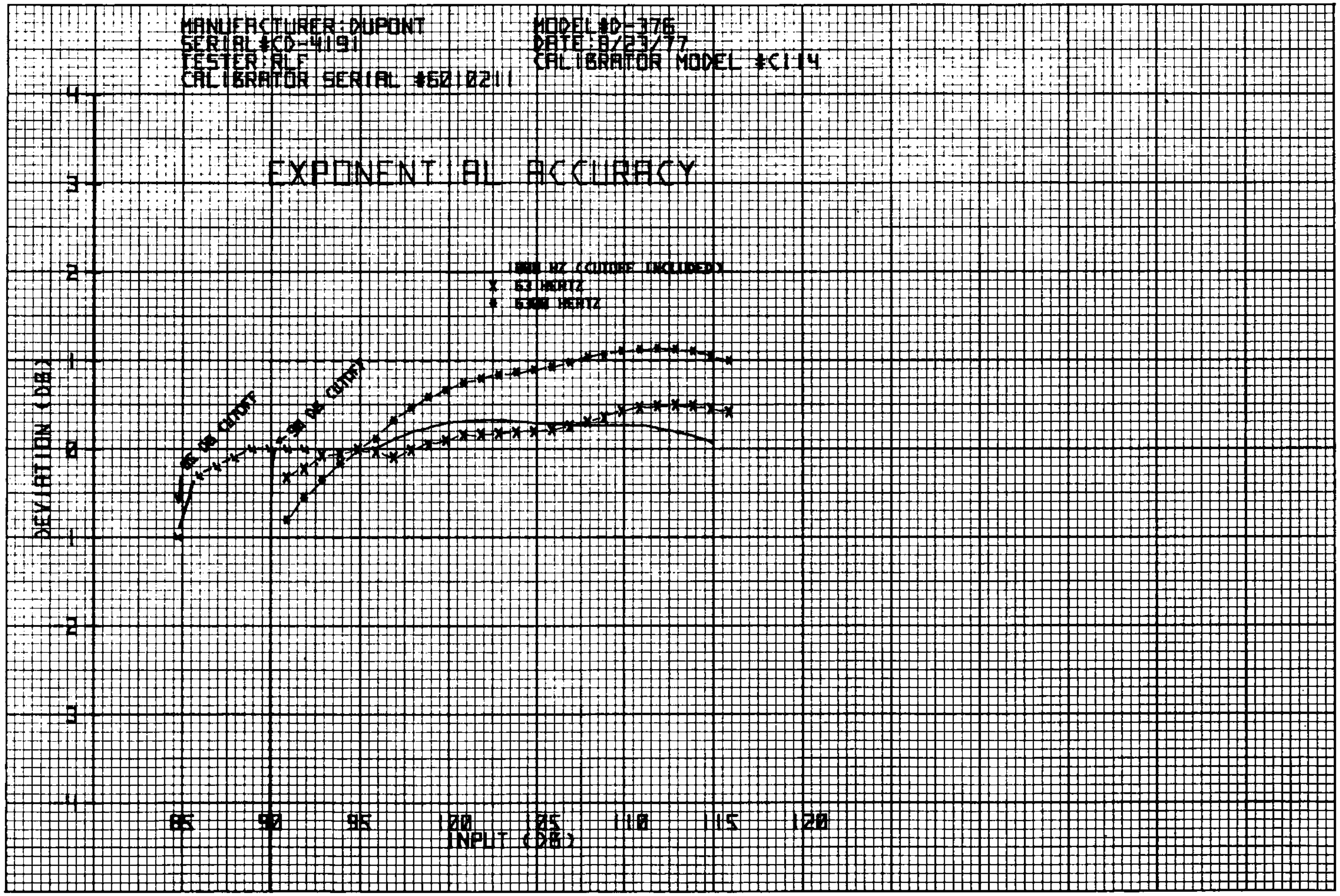

Figure 38. Exponential Accuracy Plot for Dupont Model D-376 Personal Noise Dosimeter SN CD-4191

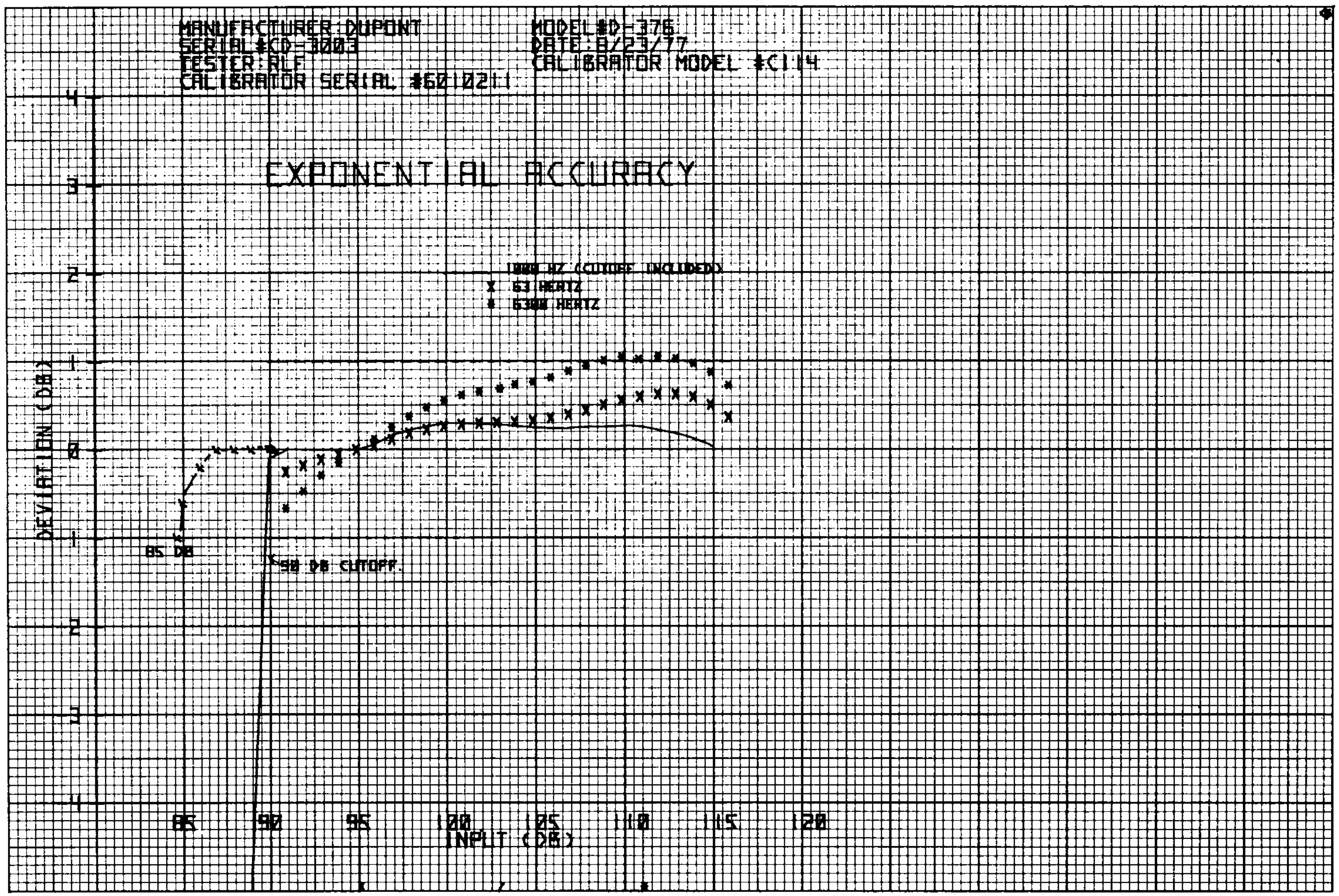

Figure 39. Exponential Accuracy Plot for Dupont Model D-376 Personal Noise Dosimeter SN CD-3003

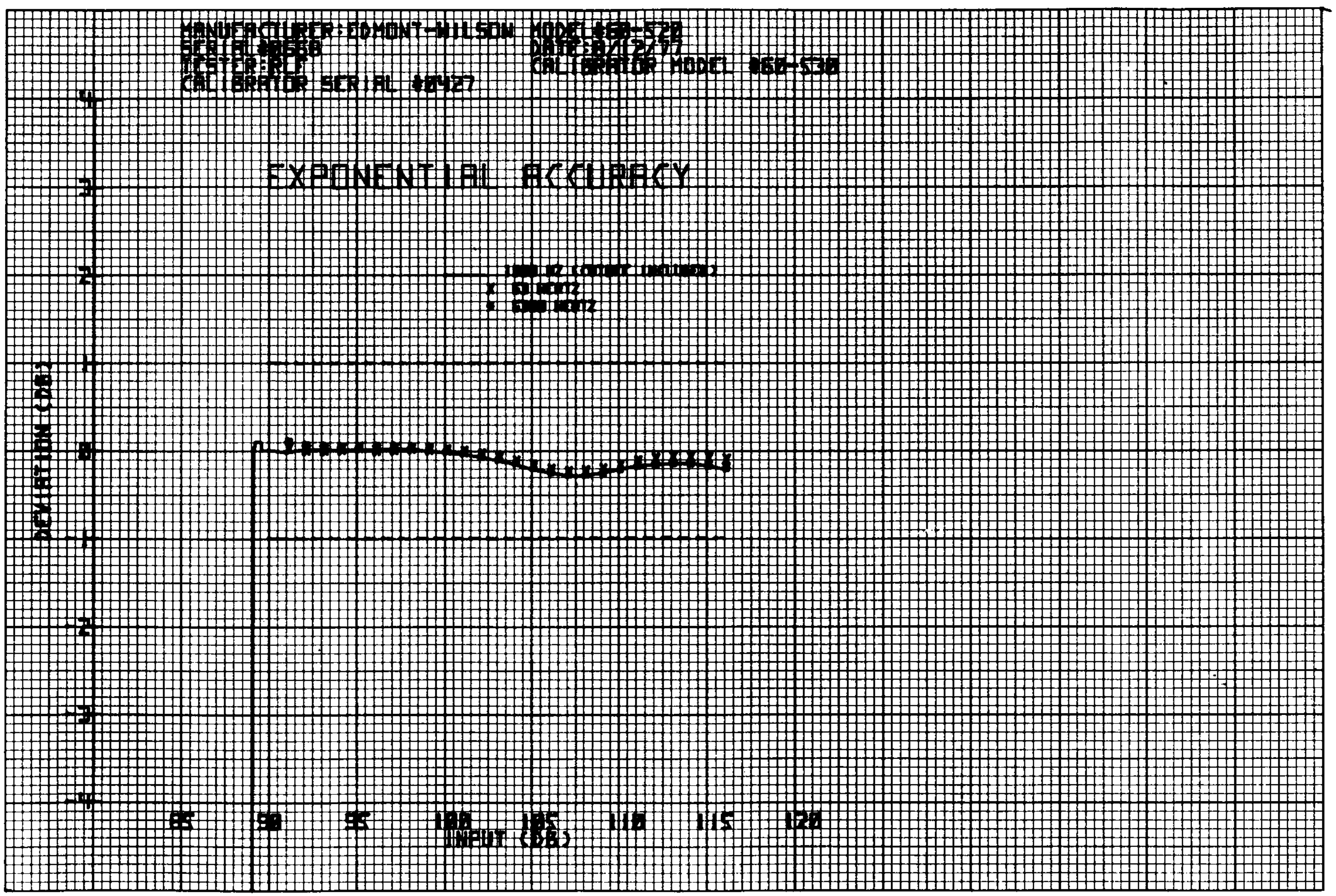

Figure 40. Exponential Accuracy Plot for Edmont-Wilson Model 60-520 Personal Noise Dosimeter SN 0668

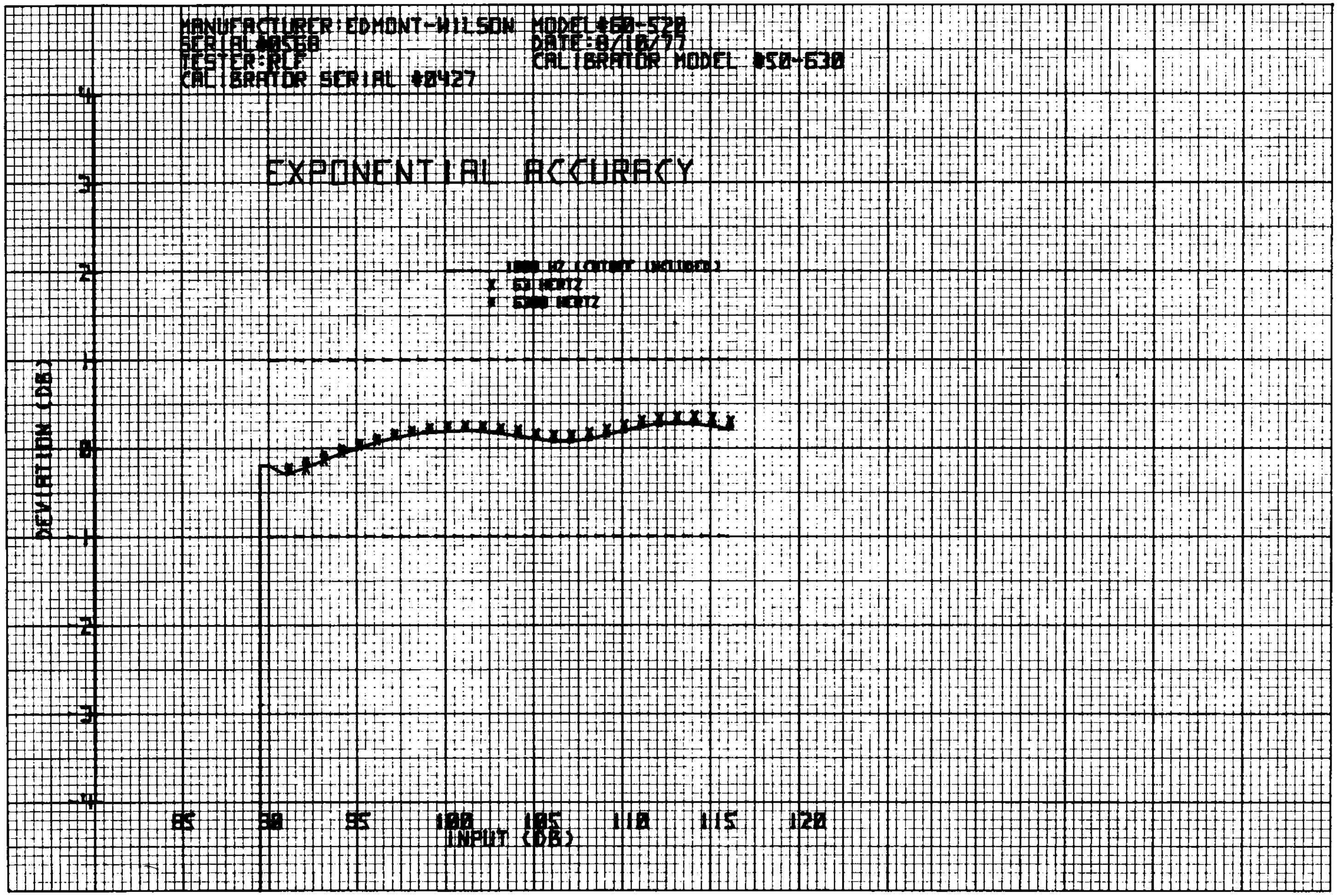

Figure 41. Exponential Accuracy Plot for Edmont-Wilson Model 60-520
Personal Noise Dosimeter SN 0568

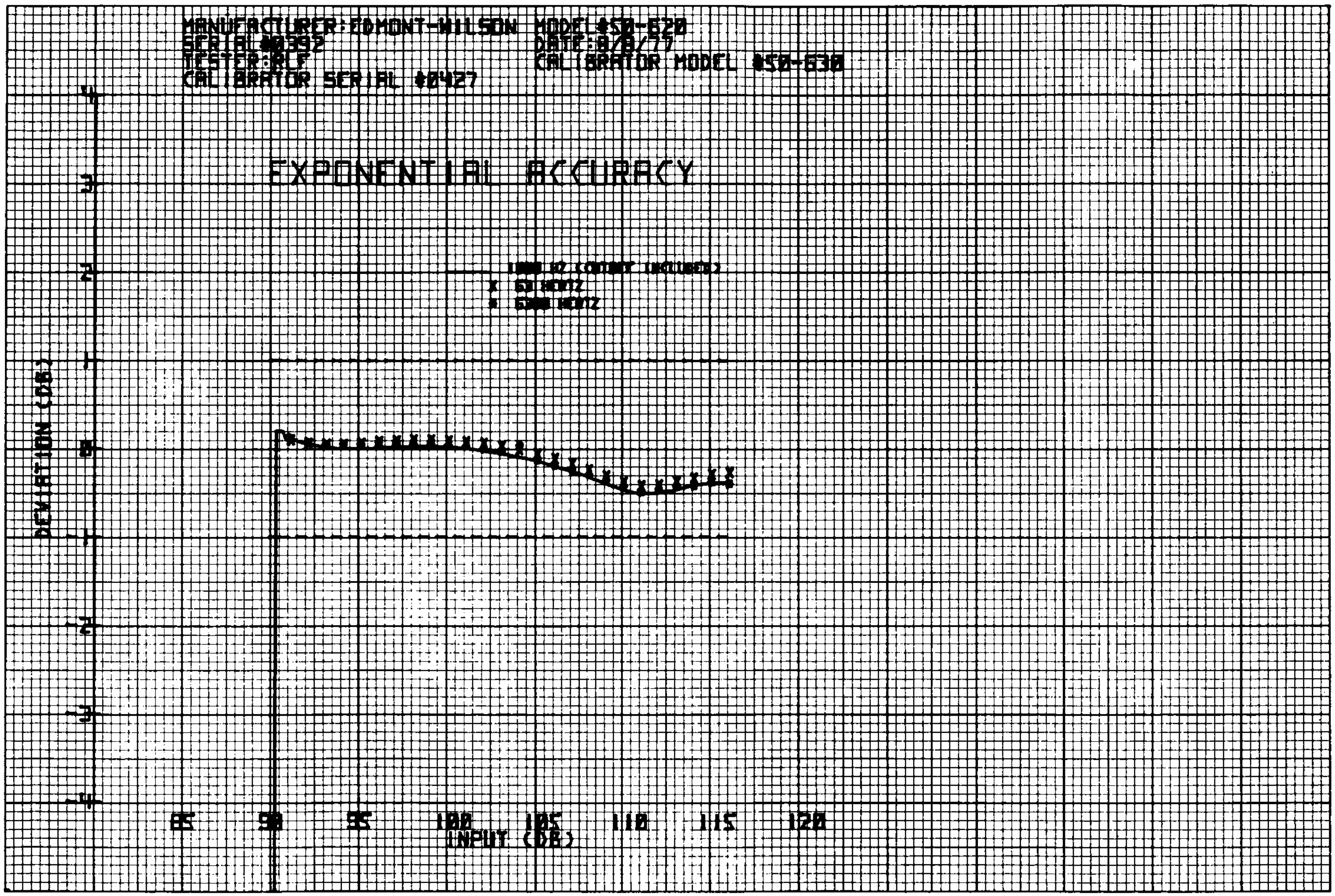

Figure 42. Exponential Accuracy Plot for Edmont-Wilson Model 60-520
Personal Noise Dosimeter SN 0392

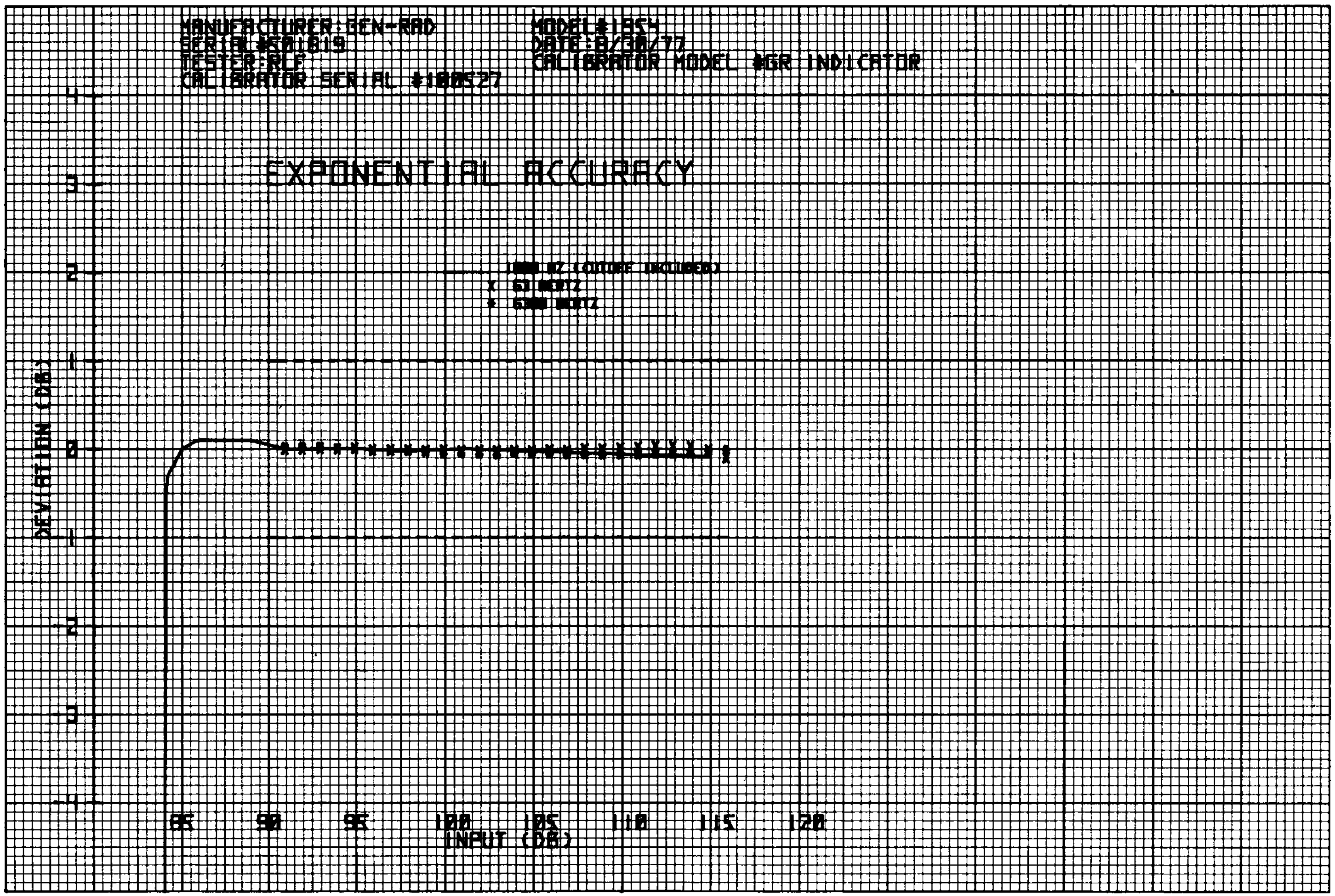

Figure 43. Exponential Accuracy Plot for GenRad Model 1954 Personal Noise Dosimeter SN 501819

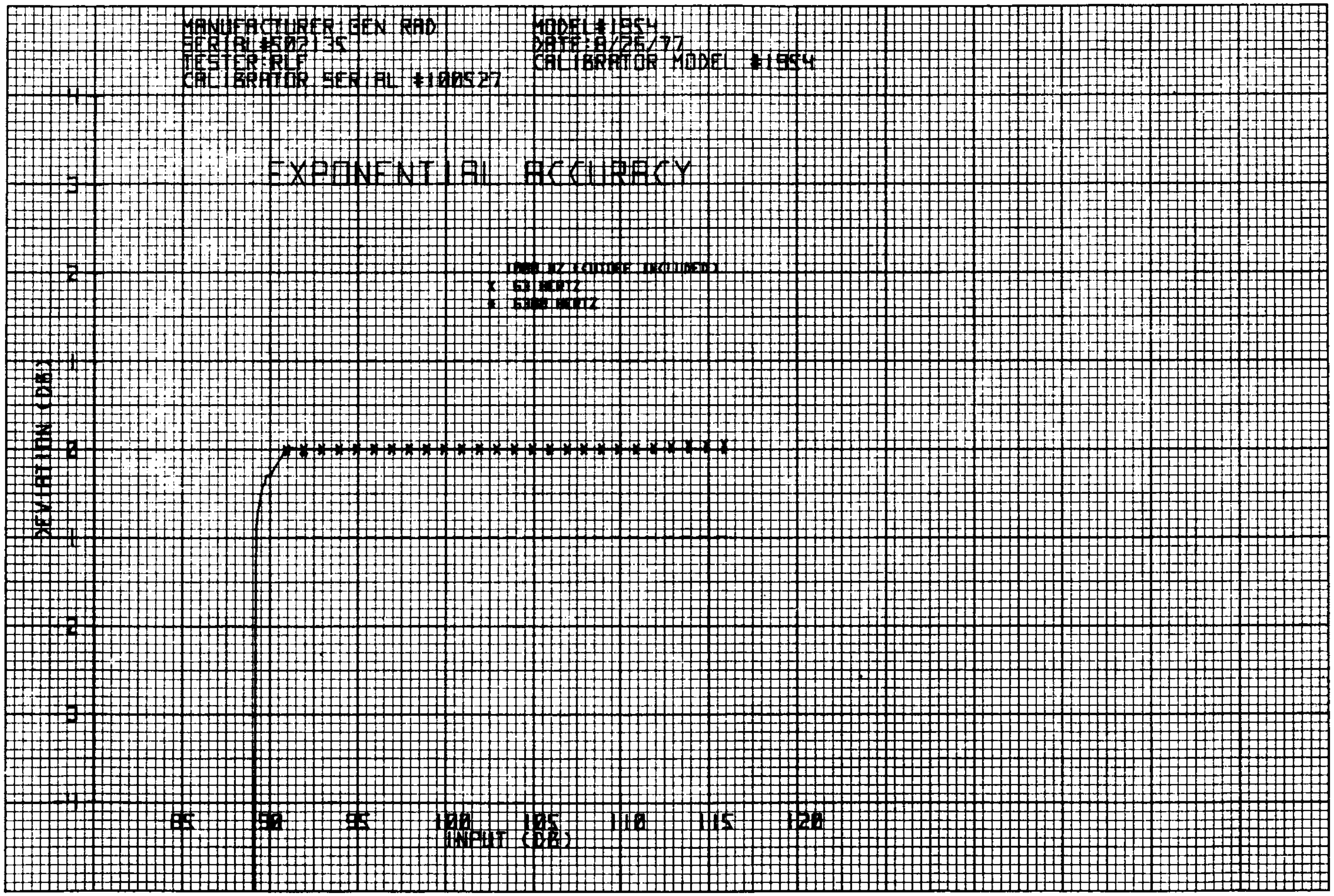

Figure 44. Exponential Accuracy Plot for GenRad Model 1954 Personal Noise Dosimeter SN 502135

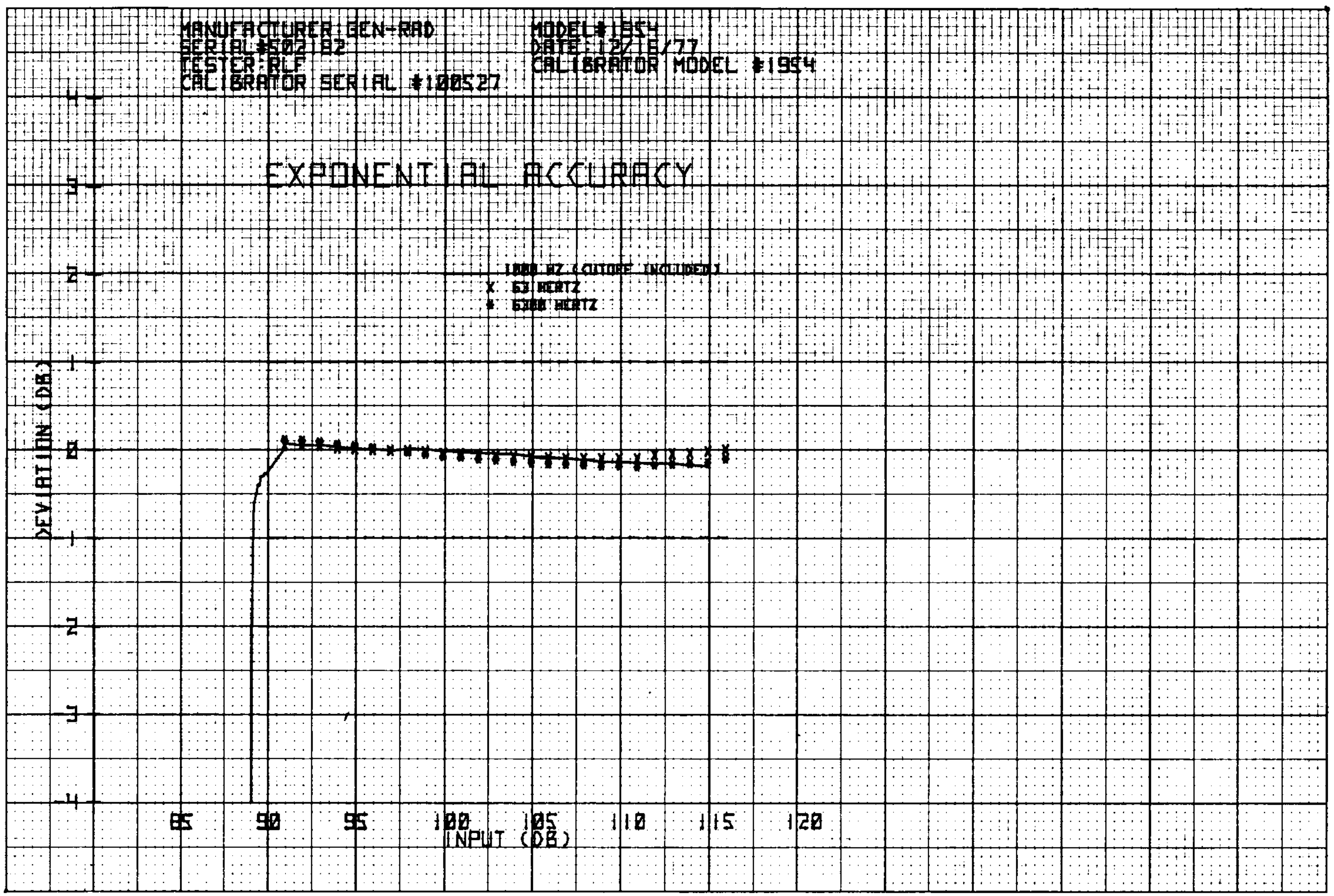

Figure 45. Exponential Accuracy Plot for GenRad Model 1954 Personal Noise Dosimeter SN 502182

