

Safe Diving Distances from Transmitting Sonar

1A-1 INTRODUCTION

The purpose of this appendix is to provide guidance regarding safe diving distances and exposure times for divers operating in the vicinity of ships transmitting with sonar. Table 1A-1 provides guidance for selecting Permissible Exposure Limits Tables; Table 1A-2 provides additional guidance for helmeted divers. Tables 1A-3 through 1A-5 provide specific procedures for diving operations involving AN/SQS-23, -26, -53, -56; AN/SQQ-14, -30, and -32; AN/BSY-1, -2; and AN/BQQ-5 sonars. Section 1A-6 provides guidance and precautions concerning diver exposure to low-frequency sonar (160-320Hz). Contact NAVSEA Supervisor of Diving (00C3B) for guidance on other sonars. This appendix has been substantially revised from Safe Diving Distances from Transmitting Sonar (NAVSEAINST 3150.2 Series) and should be read in its entirety.

1A-2 BACKGROUND

Chapter 18 of OPNAVINST 5100.23 Series is the basic instruction governing hearing conservation and noise abatement, but it does not address exposure to waterborne sound. Tables 1A-3 through 1A-6 are derived from experimental and theoretical research conducted at the Naval Submarine Medical Research Laboratory (NSMRL) and Naval Experimental Diving Unit (NEDU). This instruction provides field guidance for determining safe diving distances from transmitting sonar. This instruction supplements OPNAVINST 5100.23 Series, and should be implemented in conjunction with OPNAVINST 5100.23 Series by commands that employ divers.

The Sound Pressure Level (SPL), not distance, is the determining factor for establishing a Permissible Exposure Limit (PEL). The exposure SPLs in Tables 1A-3 through 1A-6 are based upon the sonar equation and assume omni-directional sonar and inverse square law spreading. Any established means may be used to estimate the SPL at a dive site, and that SPL may be used to determine a PEL. When the exposure level is overestimated, little damage, except to working schedules, will result. Any complaints of excessive loudness or ear pain for divers require that corrective action be taken. Section 1A-6 provides guidance for diver exposure to low-frequency active sonar (LFA), which should be consulted if exposure to LFA is either suspected or anticipated.

This appendix does not preclude the operation of any sonar in conjunction with diving operations, especially under operationally compelling conditions. It is based upon occupational safety and health considerations that should be implemented for routine diving operations. It should be applied judiciously under

special operational circumstances. The guidance in Tables 1A-3 through 1A-6 is intended to facilitate the successful integration of operations.

1A-3 ACTION

Commanding Officers or Senior Officers Present Afloat are to ensure that diving and sonar operations are integrated using the guidance given by this appendix. Appropriate procedures are to be established within each command to effect coordination among units, implement safety considerations, and provide efficient operations using the guidance in Tables 1A-3 through 1A-6.

1A-4 SONAR DIVING DISTANCES WORKSHEETS WITH DIRECTIONS FOR USE

1A-4.1 General Information/Introduction. Permissible Exposure Limits (PEL) in minutes for exposure of divers to sonar transmissions are given in Tables 1A-3 through 1A-6.

1A-4.1.1 Effects of Exposure. Tables 1A-3 through 1A-5 are divided by horizontal double lines. Exposure conditions above the double lines should be avoided for routine operations. As Sound Pressure Level (SPL) increases above 215 dB for hooded divers, slight visual-field shifts (probably due to direct stimulation of the semicircular canals), fogging of the face plate, spraying of any water within the mask, and other effects may occur. In the presence of long sonar pulses (one second or longer), depth gauges may become erratic and regulators may tend to free-flow. Divers at Naval Submarine Medical Research Laboratory experiencing these phenomena during controlled research report that while these effects are unpleasant, they are tolerable. Similar data are not available for un-hooded divers but visual-field shifts may occur for these divers at lower levels. If divers need to be exposed to such conditions, they must be carefully briefed and, if feasible, given short training exposures under carefully controlled conditions. Because the probability of physiological damage increases markedly as sound pressures increase beyond 200 dB at any frequency, exposure of divers above 200 dB is prohibited unless full wet suits and hoods are worn. Fully protected divers (full wet suits and hoods) must not be exposed to SPLs in excess of 215 dB at any frequency for any reason.

