U.S. Army Public Health Command

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Criteria and Procedures for Auditory Health Hazard Assessment of Impulse Noise (Blast Over Pressure)

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USAPHC

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1. PURPOSE

This technical guide describes the current criteria and procedures for estimating the maximum safe exposure to impulse noise from an auditory injury perspective. Criteria for estimating a non-auditory injury are not covered in this document.

2. REFERENCES

Appendix A provides a list of references used to prepare this technical guide.

3. BACKGROUND

Historically, the procedures for assessing the health hazards associated with weapons firing noise (also called blast over pressure (BOP)) were based on formulas contained in MIL-STD-1474D, Requirement 4 (reference 1) and its previous versions. These formulas use peak pressure level (PPL, in dB) and B-duration (B, in ms, a measure of the persistence of an impulse sound, as defined in MIL-STD-1474D) to calculate an allowable number of rounds (ANOR) that can be fired in a 24-hour period without a significant risk of hearing loss. These formulas assume that a certain level of hearing protection will be used by personnel exposed to the weapons noise. In the 1980s and 1990s, a number of research studies showed that the ANOR derived from MIL-STD-1474D were overly conservative (references 2, 3, and 4). In 1990, the U.S. Army Office of The Surgeon General approved a limited exception to the use of MIL-STD -1474D (references 5 and 6). This exception is currently known as the “Free Field (FF) exception.” The FF exception allows the use of different formulas to calculate the ANOR provided the pressure trace meets a set of requirements to qualify for the exception. These formulas are based only on the peak level. See paragraph 3.2 below for a detailed discussion.

Furthermore, until 2010, the ANOR per day described in a health hazard assessment (HHA) were derived from the worst-case (WC) test round using either the MIL-STD-1474D formulas or the FF exception formulas. Use of the WC test round added another layer of conservatism to the HHA process. In 1997, Patterson proposed an alternative procedure to using the WC test round (reference 7). This method still uses the appropriate formulas from MIL-STD-1474D or the FF exception to calculate the estimated ANOR for each test round, but instead of taking the WC round, it uses all test rounds to calculate an ANOR by accumulating the hazard associated with each test round. This method has come to be known as the proportional dose (PD) method for calculating ANOR. In 2010, the U.S. Army Public Health Command (USAPHC) adopted this PD method for calculating ANOR for the HHA. This guide documents how to calculate ANOR using the MIL-STD-1474D, FF criteria, and PD method. From an auditory perspective, these calculations estimate the maximum safe use of a weapon system.

3.1 MIL-STD-1474D Criteria Allowable Number of Rounds Calculations

The exposure limit criteria in MIL-STD-1474D, Requirement 4 are presented as four limit curves labeled W, X, Y, and Z in Figure 4-1 of the standard. These curves are plotted as PPL as a function of B. The W curve is a constant 140 decibels (dBP) for all durations. This is the "no protection" limit, and the ANOR for PPL below this level are unlimited. For levels at or above 140 dBP, hearing protection is required and the ANOR per day are limited by the PPL and B-duration. The Z-curve described the maximum allowable exposure to prevent non-auditory injury. Currently, this curve is only used for triggering a non-auditory assessment using the INJURY model, which is not covered in this guide. As a point of reference, the Z-curve corresponds to an ANOR of five rounds per day. Equations 1 and 2 present the currently used formulas for the ANOR per day for auditory hazard assessment when the PPL exceeds 140 dBP.

Case 1: B-duration less than or equal to 200 milliseconds (ms)

$$ANOR = INT(10^{(2+((167+6.64\times LOG10(200/B)-PPL)/5))}) \quad \text{(Equation 1)}$$

Case 2: B-duration greater than 200 ms

$$ANOR = INT(10^{(2+((167-PPL)/5))}) \quad \text{(Equation 2)}$$

The INT function truncates the total value to yield a whole number. PPL is the peak pressure level in dB, and B is the B-duration in ms from the test data.