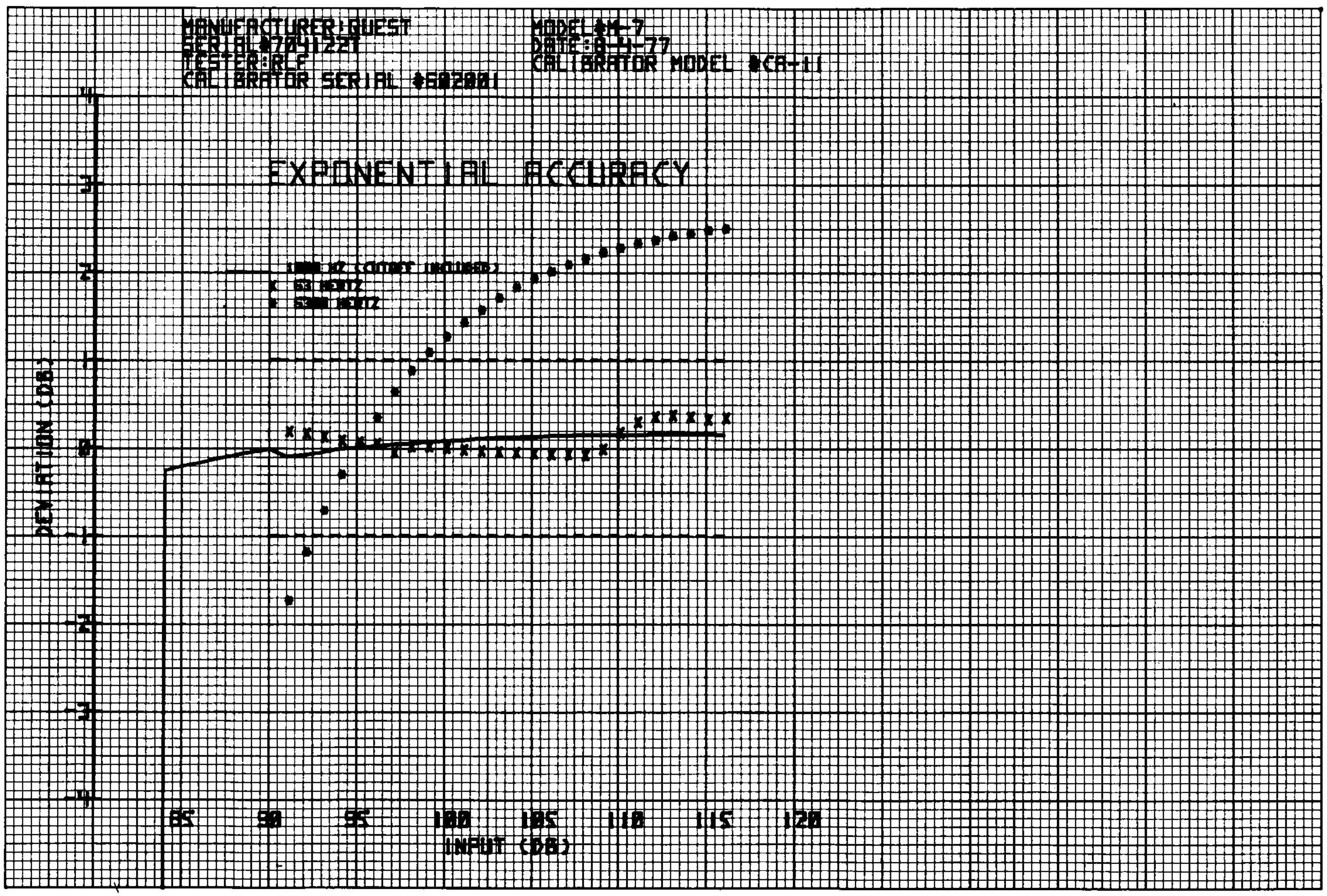

Figure 46. Exponential Accuracy Plot for Quest Model M-7
Personal Noise Dosimeter SN 704122T

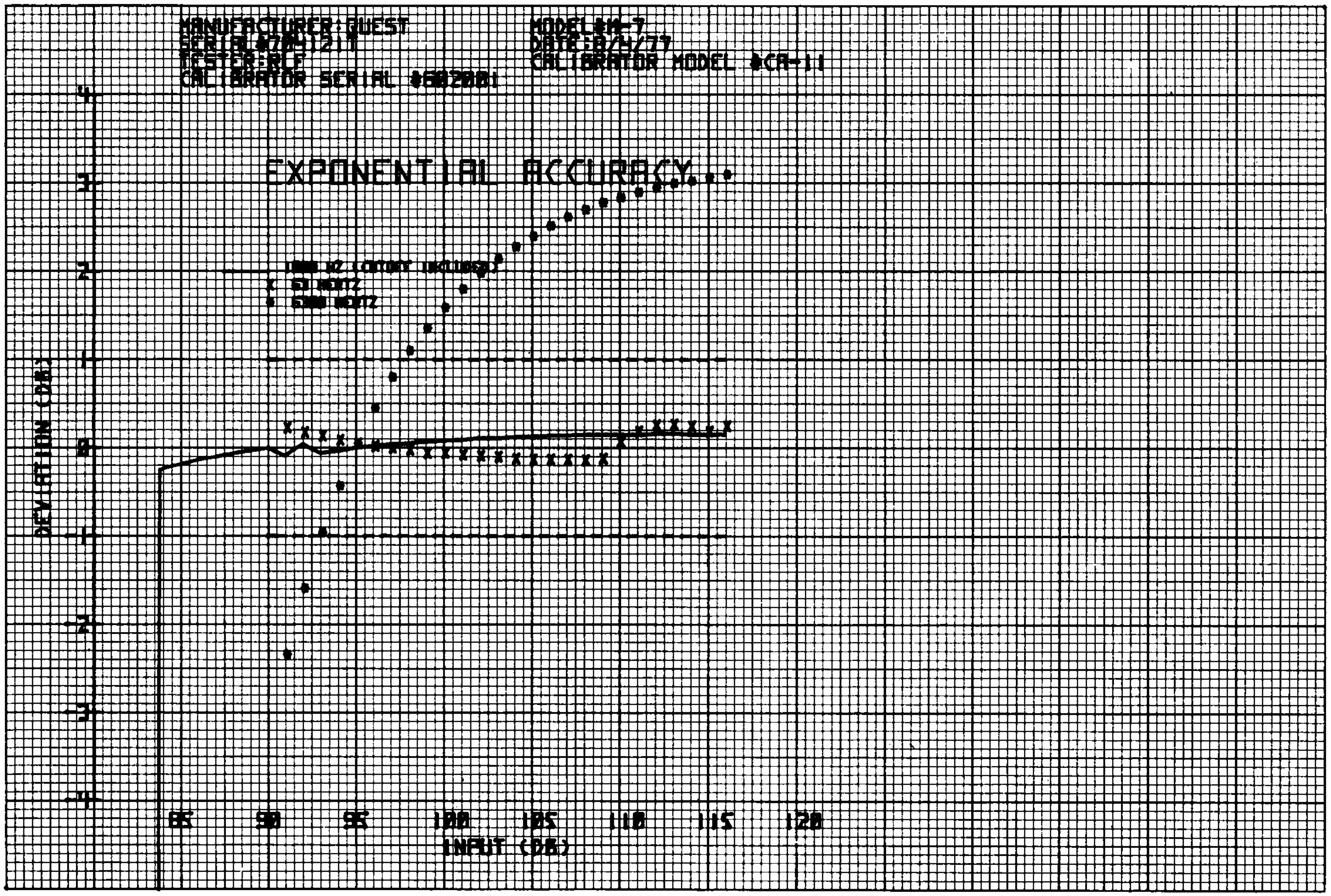

Figure 47. Exponential Accuracy Plot for Quest Model M-7 Personal Noise Dosimeter SN 704121T

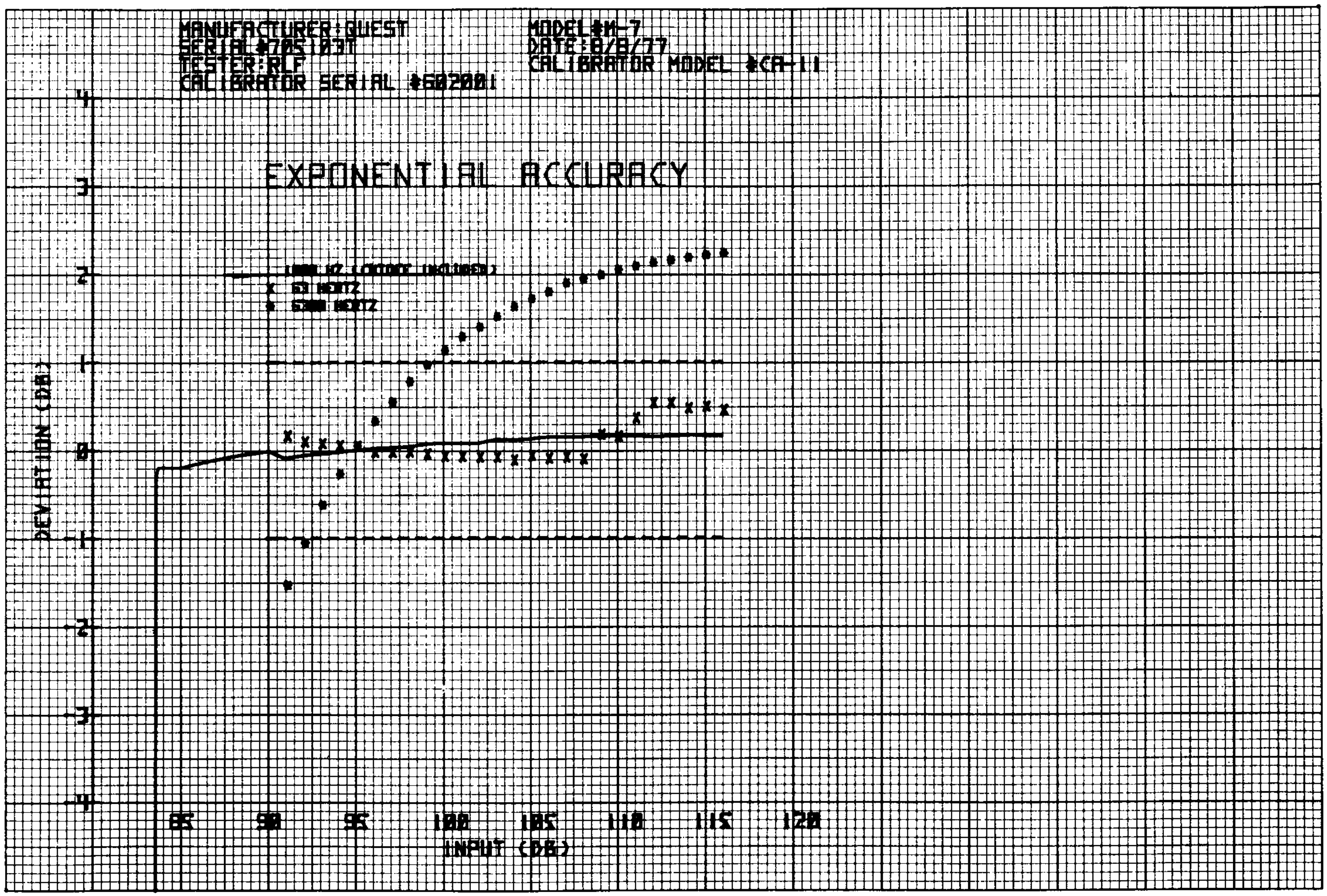

Figure 48. Exponential Accuracy Plot for Quest Model M-7 Personal Noise Dosimeter SN 705103T

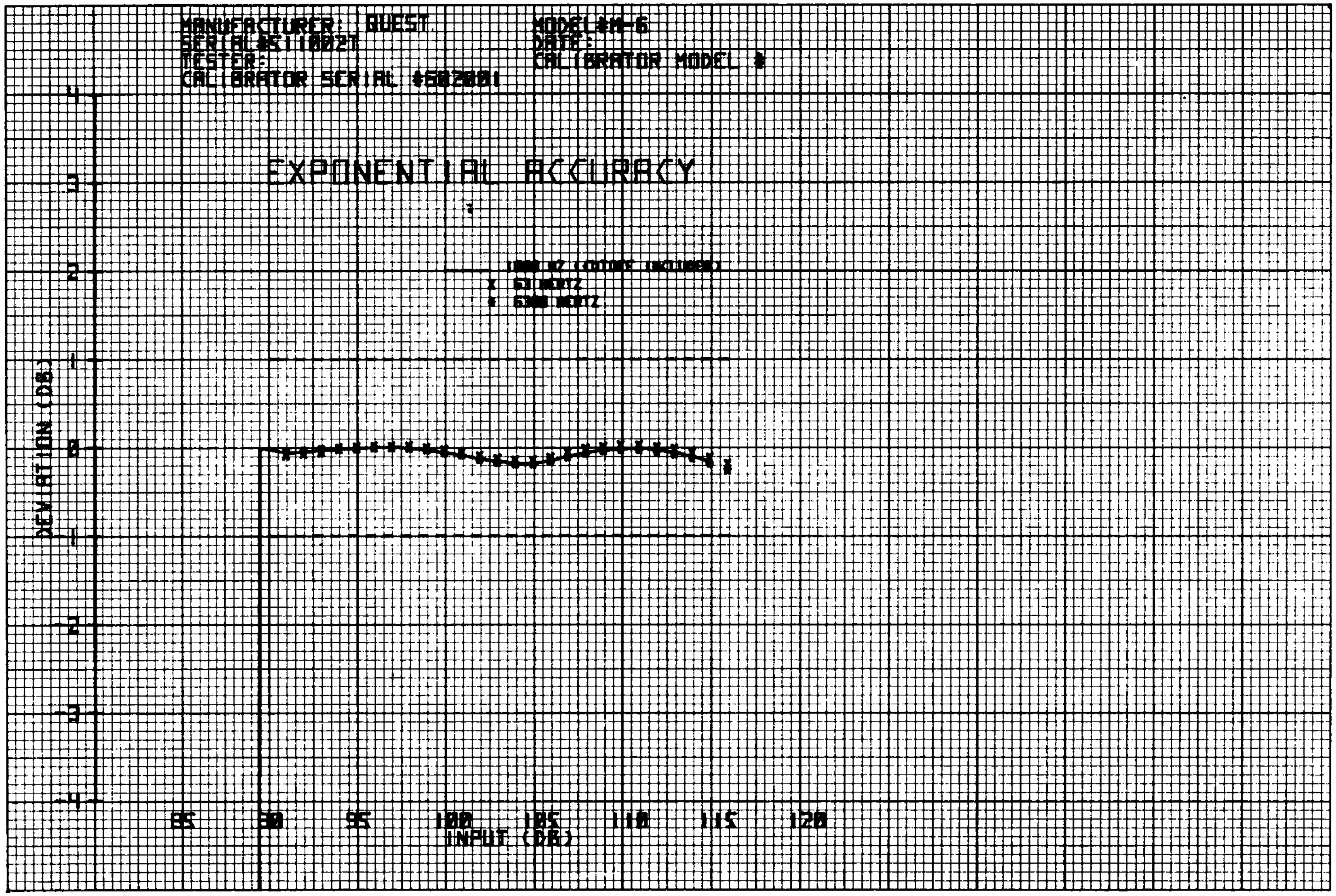

Figure 49. Exponential Accuracy Plot for Quest Model M-6 Personal Noise Dosimeter SN 511002T

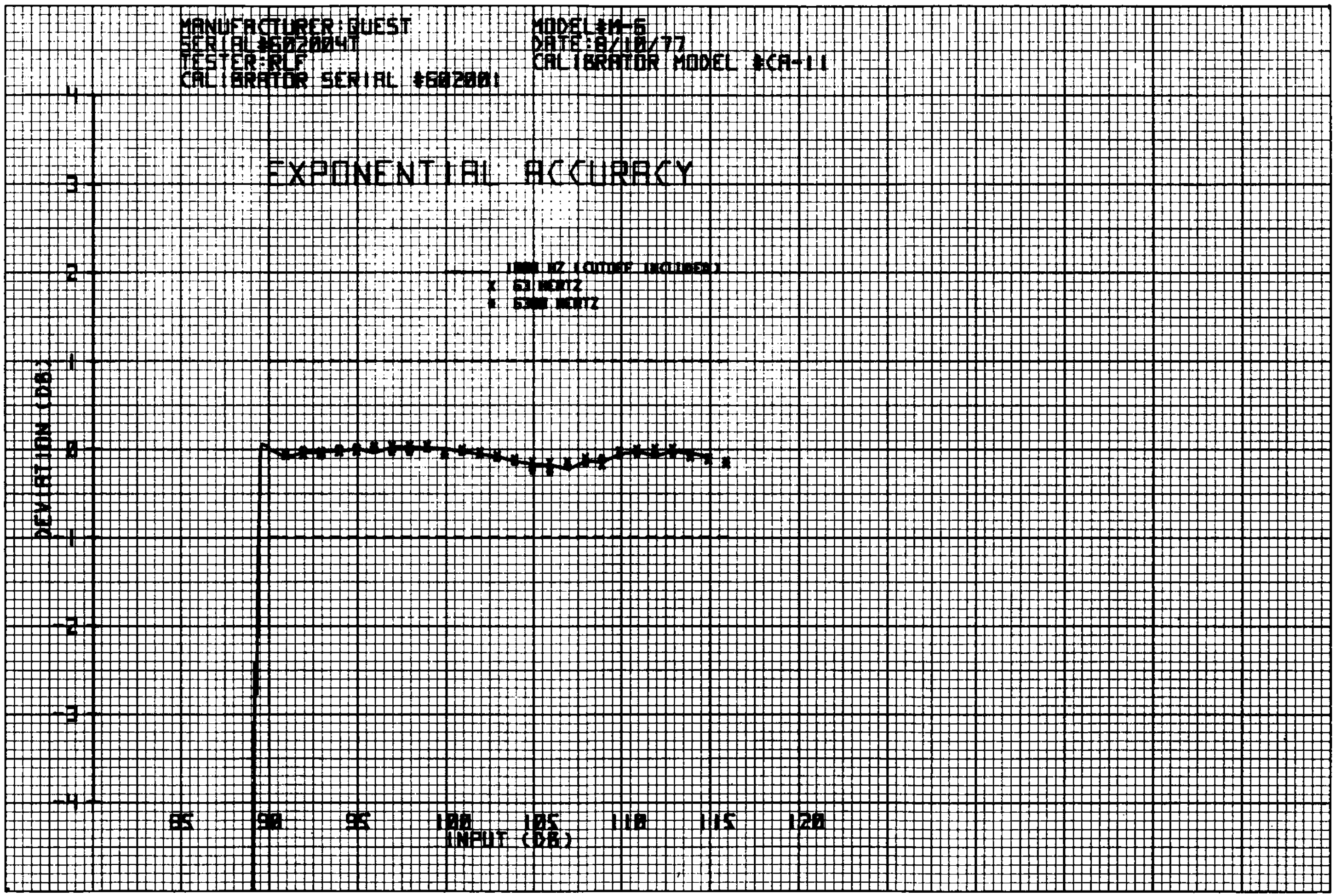

Figure 50. Exponential Accuracy Plot for Quest Model M-6 Personal Noise Dosimeter SN 602004T

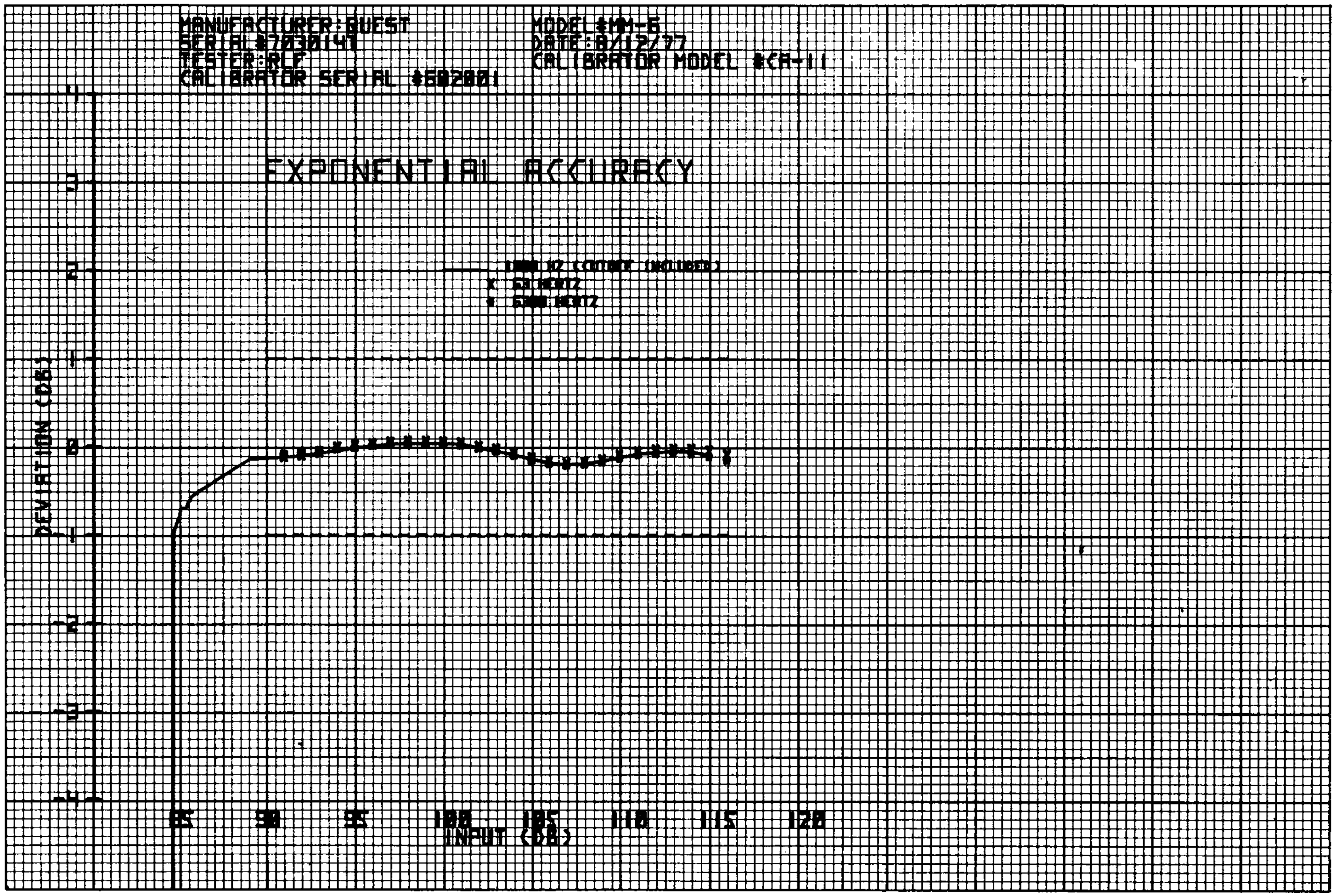

Figure 51. Exponential Accuracy Plot for Quest Model M-6 Personal Noise Dosimeter SN 703014T

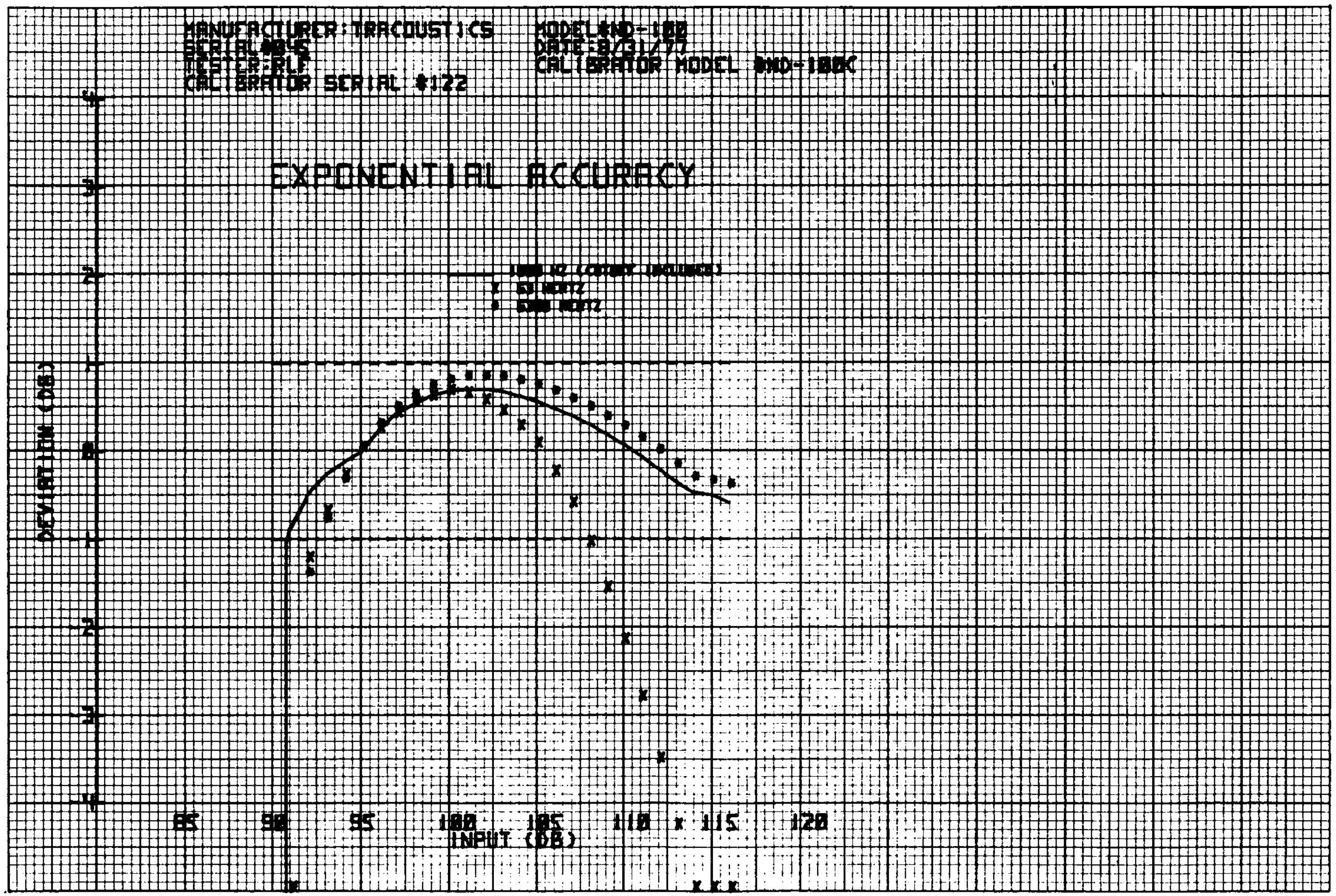

Figure 52. Exponential Accuracy Plot for Tracoustics Model ND-100 Personal Noise Dosimeter SN 045