1A-4.1.2 Suit and Hood Characteristics. There is some variation in nomenclature and characteristics of suits and hoods used by divers. The subjects who participated in the Naval Submarine Medical Research Laboratory experiments used 3/8-inch nylon-lined neoprene wet suits and hoods. Subsequent research has shown that 3/16-inch wet suit hoods provide about the same attenuation as 3/8-inch hoods. Hoods should be well fitted and cover the skull completely including cheek and chin areas. The use of wet-suit hoods as underwater ear protection is strongly recommended.

1A-4.1.3 In-Water Hearing vs. In-Gas Hearing. A distinction is made between in-water hearing and in-gas hearing. In-water hearing occurs when the skull is directly in contact with the water, as when the head is bare or covered with a wet-suit hood. In-gas hearing occurs when the skull is surrounded by gas as in the MK 21 diving

helmet. In-water hearing occurs by bone conduction—sound incident anywhere on the skull is transmitted to the inner ear, bypassing the external and middle ear. In-gas hearing occurs in the normal way—sound enters the external ear canal and stimulates the inner ear through the middle ear.

1A-4.2 **Directions for Completing the Sonar Diving Distances Worksheet.** Follow the steps listed below to determine Permissible Exposure Limits (PELs) for the case when the actual dB Sound Pressure Level (SPL) at the dive site is unknown. Figure 1A-1 is a worksheet for computing the safe diving distance/exposure time. Figures 1A-2 through 1A-5 are completed worksheets using example problems. Work through these example problems before applying the worksheet to your particular situation.

Step 1. Diver Dress. Identify the type of diving equipment—wet-suit un-hooded; wet-suit hooded; helmeted. Check the appropriate entry on step 1 of the worksheet.

Step 2. Sonar Type(s). Identify from the ship’s Commanding Officer or representative the type(s) of sonar that will be transmitting during the period of time the diver is planned to be in the water. Enter the sonar type(s) in step 2 of the worksheet.

Step 3. PEL Table Selection. Use the Table 1A-1 to determine which PEL table you will use for your calculations. For swimsuit diving use wet suit un-hooded tables. Check the table used in step 3 of the worksheet.

Table 1A-1. PEL Selection Table.

DIVER DRESS:	SONAR		
	All except AN/SQQ -14, -30, -32	AN/SQQ -14, -30, -32	Unknown Sonar
Wet suit - Un-hooded	Table 1A-3	Table 1A-6	Start at 1000 yards and move in to diver comfort
Wet suit - Hooded	Table 1A-4	Table 1A-6	Start at 600 yards and move in to diver comfort
Helmeted	Table 1A-5	No restriction	Start at 3000 yards and move in to diver comfort

For guidance for sonars not addressed by this instruction, contact NAVSEA (00C32) DSN 327-2766.

NOTE **If the type of sonar is unknown, start diving at 600–3,000 yards, depending on diving equipment (use greater distance if helmeted), and move in to limits of diver comfort.**

Step 4. Distance to Sonar. Determine the distance (yards) to the transmitting sonar from place of diver’s work. Enter the range in yards in step 4 of the worksheet.

SONAR SAFE DIVING DISTANCE/EXPOSURE TIME WORKSHEET

1. Diver dress: Wet Suit - Un-hooded _____
 Wet Suit - Hooded _____
 Helmeted _____
2. Type(s) of sonar: _____
3. PEL table 1 ____; 2 ____; 3 ____; 4 ____
4. Range(s) to sonar (yards): _____
5. Estimated SPL at range(s) in step 3 (from table/column in step 3): _____

**Reminder: If range is between two values in the table, use the shorter range.
 If the SPL is measured at the dive site, use the measured value.**