Equations 1 and 2 express the formulas that define the shape of the X, Y, and Z curves with the number vs. peak level trading rule (5 dB for a 10-fold change in ANOR) that is implicit in the MIL-STD-1474D. These equations allow interpolation between and extrapolation outside of the X, Y, and Z-curves. The equations are applied to weapon noise test data to estimate the single hearing protection MIL-STD-1474D ANOR required. The ANOR is multiplied by 20 if double hearing protection is worn.

3.2 Requirement to Qualify for the Free Field Exception to MIL-STD-1474 D Allowable Number of Rounds

The process for deciding if a pressure trace meets the requirements for the FF exception is presented below.

First, for the FF exception to apply, the weapon must be fired in the open. If that is the case, the next step is to determine if the A-duration (time in ms for the impulse pressure to first return to equilibrium) is between 1 and 6 ms and if the B-duration is less than 60 ms. If either of these duration requirements is **not** met, the pressure wave does not qualify for the FF exception and the test round should be classified as not free field (NFF).

If the duration requirements are met, the final step is to look for multiple peaks in the weapon noise pressure signature. Signatures with only one or two significant peaks are considered FF. Signatures with three or more significant peaks are considered NFF. Significant peaks are those greater than 50 percent of the actual over pressure of the highest peak and not 50 percent of the decibel level of the highest peak pressure. To count significant peaks, start at the initial rise in pressure and find the first over pressure that exceeds 50 percent of the highest peak over pressure. This will always occur before the end of the B-duration. It is not necessary to find the actual local maximum. From the first over pressure greater than 50 percent of peak over pressure, find the next point where the pressure drops below baseline. This will occur at the end of the A-duration in cases where the initial peak is the largest, but not if the initial peak is not the highest. This defines the existence and location of the first significant peak. From this baseline crossing, look for the next pressure that is above baseline by at least 50 percent of the highest peak over pressure. This defines the existence of a second significant peak. It is only necessary to search until the end of the B-duration. If no second peak is found, the signature qualifies for the FF exception, and the test round should be classified as FF. If a second peak above 50 percent of the peak over pressure is found, then look for the next point that drops below baseline. From this baseline crossing, look for another point where the pressure is at least 50 percent of the highest peak above baseline (i.e., the third peak). Again, it is only necessary to search until the end of the B-duration. If the third peak is not found, the signature qualifies for the FF exception, and the test round should be classified as FF. If the third peak is found, the signature does not qualify for the FF exception and the test round should be classified as NFF.

3.3 Free Field Criterion Allowable Number of Rounds Calculations

The calculation of ANOR using the FF criterion only depends on the PPL and not the B-duration. Equations 3 through 8 present the basic formulas for the FF ANOR.

For A-durations between 2 and 6 ms and B-durations less than 60 ms the ANOR are:

Case 1: PPL > 190 dBP

ANOR = 0 (Equation 3)

Case 2: 187 dBP < PPL ≤ 190 dBP

ANOR = 6 (Equation 4)

Case 3: PPL ≤ 187 dBP

$$ANOR = INT(10^{(2+((187-Peak)/10))}) \quad \text{(Equation 5)}$$

The INT function truncates the total value to a whole number. PPL is the peak pressure level in dBP from the test data.

Examples:

A PPL of 187 dBP results in an ANOR = 100

A PPL of 177 dBP results in an ANOR = 1000

For A-durations between 1 and 2 ms and B-durations less than 60 ms the ANOR are:

Case 1: PPL > 190 dBP (Equation 6)

ANOR = 0

Case 2: 187 dB < PPL ≤ 190 dBP

ANOR = 3 (Equation 7)

Case 3: PPL ≤ 187 dBP

$$ANOR = INT(0.5\times10^{(2+((187-Peak)/10))}) \quad \text{(Equation 8)}$$

The INT function truncates the value to a whole number. PPL is the peak pressure level in dB from the test data.

Examples: (these are ½ of the ANOR for A-durations between 2 and 6 ms)

A PPL of 187 dBP results in an ANOR = 50

A PPL of 177 dBP results in an ANOR = 500

For all other A-durations and B-durations the FF is not applicable. The pressure signatures are not FF. The level vs. ANOR trading rule for the FF criterion is 10 db for a10-fold change in ANOR. This is different from the MIL-STD-1474D rule.