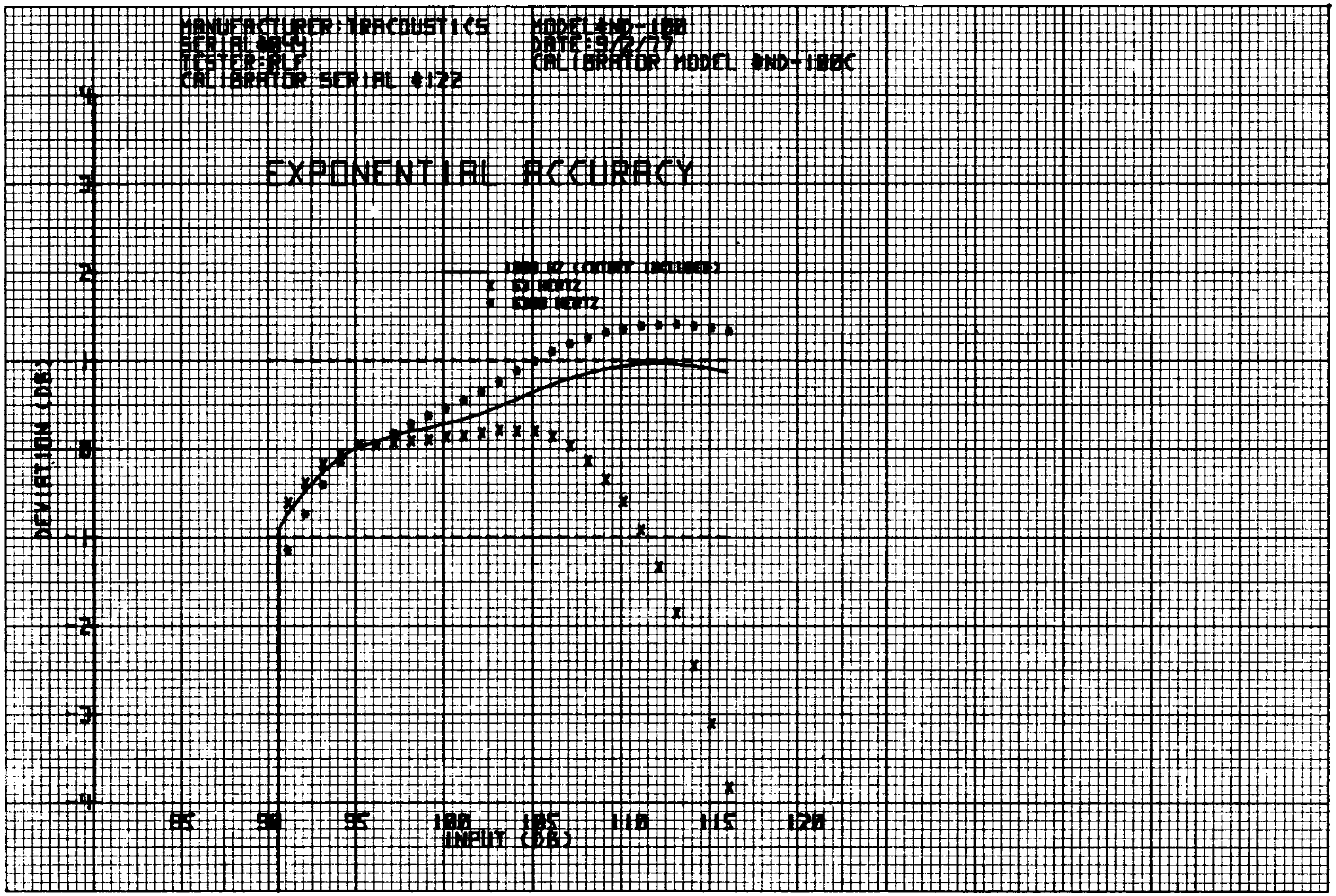

Figure 53. Exponential Accuracy Plot for Tracoustics Model ND-100 Personal Noise Dosimeter SN 044

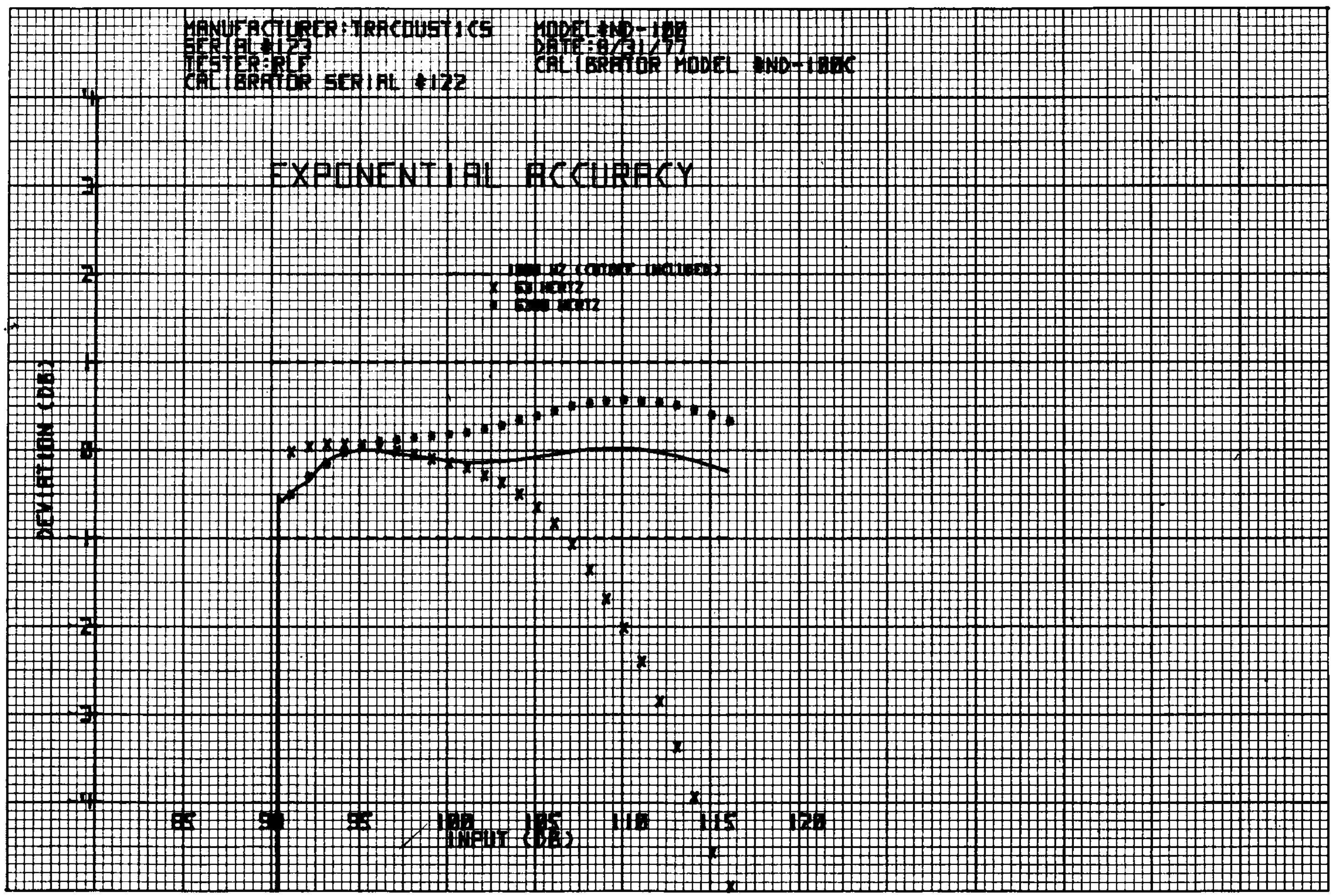

Figure 54. Exponential Accuracy for Tracoustics Model ND-100 Personal Noise Dosimeter SN 123

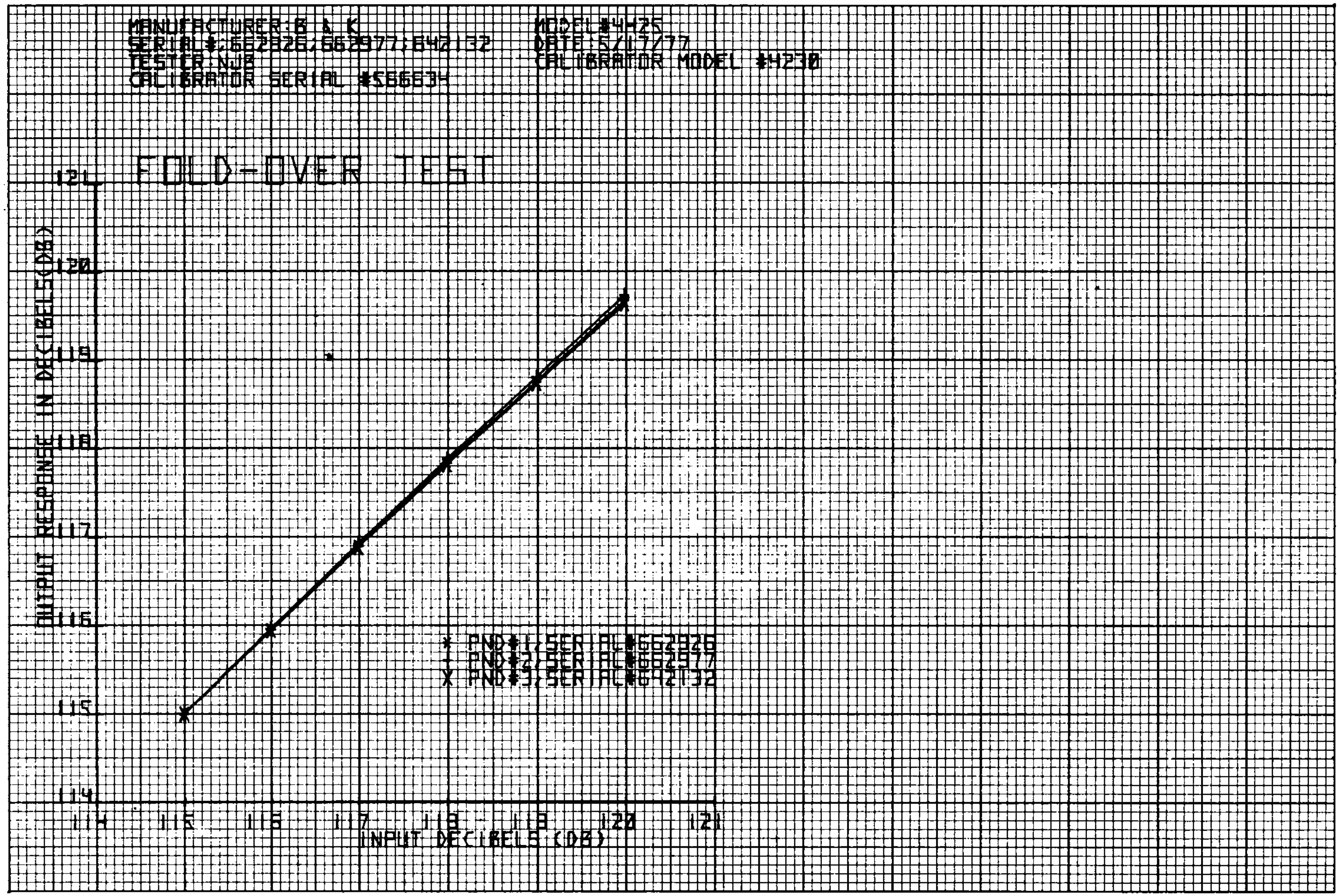

Figure 55. Fold-over Test Plot for B&K Model 4425
Personal Noise Dosimeters

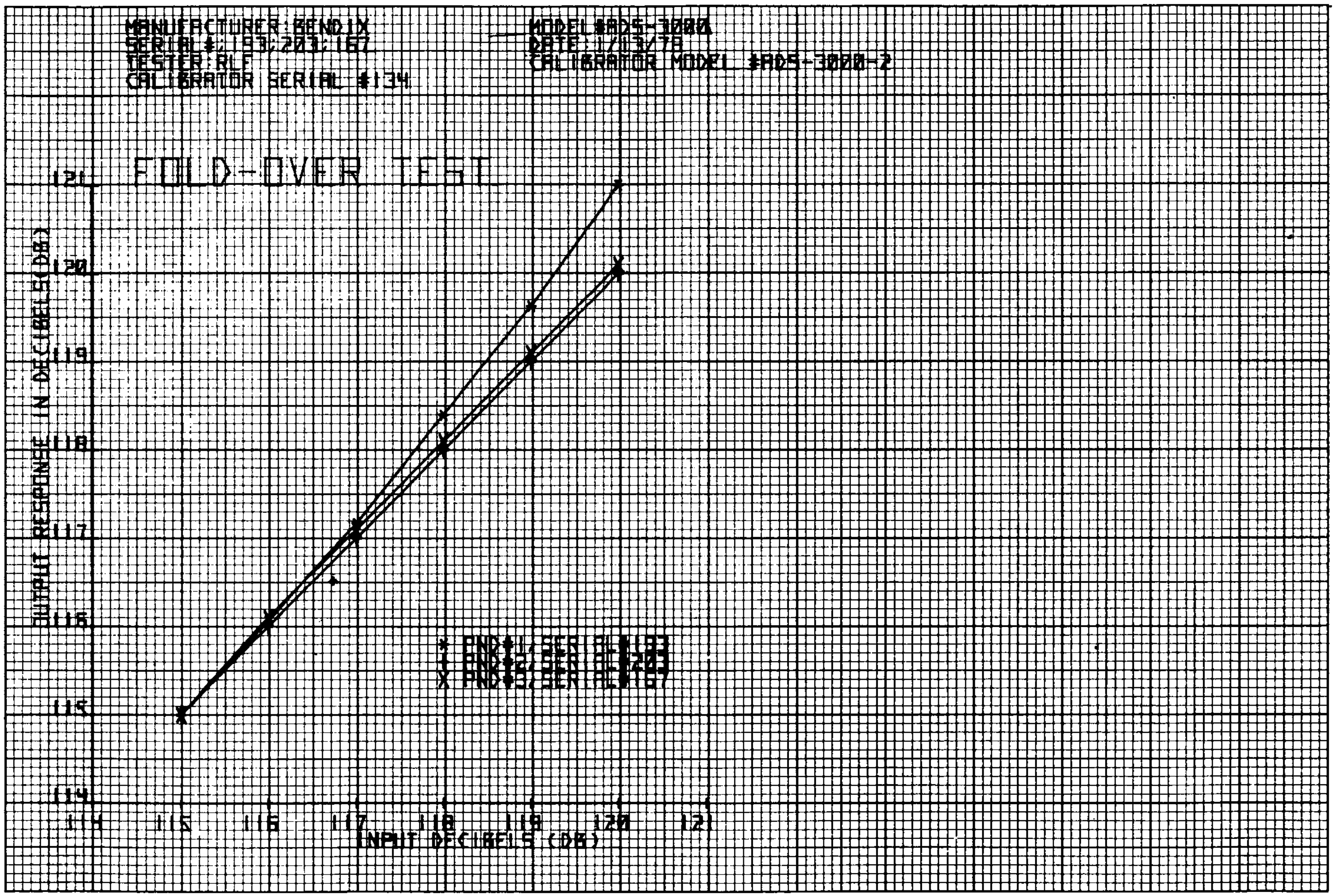

Figure 56. Fold-over Test Plot for Bendix Model ADS-3000 Personal Noise Dosimeters

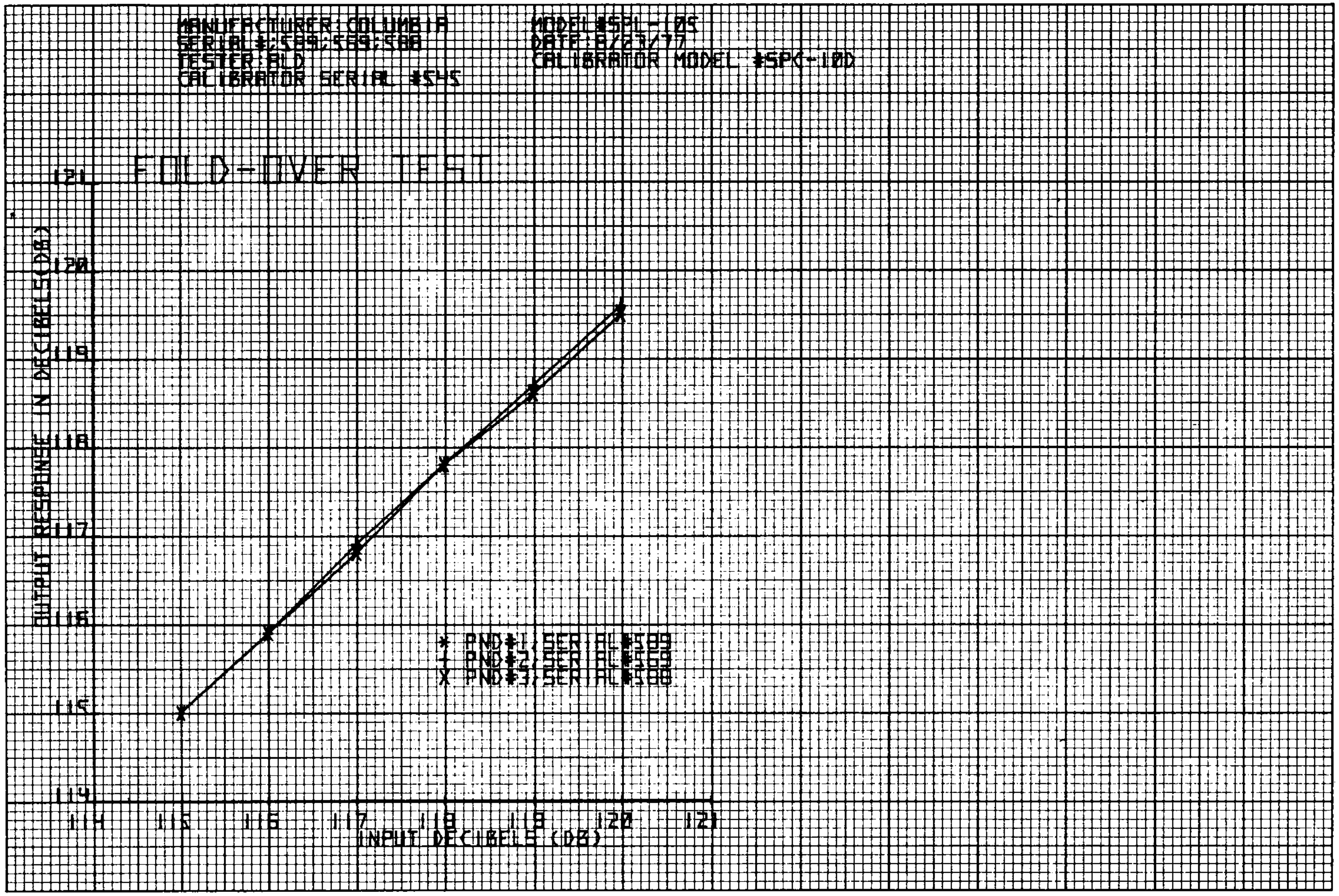

Figure 57. Fold-over Test Plot for Columbia Model SPL-105 Personal Noise Dosimeters

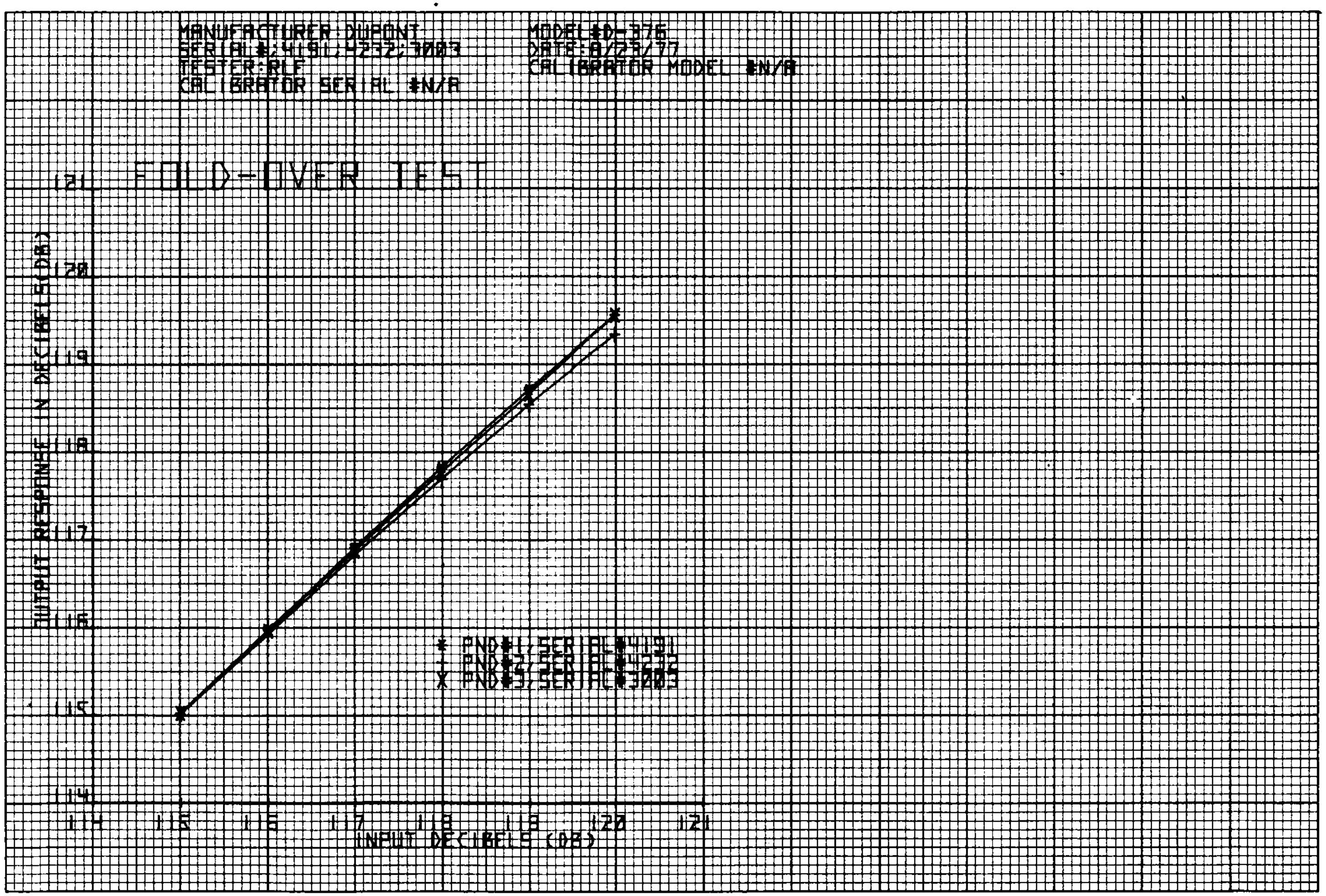

Figure 58. Fold-over Test Plot for Dupont Model D-376 Personal Noise Dosimeters

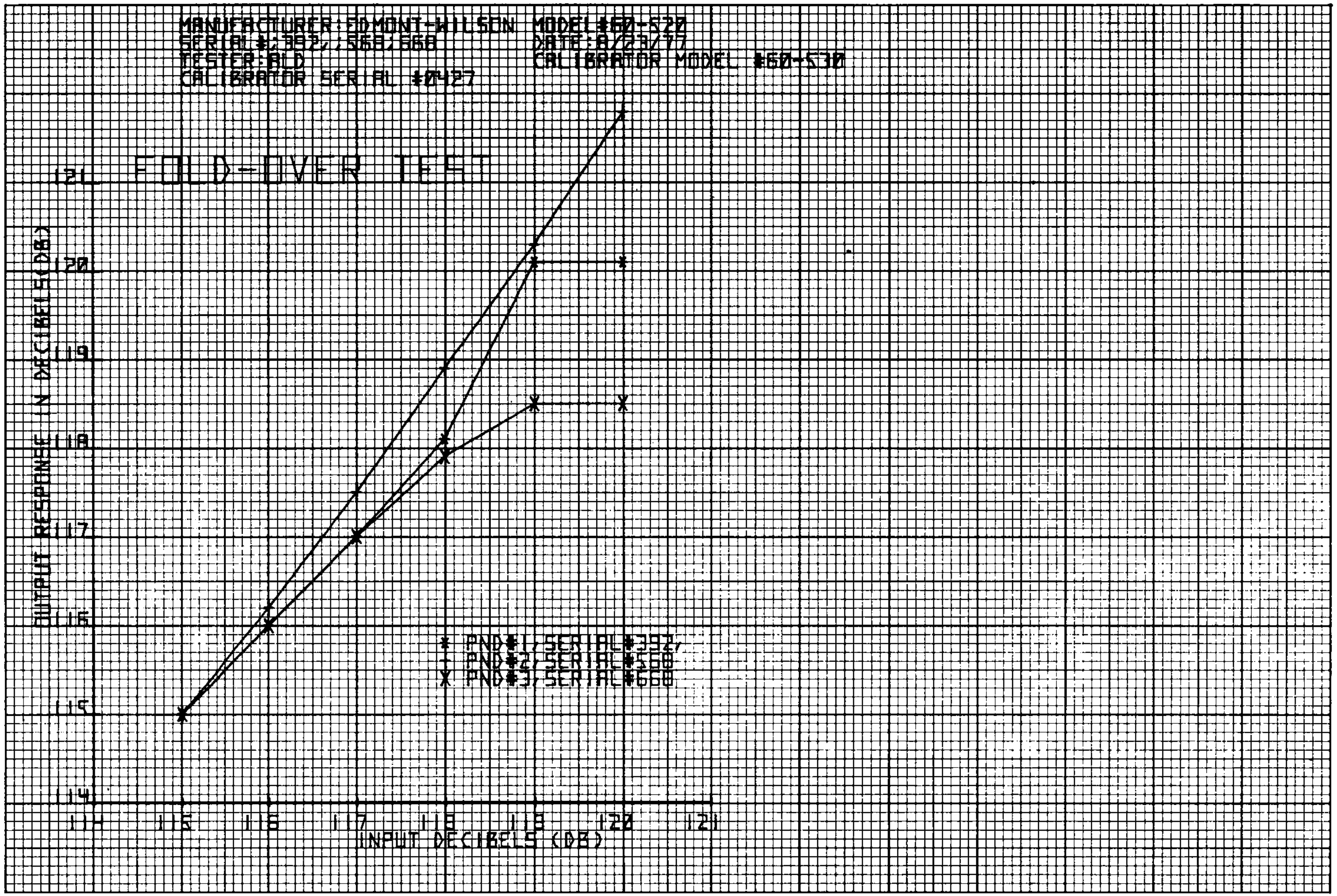

Figure 59. Fold-over Test Plot for Edmont-Wilson Model 60-520 Personal Noise Dosimeters