6. Depth Reduction _____ dB
Reminder: 0 if not helmeted, see table in instructions if helmeted.
7. Corrected SPL (Step 5 minus Step 6) _____
8. Estimated PEL at SPL (from table/column in step 3 of the appendix): _____
9. Duty Cycle Known: Yes _____ (do step 9); No _____ (stop)

Adjusted PEL for actual duty cycle

$$\text{Actual DC \%} = 100 \times \frac{\text{sec. (pulse length)}}{\text{sec. (pulse repetition period)}}$$

$$\text{Actual DC \%} = \underline{\hspace{2cm}}$$

$$\text{Adjusted PEL} = \text{PEL (from step 8)} \times 20 / \text{actual duty cycle (\%)} = \underline{\hspace{2cm}} \text{ min.}$$

PEL1 = _____ minutes; PEL2 = _____ minutes

Reminder: Do not adjust the PEL if duty cycle is unknown.

10. Multiple Sonars: Yes _____ (do step 10); No _____ (stop)

Sonar 1: DT1 = _____ (Desired dive duration)
 PEL1 = _____ (from Step 8 or 9, as applicable)
 DT1/PEL1 = _____ .

Sonar 2: DT1 = _____ (Desired dive duration)
 PEL1 = _____ (from Step 8 or 9, as applicable)
 DT1/PEL1 = _____ .

$$\text{ND} = \underline{\hspace{1cm}} + \underline{\hspace{1cm}} = \underline{\hspace{1cm}} \text{ (This is less than 1.0, so dive is acceptable and may proceed.)}$$

Reminder: The Noise Dose must not exceed a value of 1.0.

Figure 1A-1. Sonar Safe Diving Distance/Exposure Time Worksheet.

NOTE **Note: If range is between two values in the table, use the shorter range. This will insure that the SPL is not underestimated and that the PEL is conservative.**

Step 5. Estimated SPL. In the PEL selection table (Table 1A-1) determined in step 3 of the worksheet (Figure 1A-1), locate the diving distance (range) in the appropriate sonar equipment column. Read across to the leftmost column to find the SPL in dB. For ranges intermediate to those shown use the shorter range. Enter this SPL value in step 5 of the worksheet. If the SPL value in dB can be determined at the dive site, enter the measured SPL value in step 5.

Step 6. Helmeted Dive Depth Reduction.

If the diver dress is not helmeted, enter 0 in step 6 of the worksheet and go to step 7 of these instructions.

Helmeted divers experience reduced sensitivity to sound pressure as depth increases. The reductions listed in Table 1A-2 may be subtracted from the SPLs for helmeted divers in Table 1A-5. Enter the reduction in step 6 of the worksheet. If the depth is between two values in the table, use the lesser reduction since that value will produce a conservative PEL.

Table 1A-2. Depth Reduction Table.

Depth (FSW)	Reduction (dB)	Depth (FSW)	Reduction (dB)
9	1	98	6
19	2	132	7
33	3	175	8
50	4	229	9
71	5	297	10

Step 7. Corrected SPL. The corrected SPL equals the Estimated SPL from step 5 minus the reduction in dB from step 6. Enter the corrected SPL in step 7 of the worksheet.

Step 8. PEL Determination. Go to the SPL in the appropriate table and read one column right to find the PEL for the SPL shown in step 7 of the worksheet. Enter in step 8 of the worksheet.

Step 9. Duty Cycle/Adjusted PEL Calculation. Tables 1A-3 through 1A-6 assume a transmit duty cycle of 20 percent. Duty cycle (DC) is the percentage of time in a given period that the water is being ensonified (sonar transmitting). Sonar operators may use various means of computing DC that are valid for the purpose of this instruction. If the actual duty cycle is different from 20 percent, PELs may

be extended or shortened proportionally. Use step 9 of the worksheet to calculate and enter the corrected PEL.

The formula for duty cycle is:

$$DC = 100 \times \text{Pulse length (sec.)} / \text{Pulse Repetition Period (sec.)}$$

The formula for the adjusted PEL is:

$$\text{Adjusted PEL} = \text{PEL} \times 20 / \text{actual duty cycle}; \text{Equation 1}$$

Example Problem. An un-hooded wet suited diver is 16 yards from an AN/SQQ-14 sonar transmitting a 500 msec pulse (.5 seconds) every 10 seconds.