3.4 Proportional Dose Calculation for Estimating Allowable Number of Rounds

The following paragraphs describe how to implement the proportional dose (PD) calculation for estimating the ANOR. This procedure can be used with any weapon system, but will most likely be applied only to artillery and mortar systems. The PD calculation is not expected to be used with small arms, because WC assessments for small arms are generally acceptable without the more complex and expensive work involved in doing a PD calculation, or with shoulder-fired weapons due to the low likelihood of improving ANOR results.

The PD calculation uses a “traditionally” determined ANOR for each pressure signature to produce a noise dose fraction (DF) associated with that ANOR. The DF is defined as 1/ANOR. Since the ANOR is inversely related to its hazard, the DF is a direct indication of the hazard. There are three different traditionally determined ANOR values possible: the ANOR based on MIL-STD-1474D (Equations 1 and 2); the ANOR using the FF exception (Equations 3 through 5); and ½ the ANOR using the FF exception, which applies when there is an A-duration of between 1 and 2 ms (Equations 6 through 8). Typical data sets used in the PD calculation may contain DF values determined from any combination of the traditional ANOR. A screening process is used in the PD calculation to determine which traditional ANOR to apply to each noise sample. In the final calculation, the individual DFs within a data set are rank ordered from highest to lowest and added until they total 1. The number of DFs that can be added without exceeding a sum of 1 is the PD ANOR. If the sum of the DF is less than 1 after all the data are added, start at the top of the list again and keep adding until the sum reaches 1. Use as many passes through the data set as needed to get to a summed DF of 1. The number of data points involved in this process defines the PD ANOR. The PD determined value will always be greater than or equal to the traditionally determined ANOR. Appendix B illustrates the process using an example data set.

PD calculations require a larger number of test rounds than the traditional analysis. Traditionally, testing has been done with as few as five rounds for a given test condition. The number of test rounds required for PD calculations should be at least 20 and preferably 30 or more; fewer samples can yield potentially misleading results due to variability inherent in the calculation procedure with small sample sets. For some systems, certain test variables can be lumped together in the PD calculation to increase the amount of data available for the calculation. For artillery and mortar systems, the primary test variables affecting noise are charge increment (firing zone), crew position (gauge location), azimuth (AZ), quadrant elevation (QE), and temperature conditioning of the charge. However, only AZ and QE are combined in a PD calculation. Firing zone or charge increment and crew position is always assessed individually due to the significantly different noise characteristics for each. Thus, separate PD calculations are done for each charge increment and crew location. Temperature conditioning is also assessed separately because this variable does not come into play during any 24-hour use scenario. Instead, separate assessments of the effect of temperature conditioning are done, and WC temperature is used with the main body of testing. In other words, once it is determined whether hot, cold or ambient temperature conditioning produces the most noise, that temperature condition is used for the rest of the testing. This leaves variations in AZ and QE, which can both change during a 24-hour use scenario, and the data from these variables are combined in the PD calculation for each charge increment. The test parameters for AZ and QE should be chosen to cover the range of operationally relevant values, and the number of rounds at each parameter value should reflect the operational use of the system to the extent possible. To obtain the sufficiently populated data set, combine the testing done at different AZ and QE for each charge increment, but keep the data separate for each crew (gauge) position. Take sufficient samples to yield at least 20 data points.

For data sets where the highest level is greater than 185 dBP, all FF ANOR that are greater than 141 should be replaced with an ANOR of 141. The result of this modification will reduce the PD ANOR, but it will also reduce the likelihood of an overestimate of PD ANOR as the peak levels approach the 187 dB peak level where the FF ANOR drop to 6. This modification can be implemented by testing the set of test data used in the PD calculation to see if any PPL is greater than 185 dBP.