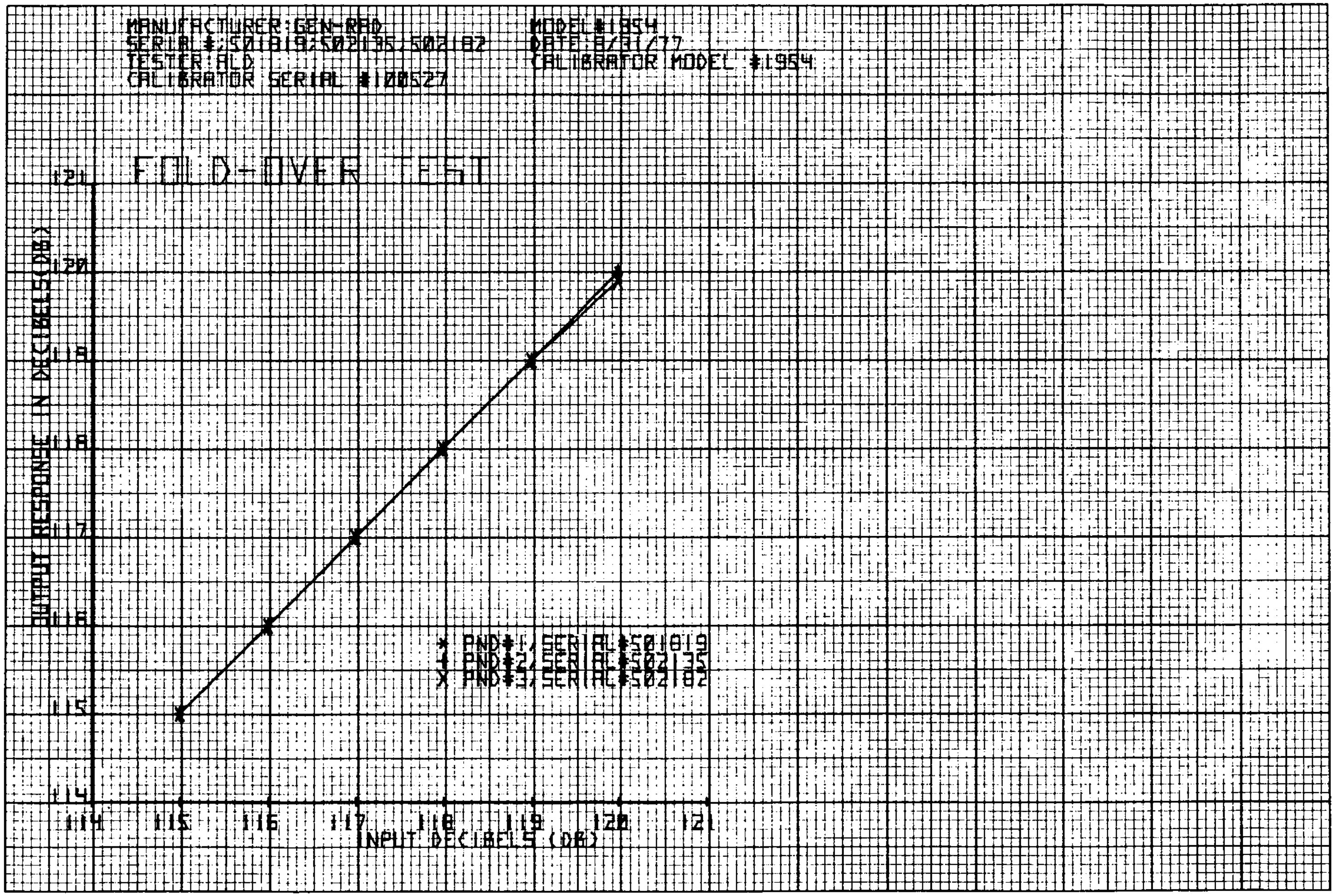

Figure 60. Fold-over Test Plot of GenRad Model 1954 Personal Noise Dosimeters

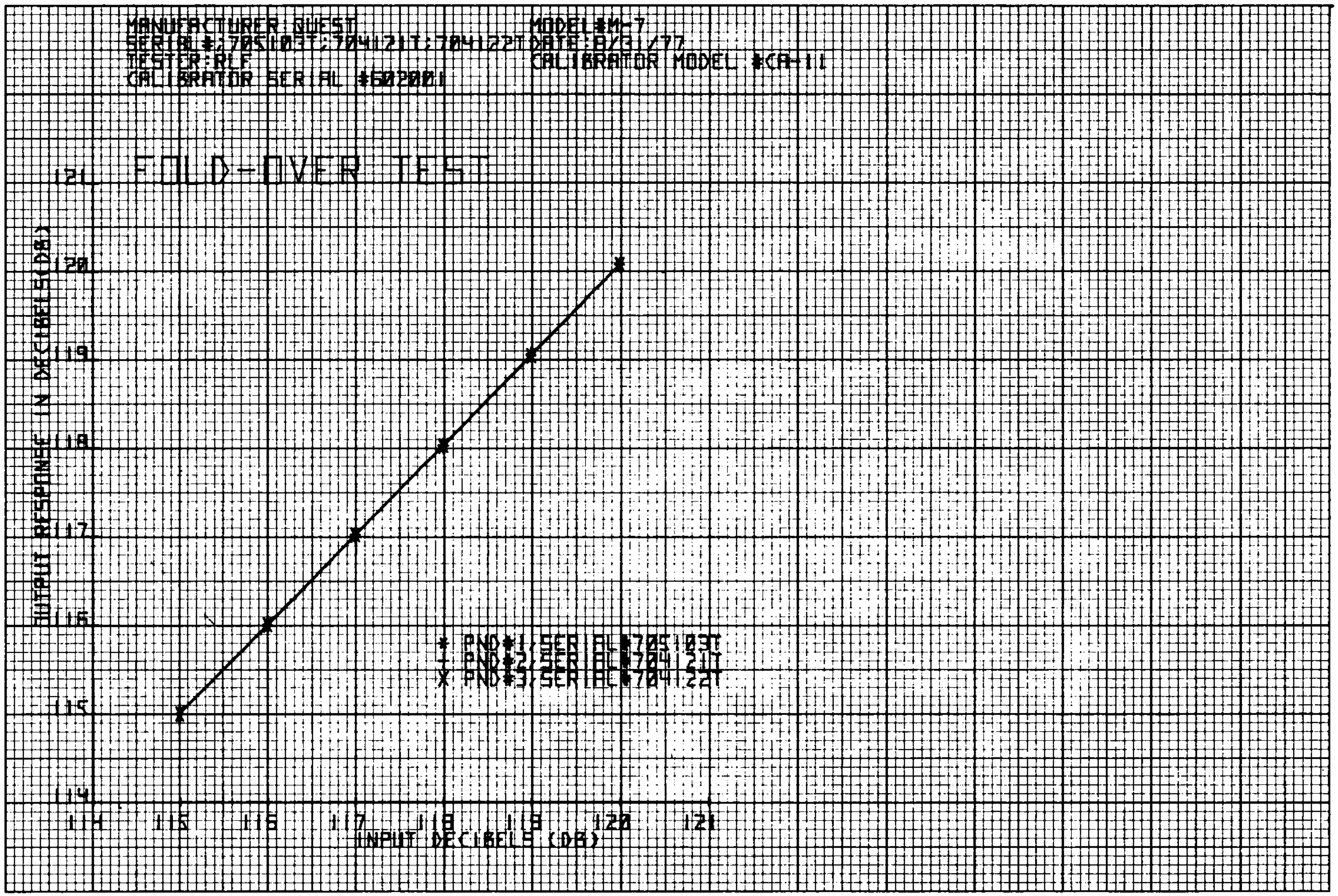

Figure 61. Fold-over Test Plot for Quest Model M-7 Personal Noise Dosimeters

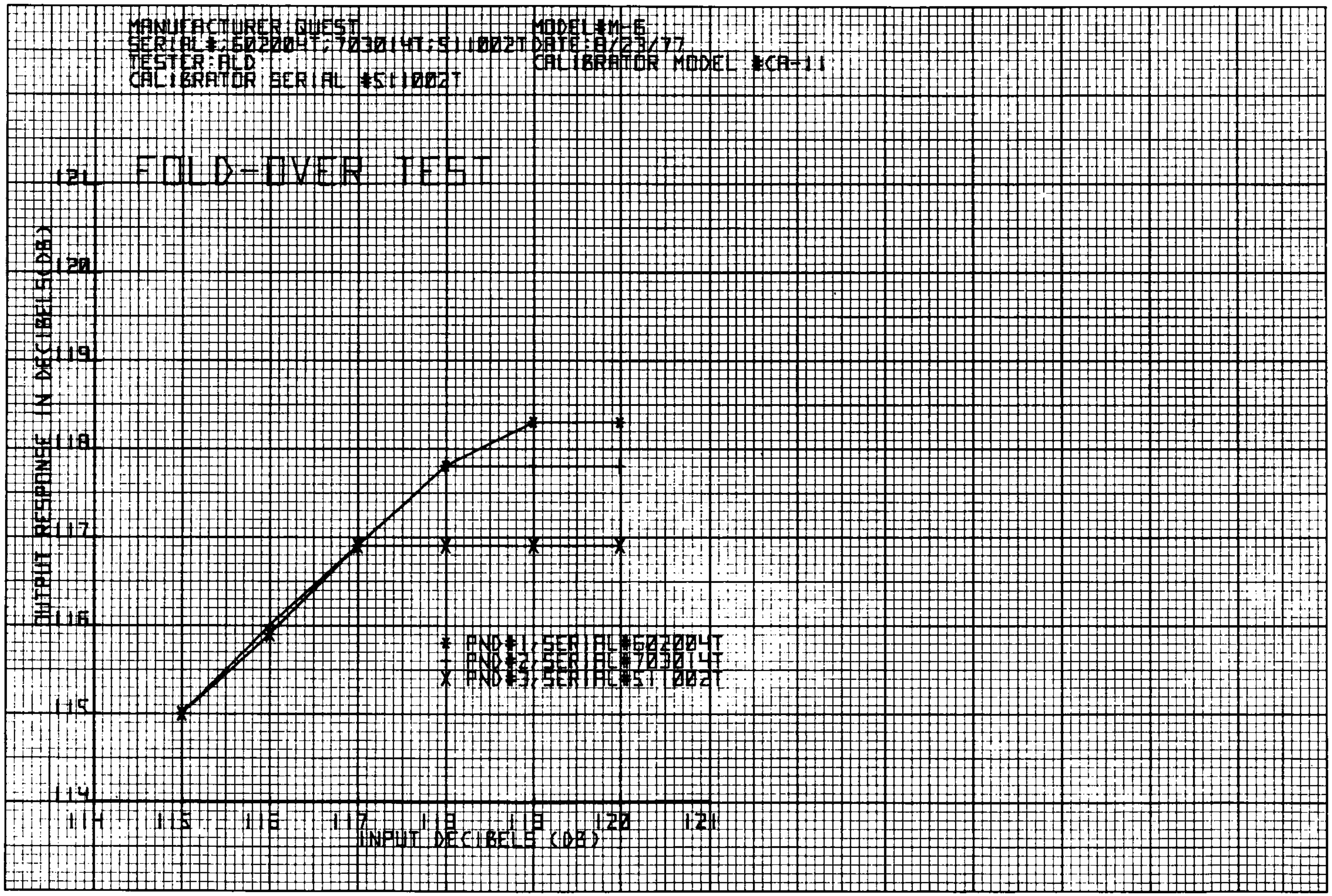

Figure 62. Fold-over Test Plot for Quest Model M-6 Personal Noise Dosimeters

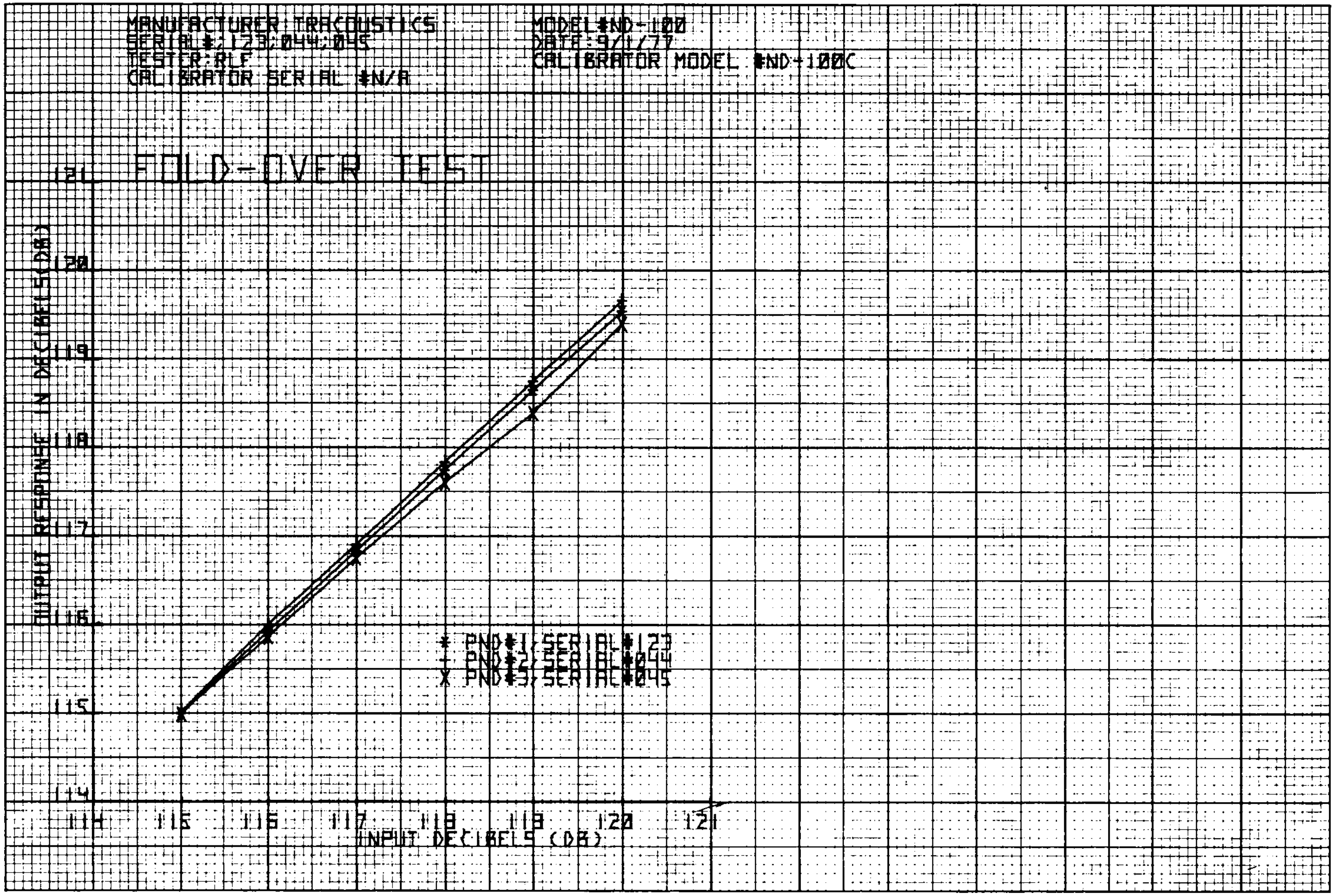

Figure 63. Fold-over Test Plot for Tracoustics Model ND-100 Personal Noise Dosimeters

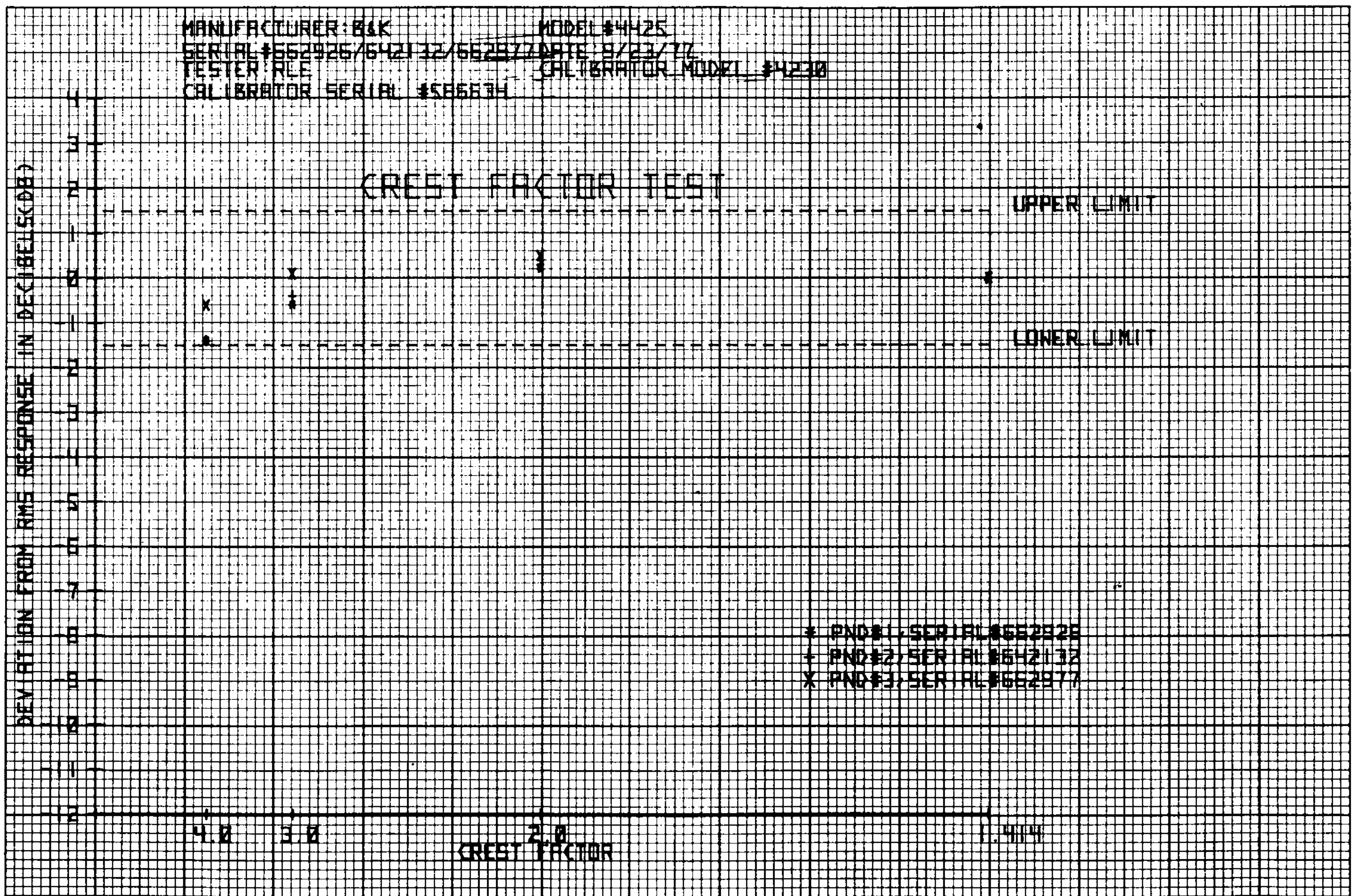

Figure 64. Crest Factor/Square Law Test Response for B&K Model 4425 Personal Noise Dosimeters

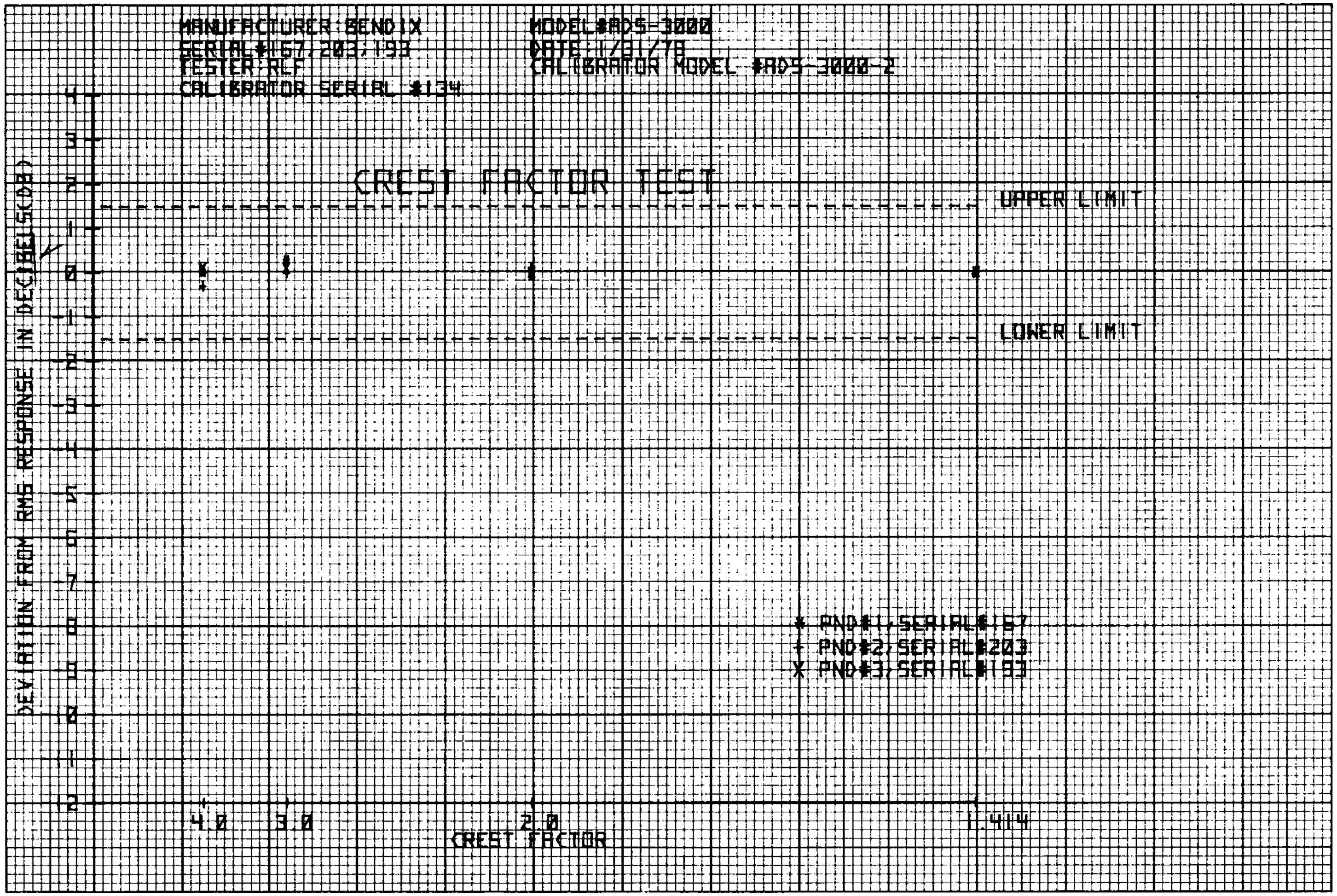

Figure 65. Crest Factor/Square Law Test Response for Bendix Model ADS-3000 Personal Noise Dosimeters

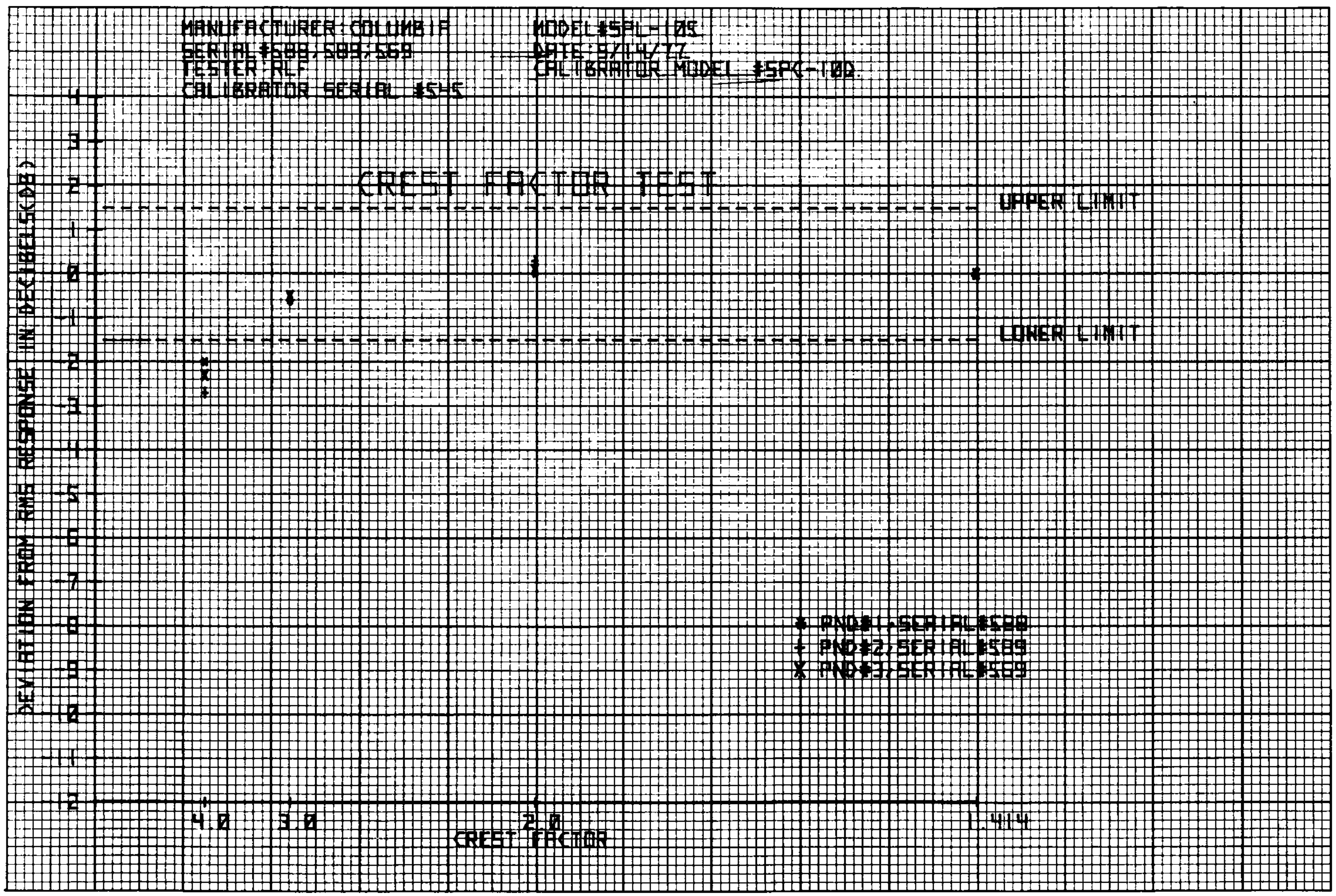

Figure 66. Crest Factor/Square Law Test Response for Columbia Model SPL-105 Personal Noise Dosimeters

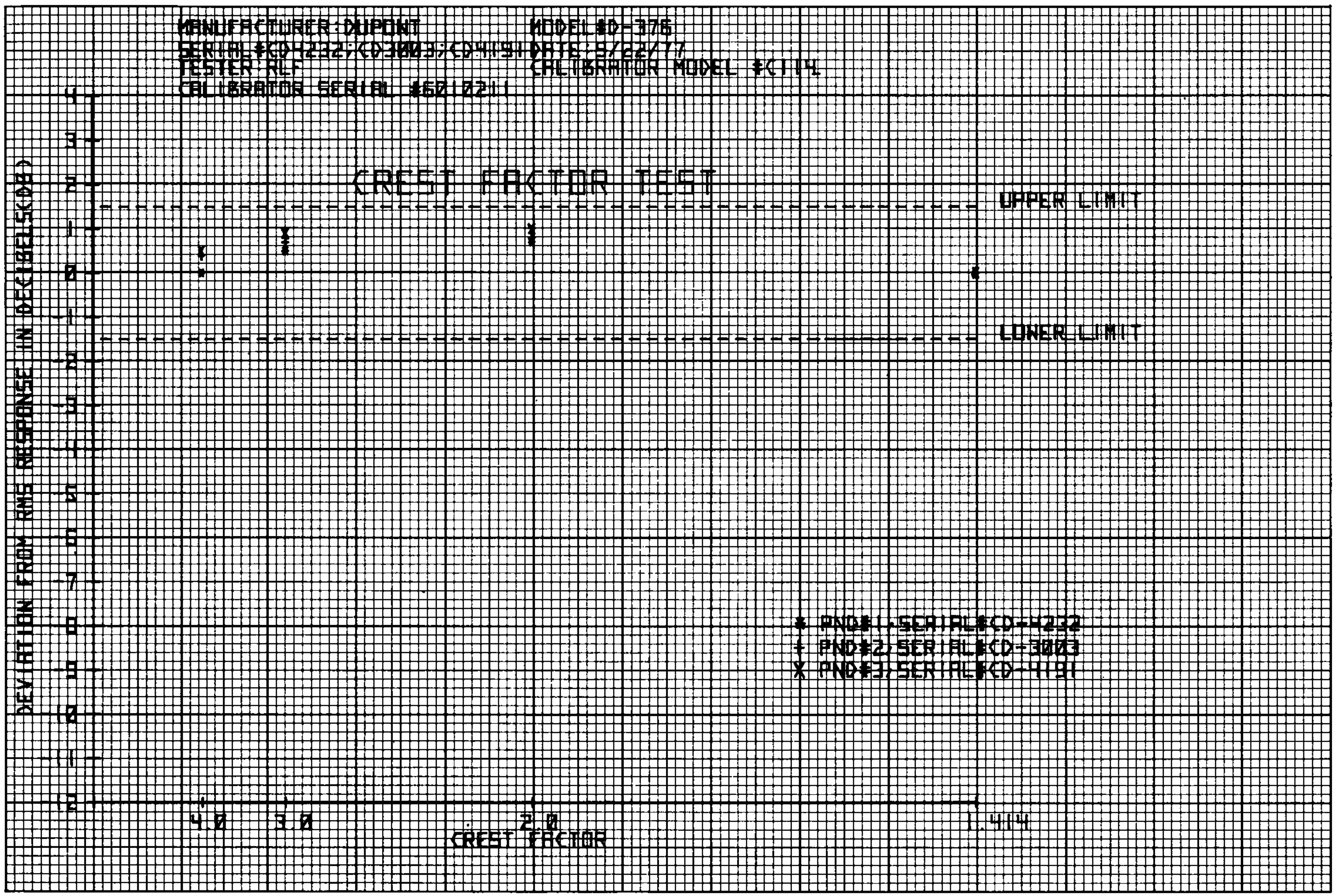

Figure 67. Crest Factor/Square Law Test Response for Dupont Model D-376 Personal Noise Dosimeters