Solution. The actual duty cycle (DC) % is:

$$\text{Actual DC \%} = 100 \times .5 / 10 = 5 \text{ percent.}$$

Locate the PEL from the table (which is for a 20% duty cycle). Compute the adjusted PEL as:

Using worksheet step 9, Adjusted PEL = PEL (from step 8) $170 \times 20/5=680$ minutes.

If variable duty cycles are to be used, select the greatest percent value.

Step 10. Multiple Sonar/Noise Dose Calculation. When two or more sonars are operating simultaneously, or two or more periods of noise exposure of different values occur, the combined effects must be considered. In the following formula, **ND is the daily noise dose and must not exceed a value of 1.0**, DT is the dive (exposure) time (left surface to reach surface), and PEL is the PEL for each noise exposure condition computed as described above:

$$ND = DT1/PEL1 + DT2/PEL2 + \dots DTn/PELn; \text{Equation 2}$$

Note: DT1/PEL1 is for the first sonar, DT2/PEL2 is for the second sonar, up to the total number of sonars in use.

To use the worksheet, go through the steps 1-9 for each sonar, entering the appropriate values in each step of the worksheet. Enter the PELs into the worksheet step 10. There is room for two sonars in the worksheet. If more than two are being used, follow the same format and continue the calculations in the white space at the end of the worksheet.

Example Problem. A hooded wet suited diver is 100 yards from a transmitting AN/SQS-53A sonar and a transmitting AN/SQS-23 sonar for fifteen minutes.

Solution.

$$DT1 = 15 \text{ minutes}$$

PEL1 (for SQS-53A) = 50 minutes
DT1/PEL1 = 15/50 = .3

DT2 = 15 minutes
PEL2 (for SQS-23) = 285 minutes
DT2/PEL2 = 15/285 = .05

ND = .3 + .05 = .35

This is less than 1.0 and therefore is acceptable.

Example 1: You are planning a routine dive for 160 minutes using wet-suited divers without hoods at a dive site 17 yards from an AN/SQQ-14 sonar. The duty cycle for the AN/SQQ-14 sonar is unknown. Is this dive permitted? Provide justification for your decision.

SONAR SAFE DIVING DISTANCE/EXPOSURE TIME WORKSHEET

1. Diver dress: Wet Suit - Un-hooded X
 Wet Suit - Hooded
 Helmeted
2. Type(s) of sonar: AN/SQQ-14
3. PEL table 1 ; 2 ; 3 ; 4 X
4. Range(s) to sonar (yards): 17
5. Estimated SPL at range(s) in step 3 (from table/column in step 3): SPL = 198 dB

Reminder: If range is between two values in the table, use the shorter range. If the SPL is measured at the dive site, use the measured value.

6. Depth Reduction 0 dB

Reminder: 0 if not helmeted, see table in instructions if helmeted.

7. Corrected SPL (Step 5 minus Step 6) SPL1 198 - 0 = 198 dB
8. Estimated PEL at SPL (from table/column in step 3 of the appendix): PEL1 = 170 minutes
9. Duty Cycle Known: Yes (do step 9); No X (stop)
 Adjusted PEL for actual duty cycle
 Actual DC % = $100 \times \frac{\text{pulse length}}{\text{pulse repetition period}}$ sec.
 Actual DC % =
 Adjusted PEL = PEL (from step 8) min. $\times 20 /$ actual duty cycle (%) = min.

Reminder: Do not adjust the PEL if duty cycle is unknown.

10. Multiple Sonars: Yes (do step 10); No X (stop)

Sonar 1: DT1 = (Desired dive duration)
 PEL1 = (from Step 8 or 9, as applicable)
 DT1/PEL1 = .

Sonar 2: DT1 = (Desired dive duration)
 PEL1 = (from Step 8 or 9, as applicable)
 DT1/PEL1 = .