Note: The basic PD method can be used for other methods of rating the hazard of test data as long as the method provides a way to estimate ANOR from each test round. For example, the Auditory Hazard Assessment Algorithm for Humans (AHAAH) model yields hazard units calculated from each pressure record analyzed by the model. A “full dose” is considered to be 500 units. So, 500 divided by the AHAAH units from each round is an estimate of the ANOR. Since the PD calculation uses 1/ANOR as the DF, the AHAAH units/500 is the DF based on the AHAAH model. The data would be rank

ordered by AHAAH units from highest to lowest. These DFs can be accumulated as discussed above to produce the PD ANOR for each charge and gauge location. The units can also be added directly. In this case, the criterion for stopping is modified to be 1 below the minimum number of test rounds required for the sum to exceed 500. Similarly, an A-weighted equivalent level (Leq)-based criterion can be used to derive an ANOR for each test round. The PD method could be applied to these ANOR in a straight forward way.

3.5 Safety Margins for Allowable Number of Rounds Calculated Using the Proportional Dose Method.

The traditional method for establishing the ANOR guidance in HHAs was to use the WC ANOR from a group of test rounds. This method embodied a safety margin, in addition to the safety margins inherent in the criteria that generated the ANOR estimates, by treating all rounds as being as hazardous as the WC test round. The PD method was adopted to better reflect a true hazard by using more of the test data to establish the ANOR guidance, thus reducing the safety margin. The following paragraphs address the remaining safety margins.

The first line of safety margin is in the basic criteria used to estimate the hazard of individual test rounds. There are two criteria currently being used: MIL-STD-1474D and the FF exception to MIL-STD-1474D. For heavy weapons noise, the MIL-STD-1474D ANOR are known to be more conservative than the FF criterion by 10 dB or more (reference 8). This is a large safety margin. Any PD calculation that includes ANOR derived from MIL-STD-1474D estimates incorporates some of this conservatism. The greater the proportion of test rounds that are evaluated using the MIL-STD-1474D, the more conservative the PD ANOR become and the larger the safety margin. The FF exception to MIL-STD-1474 allows a greater ANOR for the same peak level provided the requirements to qualify for the FF exception are met. This criterion has a smaller safety margin built into it. The criterion was derived from human volunteer studies that used temporary changes in hearing thresholds as an indicator that the exposure was approaching hazardous levels. The margin between small temporary changes in hearing and permanent hearing loss is in the range of 3 to 10 dB. The human studies also used degraded hearing protection which means an additional safety margin exists if good hearing protection is used. Therefore, PD calculations based on ANOR from FF estimates still contain significant margins of safety. Studies of the variability of PD ANOR estimates suggest that overestimates of PD ANOR are unlikely to be greater than 2 to 3 dB peak equivalent. For most heavy weapons noise this amount of overestimate of ANOR is covered by the margin of safety in the basic criteria.

The FF criterion has a precipitous drop in ANOR at 187 dBP peak level (100 to 6). For any system that produces peak levels approaching 187 dBP, there is some concern that the margin of safety may be too thin. If the test data include rounds that fail to meet the requirements for the FF exception, the conservatism in the MIL-STD-1474D ANOR should provide an adequate additional margin of safety. When all test rounds meet the FF requirements, the following modification to the PD calculation is used to provide an additional margin of safety. If any test round has a peak level greater than 185 dBP, then all ANOR used in the PD calculation are capped at 141 rounds. This serves to reduce the likelihood of overestimates of PD ANOR and to reduce the range of variability of the estimates. This modification will have no effect on systems that produce levels of approximately 180 dBP. Crew areas around current 105 millimeter (mm) and 155 mm howitzers are in this range and should not be affected.

Appendix A

References

1. Department of Defense Design Criteria Standard: Noise Limits, MIL-STD-1474D, 12 February 1997.

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3. Patterson, J.H., Jr. and B.T. Mozo. 1987. Direct determination of the adequacy of hearing protection for use with the VIPER. USAARL Report No. 87-9.

4. Patterson, J.H., Jr. and D.L. Johnson. 1990. Determination of occupational exposure limits for very high intensity impulses, 120th Meeting of the Acoustical Society of America, San Diego, California.

5. Memorandum, USAEHA, HSHB, 12 February 1991, subject: Minutes of Executive Session on Modification of the Impulse Noise Damage Risk Criteria, 12 December 1990, U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground, Maryland.

6. Memorandum, USAARL, SGRD-UAS-AS, 21 December 1990, subject: Proposed Changes in Blast Over Pressure Health Hazard Assessment Procedures, Final Recommendations.