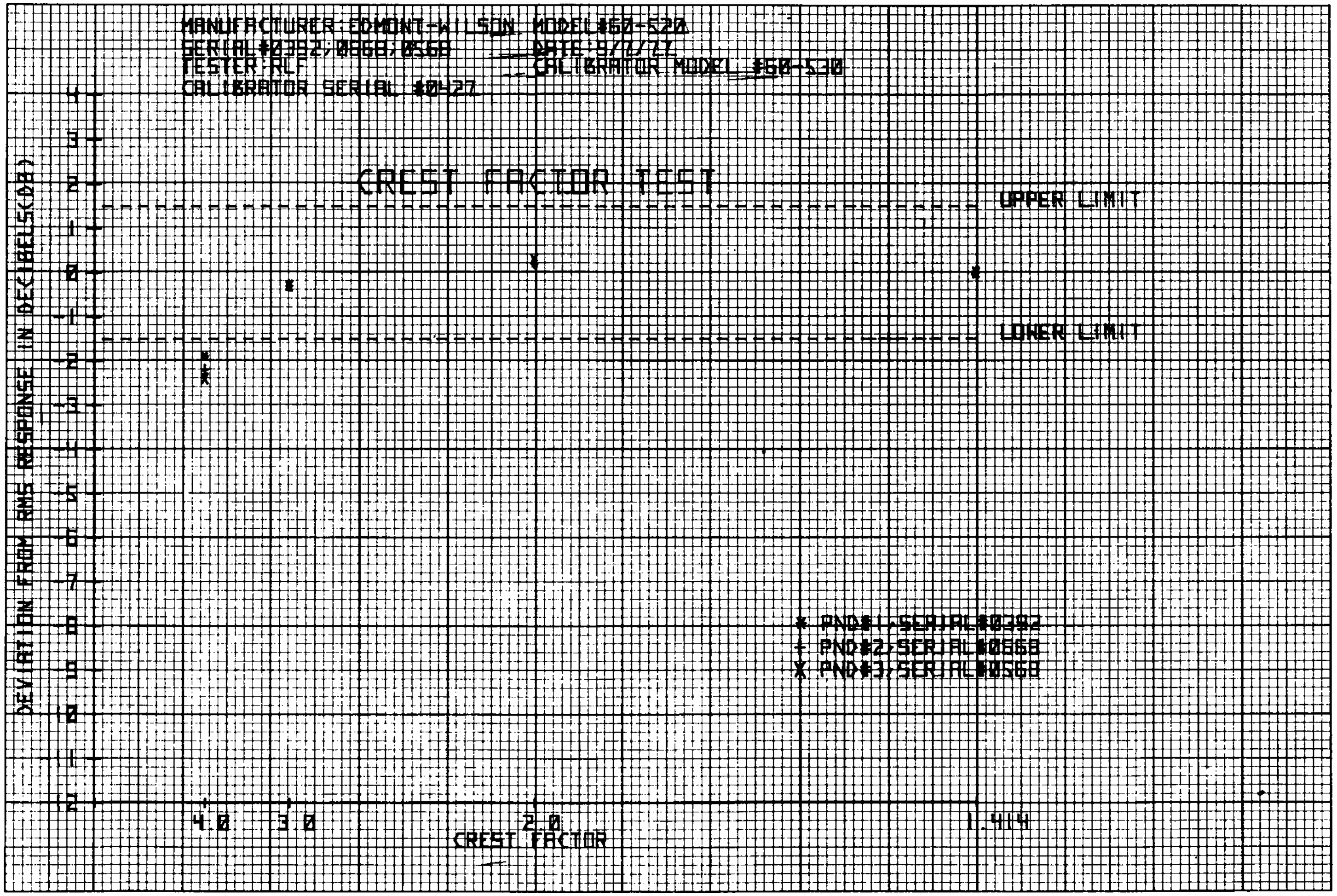

Figure 68. Crest Factor/Square Law Test Response for Edmont-Wilson Model 60-520 Personal Noise Dosimeters

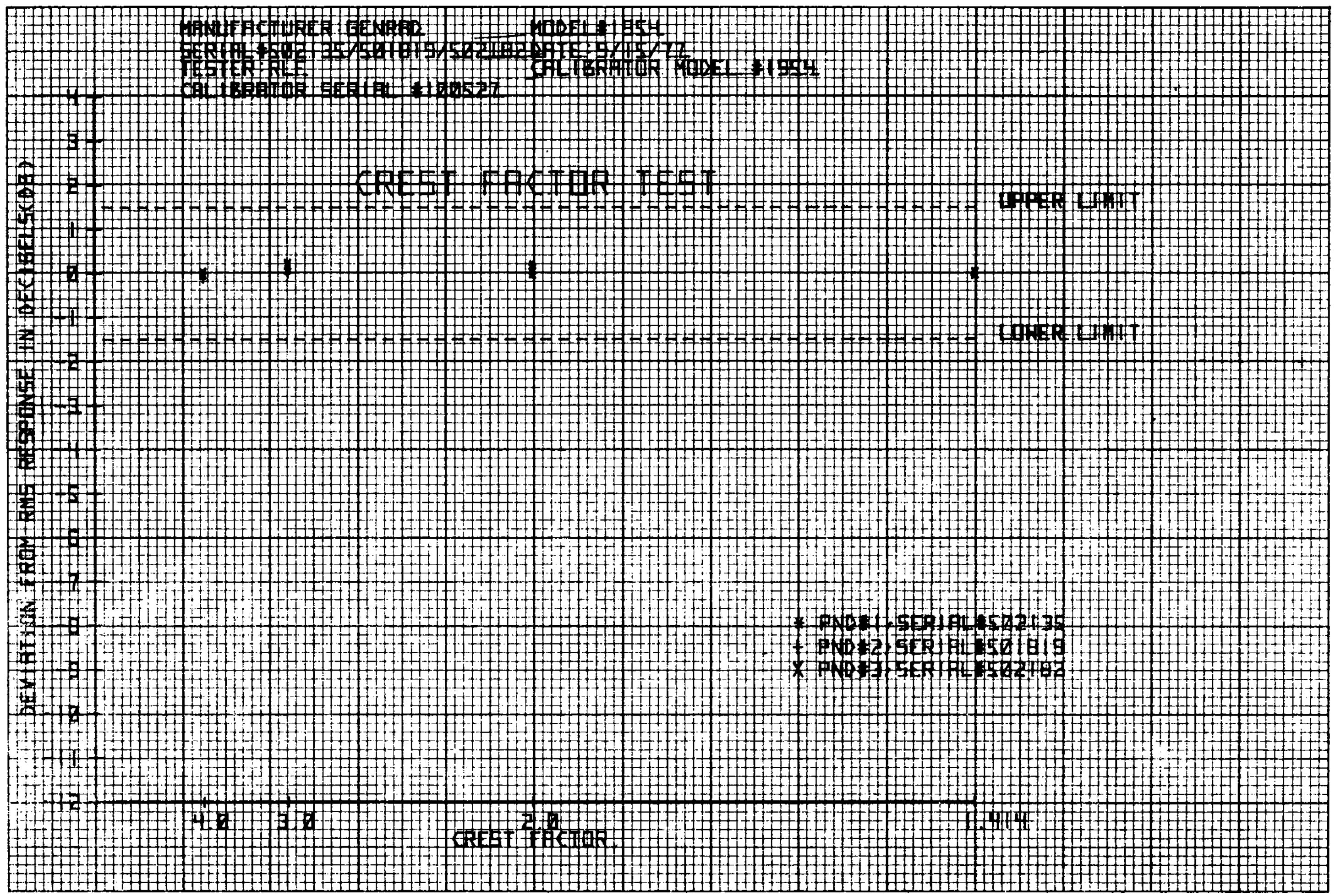

Figure 69. Crest Factor/Square Law Test Response for GenRad Model 1954 Personal Noise Dosimeters

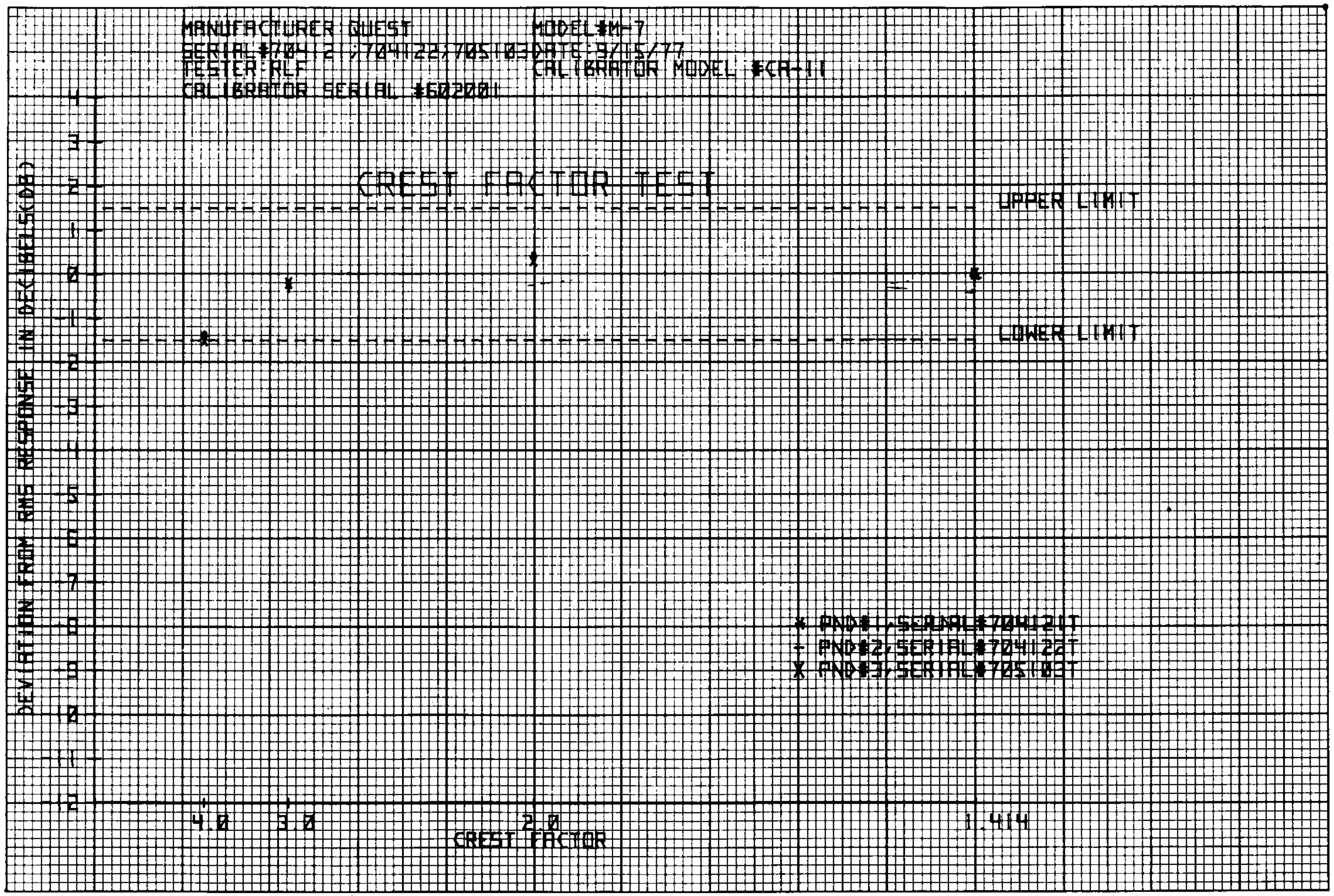

Figure 70. Crest Factor/Square Law Test Response for Quest Model M-7 Personal Noise Dosimeters

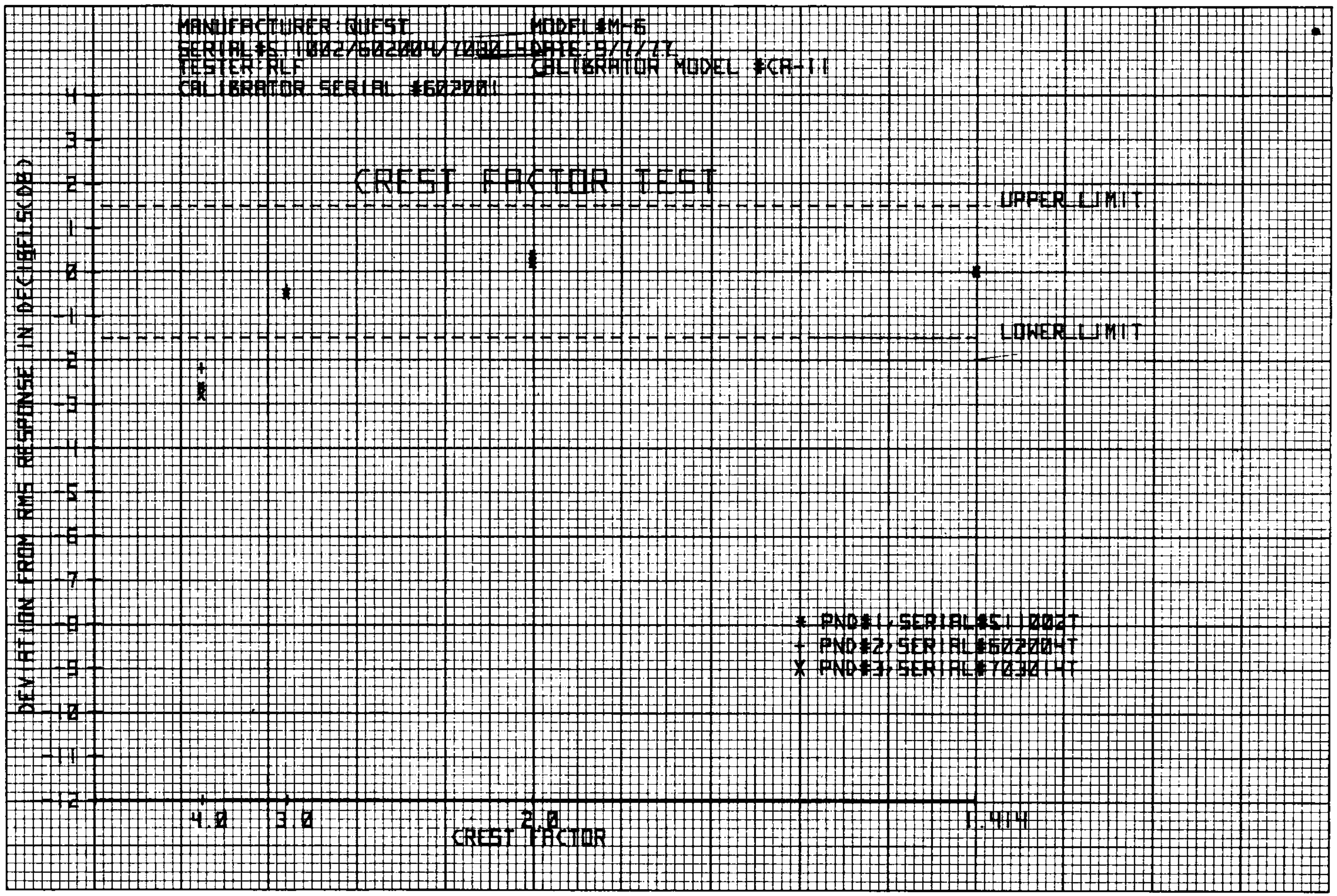

Figure 71. Crest Factor/Square Law Test Response for Quest Model M-6 Personal Noise Dosimeters

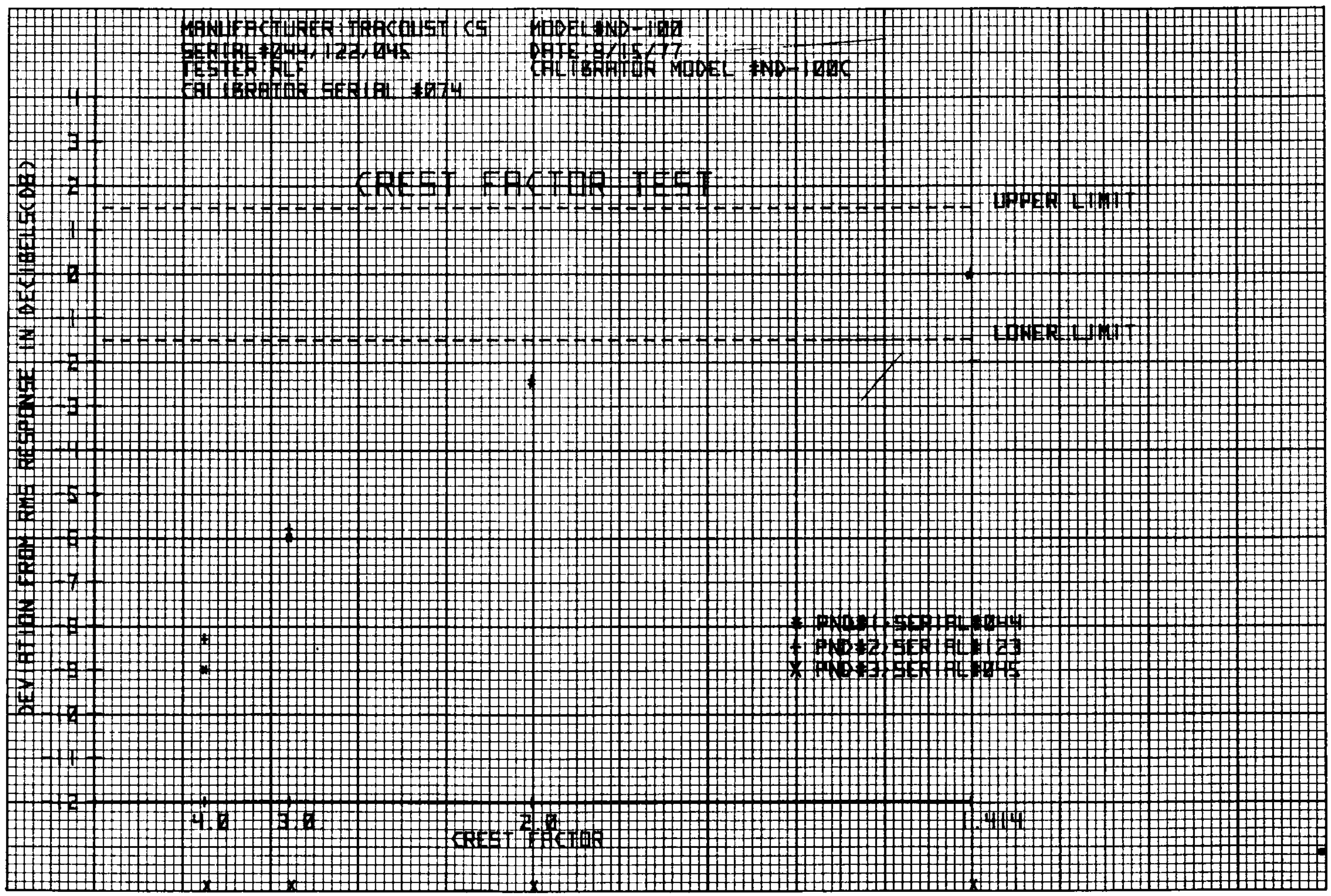

Figure 72. Crest Factor/Square Law Test Response for Tracoustics Model ND-100 Personal Noise Dosimeters

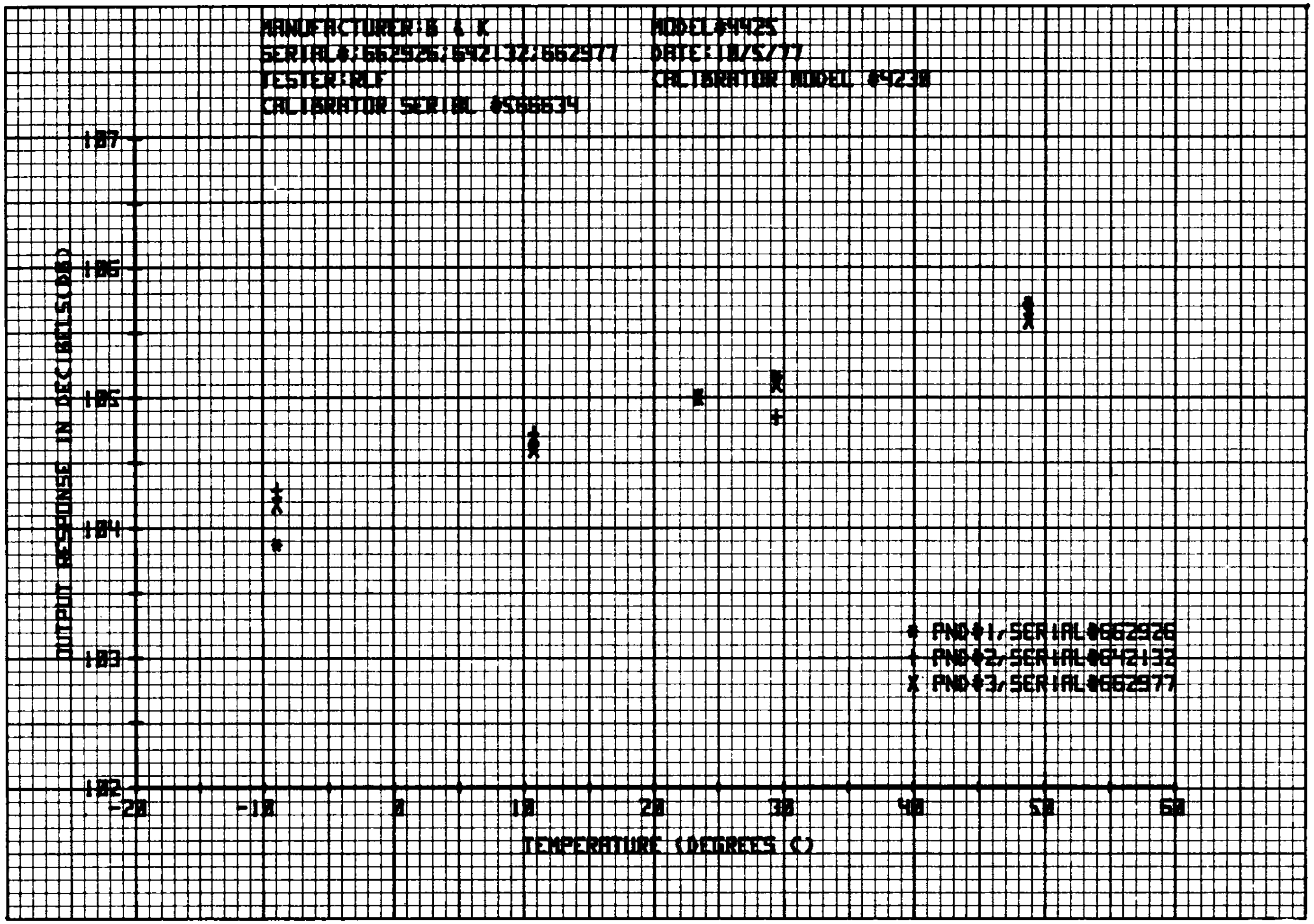

Figure 73. Temperature Sensitivity for B&K Model 4425 Personal Noise Dosimeters

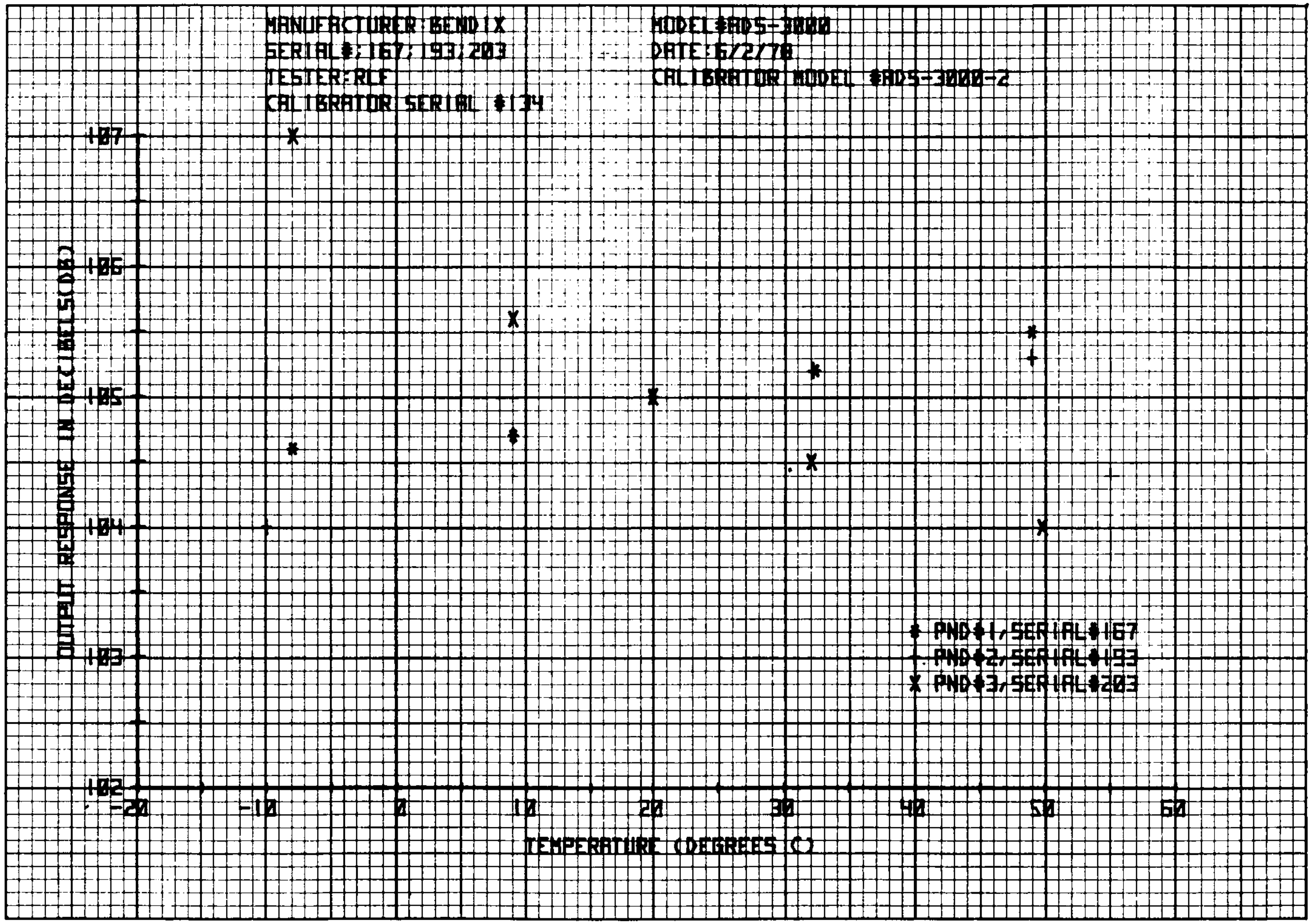

Figure 74. Temperature Sensitivity for Bendix Model ADS-3000 Personal Noise Dosimeters

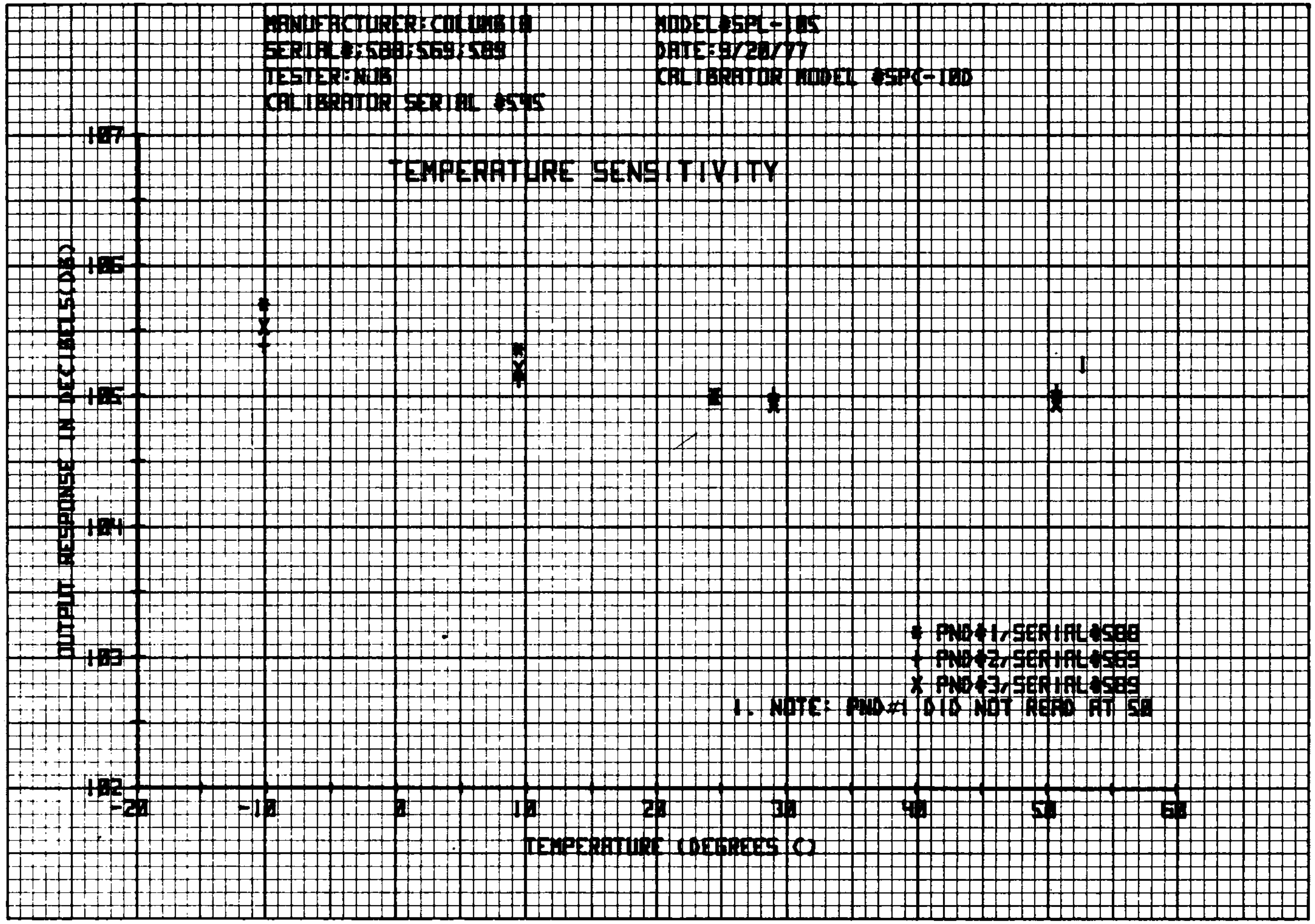

Figure 75. Temperature Sensitivity for Columbia Model SPL-105 Personal Noise Dosimeters