ND = + = (This is less than 1.0, so dive is acceptable and may proceed.)

Reminder: The Noise Dose must not exceed a value of 1.0.

The dive time of 160 minutes is permitted because the PEL is 171 minutes.

Figure 1A-2. Sonar Safe Diving Distance/Exposure Time Worksheet (Completed Example).

Example 2: You are planning a routine dive for 75 minutes using wet-suited divers without hoods at a dive site which is 1000 yards from an AN/SQS-23 sonar. The SPL was measured at 185 dB. The duty cycle for the AN/SQS-23 sonar is unknown. Is this dive permitted? Provide justification for your decision.

SONAR SAFE DIVING DISTANCE/EXPOSURE TIME WORKSHEET

1. Diver dress: Wet Suit - Un-hooded X
 Wet Suit - Hooded
 Helmeted

2. Type(s) of sonar: AN/SQS-23

3. PEL table 1 X ; 2 ; 3 ; 4

4. Range(s) to sonar (yards): 1000

5. Estimated SPL at range(s) in step 3 (from table/column in step 3): SPL = 185 dB
 **Reminder: If range is between two values in the table, use the shorter range.
 If the SPL is measured at the dive site, use the measured value.**

6. Depth Reduction 0 dB
 Reminder: 0 if not helmeted, see table in instructions if helmeted.

7. Corrected SPL (Step 5 minus Step 6) SPL1 185 – 0 = 185 dB

8. Estimated PEL at SPL (from table/column in step 3 of the appendix): PEL1 = 170 minutes

9. Duty Cycle Known: Yes (do step 9); No X (stop)
 Adjusted PEL for actual duty cycle
 Actual DC % = $100 \times \frac{\text{pulse length}}{\text{pulse repetition period}}$
 Actual DC % =
 Adjusted PEL = PEL (from step 8) min. $\times 20 /$ actual duty cycle (%) = min.
 Reminder: Do not adjust the PEL if duty cycle is unknown.

10. Multiple Sonars: Yes (do step 10); No X (stop)
 Sonar 1: DT1 = (Desired dive duration)
 PEL1 = (from Step 8 or 9, as applicable)
 DT1/PEL1 = .
 Sonar 2: DT1 = (Desired dive duration)
 PEL1 = (from Step 8 or 9, as applicable)
 DT1/PEL1 = .
 ND = + = (This is less than 1.0, so dive is acceptable and may proceed.)
 Reminder: The Noise Dose must not exceed a value of 1.0.

The dive time of 75 minutes is permitted because the PEL is 170 minutes.

Figure 1A-3. Sonar Safe Diving Distance/Exposure Time Worksheet (Completed Example).

Example 3: You are planning a 98 fsw dive for 35 minutes using the MK 21 at a dive site which is 3000 yards from an AN/SQS-53C sonar. The duty cycle for the AN/SQS-53C sonar is unknown. Is this dive permitted? Provide justification for your decision.

SONAR SAFE DIVING DISTANCE/EXPOSURE TIME WORKSHEET

1. Diver dress: Wet Suit - Un-hooded _____
 Wet Suit - Hooded _____
 Helmeted X
2. Type(s) of sonar: AN/SQS-53C
3. PEL table 1 ____; 2 ____; 3 X ; 4 ____
4. Range(s) to sonar (yards): 3000
5. Estimated SPL at range(s) in step 3 (from table/column in step 3): SPL1 = 181 dB

Reminder: If range is between two values in the table, use the shorter range. If the SPL is measured at the dive site, use the measured value.

6. Depth Reduction 6 dB

Reminder: 0 if not helmeted, see table in instructions if helmeted.

7. Corrected SPL (Step 5 minus Step 6) SPL1 181 - 6 = 175 dB
8. Estimated PEL at SPL (from table/column in step 3 of the appendix): PEL1 = 50 minutes
9. Duty Cycle Known: Yes _____ (do step 9); No X (stop)
 Adjusted PEL for actual duty cycle
 Actual DC % = $100 \times \frac{\text{_____}}{\text{_____}}$ sec. (pulse length / _____ sec. (pulse repetition period)
 Actual DC % = _____
 Adjusted PEL = PEL (from step 8) _____ min. $\times 20 /$ actual duty cycle (%) _____ = _____ min.