7. Patterson, J.H., Jr., 1997. Proposed new procedure for estimating allowable number of rounds for blast over pressure hazard assessment. USAARL Report No. 98-03.

8. Johnson, D.L., 1994. Blast over pressure studies with animals and men: a walk up study. USAARL Contractor Report No. 94-2.

Appendix B

Example of the Process for Proportional Dose Calculations Using Excel® Spreadsheets

Figures B-1 through B-3 are examples of Excel spreadsheets that illustrate the development of the proportional dose (PD) calculation of allowable number of rounds (ANOR). Figure B-1 shows an example of a data set that would be used in a PD calculation. Note that the data set presented is for a particular increment charge (zone 7) and crew position (ch004). Other data sets would be used in separate PD calculations for different charge increments or crew locations. The data set can be derived from a copy of the typical Excel work book provided by Yuma Proving Ground (YPG) for their testing, but may need to be customized for other test sites. Delete irrelevant YPG data such as ground plane channels and warmer/conditioner round data and other data columns not used in this analysis. Add columns for FF ANOR, FF/2 ANOR (the FF ANOR for short A-duration rounds), scoring for FF or NFF, FF ANOR for PD, and ANOR for PD calculations. The values for the MIL-STD-1474D ANOR are generally provided in the YPG work books, but can be obtained from the other information using Equations 1 and 2 in this technical guide. The values in the FF ANOR and FF/2 columns come from Equations 3 through 5 and 6 through 8 in this guide. The scoring for the FF/NFF column will be done according to the rules for determining if a waveform meets the requirements for the FF exception. That means examining the details of each pressure signature in the data set. Leave the entry blank if it is FF, but mark it as NFF if it is not FF. The column labeled FF ANOR uses a decision tree dependent on the A-duration value as described above. For this example, cell K2 contains "=IF(E2<2,I2,H2)", cell K3 contains "=IF(E3<2,I3,H3)," etc. The last column in Figure B-1 selects between the appropriate FF ANOR and the MIL-STD ANOR, depending on the results in the Scored FF/NFF column. Cell L2 contains "=IF(ISBLANK(J2),K2,G2)", cell L3 contains "=IF(ISBLANK(J3),K3,G3)," etc. (Excel® is a registered trademark of the Microsoft Corporation.)

Figure B-2 shows an example of the same data set as in Figure B-1, but is sorted from low to high value of the ANOR for the PD calculation.

Now add 5 columns for DF, Cumulative DF, Residual, Counter, and PD ANOR. See Figure B-3. Fill the DF column with 1/ANOR for PD calculation (cell M2 contains "=1/L2", etc). Fill the Cum DF column with the running sum of the DF column across the rows that are to be included in the PD calculation. For this example, cell N2 contains "=M2" and N3 contains "=N2+M3", etc. The last row of the Cum DF column contains the sum of the DFs across all rounds being included in the calculation.

If the Cum DF value is greater than 1, the PD ANOR will be less than the number of test rounds included in the calculation. Go back and count the number of rows above the first row that the Cum DF is greater than 1. This is the PD ANOR. If the last row in the Cum DF is less than 1, enter a formula in the last row of the Residual column that is 1-INT(1/Last row Cum DF)*Last row CUM DF. In this example spreadsheet, the formula in cell O31 is "=1-INT(1/N31)*N31." This is the amount of Cum DF left after N passes through all the test rounds (N = INT(1/Last row Cum DF). In this example N = INT(1/N31) = 17. The "counter" column is used to count how many rounds down the ordered list it takes to use up the residual. This is done by setting each cell in the Count column equal to 1 if the Cum DF column is less than or equal to the residual. For this example cell P2 contains the formula "=IF(N2<=O$31,1,"NC")," P3 contains the formula "=IF(N3<=O$31,1,"NC")" and so on through P31. The final PD ANOR is the number of data points in the calculation times N plus the number if rounds it takes to use up the residual. In this example, N = 17. There are 30 data points. There is 1 count in the counter column. This results in the PD ANOR equal to 511. Cell Q31 shows the PD ANOR and contains the formula: "=(COUNT(M2:M31)*INT(1/N31))+COUNT(P2:P31)." The equations used in this example make the counting of PD ANOR work automatically whether or not the Cum DF is less than 1. Caution: In setting up a spreadsheet to do the PD ANOR calculations, be sure that all cell references are adapted correctly and $ signs are used as in the example.