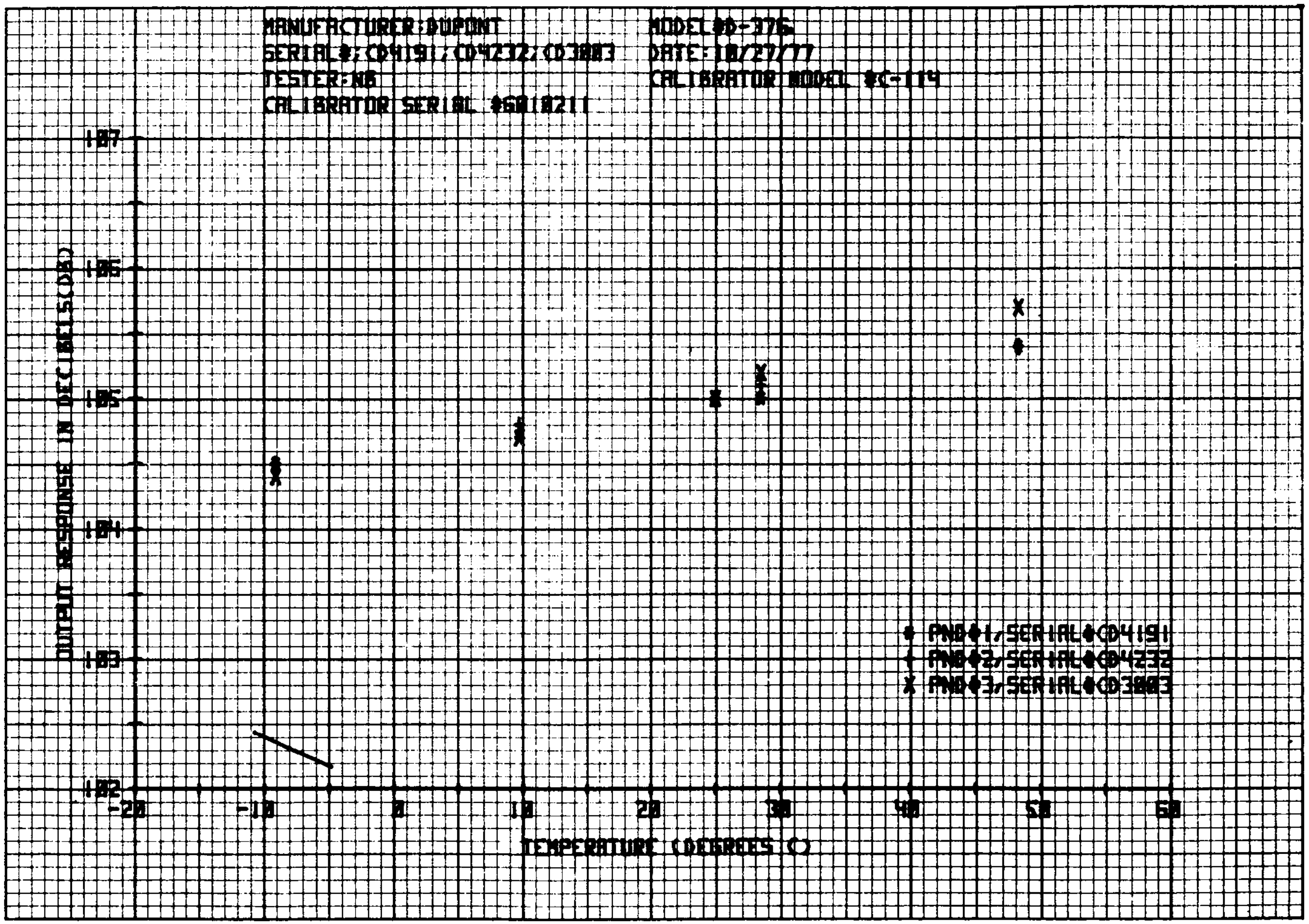

Figure 76. Temperature Sensitivity for Dupont Model D-376 Personal Noise Dosimeters

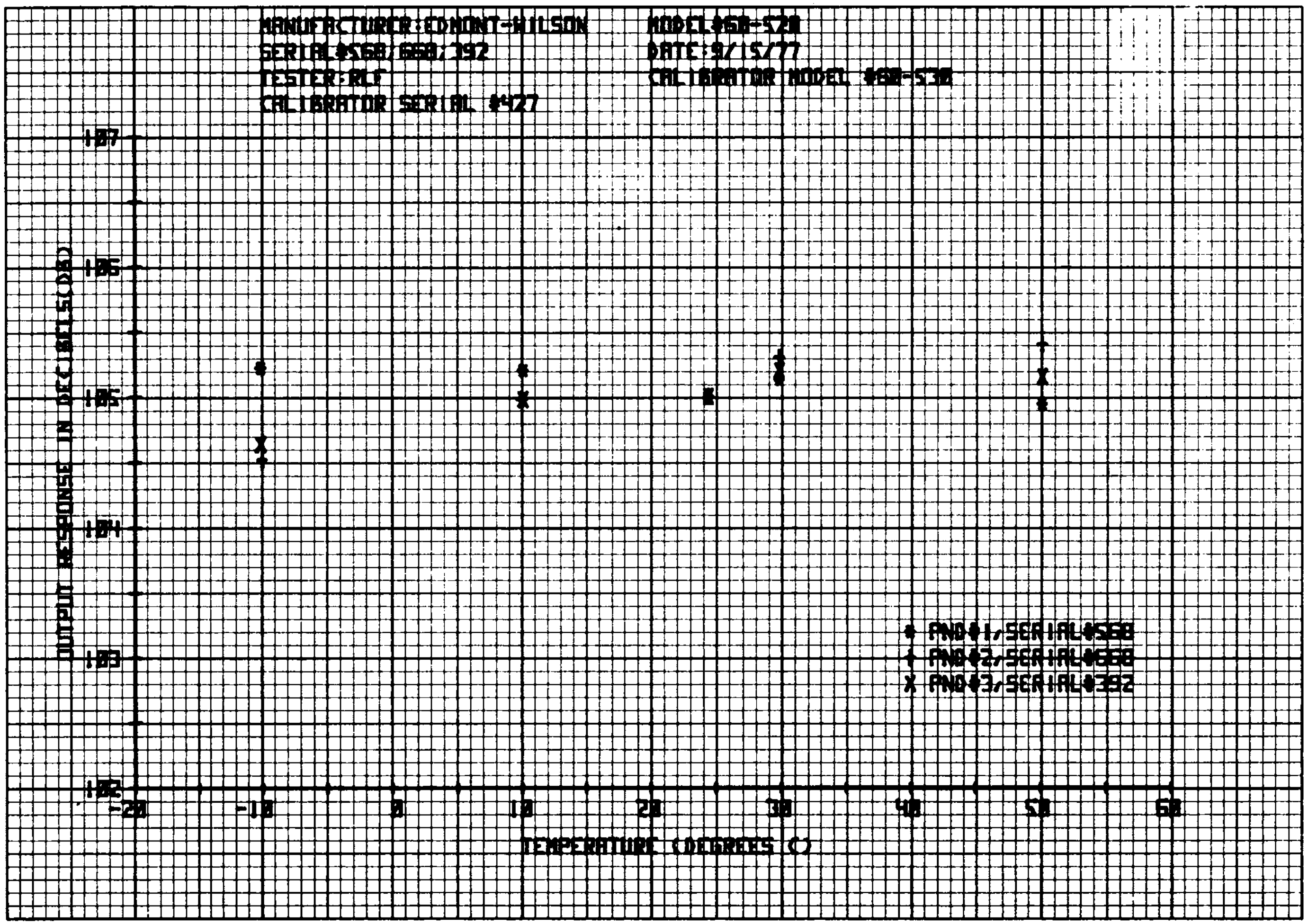

Figure 77. Temperature Sensitivity for Edmont-Wilson Model 60-520 Personal Noise Dosimeters

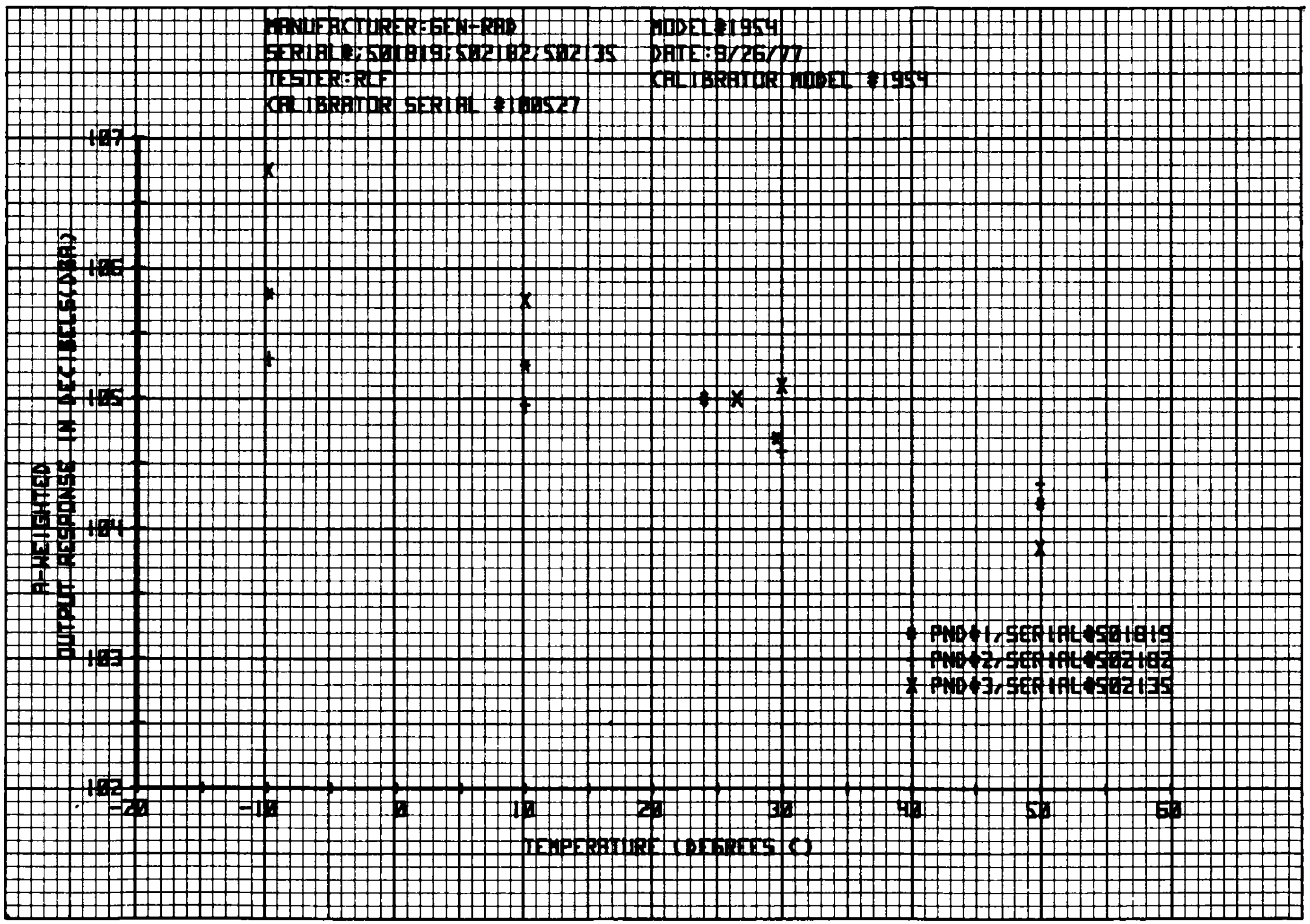

Figure 78. Temperature Sensitivity for GenRad Model 1954
Personal Noise Dosimeters

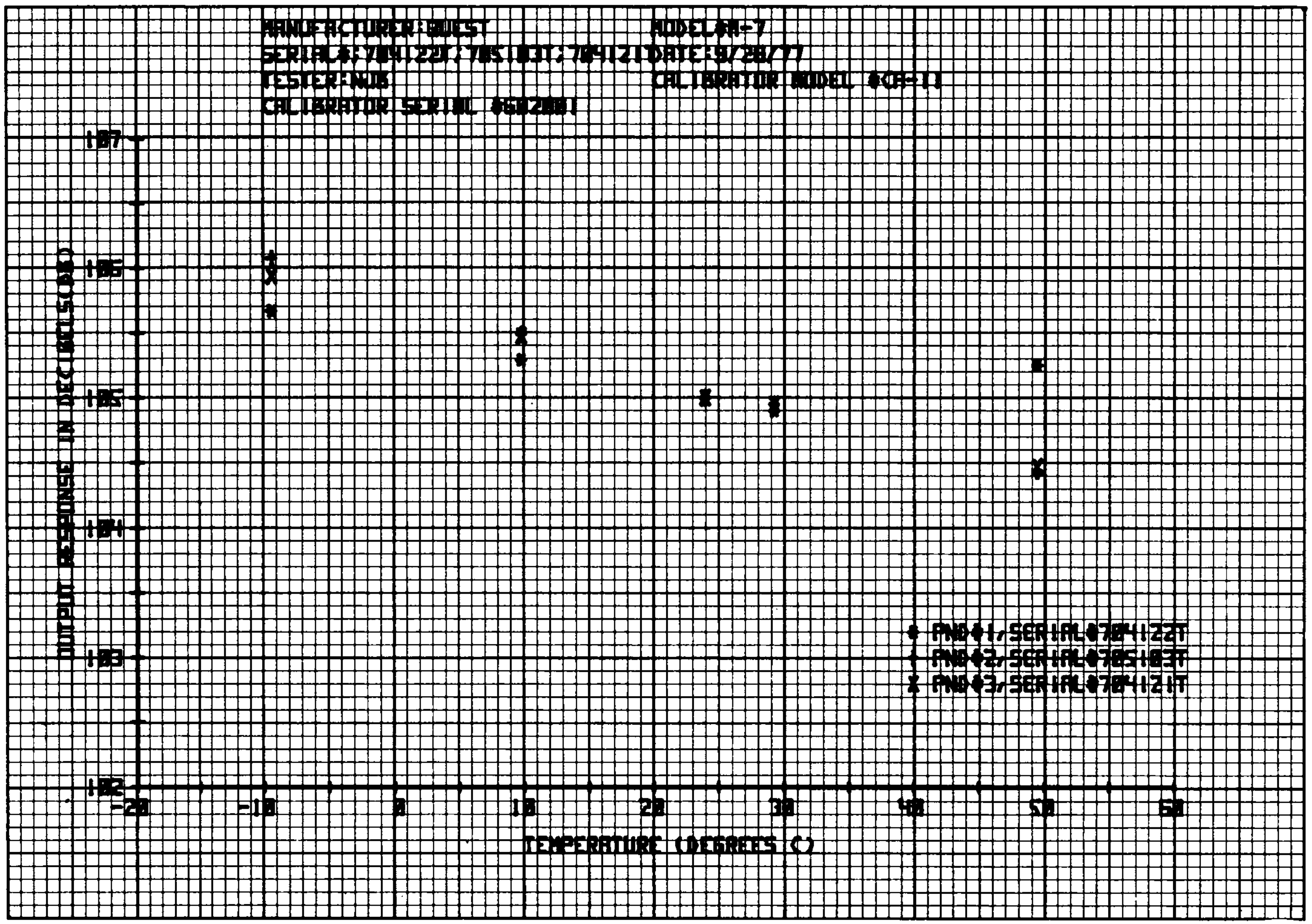

Figure 79. Temperature Sensitivity for Quest Model M-7 Personal Noise Dosimeters

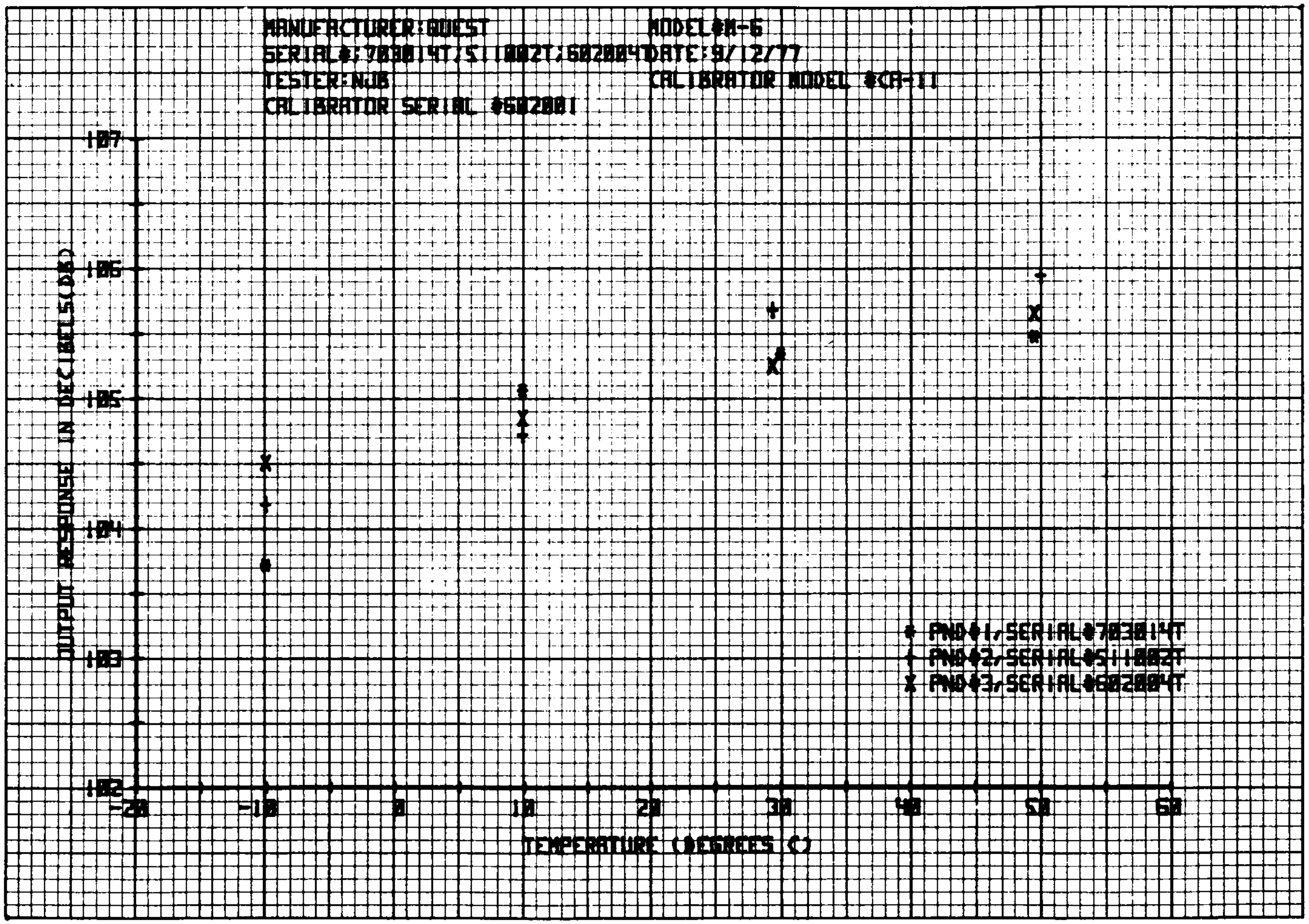

Figure 80. Temperature Sensitivity for Quest Model M-6 Personal Noise Dosimeters

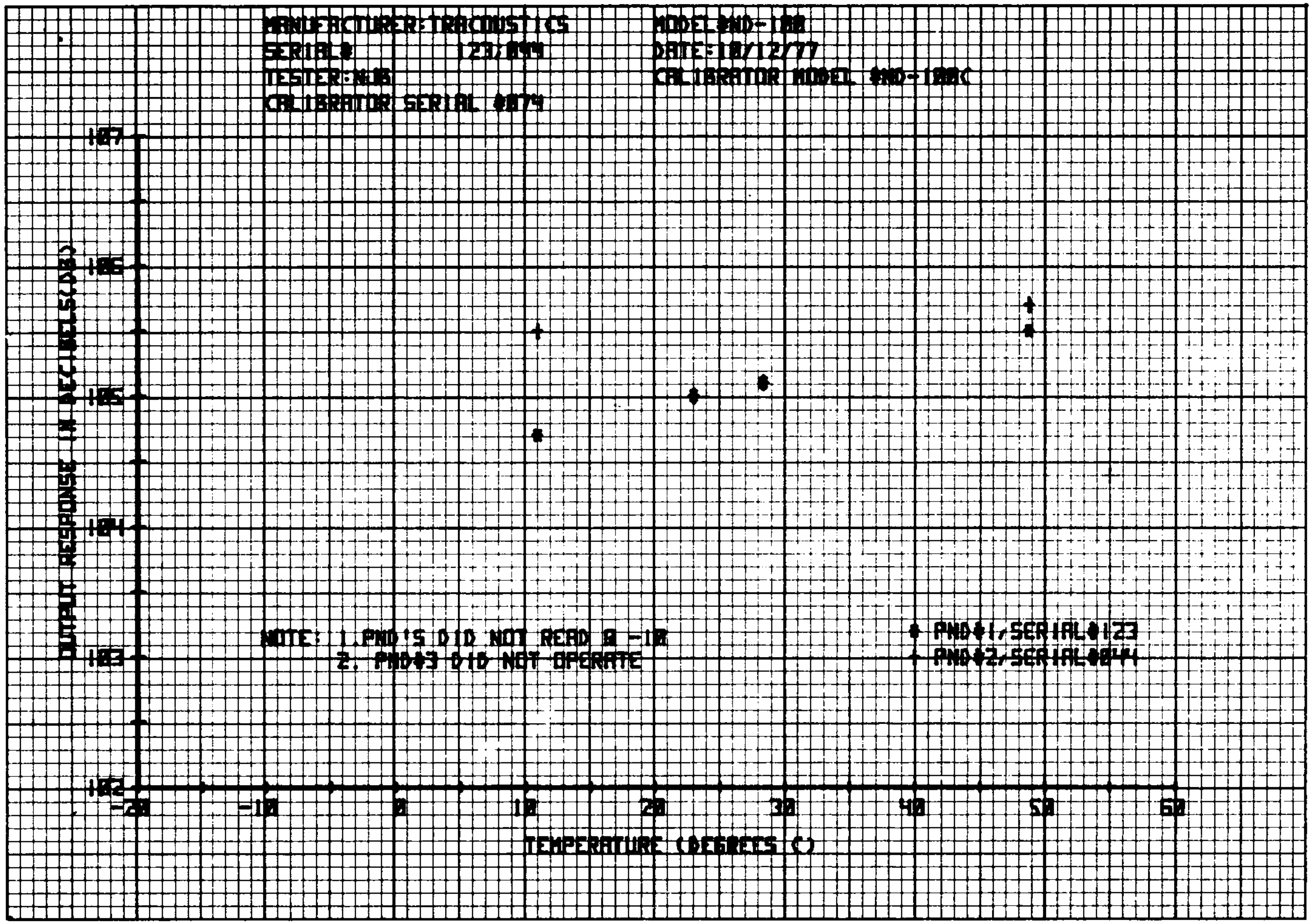

Figure 81. Temperature Sensitivity for Tracoustics Model ND-100 Personal Noise Dosimeters

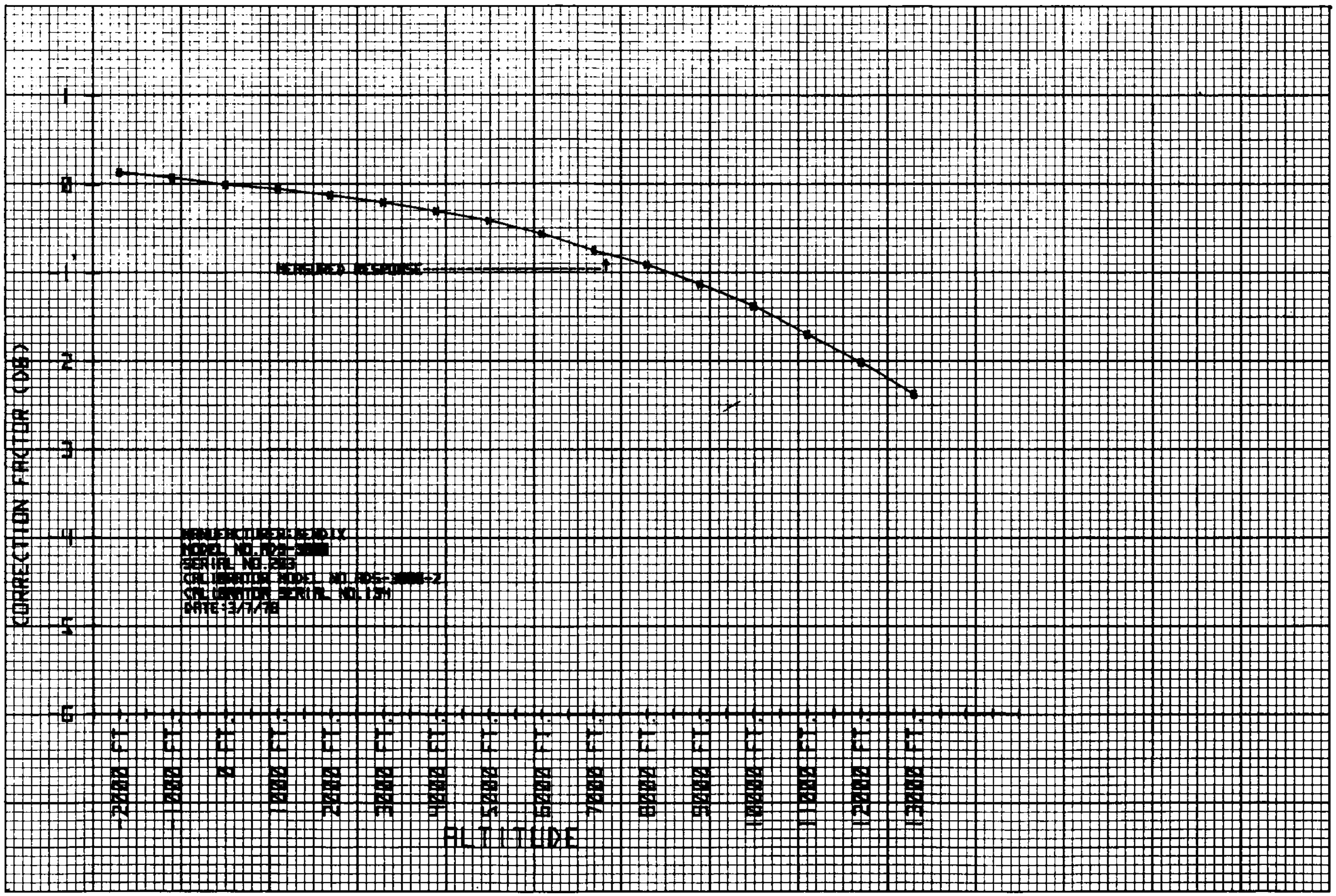

Figure 82. Atmospheric Pressure Response Test for Bendix Personal Noise Dosimeter Calibrator Model ADS-3000-2