Reminder: Do not adjust the PEL if duty cycle is unknown.

10. Multiple Sonars: Yes _____ (do step 10); No X (stop)

Sonar 1: DT1 = _____ (Desired dive duration)
 PEL1 = _____ (from Step 8 or 9, as applicable)
 DT1/PEL1 = _____ .

Sonar 2: DT1 = _____ (Desired dive duration)
 PEL1 = _____ (from Step 8 or 9, as applicable)
 DT1/PEL1 = _____ .

ND = _____ + _____ = _____ (This is less than 1.0, so dive is acceptable and may proceed.)

Reminder: The Noise Dose must not exceed a value of 1.0.

The dive time of 35 minutes is permitted because the PEL is 50 minutes.

Figure 1A-4. Sonar Safe Diving Distance/Exposure Time Worksheet (Completed Example).

Example 4: You are planning a routine dive for 120 minutes using wet-suited divers with hoods at a dive site which is 200 yards from an AN/SQS-53A sonar and 120 yards from an AN/SQS-23 sonar. The AN/SQS-53A sonar is transmitting an 800 msec pulse (0.8 sec) every 20 seconds. The duty cycle for the AN/SQS-23 sonar is unknown. Is this dive permitted? Provide justification for your decision.

SONAR SAFE DIVING DISTANCE/EXPOSURE TIME WORKSHEET

1. Diver dress: Wet Suit - Un-hooded _____
 Wet Suit - Hooded X
 Helmeted _____

2. Type(s) of sonar: AN/SQS-53A and AN/SQS-23

3. PEL table 1 ; 2 X ; 3 ; 4

4. Range(s) to sonar (yards): 200 (from SQS-53A); 120 (from SQS-23)

5. Estimated SPL at range(s) in step 3 (from table/column in step 3): SPL1 = 201; SPL2 = 196
 (per reminder, use SPL for 112 yard range)
**Reminder: If range is between two values in the table, use the shorter range.
 If the SPL is measured at the dive site, use the measured value.**

6. Depth Reduction 0 dB

Reminder: 0 if not helmeted, see table in instructions if helmeted.

7. Corrected SPL (Step 5 minus Step 6) SPL1 201 – 0 = 201 dB; SPL2 196 – 0 = 196 dB;

8. Estimated PEL at SPL (from table/column in step 3 of the appendix): PEL1 = 143 min; PEL 2 = 339 min

9. Duty Cycle Known: Yes X (do step 9); No (stop)
 Adjusted PEL for actual duty cycle
 Actual DC % = $100 \times \frac{0.8}{20}$ sec. (pulse length / 20 sec. (pulse repetition period)
 Actual DC % = 4
 Adjusted PEL = PEL (from step 8) 143 min. $\times 20 /$ actual duty cycle (%) 4 = 715 min.
 PEL1 = 715 minutes; PEL2 = 339 minutes
Reminder: Do not adjust the PEL if duty cycle is unknown.

10. Multiple Sonars: Yes X (do step 10); No (stop)

 Sonar 1: DT1 = 120 (Desired dive duration)
 PEL1 = 715 (from Step 8 or 9, as applicable)
 DT1/PEL1 = 120/715 = 0.17 .

 Sonar 2: DT1 = 120 (Desired dive duration)
 PEL1 = 339 (from Step 8 or 9, as applicable)
 DT1/PEL1 = 120/339 = .35 .

 ND = 0.17 + 0.35 = 0.52 (This is less than 1.0, so dive is acceptable and may proceed.)
Reminder: The Noise Dose must not exceed a value of 1.0.

The dive time of 120 minutes is permitted because the ND is less than 1.0.

Figure 1A-5. Sonar Safe Diving Distance/Exposure Time Worksheet (Completed Example).

Table 1A-3. Wet Suit Un-Hooded.