Round Num	Zone	Channel Name	dB Peak (re:20uPa)	A-Duration (mSec)	B-Duration (mSec)	**ANOR MIL-STD**	**ANOR FF**	**ANOR FF/2**	**Scored FF/NFF**	**FF ANOR**	**ANOR for PD Calc**
533	Zone 7	Ch004	174.52	2.02	19.50	**69**	**1770**	**885**		1770	1770
534	Zone 7	Ch004	175.13	2.15	18.65	**55**	**1538**	**769**		1538	1538
535	Zone 7	Ch004	174.78	1.75	20.47	**57**	**1667**	**833**		833	833
536	Zone 7	Ch004	174.37	1.96	19.36	**74**	**1830**	**915**	NFF	915	74
537	Zone 7	Ch004	175.08	2.03	20.32	**50**	**1555**	**777**		1555	1555
546	Zone 7	Ch004	174.83	1.91	19.65	**59**	**1647**	**823**		823	823
547	Zone 7	Ch004	175.03	1.92	20.37	**51**	**1573**	**786**		786	786
548	Zone 7	Ch004	174.82	1.76	20.36	**56**	**1650**	**825**		825	825
549	Zone 7	Ch004	174.45	1.99	19.32	**72**	**1798**	**899**		899	899
550	Zone 7	Ch004	174.54	1.65	19.33	**69**	**1763**	**881**		881	881
558	Zone 7	Ch004	175.15	1.95	19.33	**52**	**1532**	**766**		766	766
559	Zone 7	Ch004	175.01	2.03	19.23	**56**	**1582**	**791**		1582	1582
560	Zone 7	Ch004	175.40	1.86	18.43	**49**	**1444**	**722**		722	722
561	Zone 7	Ch004	175.00	1.78	19.86	**53**	**1584**	**792**		792	792
562	Zone 7	Ch004	175.66	1.77	20.48	**38**	**1360**	**680**		680	680
569	Zone 7	Ch004	174.78	1.72	20.57	**56**	**1667**	**833**		833	833
570	Zone 7	Ch004	175.31	2.01	19.84	**46**	**1474**	**737**		1474	1474
571	Zone 7	Ch004	175.61	1.92	20.14	**39**	**1376**	**688**		688	688
572	Zone 7	Ch004	174.25	2.12	19.20	**79**	**1885**	**942**	NFF	1885	79
573	Zone 7	Ch004	174.66	1.85	18.59	**68**	**1714**	**857**		857	857
580	Zone 7	Ch004	175.15	1.77	19.31	**52**	**1529**	**764**		764	764
581	Zone 7	Ch004	174.77	1.72	18.68	**65**	**1670**	**835**		835	835
582	Zone 7	Ch004	175.17	2.08	18.48	**55**	**1525**	**762**		1525	1525
583	Zone 7	Ch004	175.17	1.76	19.58	**50**	**1523**	**761**		761	761
584	Zone 7	Ch004	175.50	1.88	19.38	**44**	**1411**	**705**		705	705
591	Zone 7	Ch004	174.79	1.94	19.90	**59**	**1661**	**830**		830	830
592	Zone 7	Ch004	175.28	1.79	20.36	**45**	**1486**	**743**		743	743
593	Zone 7	Ch004	174.93	1.73	19.79	**55**	**1610**	**805**		805	805
594	Zone 7	Ch004	174.82	1.70	18.48	**64**	**1650**	**825**		825	825
595	Zone 7	Ch004	174.99	1.75	20.58	**51**	**1588**	**794**		794	794

Figure B-1. Basic Data with FF ANOR and FF/NFF Scoring and ANOR for PD Calculation Added