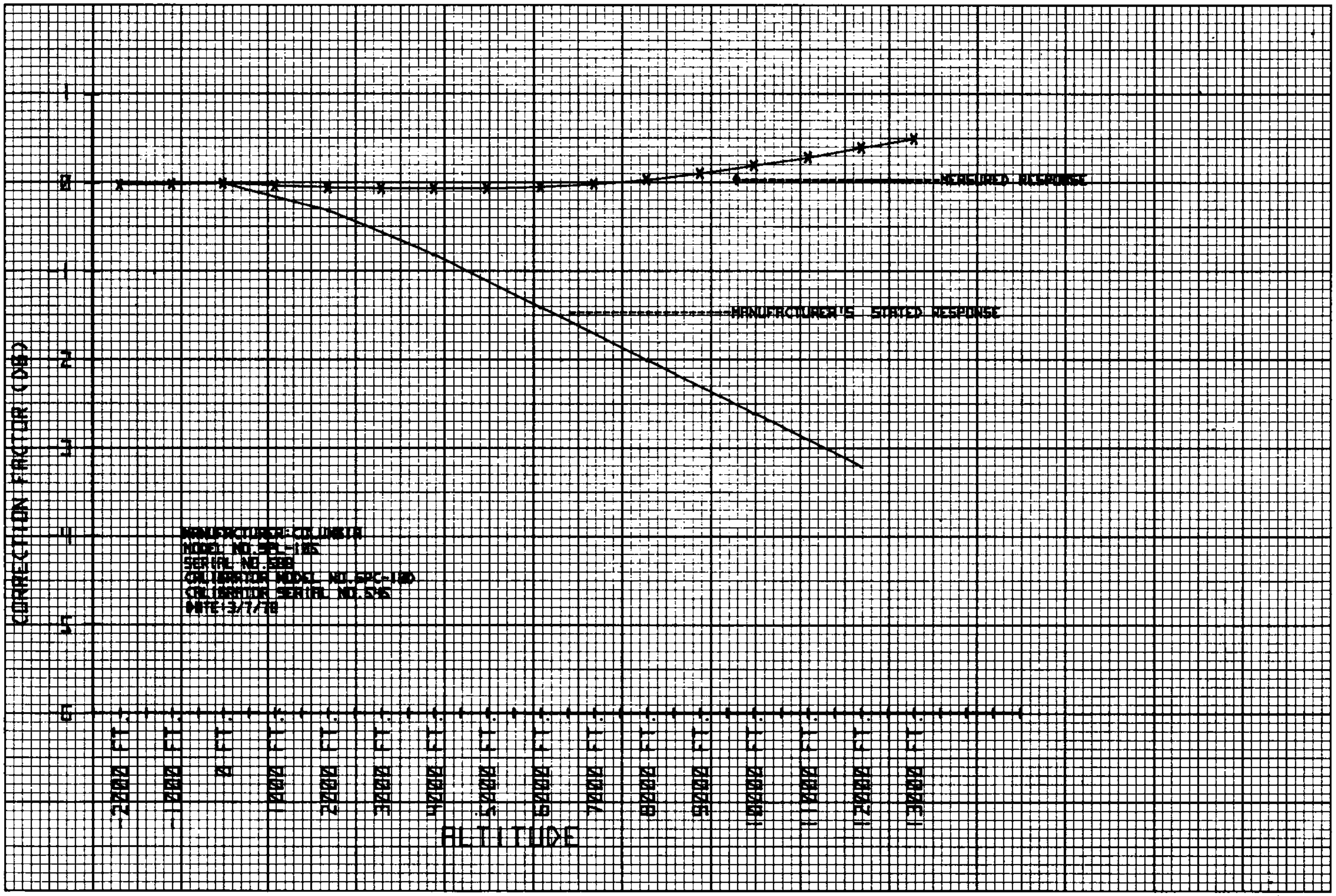

Figure 83. Atmospheric Pressure Response Test for Columbia Personal Noise Dosimeter Calibrator Model SPC-10D

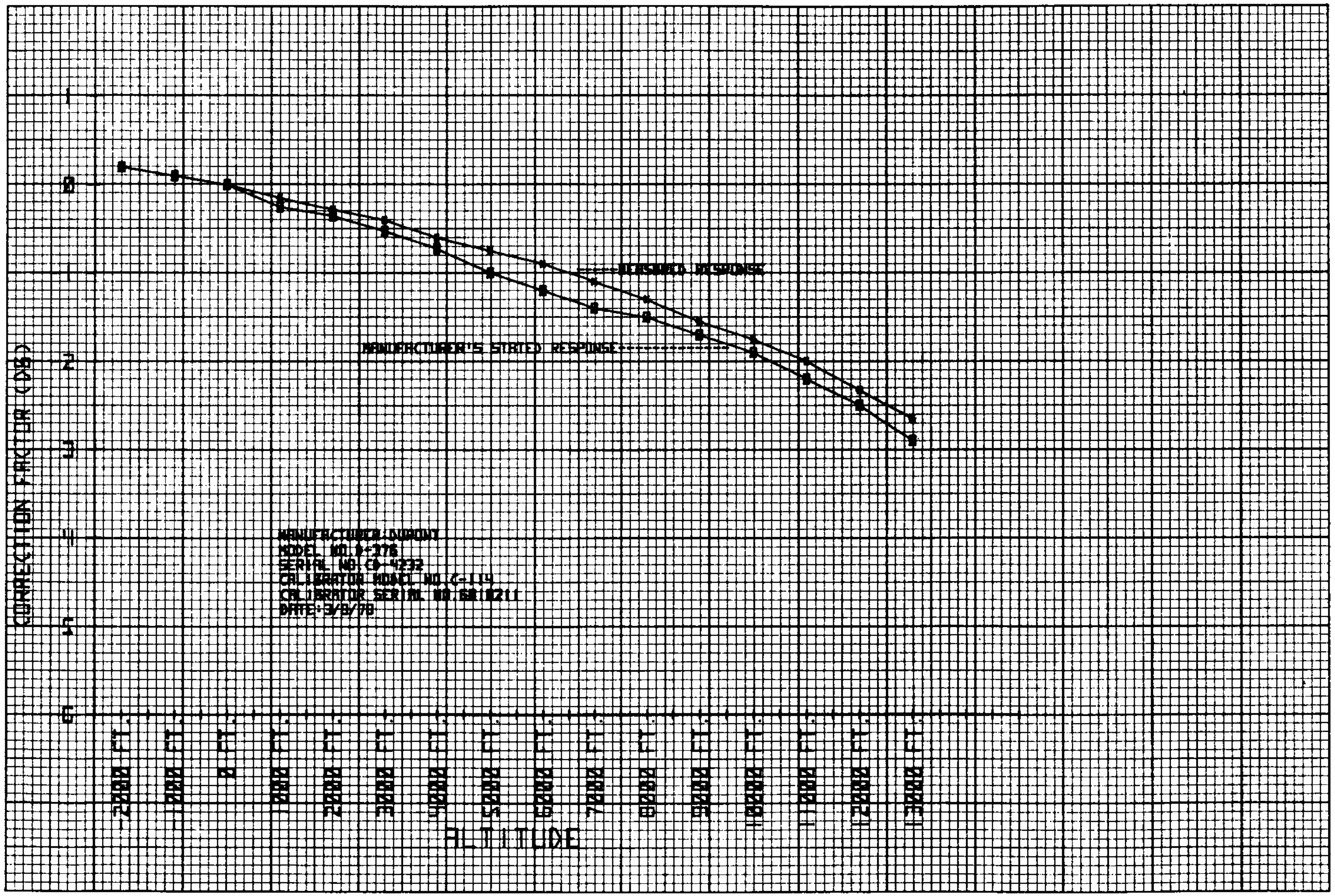

Figure 84. Atmospheric Pressure Response Test for Dupont Personal Noise Dosimeter Calibrator Model C-114

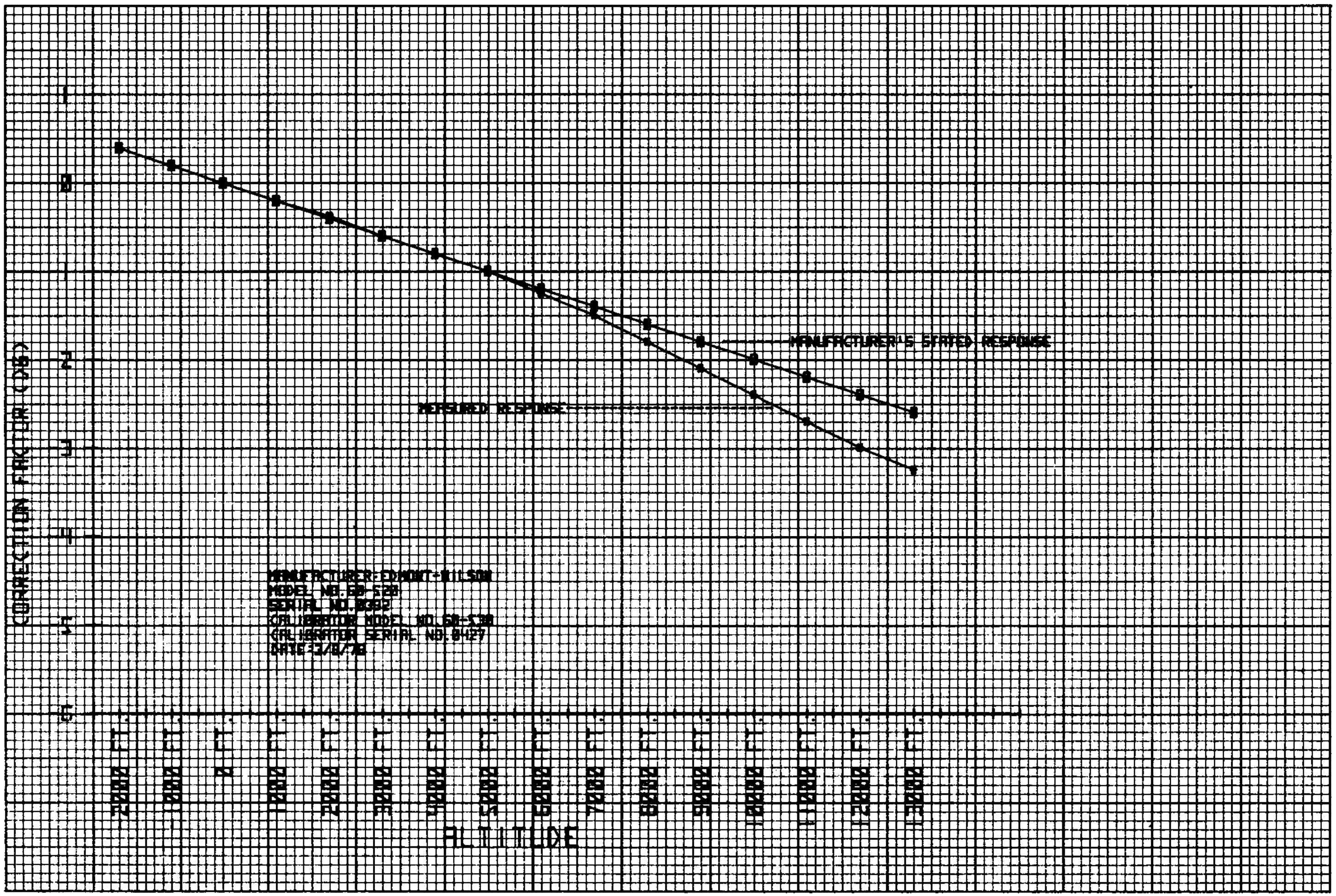

Figure 85. Atmospheric Pressure Response Test for Edmont-Wilson Personal Noise Dosimeter Calibrator Model 60-530

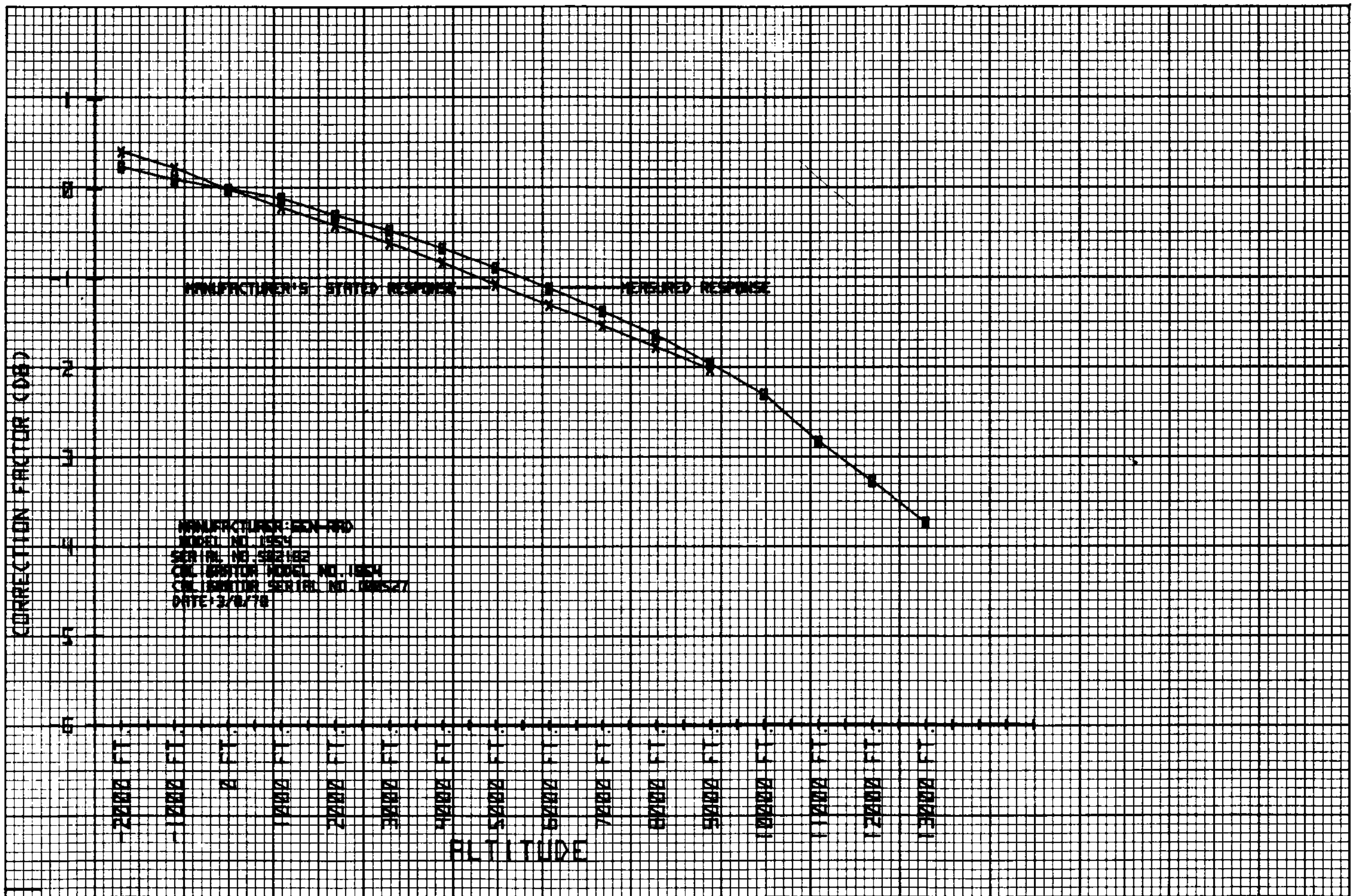

Figure 86. Atmospheric Pressure Response Test for GenRad Personal Noise Dosimeters Calibrator Model 1954

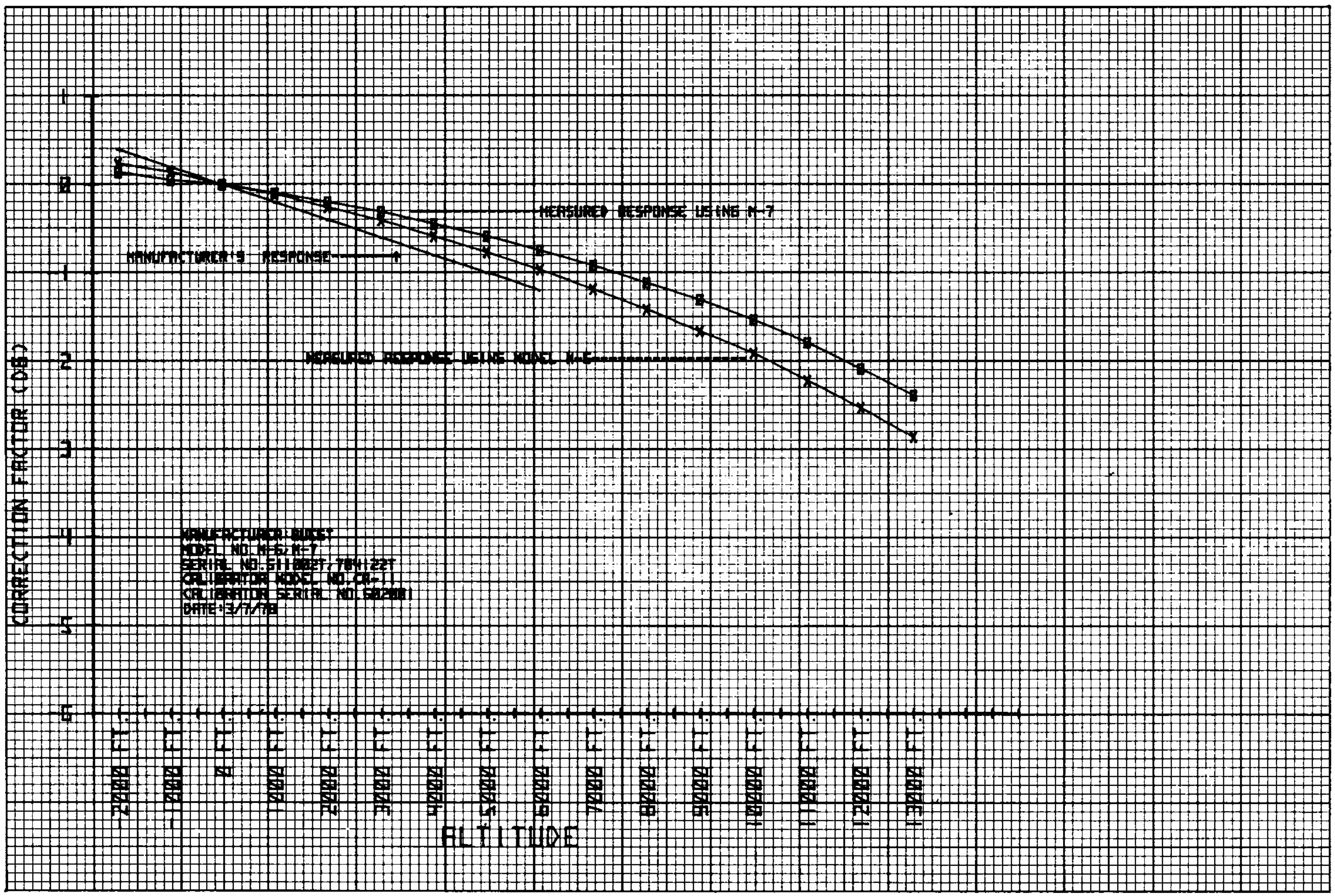

Figure 87. Atmospheric Pressure Response Test for Quest Personal Noise Dosimeter Calibrator Model CA-11

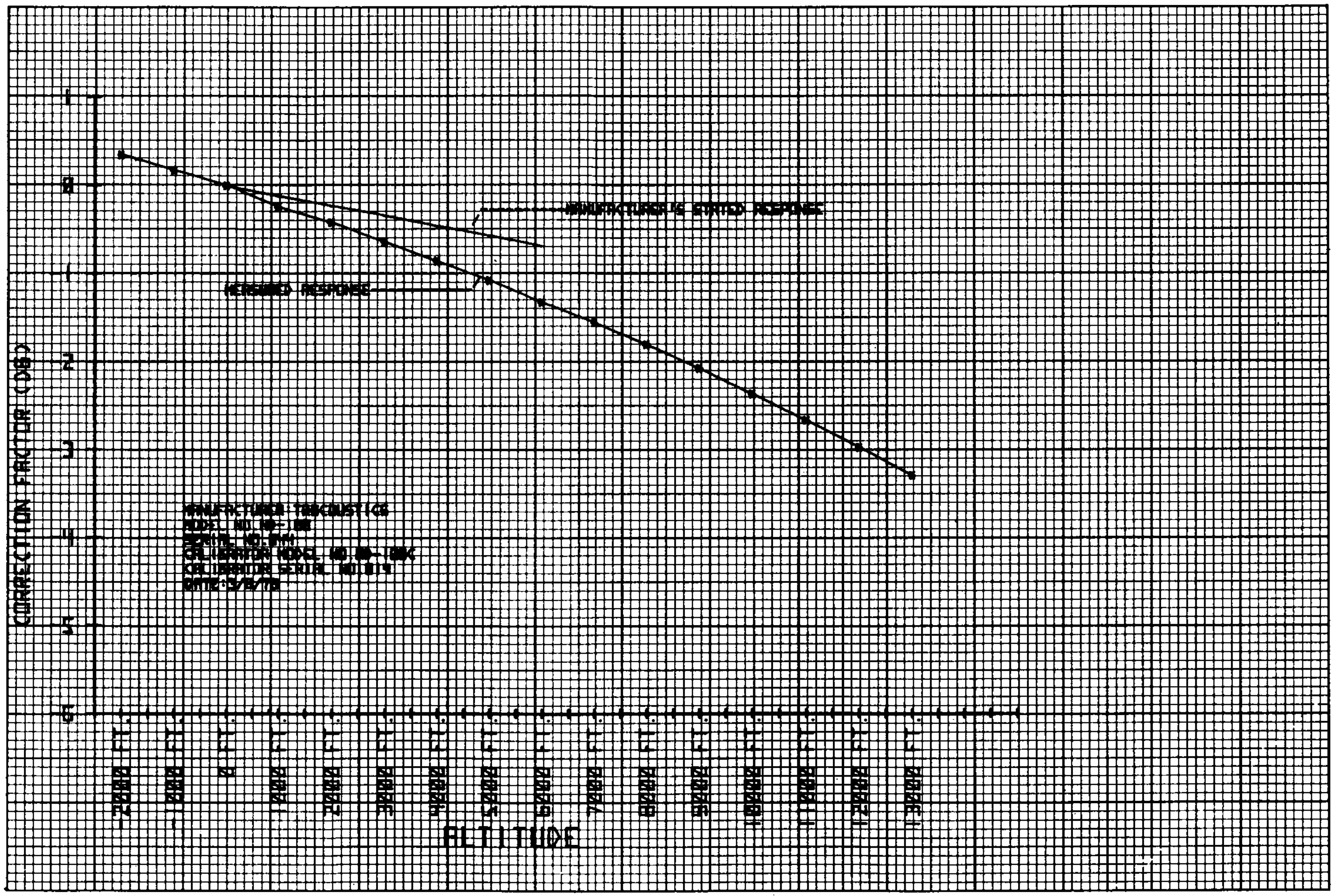

Figure 88. Atmospheric Pressure Response Test for Tracoustics Personal Noise Dosimeter Calibrator Model ND-100C

Table 1. Random-incidence relative response level and total tolerance limits as a function of frequency.

Frequency (Hz)	A-weighting relative response (dB)	Tolerance limit (dB)
63	-26.2	±3.0
80	-22.5	±3.0
100	-19.1	±2.5
125	-16.1	±2.5
160	-13.4	±2.5
200	-10.9	±2.5
250	- 8.6	±2.5
315	- 6.6	±2.0
400	- 4.8	±2.0
500	- 3.2	±2.0
630	- 1.9	±2.0
800	- 0.8	±1.5
1000	0	±2.0
1250	+ 0.6	±2.0
1600	+ 1.0	±2.5
2000	+ 1.2	±3.0
2500	+ 1.3	+4.0, -3.5
3150	+ 1.2	+5.0, -4.0
4000	+ 1.0	+5.5, -4.5
5000	+ 0.5	+6.0, -5.0
6300	- 0.1	+6.5, -5.5
8000	- 1.1	+6.5, -6.5

Table 2. Acoustical calibrator accuracy.

Acoustical calibrator	Manufacturer's stated sound pressure level * (dBA)	Measured sound pressure level (dBA)	Sound pressure level deviation (dBA)	Manufacturer's stated calibration frequency (Hz)	Measured calibration frequency (Hz)
B&K 4230 (SN 566634)	93.7	94.0	+0.3	1000	997
Bendix ADS-3000 (SN 193)	116.5	121.0	+4.5	1010	650
Columbia SPC-10D (SN 545)	90.0	90.9	+0.9	1000	1000
	114.8**	113.8	-1.0	1000	982
Dupont C114 (SN 6010211)	113.9	112.9	-1.0	1000	993
Edmont-Wilson 60-530 (SN 0427)	114.8	115.8	+1.0	1000	992
GenRad 1954 (SN 100527)	116.2	117.0	+0.8	1000	998
Quest CA-11 (SN 602001)	109.8	110.3	+0.5	1000	1010
Tracoustics ND-100C (SN 014)	114.8	115.6	+0.8	1000	1076

* Employing any corrections of instruction manual.

** Instruction manual contains contradiction concerning calibrator sound pressure level.

Table 3. Personal noise dosimeter threshold activation evaluation.

Personal noise dosimeter	Manufacturer's stated threshold (dBA)	Measured threshold (dBA)	Indicated level with input at +1dB above stated threshold (dBA)	Indicated level with input at 3dB below stated threshold (dBA)
B&K 4425				
1. SN 662926	90	89.8	91.0	00.0
	85	85.1	85.9	00.0
2. SN 642132	90	89.7	91.0	00.0
	85	80.2	86.0	81.8
3. SN 662977	90	89.2	91.0	00.0
	85	85.4	86.0	00.0
Bendix ADS-3000				
1. SN 167	90	82.0	90.4	84.9
2. SN 193	90	83.5	90.2	84.4
3. SN 203	90	89.3	90.8	00.0
Columbia SPL-105				
1. SN 589	90	90.4	91.6	00.0
2. SN 569	90	89.8	91.2	00.0
3. SN 545	90	90.8	91.9	00.0
Dupont D-376				
1. SN CD-4232	90	90.1	91.0	00.0
	85	83.9	86.0	00.0
2. SN CD-4191	90	89.6	91.0	00.0
	85	84.0	86.0	00.0
3. SN CD-3003	90	89.9	91.0	00.0
	85	84.4	86.1	00.0

(continued)

Table 3. Personal noise dosimeter threshold activation evaluation.

Personal noise dosimeter	Manufacturer's stated threshold (dBA)	Measured threshold (dBA)	Indicated level with input at +1dB above stated threshold (dBA)	Indicated level with input at 3dB below stated threshold (dBA)
Edmont-Wilson 60-520				
1. SN 0668	90	89.0	91.0	00.0
2. SN 0568	90	89.2	91.0	00.0
3. SN 0392	90	90.2	91.0	00.0
GenRad 1954				
1. SN 501819	85	84.1	86.0	00.0
2. SN 502135	90	89.1	91.0	00.0
3. SN 502182	90	89.1	91.0	00.0
Quest M-7				
1. SN 704122T	85	83.7	85.8	00.0
2. SN 704121T	85	83.5	85.9	00.0
3. SN 705103T	85	83.3	85.9	00.0
Quest M-6				
1. SN 511002T	90	89.5	91.0	00.0
2. SN 602004T	90	89.4	91.0	00.0
3. SN 703014T	90	83.6	91.0	87.1
Tracoustics ND-100				
1. SN 045	90	90.7	90.2	00.0
2. SN 044	90	90.6	90.2	00.0
3. SN 123	90	90.4	90.6	00.0

Table 4. Evaluation of instrument ability to process signal levels shifting across threshold.

Personal noise dosimeter	Manufacturer's stated threshold (dBA)	Theoretical indicated level (dBA)	Measured indicated level (dBA)
B&K 4425			
1. SN 662926	85	86	85.3
	90	91	89.7
2. SN 642132	85	86	85.3
	90	91	89.1
3. SN 662977	85	86	85.3
	90	91	90.6
Bendix ADS-3000			
1. SN 167	90	91	91.1
2. SN 193	90	91	91.1
3. SN 203	90	91	90.8
Columbia SPL-105			
1. SN 589	90	91	89.7
2. SN 569	90	91	90.0
3. SN 588	90	91	89.7
Dupont D-376			
1. SN CD-4232	85	86	86.2
	90	91	91.7
2. SN CD-4191	85	86	85.9
	90	91	91.6
3. SN CD-3003	85	86	86.0
	90	91	91.5

(continued)

Table 4. Evaluation of instrument ability to process signal levels shifting across threshold.

Personal noise dosimeter	Manufacturer's stated threshold (dBA)	Theoretical indicated level (dBA)	Measured indicated level (dBA)
Edmont-Wilson 60-520			
1. SN 0668	90	91	88.5
2. SN 0568	90	91	87.9
3. SN 0392	90	91	87.8
GenRad 1954			
1. SN 501819	90	91	91.0
2. SN 502135	90	91	91.0
3. SN 502182	90	91	91.0
Quest M-7			
1. SN 704122T	85	86	85.4
2. SN 704121T	85	86	85.4
3. SN 705103T	85	86	85.4
Quest M-6			
1. SN 511002T	90	91	90.3
2. SN 602004T	90	91	88.1
3. SN 703014T	90	91	90.4
Tracoustics ND-100			
1. SN 045	90	91	0.0
2. SN 044	90	91	0.0
3. SN 123	90	91	0.0

Table 5. Personal noise dosimeter signal response (rise and decay time) characteristic.