Permissible Exposure Limit (PEL) within a 24-hour period for exposure to AN/SQS-23, -26, -53, -56, AN/BSY-1, -2 and AN/BQQ-5 sonars, including versions and upgrades. Exposure conditions shown above the double line should be avoided except in cases of compelling operational necessity.

Estimated Ranges in yards for given SPL and PEL for sonar.

SPL (dB)	PEL (MIN)	BQQ-5 BSY-2 SQS-26CX(U)			SQS-23 SQS-26AX		A V E R S I O N S
		BSY-1 SQS-53C	SQS-53A, SQS-53B SQS-56(U)	SQS-26BX, SQS-26CX SQS-56	H R I E S		
200	13	316	224	71			
199	15	355	251	79			
198	18	398	282	89			
197	21	447	316	100			
196	25	501	355	112			
195	30	562	398	126			
194	36	631	447	141			
193	42	708	501	158			
192	50	794	562	178			
191	60	891	631	200			
190	71	1,000	708	224			
189	85	1,122	794	251			
188	101	1,259	891	282			
187	120	1,413	1,000	316			
186	143	1,585	1,122	355			
185	170	1,778	1,259	398			
184	202	1,995	1,413	447			
183	240	2,239	1,585	501			
182	285	2,512	1,778	562			
181	339	2,818	1,995	631			
180	404	3,162	2,239	708			
179	480	3,548	2,512	794			
178	571	3,981	2,818	891			
177	679	4,467	3,162	1,000			
176	807	5,012	3,548	1,122			
175	960	5,623	3,981	1,259			

All ranges and SPLs are nominal.

*SPL is measured in dB/1 μ PA at the dive site. To convert SPL for sound levels referenced to mbar, subtract 100 dB from tabled levels.

(U) = upgrade

Table 1A-4. Wet Suit Hooded.

Permissible Exposure Limit (PEL) within a 24-hour period for exposure to AN/SQS-23, -26, -53, -56, AN/BSY-1, -2, and AN/BQQ-5 sonar, including versions and upgrades. Exposure conditions shown above the double line should be avoided except in cases of compelling operational necessity.

Estimated Ranges in yards for given SPL and PEL for sonar.

SPL (dB)	PEL (MIN)	BQQ-5 BSY-2 SQS-26CX(U)			SQS-23 SQS-26AX		A V E R Y D I S T A N C E
		BSY-1 SQS-53C	SQS-53A, SQS-53B SQS-56(U)	SQS-26BX, SQS-26CX SQS-56	SQS-26BX, SQS-26CX SQS-56		
215	13	56	40	13			
214	15	63	45	14			
213	18	71	50	16			
212	21	79	56	18			
211	25	89	63	20			
210	30	100	71	22			
209	36	112	79	25			
208	42	126	89	28			
207	50	141	100	32			
206	60	158	112	35			
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205	71	178	126	40			
204	85	200	141	45			
203	101	224	158	50			
202	120	251	178	56			
201	143	282	200	63			
200	170	316	224	71			
199	202	355	251	79			
198	240	398	282	89			
197	285	447	316	100			
196	339	501	355	112			
195	404	562	398	126			
194	480	631	447	141			
193	571	708	501	158			
192	679	794	562	178			
191	807	891	631	200			
190	960	1,000	708	224			

All ranges and SPLs are nominal.

*SPL is measured in dB/1 μPA at the dive site. To convert SPL for sound levels referenced to mbar, subtract 100 dB from tabled levels.

(U) = upgrade

Table 1A-5. Helmeted.

Permissible Exposure Limit (PEL) within a 24-hour period for exposure to AN/SQS-23, -26, -53, -56, AN/BSY-1, -2, and AN/BQQ-5 sonar, including versions and upgrades. Exposure conditions shown above the double line should be avoided except in cases of compelling operational necessity.

Estimated Ranges in yards for given SPL and PEL for sonar.