Round Num	Zone	Channel Name	dB Peak (re:20uPa)	A-Duration (mSec)	B-Duration (mSec)	**ANOR MIL-STD**	**ANOR FF**	**ANOR FF/2**	**Scored FF/NFF**	**FF ANOR**	**ANOR for PD Calc**
536	Zone 7	Ch004	174.37	1.96	19.36	**74**	**1830**	**915**	NFF	915	74
572	Zone 7	Ch004	174.25	2.12	19.20	**79**	**1885**	**942**	NFF	1885	79
562	Zone 7	Ch004	175.66	1.77	20.48	**38**	**1360**	**680**		680	680
571	Zone 7	Ch004	175.61	1.92	20.14	**39**	**1376**	**688**		688	688
584	Zone 7	Ch004	175.50	1.88	19.38	**44**	**1411**	**705**		705	705
560	Zone 7	Ch004	175.40	1.86	18.43	**49**	**1444**	**722**		722	722
592	Zone 7	Ch004	175.28	1.79	20.36	**45**	**1486**	**743**		743	743
583	Zone 7	Ch004	175.17	1.76	19.58	**50**	**1523**	**761**		761	761
580	Zone 7	Ch004	175.15	1.77	19.31	**52**	**1529**	**764**		764	764
558	Zone 7	Ch004	175.15	1.95	19.33	**52**	**1532**	**766**		766	766
547	Zone 7	Ch004	175.03	1.92	20.37	**51**	**1573**	**786**		786	786
561	Zone 7	Ch004	175.00	1.78	19.86	**53**	**1584**	**792**		792	792
595	Zone 7	Ch004	174.99	1.75	20.58	**51**	**1588**	**794**		794	794
593	Zone 7	Ch004	174.93	1.73	19.79	**55**	**1610**	**805**		805	805
546	Zone 7	Ch004	174.83	1.91	19.65	**59**	**1647**	**823**		823	823
548	Zone 7	Ch004	174.82	1.76	20.36	**56**	**1650**	**825**		825	825
594	Zone 7	Ch004	174.82	1.70	18.48	**64**	**1650**	**825**		825	825
591	Zone 7	Ch004	174.79	1.94	19.90	**59**	**1661**	**830**		830	830
535	Zone 7	Ch004	174.78	1.75	20.47	**57**	**1667**	**833**		833	833
569	Zone 7	Ch004	174.78	1.72	20.57	**56**	**1667**	**833**		833	833
581	Zone 7	Ch004	174.77	1.72	18.68	**65**	**1670**	**835**		835	835
573	Zone 7	Ch004	174.66	1.85	18.59	**68**	**1714**	**857**		857	857
550	Zone 7	Ch004	174.54	1.65	19.33	**69**	**1763**	**881**		881	881
549	Zone 7	Ch004	174.45	1.99	19.32	**72**	**1798**	**899**		899	899
570	Zone 7	Ch004	175.31	2.01	19.84	**46**	**1474**	**737**		1474	1474
582	Zone 7	Ch004	175.17	2.08	18.48	**55**	**1525**	**762**		1525	1525
534	Zone 7	Ch004	175.13	2.15	18.65	**55**	**1538**	**769**		1538	1538
537	Zone 7	Ch004	175.08	2.03	20.32	**50**	**1555**	**777**		1555	1555
559	Zone 7	Ch004	175.01	2.03	19.23	**56**	**1582**	**791**		1582	1582
533	Zone 7	Ch004	174.52	2.02	19.50	**69**	**1770**	**885**		1770	1770