Personal noise dosimeter	Serial number	Measured response dosage (%)
B&K 4425	662926	22
	642132	20
	662977	21
Bendix ADS-3000	167	19
	193	20
	203	21
Columbia SPL-105	589	17.1
	569	17.1
	588	16.9
Dupont D-376	CD-4232	22.0
	CD-4191	22.5
	CD-3003	22.6
Edmont-Wilson 60-520	0668	17.1
	0568	16.9
	0392	16.9
GenRad 1954	501819	22.3
	502135	22.3
	502182	22.9
Quest M-7	704122T	20.3
	704121T	20.3
	705103T	20.3

(continued)

Table 5. Personal noise dosimeter signal response (rise and decay time) characteristic.

Personal noise dosimeter	Serial number	Measured response dosage (%)
Quest M-6	511002T	17.0
	602004T	17.0
	703014T	17.0
Tracoustics ND-100*	045	*
	044	16.3
	123	16.1

* Unit failed to function for the duration of the testing program.

Table 6. Personal noise dosimeter integration accuracy characteristic.

Personal noise dosimeter	Serial number	Dose for one minute period (D_1) (%)	15 x D_1 (%)	Dose for 15 minute period (D_{15}) (%)	15 x D_1 Minus D_{15} (%)
B&K 4425*	662926	6.0	90.0	90.0	0.0
		6.0	90.0	90.0	0.0
		6.0	90.0	89.0	0.0
	642132	6.0	90.0	90.0	0.0
		6.0	90.0	90.0	0.0
		6.0	90.0	90.0	0.0
	662977	6.0	90.0	90.0	0.0
		6.0	90.0	90.0	0.0
		6.0	90.0	89.0	1.0
Bendix ADS-3000	167	5.0	75.0	74.0	1.0
		5.0	75.0	74.0	1.0
		5.0	75.0	74.0	1.0
	193	5.0	75.0	74.0	1.0
		5.0	75.0	74.0	1.0
		5.0	75.0	74.0	1.0
	203	5.0	75.0	74.0	1.0
		5.0	75.0	74.0	1.0
		5.0	75.0	74.0	1.0
Columbia SPL-105	589	5.7	85.5	87.0	-1.5
		5.7	85.5	86.9	-1.4
		5.7	85.5	86.8	-1.3
	569	5.8	87.0	87.2	-0.2
		5.8	87.0	87.3	-0.3
		5.8	87.0	87.1	-0.1
	588	5.7	85.5	86.8	-1.3
		5.8	87.0	86.9	0.1
		5.8	87.0	86.9	0.1

(continued)

Table 6. Personal noise dosimeter integration accuracy characteristic.

Personal noise dosimeter	Serial number	Dose for one minute period (D_1) (%)	15 x D_1 (%)	Dose for 15 minute period (D_{15}) (%)	15 x D Minus D_{15} (%)
Dupont D-376	CD-4232	5.3	79.5	77.0	2.5
		5.3	79.5	76.8	2.7
		5.2	78.0	77.1	0.9
	CD-4191	6.0	90.0	88.0	2.0
		6.1	91.5	89.4	2.1
		6.0	90.0	87.6	2.4
	CD-3003	6.8	102.0	99.6	2.4
		6.8	102.0	99.5	2.5
		6.8	102.0	99.8	2.2
Edmont Wilson 60-520	0668	5.8	87.0	87.2	-0.2
		5.8	87.0	87.1	-0.1
		5.8	87.0	87.1	-0.1
	0568	5.8	87.0	86.9	0.1
		5.8	87.0	87.0	0.0
		5.8	87.0	86.9	0.1
	0392	5.8	87.0	87.0	0.0
		5.8	87.0	87.0	0.0
		5.8	87.0	87.0	0.0
GenRad 1954	501819	5.866	88.0	87.2	0.8
		5.881	88.2	87.1	1.1
		5.881	88.2	86.9	1.3
	502135	5.876	88.1	87.3	0.8
		5.887	88.3	87.0	1.3
		5.882	88.2	87.1	1.1
	502182	5.897	88.5	87.6	0.9
		5.893	88.4	87.1	1.3
		5.898	88.5	87.2	1.3

(continued)

Table 6. Personal noise dosimeter integration accuracy characteristic.

Personal noise dosimeter	Serial number	Dose for one minute period (D_1) (%)	15 x D_1 (%)	Dose for 15 minute period (D_{15}) (%)	15 x D_1 Minus D_{15} (%)
Quest M-7	704122T	5.87	88.05	86.99	1.06
		5.87	88.05	86.96	1.09
		5.88	88.20	87.03	1.17
	704121T	5.87	88.05	86.68	1.37
		5.87	88.05	87.07	0.98
		5.87	88.05	87.07	0.98
	705103T	5.86	87.90	87.10	0.80
		5.88	88.20	87.14	1.06
		5.87	88.05	87.12	0.93
Quest M-6	511002T	5.8	87.0	86.7	0.3
		5.8	87.0	86.7	0.3
		5.8	87.0	86.9	0.1
	602004T	5.8	87.0	87.0	0.0
		5.8	87.0	87.1	-0.1
		5.8	87.0	87.1	-0.1
	703014T	5.8	87.0	87.0	0.0
		5.8	87.0	87.0	0.0
		5.8	87.0	87.0	0.0
Tracoustics ND-100**	045				
	044	5.7	85.5	87.0	-1.5
		5.7	85.5	87.4	-1.9
		5.7	85.5	86.5	-1.0
	123	5.7	85.5	86.8	-1.3
		5.7	85.5	86.8	-1.3
		5.7	85.5	86.8	-1.3

* The test was modified for the B&K dosimeters since the readout does not allow an indication of tenths of a percent.

** The unit failed to function for the duration of the testing program.

Table 7. Personal noise dosimeter battery life evaluation

Personal noise dosimeter	Serial number	Deviation from reference signal (dBA) after 4 hours	after 8 hours	after 12 hours	after 16 hours
B&K 4425	662926	0.0	0.0	+0.1	+0.1
	642132	0.0	0.0	0.0	0.0
	662977	+0.8	+1.1	+2.3	+2.4
Bendix ADS-3000	167	-0.2	-0.3	0.0	0.0
	193	0.0	+0.1	+0.1	0.1
	203	0.0	+0.1	+0.0	0.0
Columbia SPL-105	589	0.0	-0.1	0.0	-0.1
	569	0.0	0.0	0.0	0.0
	588	0.0	0.0	0.0	-0.1
Dupont D-376	CD-4232	-0.2	-0.2	-0.1	-0.1
	CD-4191	-0.3	+2.7	-0.6	+2.5
	CD-3003	0.0	0.0	-0.1	-0.1
Edmont Wilson 60-520	0668	0.0	0.0	0.0	0.0
	0568	+0.4	+0.4	+0.1	+2.5
	0392	0.0	0.0	0.0	0.0
GenRad 1954	501819	-0.1	-0.1	-0.1	0.0
	502135	-0.1	-0.2	-0.1	-0.2
	502182	0.0	0.0	0.0	+0.2
Quest M-7	704122T	+0.1	+0.1	+0.1	0.0
	704121T	-0.1	-0.2	-0.1	-0.1
	705103T	-0.1	-0.3	-0.4	-0.3

(continued)

Table 7. Personal noise dosimeter battery life evaluation.

Personal noise dosimeter	Serial number	Deviation from reference signal (dBA) after 4 hours	after 8 hours	after 12 hours	after 16 hours
Quest M-6	511002T	0.0	0.0	0.0	+0.1
	602004T	0.0	0.0	0.0	+0.1
	703014T	0.0	0.0	0.0	+1.0
Tracoustics ND-100	045*	-	-	-	-
	044	-0.1	-0.1	-0.1	-0.2
	123	0.0	0.0	0.0	0.0

* Unit failed to function for the duration of the testing program.

Table 8. Personal noise dosimeter performance at low battery indication.

Personal noise dosimeter	Serial number	Deviation from reference signal (dBA)		
		Batt. 1 low	Batt. 2 low	Batt. 1 & 2 low
B&K 4425	662926	+0.2	+0.3	+0.2
	642132	+0.2	+0.1	+0.1
	662977	+0.3	+0.1	-0.1
Bendix ADS-3000 *	167	0.0	-	-
	193	0.0	-	-
	203	0.0	-	-
Columbia SPL-105*	589	0.0	-	-
	569	0.0	-	-
	588	0.0	-	-
Dupont D-376*	CD-4232	-1.1	-	-
	CD-4191	-0.9	-	-
	CD-3003	-1.1	-	-
Edmont Wilson 60-520	0668	+0.6	+0.4	0.0
	0568	+0.2	0.0	0.0
	0392	0.0	+0.4	0.0
GenRad 1954*	501819	0.0	-	-
	502135	0.0	-	-
	502182	0.0	-	-
Quest M-7*	704122T	0.0	-	-
	704121T	0.0	-	-
	705103T	0.0	-	-

(continued)

Table 8. Personal noise dosimeter performance at low battery indication.

Personal noise dosimeter	Serial number	Deviation from reference signal (dBA)		
		Batt. 1 low	Batt. 2 low	Batt. 1 & 2 low
Quest M-6	511002T	+0.3	+0.1	0.0
	602004T	+0.7	0.0	-0.1
	703014T	+0.9	0.0	0.0
Tracoustics ND-100**	-	-	-	-

* These dosimeters contain one battery.
** This dosimeter is not equipped with a battery indicator.

Table 9. Personal noise dosimeter dose storage evaluation.

Personal noise dosimeter	Serial number	Accumulated Dose (%)	Accumulated dose after 24 hour storage (%)	Dose change (%)
B&K 4225*				
Bendix ADS-3000	167	14,379.0	14,379.0	0.0
	193	476.0	476.0	0.0
	203	476.0	476.0	0.0
Columbia SPL-105*				
Dupont D-376	CD-4232	100.0	100.0	0.0
	CD-4191	101.0	101.0	0.0
	CD-3003	100.0	100.0	0.0
Edmont Wilson 60-520**				
GenRad 1954	501819	105.6	105.8	0.2
	502135	111.9	111.9	0.0
	502182	105.9	105.9	0.0
Quest M-7	704122T	100.18	100.19	0.01
	704121T***			
	705103T	102.92	102.93	0.01
Quest M-6**				
Tracoustics ND-100*				

* These PND's do not have the capability of storing a dose when turned off.
** These PND's contain stable mechanical counters.
*** This unit failed to function for the duration of the testing program.

Table 10. Personal noise dosimeter 115 dB (A, Slow) indicator latch evaluation.

Personal noise dosimeter	Serial number	Latch triggered at 115 dBA continuous	Latch triggered after 2 second application of 117 dBA
B&K 4425	662926	yes	yes
	642132	yes	yes
	662977	yes	yes
Bendix ADS-3000	167	yes	yes
	193	no	yes
	203	no	yes
Columbia SPL-105	589	yes	yes
	569	yes	yes
	588	yes	yes
Dupont D-376	CD-4232	no	yes
	CD-4191	no	yes
	CD-3003	no	yes
Edmont Wilson 60-520	0668	yes	yes
	0568	no	yes
	0392	no	yes
GenRad 1954	501819	yes	yes
	502135	yes	yes
	502182	yes	yes
Quest M-7	704122T	no	no
	704121T	no	no
	705103T	no	no

(continued)

Table 10. Personal noise dosimeter
115 dB (A, Slow) indicator latch evaluation.

Personal noise dosimeter	Serial number	Latch triggered at 115 dBA continuous	Latch triggered after 2 second application of 117 dBA
Quest M-6	511002T	no	yes
	602004T	no	yes
	703014T	no	yes
Tracoustics ND-100	045*		
	044	no	yes
	123	no	yes

* Unit failed to function for the duration of the testing program.

Table 11. Overall performance summary.

Personal noise dosimeter	Serial number	Frequency Response	Calibrator Accuracy	Cut/off Level	Shifting Level	Rise and Decay Time	Exponential Formula	Fold/over Test	Integration Accuracy	Crest Factor/ Square Law	Battery Life	Battery Indicator	Dose Storage	Temperature Sensitivity
B&K 4425	662926	P	P	P	F	P	P	P	P	P	P	P	–	F
	642132	P	P	F	F	P	P	P	P	P	P	P	–	F
	662977	P	P	P	P	P	P	P	P	P	F	P	–	F
Bendix ADS-3000	167	P	F	F	P	F	F	P	P	P	P	P	P	P
	193	F	F	F	P	P	F	P	P	P	P	P	P	F
	203	P	F	P	P	P	F	P	P	P	P	P	P	F
Columbia SPL-105	589	P	P	P	F	F	F	P	P	P	P	P	–	F
	569	P	P	P	P	F	F	P	P	P	P	P	–	P
	588	P	P	P	F	F	F	P	P	P	P	P	–	F
Dupont D-376	CD-4232	P	P	P	P	P	P	P	P	P	P	F	P	P
	CD-4191	P	P	P	P	P	F	P	P	P	F	F	P	P
	CD-3003	P	P	P	P	P	P	P	P	P	P	F	P	F
Edmont-Wilson 60-520	0668	P	P	P	F	F	P	P	P	P	P	F	P	P
	0568	P	P	P	F	F	P	P	P	P	F	P	P	P
	0392	P	P	P	F	F	P	P	P	P	P	P	P	P
GenRad 1954	501819	P	P	P	P	P	P	P	P	P	P	P	P	F
	502135	P	P	P	P	P	P	P	P	P	P	P	P	F
	502182	P	P	P	P	P	P	P	P	P	P	P	P	F
Quest M-7	704122T	P	P	P	P	P	F	P	P	P	P	P	P	F
	704121T	P	P	P	P	P	F	P	P	P	P	P	*	F
	705103T	P	P	P	P	P	F	P	P	P	P	P	P	F
Quest M-6	511002T	P	P	P	P	F	P	P	P	P	P	P	P	F
	602004T	P	P	P	F	F	P	P	P	P	P	F	P	F
	703014T	P	P	F	P	F	P	P	P	P	F	F	P	F
Tracoustics ND-100	045	F	F	P	F	*	F	P	*	*	*	–	–	*
	044	P	F	P	F	F	F	P	P	F	P	–	–	F
	123	P	F	P	F	F	F	P	P	F	P	–	–	F

(Continued)

Table 11. Overall performance survey.

Personal noise dosimeter	Serial number	Magnetic Field Sensitivity	115 dB (A, Slow) Latch	Atmospheric Pressure Evaluation	Drop	Cable	Temperature Endurance	% of Tests Passed
B&K 4425	662926	P	F	–	–	–	–	78.6
	642132	P	F	–	F	F	P	64.7
	662977	P	F	–	–	–	–	78.6
Bendix ADS-3000	167	P	F	–	–	–	–	66.7
	193	P	P	–	F	P	F	61.1
	203	P	P	P	–	–	–	81.2
Columbia SPL-105	589	P	F	–	–	–	–	64.2
	569	P	F	–	P	P	P	82.4
	588	P	F	F	–	–	–	60.0
Dupont D-376	CD-4232	P	P	P	F	P	P	89.5
	CD-4191	P	P	–	–	–	–	80.0
	CD-3003	P	P	–	–	–	–	86.7
Edmont-Wilson 60-520	0668	P	F	–	P	P	P	77.8
	0568	P	P	–	–	–	–	80.0
	0392	P	P	P	–	–	–	87.5
GenRad 1954	501819	P	F	–	–	–	–	86.7
	502135	P	F	–	F	P	F	77.7
	502182	P	F	P	–	–	–	87.5
Quest M-7	704122T	P	F	P	–	–	–	81.3
	704121T	P	F	–	P	P	P	77.7
	705103T	P	F	–	–	–	–	80.0
Quest M-6	511002T	P	P	–	–	–	–	86.7
	602004T	P	P	P	–	–	–	75.0
	703014T	P	P	–	P	P	P	72.2
Tracoustics ND-100	045	*	*	–	–	–	–	15.4
	044	P	P	P	*	*	*	47.1
	123	P	P	–	–	–	–	53.8

* Unit failed to function for the duration of the testing program.

PND DROP TEST

DATA SHEET #1

Manufacturer B&K — Date 1-9-78

Model No. 4425 — Tester R. L. Fortner

Serial No. 642132

Height of Drop 36"

Calibration value before drops 29% - 94 dB

Condition afterdrop#

1. Scratched
2. "
3. "
4. "
5. "
6. "
7. "
8. "
9. "
10. "

Calibration value after drops inoperable

Comments:

Cover popped and warped.

PND DROP TEST

DATA SHEET # 2

Manufacturer Bendix

Date 5/15/78

Model No. ADS-3000

Tester R. L. Fortner

Serial No. 193

Height of Drop 36"

Calibration value before drops 006/007

Condition afterdrop#

1. -OK
2. -Scratches
3. "
4. "
5. "
6. Battery popped out-
7. Scratches
8. "
9. "
10. "

Calibration value after drops would not calibrate

Comments:

PND DROP TEST

DATA SHEET #3

Manufacturer Columbia

Date 1-9-78

Model No. SPL-105

Tester R. L. Fortner

Serial No. 569

Height of Drop 36"

Calibration value before drops 1.1% in 10 seconds (115 dBA)

Condition afterdrop#

1. Scratched
2. "
3. "
4. "
5. "
6. "
7. "
8. "
9. "
10. "

Calibration value after drops 1.1 in 10 seconds (115 dBA)

Comments:

Inner faceplate dislodged and buckled.

PND DROP TEST

DATA SHEET # 4

Manufacturer Edmont-Wilson   Date 1-9-78

Model No. 60-520   Tester R. L. Fortner

Serial No. 0668

Height of Drop 36"

Calibration value before drops 3.67% in 60 seconds at 110 dBA

Condition afterdrop#

1. Scratched
2. "
3. "
4. "
5. "
6. "
7. "
8. "
9. "
10. "

Calibration value after drops 3.79% in 60 seconds at 110 dBA

Comments:

Guard in place. Battery check did not work. On-off knob loose. Calibration after test remained within manufacturer's tolerances.

PND DROP TEST

DATA SHEET #5

Manufacturer Quest Date 1-9-78

Model No. M-7 Tester R. L. Fortner

Serial No. 704121T

Height of Drop 36"

Calibration value before drops 3.80% at 110 dBA for 68 seconds

Condition afterdrop#

1. Scratched
2. "
3. "
4. "
5. "
6. "
7. "
8. "
9. "
10. "

Calibration value after drops 3.77% at 110 dBA for 68 seconds

Comments:

On/off switch activated after 10 drops.
Calibration after test remained within manufacturer's tolerances.

PND DROP TEST

DATA SHEET #6

Manufacturer Quest Date 1-9-78

Model No. M-6 Tester R. L. Fortner

Serial No. 703014T

Height of Drop 36"

Calibration value before drops 3.5% in 68 seconds @ 110 dBA

Condition afterdrop#

1. Scratched
2. Reset button broken off - guard bent
3. Scratched
4. "
5. "
6. "
7. "
8. "
9. "
10. "

Calibration value after drops 3.5% in 68 seconds @ 110 dBA

Comments:

Case buckled.
Register digits moved to give a false reading.

PND DROP TEST

DATA SHEET #7

Manufacturer GenRad Date 1-9-78

Model No. 1954 Tester R. L. Fortner

Serial No. 502135

Height of Drop 36"

Calibration value before drops .122% in 1.0 seconds

Condition afterdrop#

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Calibration value after drops inoperable after drops

Comments:

PND DROP TEST

DATA SHEET # 8

Manufacturer Dupont

Date 1-9-78

Model No. D-376

Tester R. L. Fortner

Serial No. CD-4232

Height of Drop 36"

Calibration value before drops 113 dB

Condition afterdrop#

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Calibration value after drops 112.8 dB

Comments:

Calibration after test was outside of the manufacturer's tolerances.

PND CABLE TEST

DATA SHEET #9

Manufacturer B&K | Date 1-9-78

Model No. 4425 | Tester R. L. Fortner

Serial No. 642132

Comments after test:

Cable is 37" long.
Unit was not operational after test. Shield was broken loose at connector on PND.

PND CABLE TEST

DATA SHEET #10

Manufacturer Bendix

Date 5-15-78

Model No. ADS-3000

Tester R. L. Fornter

Serial No. 193

Comments after test:

Unit was calibrated before test to 006/007.
Unit still calibrated after test to 006/007.

PND CABLE TEST

DATA SHEET #11

Manufacturer Columbia

Date 1-9-78

Model No. SPL-105

Tester R. L. Fortner

Serial No. 569

Comments after test:

No effect.

PND CABLE TEST

DATA SHEET # 12

Manufacturer Dupont	Date 1-9-78
Model No. D-376	Tester R. L. Fortner
Serial No. CD-4232	

Comments after test:

Cable is 29" long.
Test had no effect on the dosimeter.

PND CABLE TEST

DATA SHEET #13

Manufacturer Edmont-Wilson — Date 1-9-78

Model No. 60-520 — Tester R. L. Fortner

Serial No. 0668

Comments after test:

Cable is 24" long.
Test had no effect on the dosimeter.

PND CABLE TEST

DATA SHEET # 14

Manufacturer GenRad Date 1-9-78

Model No. 1954 Tester R. L. Fortner

Serial No. 502135

Comments after test;

32" cable.
No effect.

PND CABLE TEST

DATA SHEET # 15

Manufacturer Quest

Date 1-8-78

Model No. M-7

Tester R. L. Fortner

Serial No. 704121T

Comments after test:

No effect on dosimeter.

PND CABLE TEST

DATA SHEET #16

Manufacturer Quest Date 1-9-78

Model No. M-6 Tester R. L. Fortner

Serial No. 703014T

Comments after test:

Cable is 35" long.
Test had no effect.

PND TEMPERATURE ENDURANCE TEST

DATA SHEET # 17

Manufacturer B&K | Date 1-9-78

Model No. 4425 | Tester R. L. Fortner

Serial No. 642132

Calibration value before test 29% @ 94 dB

Calibration value after test 30% @ 94 dB

Comments:

Calibration within manufacturer's tolerances after test.

PND TEMPERATURE ENDURANCE TEST

DATA SHEET # 18

Manufacturer Bendix

Date 1-9-78

Model No. ADS-3000

Tester R. F. Fortner

Serial No. 193

Calibration value before test 006/007

Calibration value after test not able to calibrate

Comments:

Battery checked good but the display would only stay "on" for approximately 1 second.

PND TEMPERATURE ENDURANCE TEST

DATA SHEET # 19

Manufacturer Columbia

Date 1-9-78

Model No. SPL-105

Tester R. L. Fortner

Serial No. 569

Calibration value before test 1.1% in 10 seconds

Calibration value after test 1.1% in 10 seconds

Comments:

None

PND TEMPERATURE ENDURANCE TEST

DATA SHEET #20

Manufacturer Dupont Date 1-9-78

Model No. D-376 Tester R. L. Fortner

Serial No. CD-4232

Calibration value before test 113.2 dBA

Calibration value after test 113.4 dBA

Comments:

Calibration within manufacturer's tolerances after test.

PND TEMPERATURE ENDURANCE TEST

DATA SHEET # 21

Manufacturer Edmont-Wilson Date 1-9-78

Model No. 60-520 Tester R. L. Fortner

Serial No. 0668

Calibration value before test 3.6% - 68 seconds @ (109.6 dBA)

Calibration value after test 3.5% - 68 seconds @ (109.5 dBA)

Comments:

Calibration within manufacturer's tolerances after test.

PND TEMPERATURE ENDURANCE TEST

DATA SHEET # 22

Manufacturer GenRad

Date 1-9-78

Model No. 1954

Tester R. L. Fortner

Serial No. 502135

Calibration value before test .123 in 1 second @ (115.6 dBA)

Calibration value after test .166 in 1 second @ (114.5 dBA)

Comments:

Unit out of calibration after test (1.1 decibel).

PND TEMPERATURE ENDURANCE TEST

DATA SHEET # 23

Manufacturer Quest

Date 1-9-78

Model No. M-7

Tester R. L. Fortner

Serial No. 704121T

Calibration value before test 3.6% in 61 seconds @ 110 dBA

Calibration value after test 3.6% in 61 seconds @ 110 dBA

Comments:

No apparent effect.

PND TEMPERATURE ENDURANCE TEST

DATA SHEET # 24

Manufacturer Quest | Date 1-9-78

Model No. M-6 | Tester R. L. Fortner

Serial No. 703014T

Calibration value before test 3.8% in 68 seconds @ (110 dBA)

Calibration value after test 3.5% in 68 seconds @ (109.5 dBA)

Comments:

Calibration within manufacturer's tolerances after test.

GLOSSARY

Accumulated Noise Dose (N): The value of N derived from the equation:

$N = C_1/T_1 + C_2/T_2 + \ldots + C_n/T_n$

where $C_1, C_2 \ldots C_n$ are the actual durations of exposure for an exposed worker at the various noise levels; and $T_1, T_2 \ldots T_n$ are the respective regulatory duration limits at those same noise levels. For purposes of accumulated dose computation the actual duration increments may be assumed to be infinitesimally small i.e. continuous integration shall be performed. The dose is also expressed as a percentage or N x 100%.

Acoustical Calibrator: A device compatible with the microphone of a personal noise dosimeter which emits one or more sound pressure levels, providing a calibration check on the general operation of a personal noise dosimeter set.

A-weighting: The prescribed frequency response (Table 1) provided in a personal noise dosimeter.

Calibration Check: A check of the performance of a personal noise dosimeter set in which the accuracy of the indicated accumulated noise dose is verified but no adjustments are made to alter the accuracy of the indicated reading.

Crest Factor: The ratio of the peak voltage to the root-mean-square (RMS) voltage of a waveform where both values are measured in reference to the arithmetic mean value of the waveform.

dB(A, Slow): A unit of sound level as would be indicated by a sound level meter with the A-weighting specified in Table 1 and otherwise conforming to the slow dynamic characteristics specified for Type 2 sound level meters in Section 5.4 of ANSI S1.4-1971, with the exception of Section 5.4.4 which need not apply. The time constant of the exponential averaging device connected to the output of the square law device is nominally 1 second corresponding to the SLOW response of a sound level meter meeting ANSI S1.4-1971 Type 2 specifications.

Indicated Level, Indicated Noise

The noise level (L) calculated from the equation:

$$T = 16 \div 2^{\left(\frac{L - 85}{5}\right)}$$

where T is the time in hours required for the personal noise dosimeter to accumulate a noise dose of 1.00 based on the dose accumulation rate (i.e. T=1.00 dose/dose accumulation rate).

Microphone Configuration

The physical attachment and support for the microphone as well as any environmental shield or screen used to cover the microphone during operation, and also includes the selection of a particular microphone if the personal noise dosimeter is designed to be used with an assortment of microphones.

Normal Microphone Configuration

The microphone of the personal noise dosimeter is not on a length of cable other than that length needed to use the device for personal monitoring (e.g. excluding extension cables) and is not covered by an optional windscreen or other environmental shield.

Personal Noise Dosimeter

That portion of the personal noise dosimeter set which must actually be worn by the worker, including the microphone. If the readout is a physically separate device, it is not considered to be part of the personal noise dosimeter.

Personal Noise Dosimeter Set	A device or devices, which computes, stores and displays the accumulated noise dose and which includes a compatible acoustical calibrator and associated instruction manuals.
Random-Incidence Response	The mean square response over time and angle to a sound whose angle of incidence is a random variable.
Rapid Readout of Indicated Noise	A method for rapidly determining the indicated level in dB(A, Slow) of pure tone signals introduced into the personal noise dosimeter for laboratory tests of performance.
Readout	That portion of the personal noise dosimeter set which displays the accumulated noise dose in digital form.
Relative Responses Level	The amount in decibels by which the sound level exceeds the sound pressure level. The relative response may be negative.
Sensitivity Adjustment	A procedure used to improve the accuracy of the personal noise dosimeter by mechanical adjustment of gain controls or other methods designated by the applicant.
Sound Level, Noise Level	The weighted sound pressure level measured by the use of designated metering and weighting characteristics with A-weighting and slow response being understood to apply unless another weighting is indicated. The units of the resulting measurement are: decibel, dB; decibel (A), dBA; A-weighted decibel measured with slow response, dB(A, Slow).
Sound Pressure Level	Twenty (20) times the logarithm to the base of 10 of the ratio of the pressure of a sound to the reference pressure. The reference pressure used shall be 20 micropascals (2×10^{-4} microbars). The

unit of the resulting measurement is the decibel, dB.

Storage Device	The components of a personal noise dosimeter which stores the information that represents the accumulated noise dose.

★ U.S. GOVERNMENT PRINTING OFFICE: 1978—757-141/1831

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
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CENTER FOR DISEASE CONTROL
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DHEW (NIOSH) Publication No. 78-186