SPL (dB)	PEL (MIN)	BSY-1 SQS-53C	BQQ-5 BSY-2 SQS-26CX(U)	SQS-23 SQS-26AX	A V E R I S T H I S
			SQS-53A, SQS-53B SQS-56(U)	SQS-26BX, SQS-26CX SQS-56	
183	13	2,239	1,585	501	A
182	15	2,512	1,778	562	V
181	18	2,818	1,995	631	O
180	21	3,162	2,239	708	I
179	25	3,548	2,512	794	D
178	30	3,981	2,818	891	S
177	36	4,467	3,162	1,000	T
176	42	5,012	3,548	1,122	H
175	50	5,623	3,981	1,259	I
174	60	6,310	4,467	1,413	S
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173	71	7,079	5,012	1,585	
172	85	7,943	5,623	1,778	
171	101	8,913	6,310	1,995	
170	120	10,000	7,079	2,239	
169	143	11,220	7,943	2,512	
168	170	12,589	8,913	2,818	
167	202	14,125	10,000	3,162	
166	240	15,849	11,220	3,548	
165	285	17,783	12,589	3,981	
164	339	19,953	14,125	4,467	
163	404	22,387	15,849	5,012	
162	480	25,119	17,783	5,623	
161	571	28,184	19,953	6,310	
160	679	31,623	22,387	7,079	
159	807	35,481	25,119	7,943	
158	960	39,811	28,184	8,913	

All ranges and SPLs are nominal.

*SPL is measured in dB/1 μ PA at the dive site. To convert SPL for sound levels referenced to mbar, subtract 100 dB from tabled levels.

(U) = upgrade

Table 1A-6. Permissible Exposure Limit (PEL) Within a 24-hour Period for Exposure to AN/SQQ-14, -30, -32 Sonars.

Estimated Ranges in yards for given SPL and PEL for sonar.

WET SUIT UN-HOODED		
SPL (dB)	PEL (MIN)	Range (yards)
200	120	13
199	143	14
198	170	16
197	202	18
196	240	20
195	285	22
194	339	25
193	404	28
192	480	32
191	571	35
190	679	40
189	807	45
188	960	50
WET SUIT HOODED		
SPL (dB)	PEL (MIN)	Range (yards)
215	120	2
214	143	3
213	170	3
212	202	3
211	240	4
210	285	4
209	339	4
208	404	5
207	480	6
206	571	6
205	679	7
204	807	8
203	960	9

Dry suit helmeted divers: no restriction for these sonars. All ranges and SPLs are nominal.

*SPL is measured in dB/1 μ PA at the dive site. To convert SPL for sound levels referenced to mbar, subtract 100 dB from tabled levels.

1A-5 GUIDANCE FOR DIVER EXPOSURE TO LOW-FREQUENCY SONAR (160–320 Hz)

If possible, you should avoid diving in the vicinity of low-frequency sonar (LFS). LFS generates a dense, high-energy pulse of sound that can be harmful at higher power levels. Because a variety of sensations may result from exposure to LFS, it is necessary to inform divers when exposure is likely and to brief them regarding possible effects; specifically, that they can expect to hear and feel it. Sensations may include mild dizziness or vertigo, skin tingling, vibratory sensations in the throat and abdominal fullness. Divers should also be briefed that voice communications are likely to be affected by the underwater sound to the extent that line pulls or other forms of communication may become necessary. Annoyance and effects on communication are less likely when divers are wearing a hard helmet (MK 21) diving rig. For safe distance guidance, contact NAVSEA (00C3) Telephone numbers are listed in Volume 1, Appendix C.

1A-6 GUIDANCE FOR DIVER EXPOSURE TO ULTRASONIC SONAR (250 KHz AND GREATER)

The frequencies used in ultrasonic sonars are above the human hearing threshold. The primary effect of ultrasonic sonar is heating. Because the power of ultrasonic sonar rapidly falls off with distance, a safe operating distance is 10 yards or greater. Dive operations may be conducted around this type of sonar provided that the diver does not stay within the sonar's focus beam. The diver may finger touch the transducer's head momentarily to verify its operation as long as the sonar is approached from the side.