Figure B-2. Data After Sorting on “ANOR for PD Calc.” Column

Round Num	Zone	Channel Name	dB Peak (re:20uPa)	A-Duration (mSec)	B-Duration (mSec)	**ANOR MIL-STD**	**ANOR FF**	**ANOR FF/2**	**Scored FF/NFF**	**FF ANOR**	**ANOR for PD Calc**	**Dose Fraction**	**Cum DF**	**Residual**	**Counter**	**PD ANOR**
536	Zone 7	Ch004	174.37	1.96	19.36	**74**	**1830**	**915**	NFF	915	74	0.0135	0.0135		1	
572	Zone 7	Ch004	174.25	2.12	19.20	**79**	**1885**	**942**	NFF	1885	79	0.0127	0.0262		NC	
562	Zone 7	Ch004	175.66	1.77	20.48	**38**	**1360**	**680**		680	680	0.0015	0.0276		NC	
571	Zone 7	Ch004	175.61	1.92	20.14	**39**	**1376**	**688**		688	688	0.0015	0.0291		NC	
584	Zone 7	Ch004	175.50	1.88	19.38	**44**	**1411**	**705**		705	705	0.0014	0.0305		NC	
560	Zone 7	Ch004	175.40	1.86	18.43	**49**	**1444**	**722**		722	722	0.0014	0.0319		NC	
592	Zone 7	Ch004	175.28	1.79	20.36	**45**	**1486**	**743**		743	743	0.0013	0.0332		NC	
583	Zone 7	Ch004	175.17	1.76	19.58	**50**	**1523**	**761**		761	761	0.0013	0.0346		NC	
580	Zone 7	Ch004	175.15	1.77	19.31	**52**	**1529**	**764**		764	764	0.0013	0.0359		NC	
558	Zone 7	Ch004	175.15	1.95	19.33	**52**	**1532**	**766**		766	766	0.0013	0.0372		NC	
547	Zone 7	Ch004	175.03	1.92	20.37	**51**	**1573**	**786**		786	786	0.0013	0.0384		NC	
561	Zone 7	Ch004	175.00	1.78	19.86	**53**	**1584**	**792**		792	792	0.0013	0.0397		NC	
595	Zone 7	Ch004	174.99	1.75	20.58	**51**	**1588**	**794**		794	794	0.0013	0.0410		NC	
593	Zone 7	Ch004	174.93	1.73	19.79	**55**	**1610**	**805**		805	805	0.0012	0.0422		NC	
546	Zone 7	Ch004	174.83	1.91	19.65	**59**	**1647**	**823**		823	823	0.0012	0.0434		NC	
548	Zone 7	Ch004	174.82	1.76	20.36	**56**	**1650**	**825**		825	825	0.0012	0.0446		NC	
594	Zone 7	Ch004	174.82	1.70	18.48	**64**	**1650**	**825**		825	825	0.0012	0.0458		NC	
591	Zone 7	Ch004	174.79	1.94	19.90	**59**	**1661**	**830**		830	830	0.0012	0.0471		NC	
535	Zone 7	Ch004	174.78	1.75	20.47	**57**	**1667**	**833**		833	833	0.0012	0.0483		NC	
569	Zone 7	Ch004	174.78	1.72	20.57	**56**	**1667**	**833**		833	833	0.0012	0.0495		NC	
581	Zone 7	Ch004	174.77	1.72	18.68	**65**	**1670**	**835**		835	835	0.0012	0.0507		NC	
573	Zone 7	Ch004	174.66	1.85	18.59	**68**	**1714**	**857**		857	857	0.0012	0.0518		NC	
550	Zone 7	Ch004	174.54	1.65	19.33	**69**	**1763**	**881**		881	881	0.0011	0.0530		NC	
549	Zone 7	Ch004	174.45	1.99	19.32	**72**	**1798**	**899**		899	899	0.0011	0.0541		NC	
570	Zone 7	Ch004	175.31	2.01	19.84	**46**	**1474**	**737**		1474	1474	0.0007	0.0547		NC	
582	Zone 7	Ch004	175.17	2.08	18.48	**55**	**1525**	**762**		1525	1525	0.0007	0.0554		NC	
534	Zone 7	Ch004	175.13	2.15	18.65	**55**	**1538**	**769**		1538	1538	0.0007	0.0561		NC	
537	Zone 7	Ch004	175.08	2.03	20.32	**50**	**1555**	**777**		1555	1555	0.0006	0.0567		NC	
559	Zone 7	Ch004	175.01	2.03	19.23	**56**	**1582**	**791**		1582	1582	0.0006	0.0573		NC	
533	Zone 7	Ch004	174.52	2.02	19.50	**69**	**1770**	**885**		1770	1770	0.0006	0.0579	0.0158	NC	511

Figure B-3. Data Sheet with Columns Added to Accomplish the PD ANOR Calculation